ULE and Battery Lifetime

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PN: 506-001241-01 REV A

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1. Distinguish between Pageable and non-Pageable Devices
2. Account for various operation mode contributions
3. Provide some examples for various Use Cases

1. Pageable and non-Pageable Devices

1.1 Pageable Versus Non-Pageable Devices

- Most ULE Home Automation Devices are **non-pageable** – they are not “immediately” available for updates/re-configurations/queries from the ULE Hub (Controller). Examples of such devices are Smoke & Motion Detectors, Open/Close Detectors. They exit hibernation mode only to send maintenance packet (Keep Alive) or an Alert/Event (=Transactions). At such junctures, the ULE Hub can initiate a transaction as well. The average current of such devices is typically dictated by the interval of the Keep Alive transaction

- Battery-Powered **Pageable** devices are also found in the home. Examples: Battery-powered Alarms or Warning Lights or Door Locks. Such ULE Devices need to wakeup and check for a page at an interval which satisfies the response latency tolerance. The average current of such devices is dictated by the wakeup interval

1.2 Non-Pageable Device Activity Profiles

- Devices spend the large majority (>99%) of their lifetime in hibernation. In this mode, only the ULE block within the DHX91 is active, draining 1.7uA.

- ULE devices are designed with a “Keep Alive” (maintenance) function where the ULE timer is programmed to occasionally wake up the device and allow it to Sync and Exchange a single 32-Byte Data Packet with the ULE Controller. Typical Wakeup interval is 15 minutes

- Home Automation Devices will also awake from hibernation to transfer data (eg temperature, humidity), Control (light On-Off) and alarms (door-window entry, smoke) with the Controller via a 32-Byte Data Packet

1.3 Computing Battery Life for Non-Pageable Device

- Add the depletion caused by each of the 3 activity modes to obtain the Total average current:
  - Hibernate: 1.7uA x Duty Cycle (~1) = 1.7uA, average
  - Keep Alive: Charge Depletion (μC) per 32-Byte Data Transaction x Duty Cycle (Duty Cycle = # of transactions per day/86400seconds)
  - Events, Alarms, Etc: Computed the same as Keep Alive

- Note that this calculation only accounts for "ULE Communication Pipe". Additional budget must be allocated for external sensors and/or controllers

- Battery Lifetimes are typically specified in mAh (ie AAA = 1000mAh, CR123A= 1500mAh). So to predict lifetime it is convenient to convert total average current to mAh/year. Each μA of current depletes at the rate of 8.76mAh/year!

2. Operation Mode Contribution

2.1 Charge Depleted During 32-Byte Transaction

- Each 32-Byte transaction "costs" 2mC (and ~100mS) – See Backup slide for breakdown
- The contribution of these transaction to average current increases linearly with the # of transactions – see the tabulation below:

Transfer a single packet of Data (32Bytes) as a function of events per day			
charge/transfer(uC)	**events/day**	**average current (uA)**	**Battery Drain (mAh/yr)**
2000	10	0.2	2
2000	100	2.3	20
2000	500	11.6	100

3. Use Cases

3.1 Use Case Example: Motion Detector

- A motion detector with Keep Alive every 15 minutes (=~100 time/day) and 100 detections per day:
    - 4.6μA contributed by 200 Events (per tabulation in previous page)
    - 1.7μA contributed by Hibernate
    - Total of 6.3μA avg (=55mAh/yr) for ULE "communication pipe"
    - Assume another 7μA for actual motion sensor, gives 13.3μA avg or 116mAh/year
    - Supplied by a CR123A LiOn Battery (specified with 1500mAh capacity), this corresponds to 1500/116 = 12 years
- Door and Window Magnet, Smoke Detector, Thermostat and Light Switch would have similar battery drain profiles

3.2 Current Versus Time Template for 32-Byte Transaction

3.3 Pageable Device Activity Profile: DHX101

- In addition to hibernating (99% of the time, as previously) and occasional 32-byte transactions, pageable devices wake up at short intervals to check for incoming page
- Each wakeup “costs” 75μC (new DHX101 SOC) and 6mS (Note: Its predecessor, DHX91, requires ~500μC) per wakeup)
- The contribution of wakeups to average current decrease linearly with the interval between wakeups – see table below:

Pageable Device Battery Drain as a function of latency			
charge/wakeup (uC)	latency (s)	average current (uA)	Battery Drain (mAh/yr)
100	1	100	876
100	3	33	292
100	5	20	175
100	10	10	88

3.4 Use Case Example: Door Lock

- A Door Lock with Keep Alive every 15 minutes (=~100 time/day) and 10 Open/Close Events per day and 1.28s Latency in response tolerance:
    - 1.7μA contributed by Hibernate
    - 2.3μA contributed by 100 Keep Alives
    - 0.2μA contributed by Open/Close Events
    - 65μA contributed by Wakeups (See Table on previous page)
    - Total of 69.2μA avg (=606mAh/yr) for ULE "communication pipe"
    - Supplied by a 2xAAA LiOn Battery (specified with 750mAh capacity), this corresponds to 750/606 = 1.23 Years

3.5 Pageable Device: DHX101 Measurements

- Test Platform: EVB with DHX101
- SW Image: ULE SDK 37.05, Voice Call
- Paging with PMSS Enabled
- Wakeup Interval (= Response Time, 1.28s)

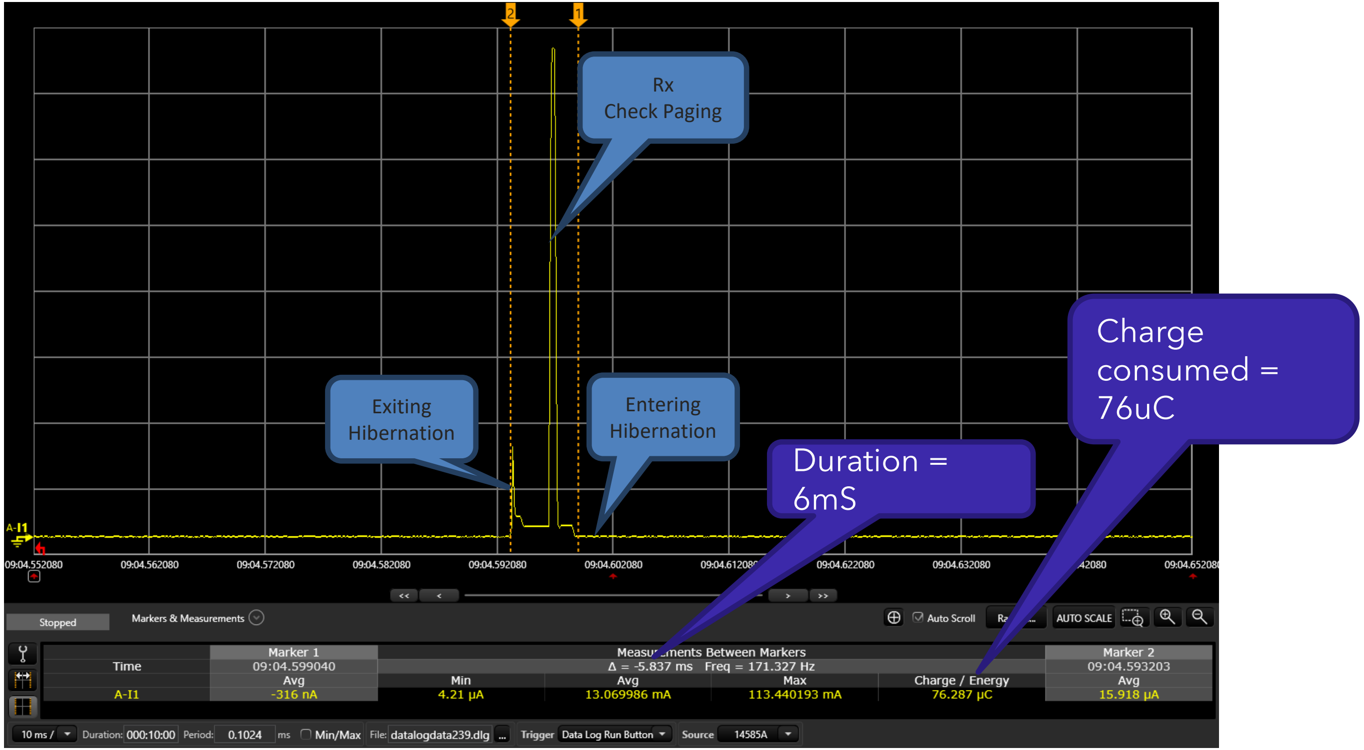
Device 1 Information

(0x01) HF Core Release (R)	02
(0x02) Profile Release (R)	01
(0x03) Interface Release (R)	01
(0x04) Paging Caps (R)	03
(0x05) Min Sleep Time (R)	0x000003E8 (1000)
(0x06) Actual Response Time (R)	0x00000500 (1280)
(0x07) Application Version (R)	37.05
(0x08) Hardware Version (R)	dhx101-dhan_mb-c
(0x09) EMC (R)	0FEB
(0x0A) IPUI (R)	02E9E23456
(0x0B) Manufacture (R)	DSP Group
(0x0C) Location (R/W)	Living room
(0x0D) Device Enable (R/W)	01
(0x0E) Friendly Name (R/W)	ULE Voice Call
(0x0F) Device UID (R)	(None)

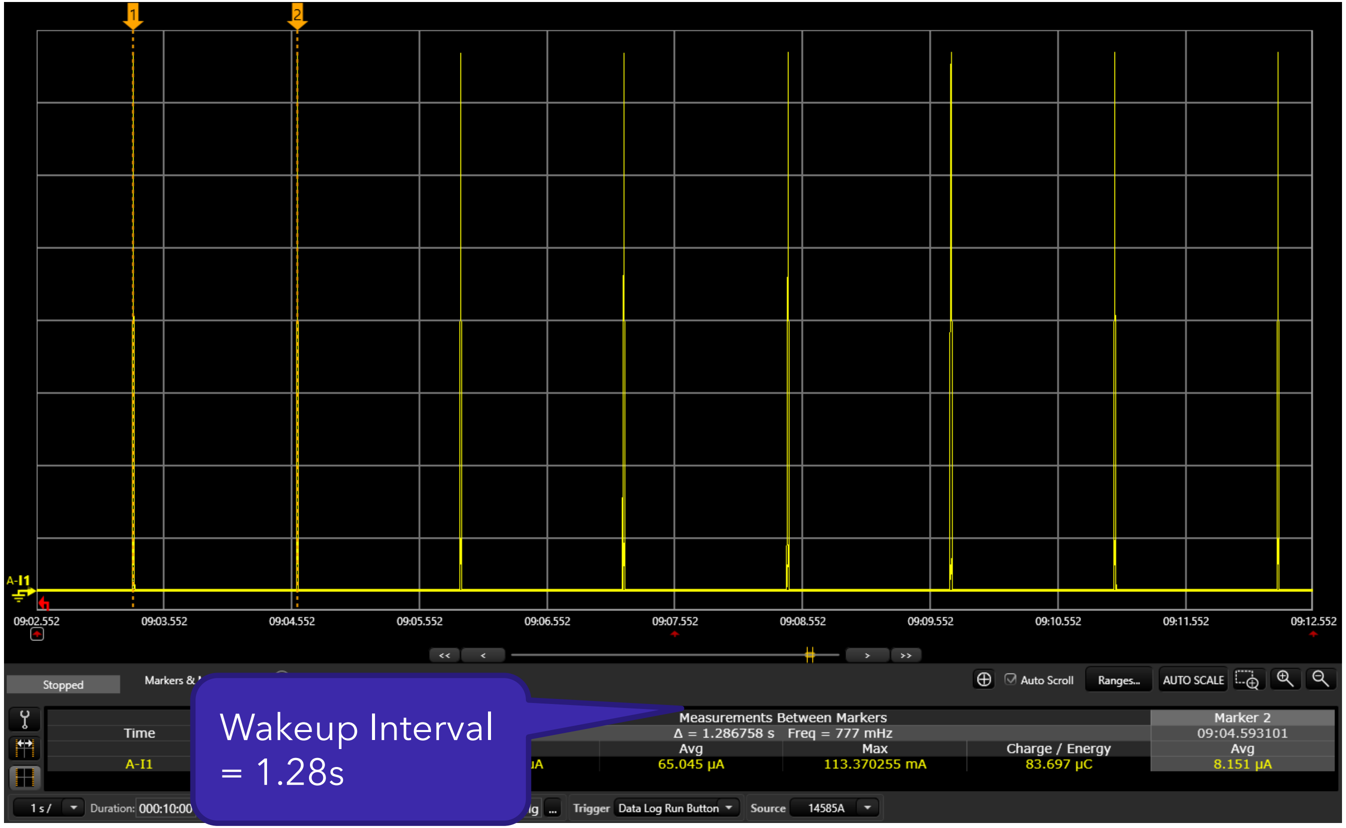
3.6 Current Drain Profile: Wakeup, Check for Page

X-Axis: Time, 10mS/Div
Y-Axis: Current, 20mA/Div

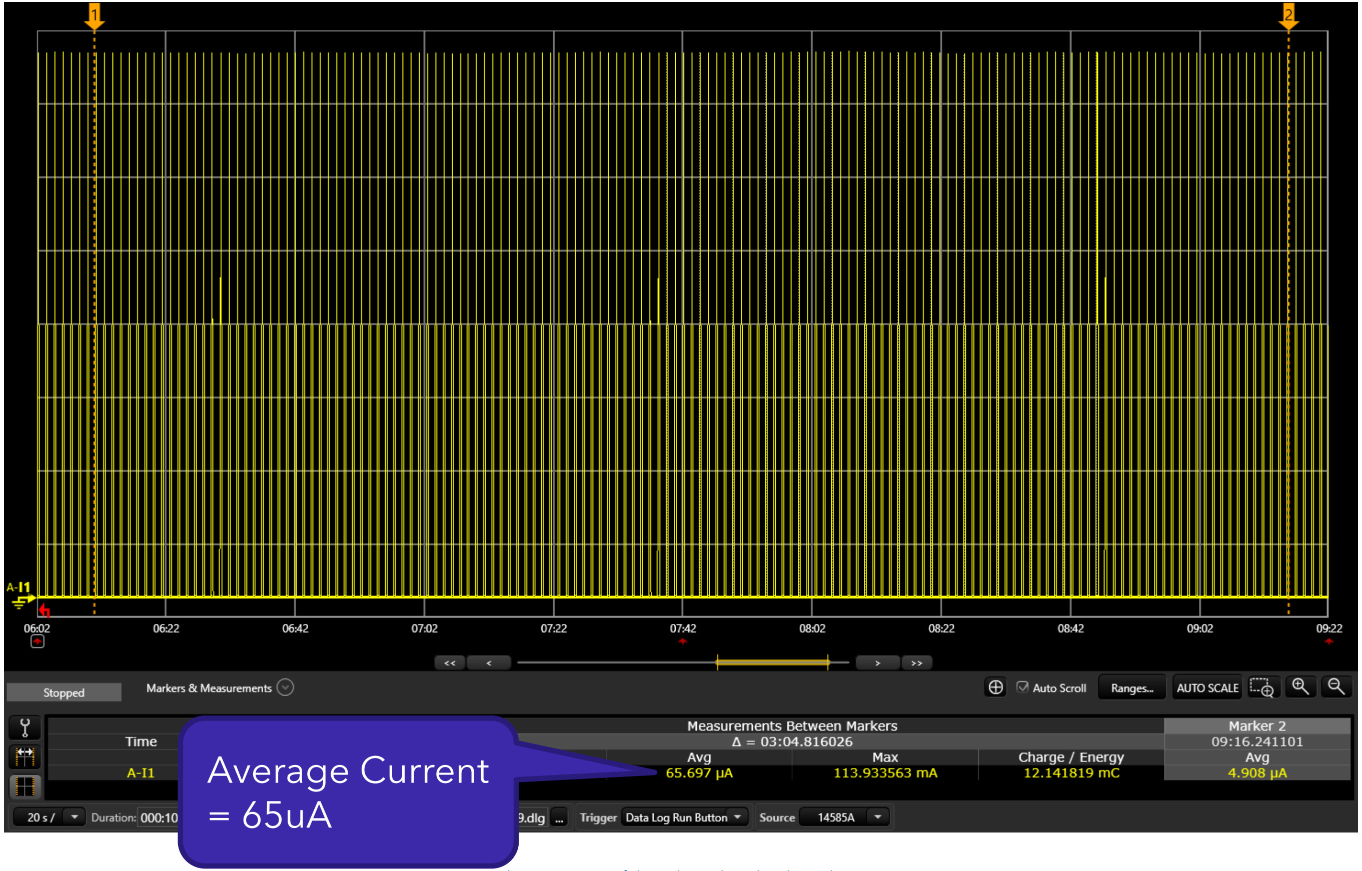
Wakeup Duration ~6mS
Charge Consumed ~76uA



3.7 Wakeup Interval: Checking for Page Every 1.28s



3.8 Average Current Drain for 1.28s Wakeup Interval



Revision History

Revision	Description
1	Initial release.
A	Initial production release.

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