Industry Session 15: Energy Harvesting

APEC 2019 Tektronix

Power Sources Manufacturers Association
The Multinational Power Electronics Association

Solving the Energy Harvesting and IoT Power Consumption Measurement Challenges

Presented by

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Energy and Automotive

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KEITHLEY
A Tektronix Company

Wednesday, March 20, 2019

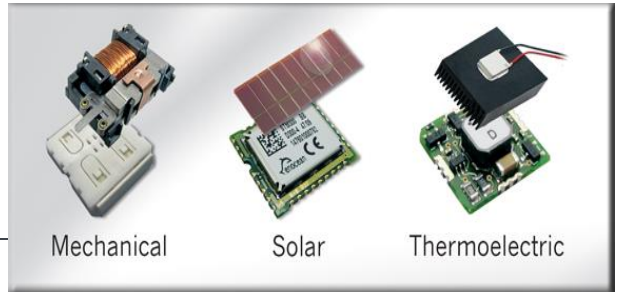

Image source: eeweb.com

Energy Harvesting Power Analysis Summary

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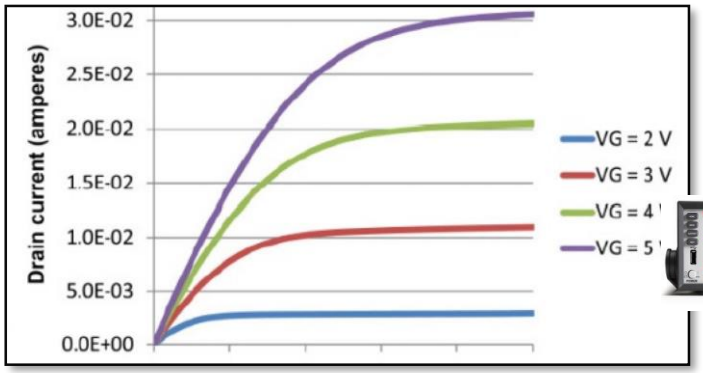
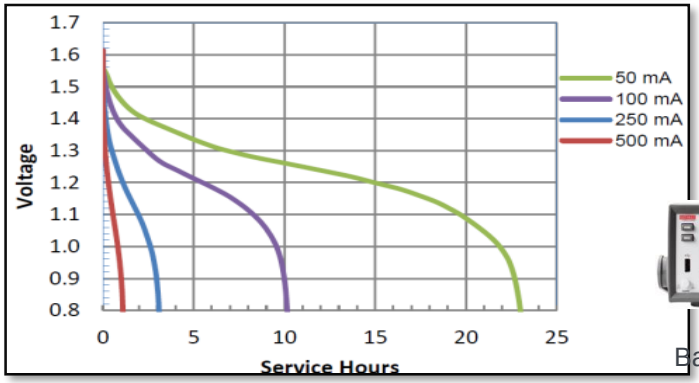
  - Check PMIC efficiency and consumption
  - Check discrete component characterization if necessary
  - Generate models to make testing easier



2450 SMU

- **Characterize and model batteries**
  - How battery performs in end app
  - See how changing battery profile can help
  - Check how other circuit performs with different battery characteristics (Voltage and Resistance)
  - Efficient and repeatable testing at any state of the battery



2281
Battery Simulator

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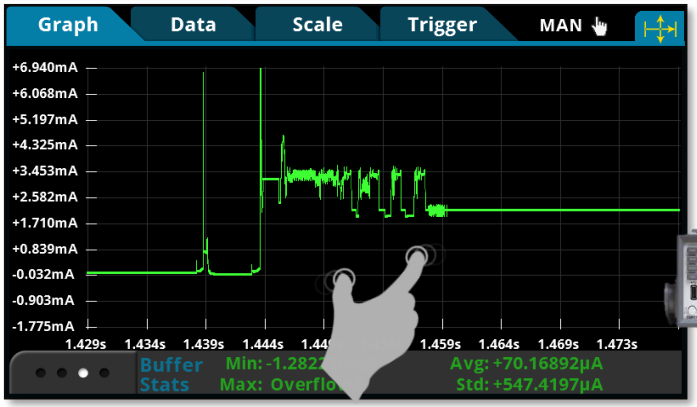


7510 DMM

Harvesting System Desired Properties

Power Management
- High Efficiency
- Low standby
- Process small energy packets
- Wide Voltage and Current range

Storage System
- High energy retention
- High density
- Low leakage

Load
- Irregular and fast on/off
- Low active consumption
- Deep Sleep

Image source: eeweb.com

Obvious, but difficult….

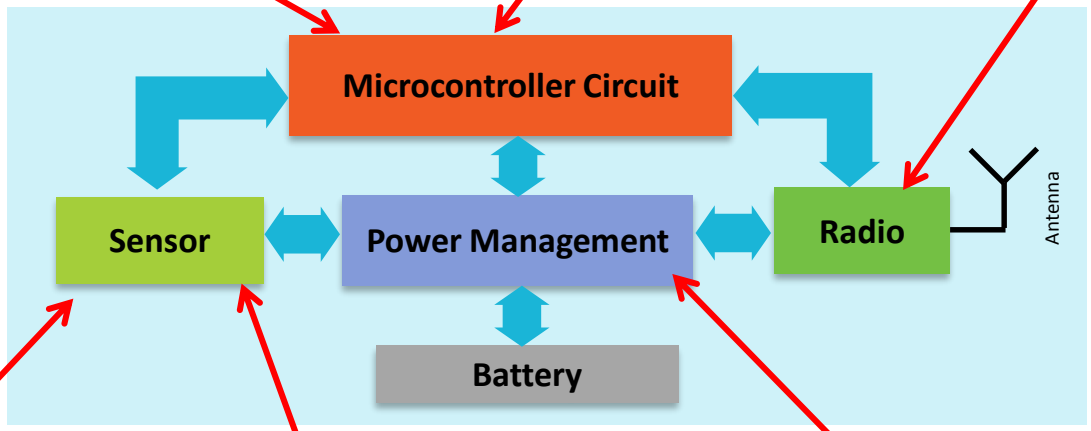
The Engineering Challenge

DEFINING A POWER BUDGET

Lo Power Microcontrollers
- Sleep mode: **100nA**
- Standby mode: **1µA**
- Active mode: **35 µA/MHz**

Real Time Clocks
Active Mode: **240nA**

Bluetooth Low Energy
Tx/Rx Chipsets
Sleep Mode: **<100nA**



Sensors
Active Mode: **360nA**

Amplifiers:
Supply Current: **<1µA**

DC-DC Converter:
Quiescent Current: **680nA**

Understanding requirements in a dynamic environment.

Measuring Requirements

IT'S A DEMANDING TASK

Measuring sleep mode currents

- ≤0.1nA sensitivity
- Dynamic range
- High accuracy

Capturing current bursts (radio)

- High sampling
- High BW
- Triggers
- Waveform display
- Signal analysis

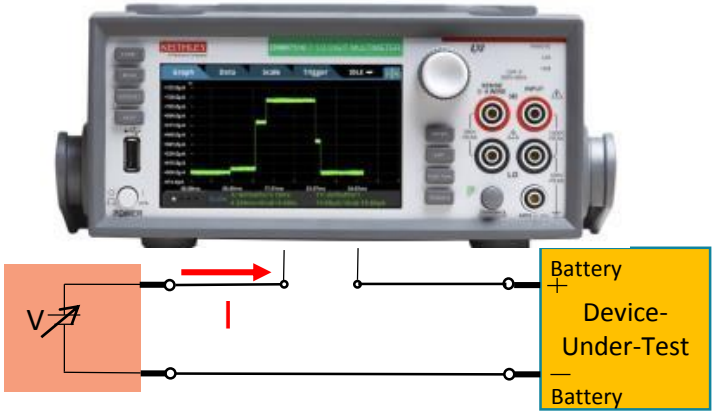
Capturing the load current profile

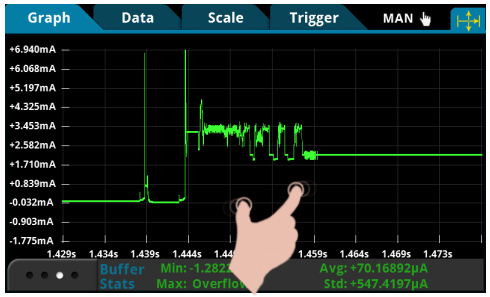
- Deep buffer memory

What do you think is the right tool?

7.5 Digit Sampling Graphical DMM

ONE-INSTRUMENT WITH HIGH SENSITIVITY, BW, SPEED



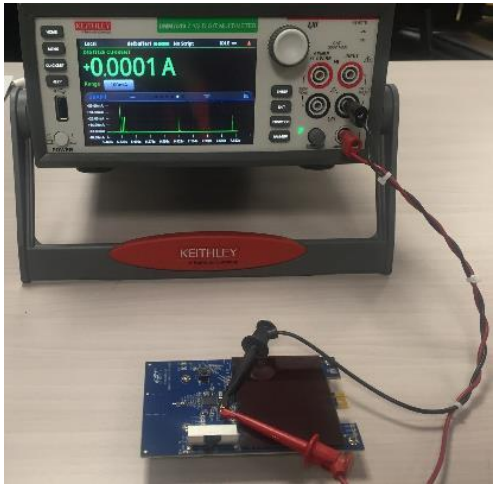


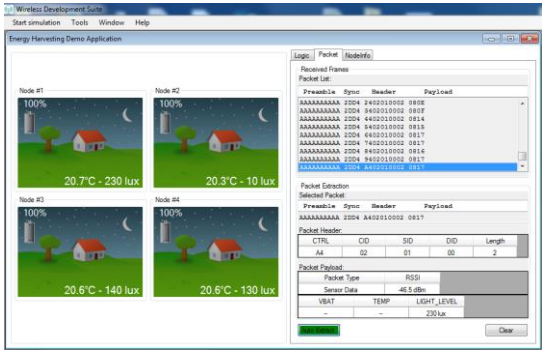
Requirements	Ability to meet the Requirements
Sleep mode Measurements	• 1 pA sensitivity with dynamic range • Extremely low voltage burden, 15mV
Capturing short current bursts	• 1Msample/s sampling rate • Level, slope, and other triggering modes
Capturing a load current profile	• 27M readings
Visualizing the data	• Large graphical touchscreen display with statistics and pinch and zoom capability

Si1012 Energy Harvesting Power Analysis

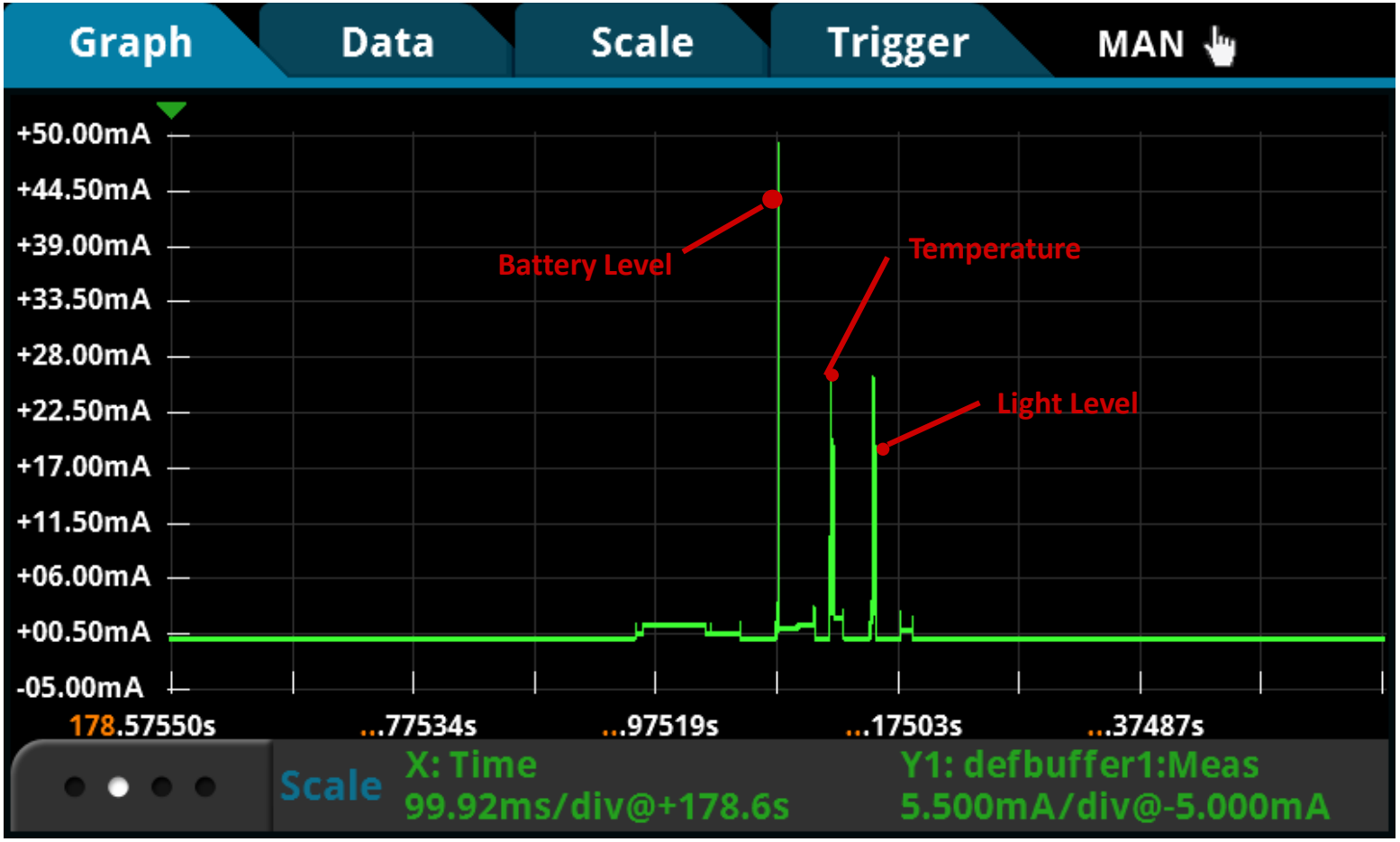
BATTERY LESS WIRELESS SENSOR (SOLAR CELL BASED)

- Transmits Temp, Light & Battery life
- Life expectancy >15 years or 7000 uA-H
- Node operates at 919.84 MHz
- Low-power state ≤50 nA
- The leakage current PV is ~3 µA
- Works both in indoor and outdoor lighting
- Can last 7 days in a dark closet



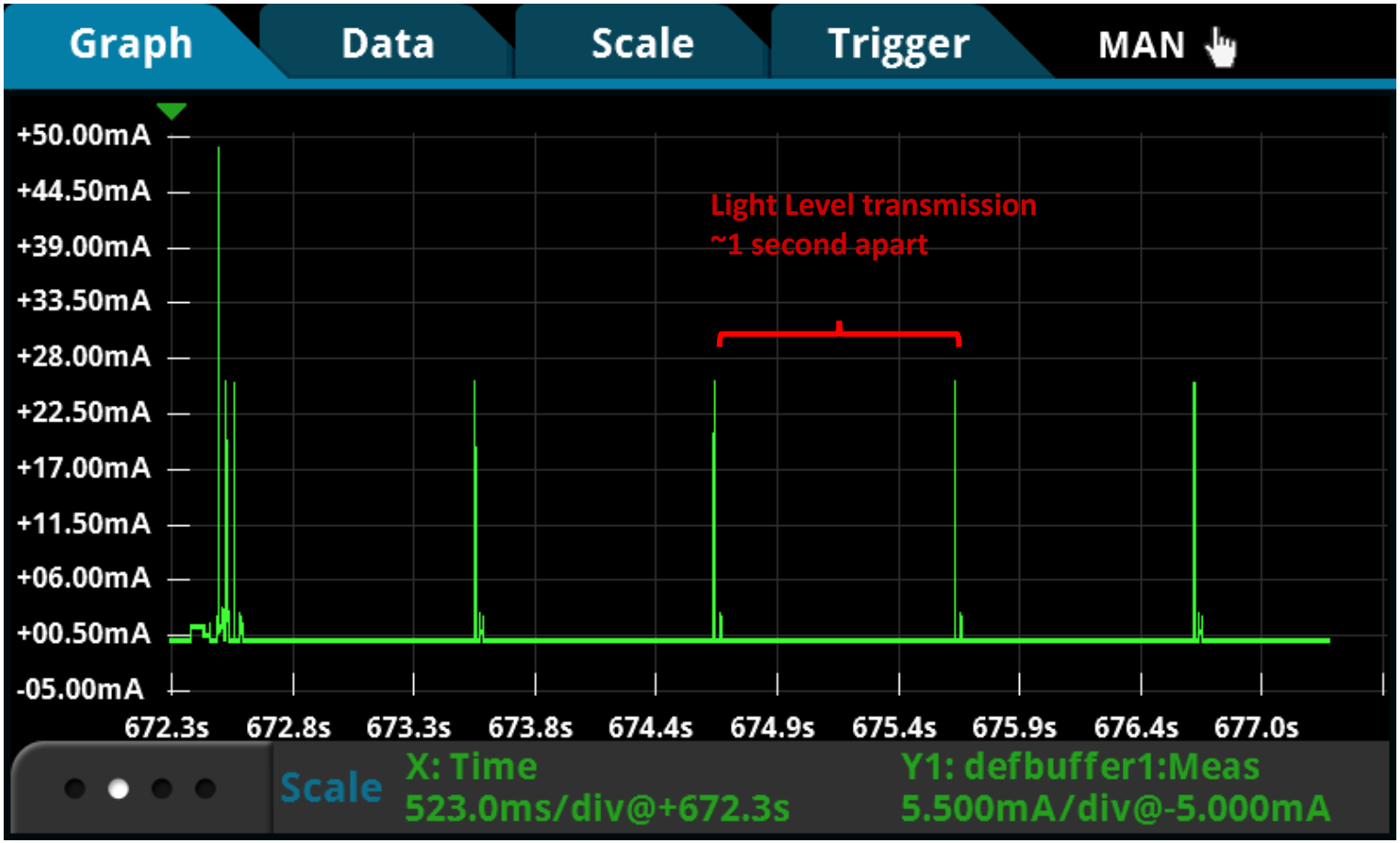


Button press - 3 Distinct Transmissions



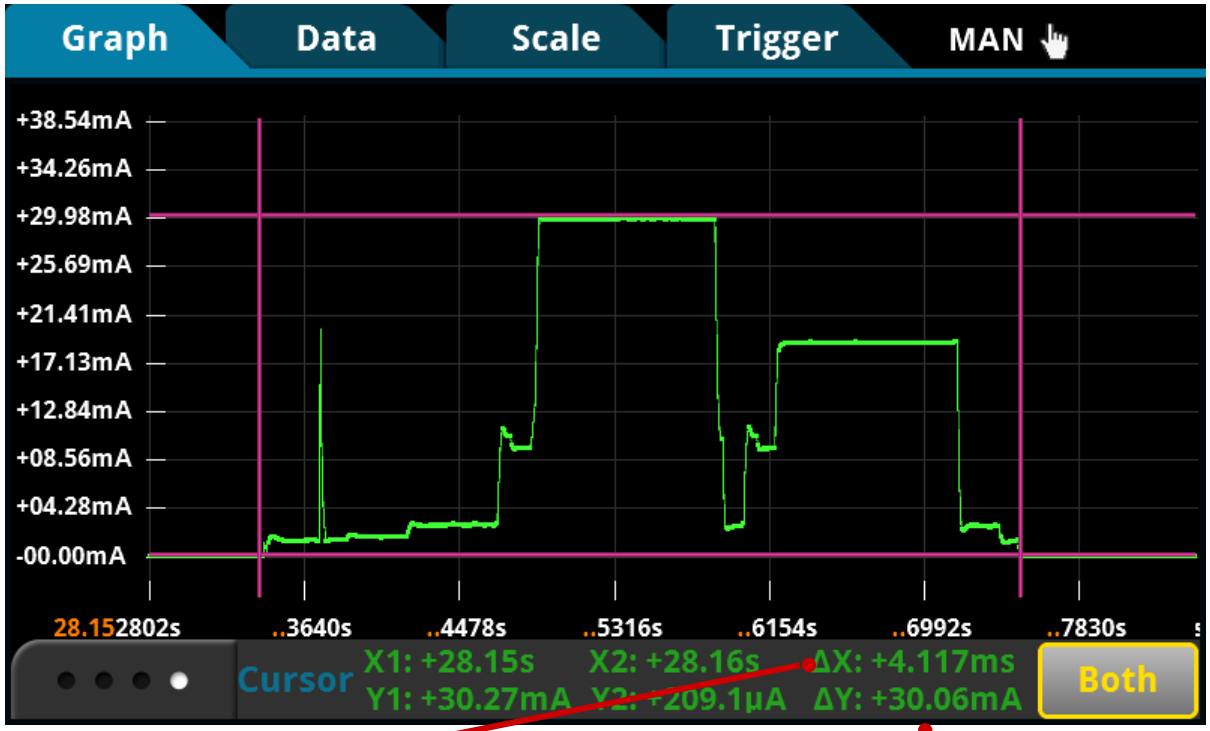
Distinct Pulse Train Current Profiles

Analyze: Light Level Tc



More analysis...

Active State Analysis (zooming in)



Tx and Rx each are about 1ms

Total active state lasts about 4ms including the transient

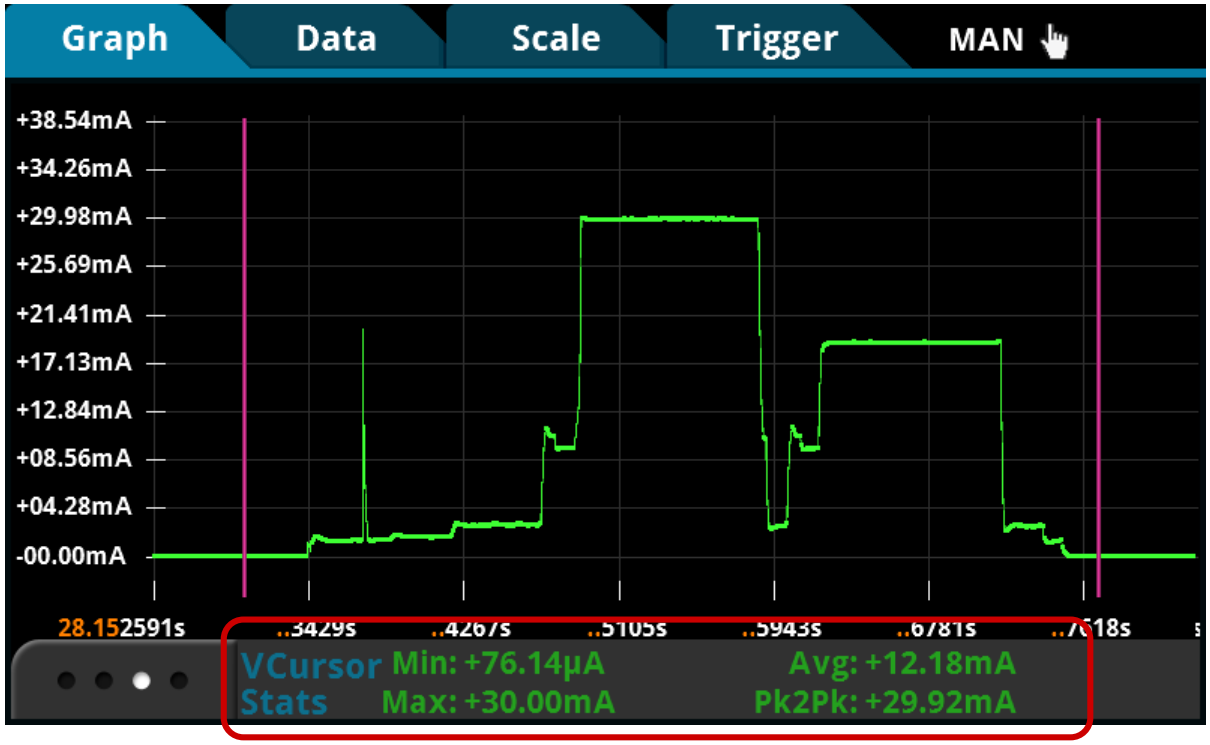
Tx ~29mA

Rx ~18mA

- **Each Active State lasts about 4ms**
- **Tx Pulse is 1ms**

- **Tx Peak Current**

Average Current measurement

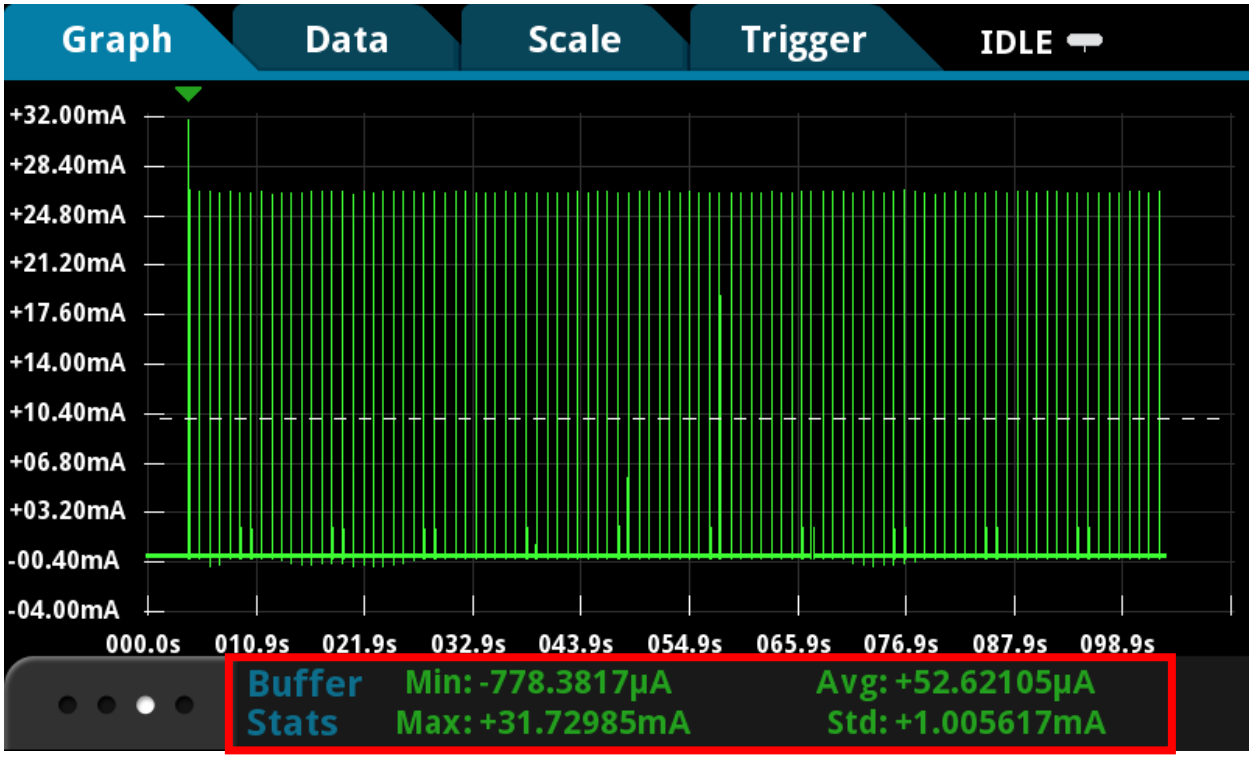


Gated triggers presents average current over the active period

Average current measurement ~ Battery Life Requirements

- **“Gated” cursor statistics**
- **Average current automated calculated**

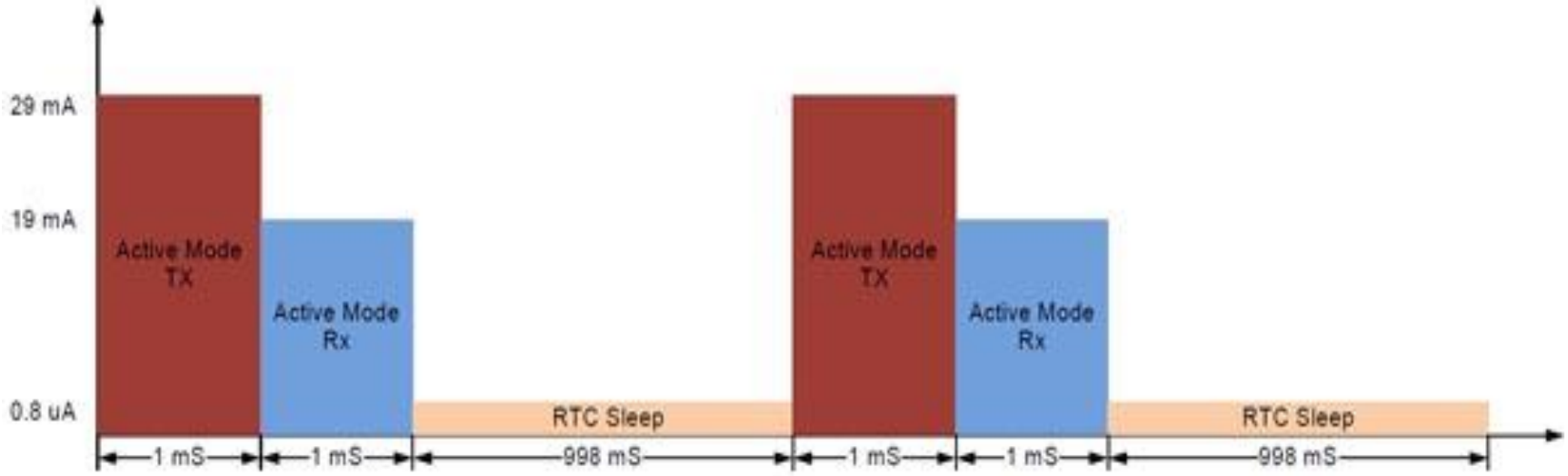
Average Active Mode Current



For Average Active mode current, accumulate as many cycles as possible in active mode for average power consumption.

Si1012 Published Activity Profile

- Sensing and RF transmission functions
- Sleep current is 50nA
- Push button – samples temp, charge and light.
- Temp and charge tx once per button press
- Light level tx once a second for three minutes.
- Transceiver short wake up time
- Active mode – 1ms each (1 packet each time)
- The average current consumption 51uA over 3 mins.



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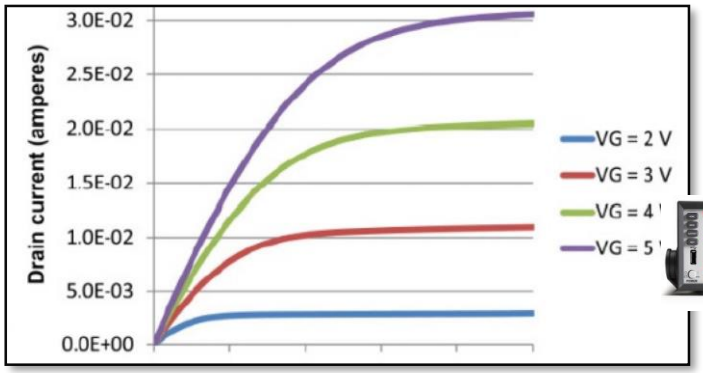

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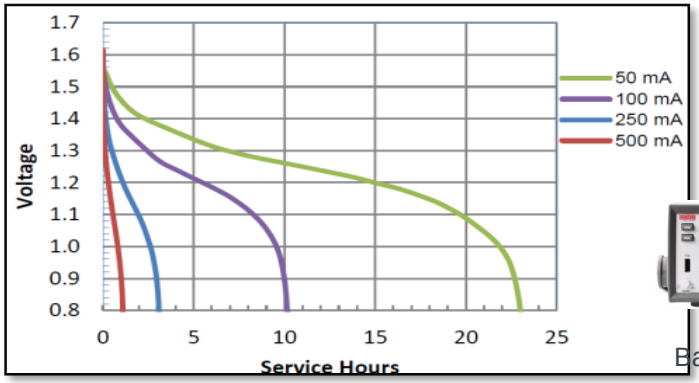

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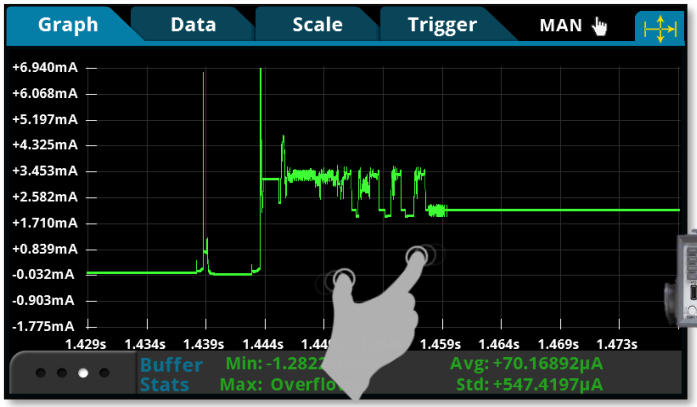

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Thanks for Attending

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