PARAGON® INNOVATIONS

Product Development from start to success™

APP-201

Optimization of Battery Life

Outline

- Wireless IoT environment
- Where does power get use
- Strategies to reduce power consumption
- Battery selection
- CPU / Radio power management
- Using SiLabs power estimation tool

Wireless Network Power

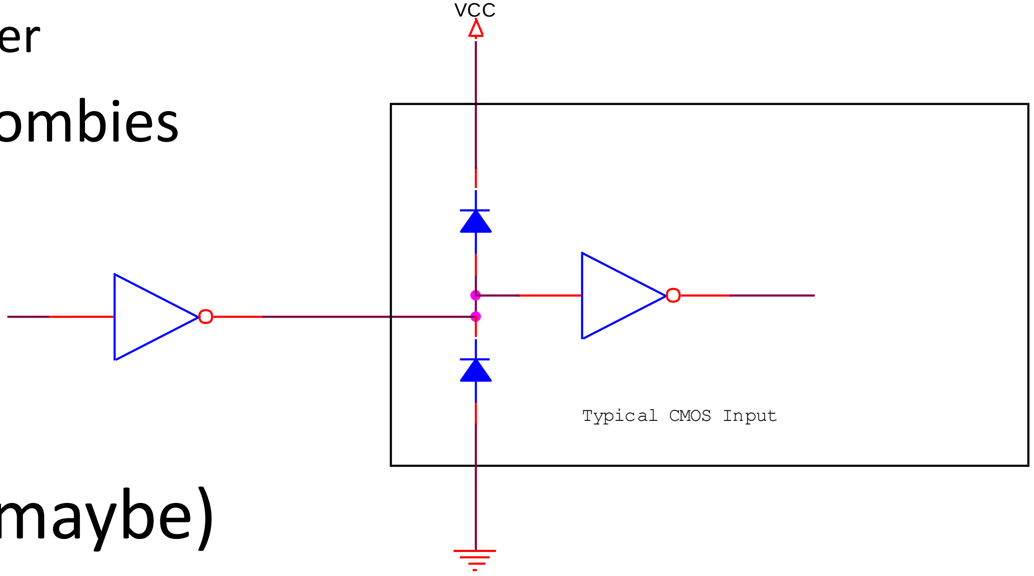
- Gateways and Border Routers
  - Mains powered
  - Manage the network
- Routers
  - Mains powered (usually)
  - Mesh routing services
- End Devices
  - Often battery powered
  - Spend most of their time sleeping

What Consumes Power?

- CPU
- Radio(s)
- I/O
- Self Discharge / Leakage

Strategies to reduce power

- Just turn it off!
  - Use I/O to turn on/off sensors
    - I/O pins sometimes have adequate drive (look for I_{OH}(max) on the data sheet)
    - Use a high side driver
  - Watch out for the zombies



- Lower the voltage (maybe)

Local Power Regulation

- Direct from battery
  - No excess power consumed for the purpose of regulation
  - Poor voltage regulation
- Linear Regulators (LDO)
  - Clean power, low RF emissions
  - Burns the excess voltage off as heat (V=IR, P=IV)
  - Requires battery voltage higher than the output rail
- Switch mode power supplies
  - Can be very efficient and provide good regulation
  - Flexible selection of battery voltage
  - May contribute RF emissions and power rail noise

Self Discharge & Leakage

- Batteries have self discharge issues
  - Primary cells list a “shelf life” which is time to 80% charge
  - Secondary cells list a “self discharge” or “capacity retention”
- Capacitors have leakage
  - Listed as “leakage current”
  - Electrolytic caps often have high leakage
- Model as a resistor in parallel

Battery Selection

- Primary Cells
  - Non-chargeable
  - Alkaline, Lithium-metal, Lithium Thionyl Cloride
- Secondary
  - Chargeable
  - Lithium Ion, Lithium Polymer, NiCad, NiMH, Lead Acid

Primary vs secondary cells

- Availability of charging power
- Limitations on recharge cycles
- Availability of replacement cells
- Complexity and cost of charging circuits
- Perceived operating cost vs actual operating costs
- Self discharge of secondary cells
- Usage model

CPU Energy Management Unit (EMU

- Feature of SiLabs Devices
  - Manages energy modes and power routing
  - Internal DC/DC control
  - Reset management
  - Brown Out Detection
  - Supply Voltage Scaling / LDO Control
- Modes (High power to low powr)
  - EM0 (run) → EM1(sleep)→EM2(deep sleep)→EM3(stop)→EM4(shutoff)

Estimating Battery Life

- Power is in Watt-Hours ALWAYS
  - AA Battery 1.5V 2.5 AH = 3.75 WH
  - 2 in parallel = 1.5V, 5 AH, 7.5 WH
  - 2 in series = 3.0V, 2.5 AH, 7.5 WH

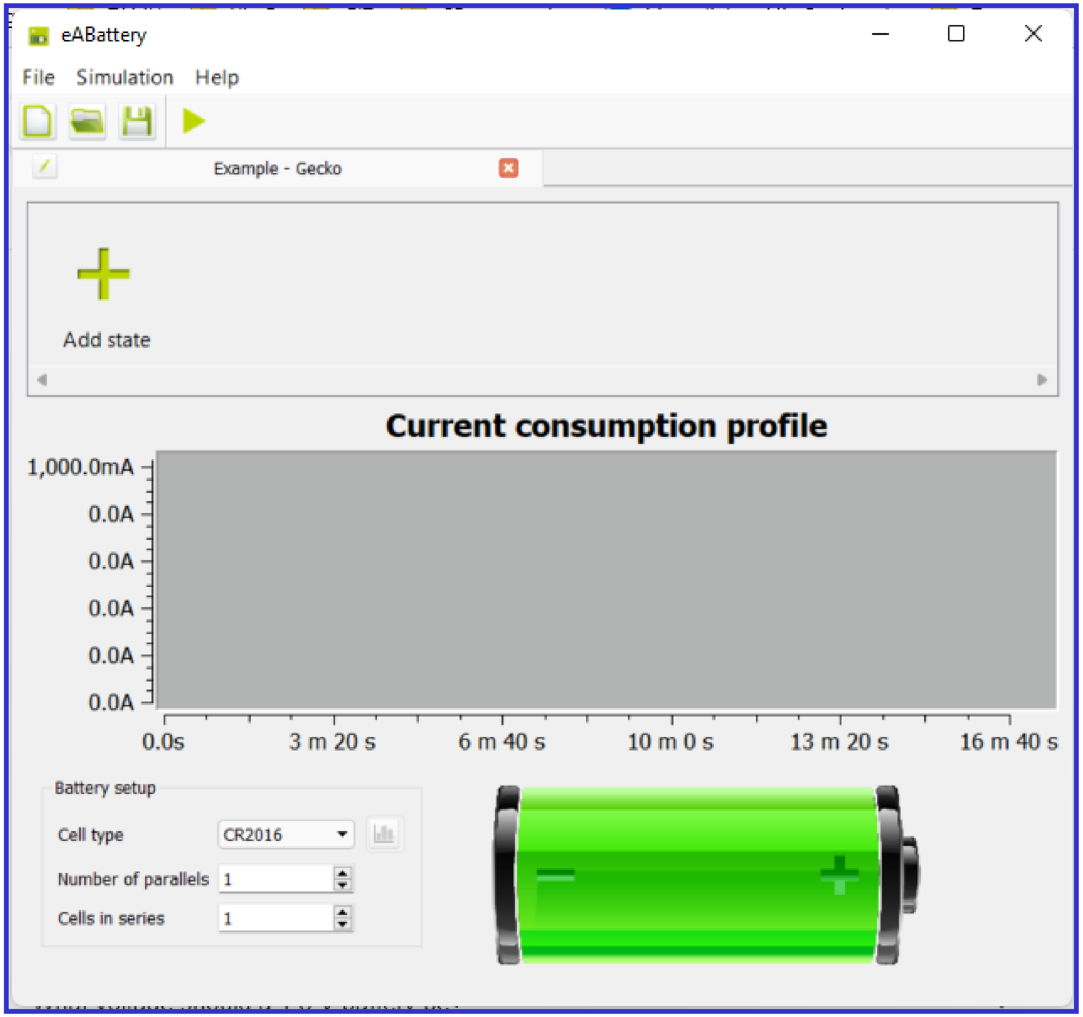
- Split the time into periodic and aperiodic events

Power Consumption Model

- Series of repeated states
  - Sleep
  - Measure
  - Receive
  - Transmit
  - Repeat
- One time / Infrequent events
  - Updates
  - Log Querry

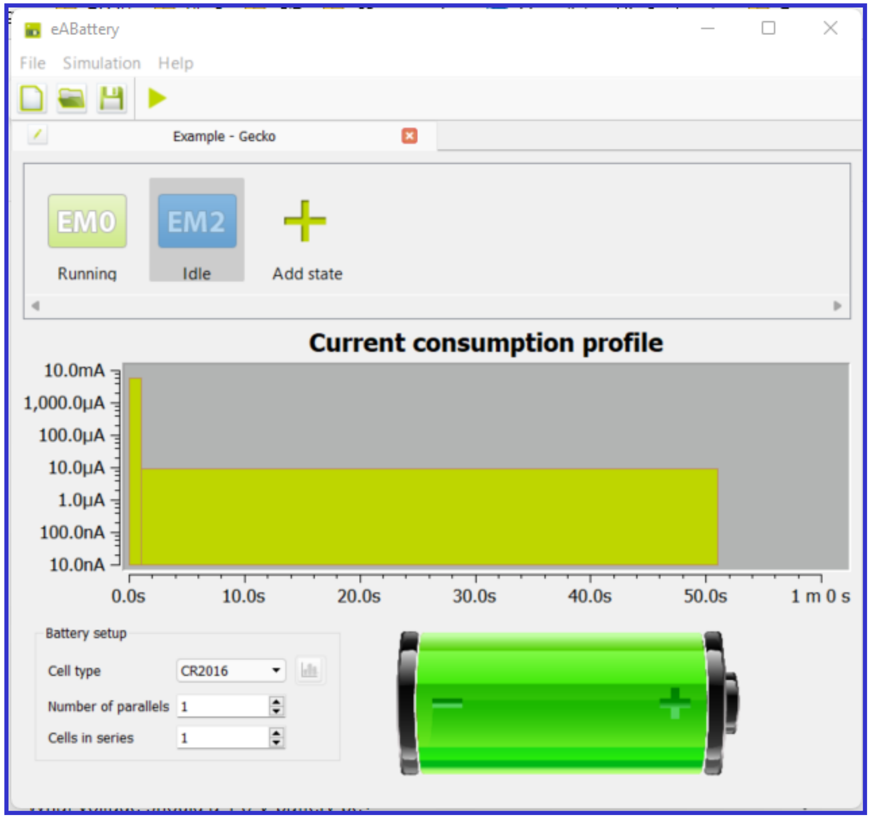
Energy Aware Battery Tool

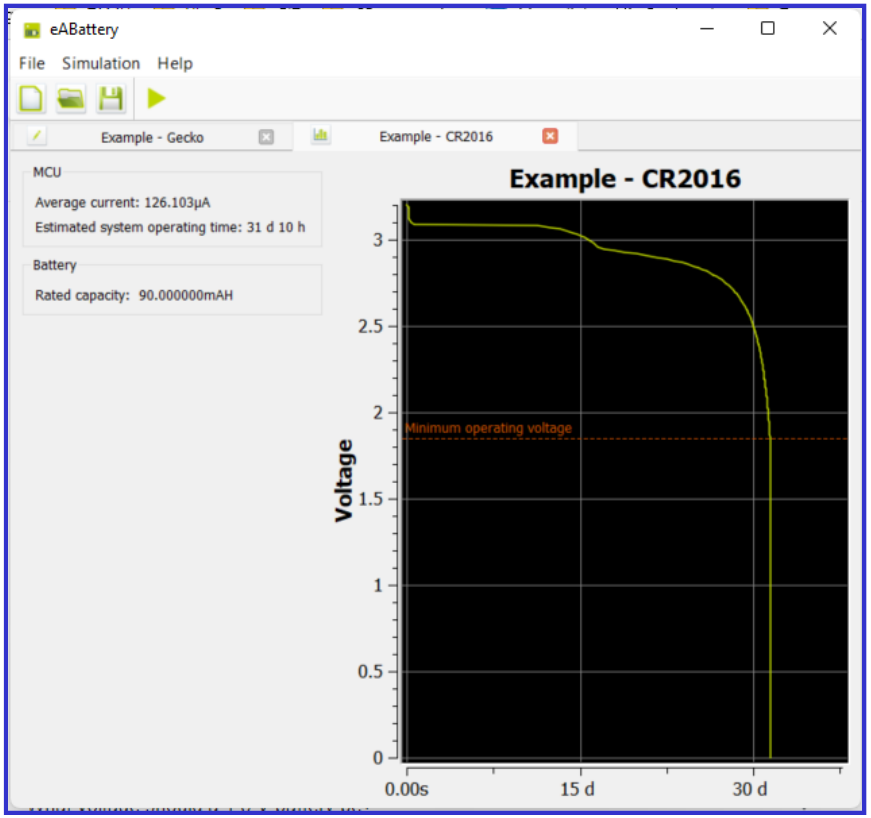
- EV5 Tools



Create a State

Simulate


eABattery
File Simulation Help
Example - Gecko
EM0
Running
EM2
Idle
Add state
Current consumption profile
10.0mA
1,000.0µA
100.0µA
10.0µA
1.0µA
100.0nA
10.0nA
0.0s
10.0s
20.0s
30.0s
40.0s
50.0s
1 m 0 s
Battery setup
Cell type
CR2016
Number of parallels
1
Cells in series
1


eABattery
File Simulation Help
Example - Gecko
Example - CR2016
MCU
Average current: 126.103µA
Estimated system operating time: 31 d 10 h
Battery
Rated capacity: 90.000000mAH
Example - CR2016
Voltage
Minimum operating voltage
3
2.5
2
1.5
1
0.5
0
0.00s
15 d
30 d

Demo of Tool