CS 179J: Project in Architecture / Embedded Systems
Power Estimation Example

## Equations / Defenitions

| | |
|---|---|
| P = VI | P = power in watts, V = voltage in volts, I= current in amperes |
| 1 W = 1 J/s | 1 watt is equaled to 1 Joule per second |
| E = Pt | E = energy in joules, P = power in watts, t = time in seconds |

## Battery

Battery used in eBlocks : Duracell 9V, MN1604
According to mouser.com a 9V Duracell Alkaline battery contains 565 mAh

| | |
|---|---|
| 9 V * 595 mAh = 5355 mWh | *when we multiply these two numbers the units become mAhV, the AV reduces to W* |
| 5355 mWh * 3600 sec/hr * 1/1000 = 19,278 Ws | *we get rid of the m by dividing by 1000, and convert Wh to Ws by multiplying by 3600* |
| 19,278 Ws = 19,278 Joules | *1 W = 1 J/s, or if we change things around 1 Ws = 1 J* |

Thus, the energy contained in a 9V battery is 19,278 Joules

## PIC processor

PIC Processor used in eBlocks : PIC16F628
We look at microchip.com to find the datasheet for the corresponding PIC characteristics

| | |
|---|---|
| Normal Operating Voltage | 5V |
| Normal Operating Current | 20 uA |
| Power Down Current | 0.2 uA |
| Watch Dog Timer Current | 6 uA |
| drive a high on output port | 3 mA |
| drive a low on output port | 8.5 mA |

bits transmitted in single packet - start bit, bit0, bit1, bit2, bit3, stop bit => 6 bits
Assummption : 5 instructions to send 1 bit
6 bits/packet * 5 instructions/bit = 30 instructions to send a packet
Given default clk speed, it takes 1 u second/ instruction
30 u seconds to send a packet

## Energy Estimation

*We first figure out the current required to transmit a packet, for simplicity we assume the packet consists soley of 0's*

| | |
|---|---|
| tx current | = current to drive port low during transmission + PIC operating current |
| | = 8.5 mA + 20 uA |
| | = 0.0085 A + 0.000020 A |
| | = 0.00852 A |

*When the processor is not transmitting a packet it goes to power down for remaining time*
*If we use power down feature, we must factor in watchdog timer to wake up processor, wdt is off during tx*

| | |
|---|---|
| total power down current | = PIC power down current + watch dog timer current |
| | = 0.20 uA + 6 uA |
| | = 6.2 uA |

*Now we figure out how much time is spent transmitting and how much time is spent in power down*
*Assume we tx a packet every 3 seconds :*

86400 sec per day / 3 s = 28,800 tx per day
28,800 tx per day * 30 uS per tx = 0.864 seconds per day spend on tx of packets

86400 seconds per day - 0.864 seconds per day spent on tx of packet = 86399.136 seconds per day spent in power down mode

*Now we figure out the energy associated with transmitting and power down:*

energy for transmit = 5V * 0.00852A * 0.864 seconds
= 0.0368 Joules for tx per day

power down energy = 5V * 0.0000062A * (86400 - 0.864) seconds
= 2.678 Joules for idle operation per day

*No to figure out the estimated battery lifetime:*

19,278 Joules in a 9V battery / (0.0368 J + 2.678 J) = 7101.076 days
battery will last 7101.076 days if we tx once every 3 seconds and proceesor power down remaining time

## Exercise

Try to figure out the estimated battery life of a 2-input logic block eBlock (2 inputs, 1 output).

| | | |
|---|---|---|
| tx current | = 0.00852 A | *these are from the previous example* |
| total power down current | = 0.0000062 uA | |
| seconds spent on tx | = 0.864 seconds per day | |
| energy for transmit | = 0.0368 Joules for tx per day | |
| rx current | = PIC operating current<br>= 20 uA | |
| seconds spent on rx | = 0.864 seconds per day | *the seconds spend on rx should match tx, it's recieving what's sent* |
| energy for rx | = 5V * 0.00002A * 0.864 seconds<br>= 0.0000864 Joules for rx per day | |
| power down energy | = 5V * 0.0000062A * (86400 - (0.864*3)) seconds<br>= 2.678 Joules for idle operation per day | |

19,278 Joules in a 9V battery / (0.0368 J + (0.0000864 J * 2) + 2.678 J) = 7100.623 days
battery will last 7100.623 days (worst case assumption)

Try to figure out the estimated battery life of an led eBlock (1 input). The led requires 2.1 volts and draws 20 mA.
Assume the led is on 30% of the day.

| | | |
|---|---|---|
| rx current | = PIC operating current<br>= 20 uA | |
| seconds spent on rx | = 0.864 seconds per day | *the seconds spend on rx should match tx, it's recieving what's sent* |
| energy for rx | = 5V * 0.00002A * 0.864 seconds<br>= 0.0000864 Joules for rx per day | |

| | | |
|---|---|---|
| led current | = 20 mA | |
| seconds led spends on | = 0.3 * 86400 seconds/day<br>=25920 seconds/dasy | |
| energy for led | = 2.1 * 0.020 A * 25920 seconds<br>= 1088.64 Joules per day | |

19,278 Joules in a 9V battery / (0.0000864 J + 1088.64 J ) = 17.71 days

What happens if we decide to blink the led to conserve the battery (turn the led on for 0.5 seconds every 2 seconds).

| | | |
|---|---|---|
| rx current | = PIC operating current<br>= 20 uA | |
| seconds spent on rx | = 0.864 seconds per day | *the seconds spend on rx should match tx, it's recieving what's sent* |
| energy for rx | = 5V * 0.00002A * 0.864 seconds<br>= 0.0000864 Joules for rx per day | |
| led current | = 20 mA | |
| seconds led spends on | = 0.3 * 86400 seconds/day * 0.25<br>=6480 seconds/day | led is on 0.5 seconds for every 2 seconds, 0.5/2 = 25% |
| energy for led | = 2.1 * 0.020 A * 6480 seconds<br>= 272.16 Joules per day | |

19,278 Joules in a 9V battery / (0.0000864 J + 272.16 J ) = 70.83 days