



# MSP430 Family

October 23, 2016, Bulat Valeev

## Lecture 7. Low power modes.



Challenges

Motivation

Internet of things

Low power modes

Task in the class

Hometask



# Challenges

What you should know at the end of the day.

- Learn how minimize the power consumption in the low performance MCU
- Learn different low power modes and ways to use them
- Maximize efficiency of the written code



# Motivation

Each of the MCU types has certain place in the device market.  
The lower performance MCU's are used in the cheap devices with low power consumption.

If you will develop for low performance MCU, you definitely will think about power consumption.

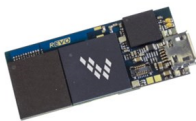


# Internet of things

One of the possible implementation of the low performance MCU's in the IoT space is wearable electronics.

For example you can look at the cc2650-Sensortag with 3 wireless interfaces(Bluetooth, Zig-bee, 6LOWPAN), with MCU subsystem for sensor measurements.It has 12 mA current consumption with enabled wireless interface.

Low performance leads to the small size and case of usage, when you buy extremely cheap device, use it as long as possible and after that through it away.



# Power consumption

The power consumption depends from the three variables: input current, clock frequency and voltage supply.

The voltage strongly limited by technical documentation. The main solution to become more efficient: **decrease input current and clock frequency.**

Input current also depend from **efficiency of the energy usage.** Less you heat the air - less power consumption you archive.



# How increase time to work?

Practically in the MCU you can do very small number of steps: pull unused pins, turn off unused periphery and so on.

But there are additional ways which provide MSP430: you can **turn off CPU**, and **use low frequency** and **low performance clock** to turn off MCU for a long interval. Then interrupt from low frequency oscillator turn on the MCU for a 1 – 2ms and turn off back.

This strategy allow to increase life-cycle thousand times.





# Low power modes

The MSP430 provide special modes to save battery. There are 5 modes which allow to adjust, how deep and efficient you will use controller.

They called :

- Low power mode 0 (LPM0)

- Low power mode 1 (LPM1)

- Low power mode 2 (LPM2)

- Low power mode 3 (LPM3)

- Low power mode 4 (LPM4)



# Low power modes

Here presented short diagram of the low power modes from technical pages

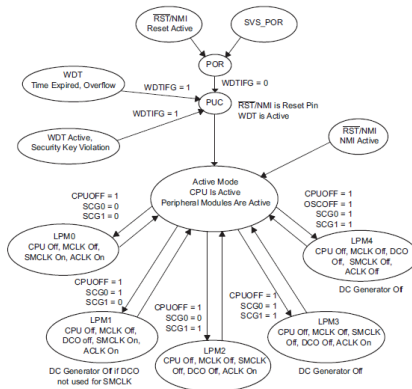


Figure 2-9. Operating Modes For Basic Clock System

# LPM0

Low power mode 0 allows to put CPU, MCLK off.  
The current consumption become  $55\mu A$  at  $1Mhz$ .  
Master clock (MCLK) is used for the CPU clocking



# LPM1

Low power mode 1 allows to put CPU, MCLK, DCO, DC off.

The current consumption become  $55\mu A$  at  $1Mhz$ .

Digitally controlled oscillator (DCO) is used for wide frequency range clocking.

Direct current source(DC) is used for ADC reference source.



# LPM2

Low power mode 2 allows to put CPU, SMCLK, MCLK, DCO off.  
The current consumption become  $17\mu A$  at  $1Mhz$ .  
Sub main clock (SMCLK) is used for the periphery clock.



# LPM3

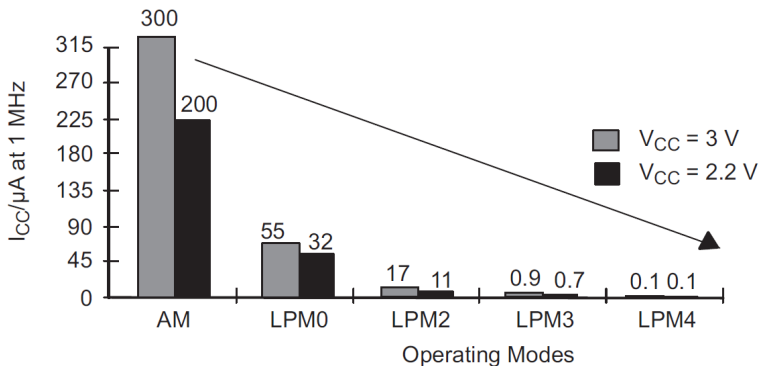
Low power mode 3 allows to put CPU, SMCLK, MCLK, DCO, DC off.  
The current consumption become  $0.9\mu A$  at  $1MHz$ .  
Here stay only auxiliary clock (ACLK) which clocked with low frequency oscillator (32kHz).



Low power mode 4 allows to put CPU and all clocks off. The current consumption become  $0.1\mu A$  at  $1Mhz$  Here works nothing. How wake up the MCU? The system turned on via external interrupt or reset.

# Power consumption

Here presented power consumption diagram for the different low power modes.

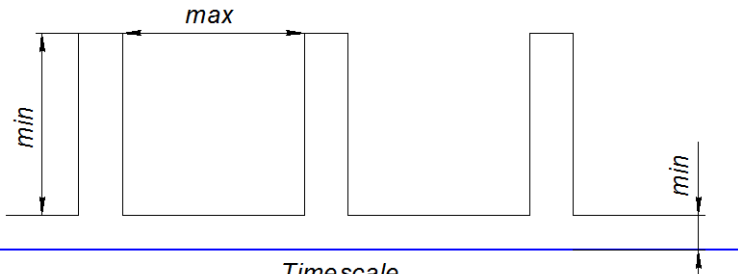




# Code efficiency

Explained low power modes lead to the certain code construction methods. Better to use CPU and measure values as less as possible. The power consumption become very similar to the PWM signal.

*Power consumption*



# Typical implementation of the low power modes

The best solution of the software become sleep in the LPM3 or LPM4 and wake up on the LF oscillator or external interrupt. Then MCU will work as less as possible in the LPM0-LPM2 and go sleep again.



# Task in the class

Write the UART messages receiver which will work maximally efficient in the power consumption meaning.

Use baudrate equal to 9600 and send message back with incrementation.



# Result



# Hometask

Improve the code in the ADC module. As reference values take ADC measurements interval equal to 1 sec.



# Hints

Try to decide which strategy better, user as lower clock for UART as possible, of try to achieve lower inter-pause time.



Thanks for your attention

