Ultra Low Power Microcontroller
- Design Criteria -

June 2017
Agenda

1. Low power technology features
2. Intelligent Clock Generator
3. Short wake-up times
4. Intelligent memory access
5. Use case scenario influence
   -> Impact of power-save and operation modes
6. Software development efficiency
Technology Features – Low power consumption -

- Three Core Technologies
  - Low current leakage process
  - Eco-friendly power algorithm
  - Low power analog IP

Example of graphic display controller circuit
Basic block diagram of an microcontroller system

*MCU circuits mainly contributing to get an ultra low power design

*Use case scenario dependent

*Intelligent memory accesses

Supply Voltage Detector

Monitoring voltage level

Select detect voltage by S/W

Epson Europe Electronics GmbH
Intelligent clock generator (1)

• Optimal clock frequency can be selected from different clock sources for each circuit

High accuracy built-in oscillation circuit
  • 700kHz±3% accuracy

Low Power oscillation circuit for timepiece
  • 32.768kHz crystal oscillation

High speed oscillation circuit
  • Crystal/Ceramic oscillation, internal oscillation, external resistance CR oscillation changeable by software

System clock can be chosen from 4 sources!
Intelligent clock generator (2)

1. **Flexible Clock Generator** operates as a backbone of a microcontroller
   -> all synchronous peripherals are connected

2. **Trade off between flexibility and accuracy of internal clocks**
   -> more flexibility because different frequencies can be used, but accuracy is often temperature dependent

3. **Temperature compensation**
   -> most microcontrollers offer precise external clock source to achieve higher accuracy by calibration

4. **For exact time measurement external clock source is recommendable**
Short wake-up times

**Example for an inflexible clock generator system**

Inflexible clock generator systems require much longer wake-up times to switch between different power save modes. OSC stabilization times are wasted times for applications and burn just energy.

**Example for a flexible clock generator system**

Flexible clock generator systems offer clock selections which are still available in power save modes, e.g. RTC/LCD driver clock could be still available in SLEEP mode. No OSC stabilization times waste time and energy.

Flexible clock generator systems offer very short wake-up times, where e.g. CPU could run immediately by internal OSC by interrupt when clocks are available in power save modes.

RTC/LCD can be used in sleep mode.
**Intelligent memory access**

Example: Improvement of display performance

- **Standard system:**
  - CPU read out / write display data to memory
  - Result: high CPU workload and high power consumption

- **Intelligent system:**
  - Only “Custom circuit“ is handling display data
  - Result: much lower power consumption
Use case scenario – Active Operation Mode (1)

Example: Sensor Hub System

1. Processing high performance functions

- Acceleration
- Gyro
- Compass
- I²C
- Moving / Rest detection
- Motion detection
- Vehicle detection
- Steps, calorie measurement
- Sensor data detection
- Azimuth detection
- Dead Reckoning

MCU

- FLASH
- CPU
- RAM
- OSC1
- Real-Time clock
- Internal OSC
- Timer
- AFE
- GPIO
- SVD/ADC
- SPI / I²C / UART
- LCD Driver with internal booster circuit

Usually characterized by current consumption in µA/MHz
Coremark value:
In ULP (Ultra Low Power) designs „µA/MHz“ has only limited relevance, because processing power must be considered too to get total overview
-> therefore Coremark is a useful indication about MCU performance

Example:
An 16-bit MCU achieves a benchmark value of 0.6 Coremark/MHz while an 32-bit MCU achieves 2.9 Coremark/MHz
-> 32-bit processor can execute same task five times faster than 16-bit processor
-> total power consumption is reduced if MCU active time is short!
-> Result: An intelligent processor core architecture, in this case a 32-bit MCU could be more energy efficient than a 16-bit MCU
Use case scenario – Power Save Mode (1)

1. Important when CPU workload is small and applications are battery powered

2. Sleep Mode is most energy-efficient power save mode of a processor

3. Some MCU`s offer various Sleep Modes where different peripheral circuits remain (non-)active
   -> Caution: many power save modes are unrealistic for the application!

4. Many applications can be kept for a long time in Sleep Mode which made Sleep Mode value important
   -> some time keeping function in Sleep Mode is beneficial to wake-up MCU by event (RTC, Timer etc.)
1. Supply voltage conditions have big influence on MCU operation conditions and some energy-efficient power save modes
2. MCU's operating below 1.8V could bring some benefits
3. Integrated DC/DC converter technology can be key to achieve attractive power consumption values
   -> e.g. Sleep Mode: 32-bit ARM Cortex M0+: 800nA or 16-bit MCU: 150nA
   -> e.g. Run Mode: 16-bit MCU only 4µA in active mode still driving a LCD
Use case scenario
High performance appl.
Example: Multi functional non-rechargeable watch

• Expected functions:
  - Display driving
  - Sensor data processing
  - Wireless function
  - Long battery lifetime

• Important MCU functions/circuits:
  - Lowest possible total power consumption during active mode operation (High Coremark benchmark or low µA/MHz)
  - Low power LCD driver
  - Intelligent memory access options
  - Intelligent MCU power save modes
Use case scenario
Low performance appl.

Example: Heat Cost Allicator

• Expected functions:
  ✓ Display driving
  ✓ Temperature/Humidity Measurement
  ✓ Long battery lifetime

• Important MCU functions/circuits:
  ✓ Lowest possible power consumption during Sleep Mode
  ✓ Low power LCD driver
  ✓ Short wake-up times
  ✓ Special circuits (RFC, SVD)

*Important MCU functions circuits
Software development efficiency

- GNU17 Eclipse
- ARM

Compiler: GNU17
On chip debugging

USB
PC
Debugger Tool

Target board
Evaluation board

Evaluation board
IDE
Emulator
Ex) S1C17W18 for HCA

- LCD panel
- 7-segment
- Dot-matrix

- S1C17W18
  - FLASH: 128KB
  - RAM: 8KB
  - SVD
  - OSC1
  - Sound Gen.
  - Temp. sensor / Ref. voltage gen.
  - SPI / I²C / UART
  - UPMUX
  - OSC3
  - LCD Driver: 48 x 4
  - GPIO
  - 3.6V
  - 32.768kHz

Ex) S1C31W74 for high performance appl.

- LCD panel
- 7-segment
- Dot-matrix

- S1C31W74
  - CASH
  - ARM ® Cortex ® -M0+
  - RAM: 512KB
  - SVD
  - OSC1
  - X’tal/Int.
  - OSC3
  - Cera / Int.
  - Sound Gen.
  - SPI / I²C / UART
  - UPMUX
  - LCD Driver (1/5 or 1/4B)
  - 72x32 / 80x24 / 88x16
  - GPIO
  - 3.6V
  - 32.768kHz
  - USB Device
  - DMA
  - IOSC
  - QSPI