Introduction to the Atmel AVR Butterfly
The AVR Butterfly is designed to demonstrate the benefits and key features of the AVR microcontrollers:

- The AVR architecture in general and the ATmega169 in particular
- Low Power Design
- The MLF package type
- Using peripherals
  - LCD controller
  - Memories
    - Flash, eeprom, sram, external Data Flash
  - Communication interfaces
    - UART, SPI, USI
  - Programming methods
    - Selfprogramming/ Bootloader, SPI, Parallel, JTAG
  - Analog to Digital Converter (ADC)
  - Timers/Counters
    - Real Time Counter (RTC)
    - Pulse Width Modulation (PWM)
  - etc....
- It also serves as a development kit for the ATmega169, and can be bought and used as a standard module in the customers own products
- Sales price: 19$
Graphical overview
ATmega169

- 16KB Flash
- 512B EEPROM
- 1KB Internal SRAM
- JTAG Interface
- 4 x 25 Segment LCD Driver
- Two 8-bit Timer/Counters
- One 16-bit Timer/Counter
- Real Time Counter
- Four PWM Channels
- 8-channel, 10-bit ADC
- USART
- SPI
- Universal Serial Interface
- Watchdog Timer
- Analog Comparator
- Power-on Reset and Brown-out Detection
- Internal Calibrated Oscillator
- Five Sleep Modes:
  - Idle, ADC Noise Reduction, Power-save, Power-down, and Standby
- 53 Programmable I/O Lines and 1 Input Line
- 64-lead TQFP and 64-pad MLF
- Operating Voltage:
  - 1.8 - 3.6V for ATmega169V
  - 2.7 - 3.6V for ATmega169L
- Temperature Range:
  - 0°C to 70°C
- Speed Grade:
  - 0 - 1 MHz for ATmega169V
  - 0 - 4 MHz for ATmega169L
- Ultra-Low Power Consumption
  - Active Mode:
    - 1 MHz, 1.8V: 300µA
    - 32 kHz, 1.8V: 20µA (including Oscillator)
    - 32 kHz, 1.8V: TBD (including Oscillator and LCD)
  - Power-down Mode:
    - 0.5µA at 1.8V

ATmega169 MLF
Input Resources

- **Joystick**
  - 4 directions
  - 1 center push

- **UART**
  - Available on pin header J406
  - With level converters
    - Just connect TxD, RxD and GND
    - Vcc min 2.0V

- **USI**
  - Available on pin header J405
  - Uses 3 pins: PE4, PE5, PE6
  - If USI is not needed then the pins can be used as normal IO

- **Reset**
  - Short cut pin 5 & 6 on the ISP header (J403)
**Analog Measurements**

- **Temperature**
  - Surface mounted NTC (Negative Temperature Coefficient) thermistor
  - Tested -10 → +60 deg
  - Connected to ADC0 (PF0)

- **Light**
  - Trough hole mounted LDR (Light Dependent Resistor)
  - NSL19M51 CdS photoconductive cell
  - 6K@10lux, 20M@darkness
  - Connected to ADC2 (PF2)

- **Voltage**
  - 2 pin header
  - Voltage readings from 0-5V
  - Connected to ADC1 (PF1)
Output Resources

- LCD (Liquid Crystal Display)
  - Features six 14-segments digits, and some additional segments
  - All in all the display supports 120 segments
  - ATmega169 supports 100 segments
  - Same LCD and selected segments as on STK502

- Piezo-element
  - For alarms and “music”
  - Connected to Timer1 PWM Output A (PB5)
Memory

- **ATmega169**
  - 16Kbyte FLASH
  - 512byte EEPROM
  - 1Kbyte SRAM

- **AT45DB041B**
  - 4Mbit data flash
  - SPI interface
  - Vcc 2.5-3.6V
  - Low level drivers included
  - Connected to SPI bus for external programming
Clock sources

- **Real Time Counter (RTC)**
  - On-board 32kHz Xtal for tracking of clock and date

- **Internal Calibrated RC oscillator on ATmega169**
  - Use prescaler to get 31k-8MHz system clock
Power sources

- **Button cell battery**
  - CR-2450
  - 3V
  - 600mAh

- **Using external power supply**
  - GND and Vcc are available on several pin headers
  - J400 & J401 pin 9 & 10
    - Parallel programming header
  - J402 pin 2 & 4
    - JTAG header
  - J403 pin 6 & 2
    - SPI header
  - Use of external power will not charge the battery
  - Remove the battery, or use a voltage level higher than the battery
Programming & debugging

- **Bootloader**
  - Enables upgrade of the application code from a PC without any external hardware
  - Frontend software: AVRprog (included with AVR Studio)
  - Uses UART (J406)
  - While in the bootloader: Hold the ENTER button while starting AVRprog

- **JTAG**
  - Programming and On-Chip Debugging
  - JTAG header (J402) is located on the “back side” of the PCB
  - Use an external power source when using JTAGICE due to increased power consumption
  - Always press “stop debugging” in AVR Studio to automatically disable the OCD fuse

- **In System Programming (ISP)**
  - STK500
    - Connect ISP6PIN to SPI bus (J403)
    - Note that ATmega169 uses PB0 to control the external data flash

- **Parallel programming (High voltage)**
  - STK500
    - On the Butterfly, move the 0ohm resistors: R404 to R403 and R203 to R204
    - Make these connections between the STK500 and the Butterfly:

<table>
<thead>
<tr>
<th>STK500</th>
<th>AVR Butterfly</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROGCTRL</td>
<td>J401 (PORTD)</td>
</tr>
<tr>
<td>PROGDATA</td>
<td>J400 (PORTB)</td>
</tr>
<tr>
<td>BSEL2.1</td>
<td>J402.8 (JTAG)</td>
</tr>
<tr>
<td>XTAL1.1</td>
<td>J402.10 (JTAG)</td>
</tr>
</tbody>
</table>
• Written in IAR EWAVR
• All source code included
• Bootloader code
• Application code
  ➢ State machine
  ➢ Features included
    Name-tag
    Clock (date)
    Temperature measurements
    Light measurements
    Voltage readings
    Play tunes/melodies
    Auto power save
    Adjust LCD contrast
  ➢ More functions that can be added later on....
    Calculator
    Reminder function
    Alarm (daily alarms, kitchen-timers, etc...)
    Play tunes/melodies (Karaoke-function)
With the 4Mbit dataflash one can store large amount of data. Some examples:
• AVR Info bank (Basic info on all AVR-parts)
• Your local bus-table
• Melodies
• +++
Bootloader

- Enables upgrade of the application code from a PC without any external hardware
- Based on the appnote AVR109: Self Programming AVR
  - But uses the new buffer mode for more efficient data downloading
- Uses AVRprog as PC frontend
  - Included with AVR Studio
- Uses UART
- Uses the 1024Byte boot block size

Operation
- AVR fused to start in bootloader after Reset
- Short cut J403 pin 5 & 6 to make a hardware reset (or jump to bootloader from your application code)
- Bootloader goes straight into sleep
  - Power Save Mode
- Hold ENTER button while starting AVRprog to enable downloading of new application code over the UART.
- Press UP on joystick to wake up from sleep and enter Application section
- Lockbits are used to avoid self deletion
  - SPM is not allowed to write to the Boot Loader section
Use the joystick to navigate in the menu

- **UP/DOWN**
  Jump between the menu items
- **RIGHT**
  Enter a sub menu item
- **LEFT**
  Jump back one level
- **Center button is ENTER**
  Edit/play a menu item

### AVR Butterfly

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Clock</th>
<th>&quot;12:35:45&quot;</th>
<th>Adjust clock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date</td>
<td>&quot;03:04:25&quot;</td>
<td>Adjust date</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Music</td>
<td>&quot;Fur Elise&quot;</td>
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<tr>
<td></td>
<td>&quot;Mozart&quot;</td>
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<td></td>
<td>&quot;Minuet&quot;</td>
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<tr>
<td></td>
<td>&quot;Sirene1&quot;</td>
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<tr>
<td></td>
<td>&quot;Sirene2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>&quot;Your Name&quot;</td>
<td>Enter name</td>
<td></td>
<td>Download name</td>
</tr>
<tr>
<td>Temperature</td>
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<td></td>
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<tr>
<td>Voltage</td>
<td>&quot;2V3&quot;</td>
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<tr>
<td>Light</td>
<td>&quot;ADC28A&quot;</td>
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</tr>
<tr>
<td>Options</td>
<td>Display</td>
<td>Adjust contrast</td>
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<td></td>
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<tr>
<td></td>
<td>Bootloader</td>
<td>Jump to Bootloader</td>
<td></td>
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<tr>
<td></td>
<td>Power Save Mode</td>
<td>Press Enter to sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auto Power Save</td>
<td>Min 90</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Min (...)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Min 05</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>OFF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Download text from PC for name tag

- Connect RS-232 on PC to UART on Butterfly
- Use joystick to enter sub menu “Download name” and press ENTER to enable UART
- Start any PC terminal software
  - Use connection settings:
    - Baudrate: 19200
    - Databits: 8
    - Parity: None
    - Stop bits: 1
  - In terminal window:
    - <Type text>
    - Press ENTER (∋)
- The text is stored in eeprom and scrolls over the display
- Stores up to 25 characters
Sleep modes are used to minimize power consumption

- Normally Power Save Mode is used. But Idle Mode is used for:
  - Piezo-element (playing tunes)
  - UART communication

- In Power Save Mode
  - LCD controller is running (if enabled)
  - Asynchronous timer is running
    - Used for wake up for
      - LCD update
      - RTC update

- “Auto Power Save”
  - Turns off the display controller before entering the sleep mode: Power Save Mode
Power consumption and estimated lifetime

- **Playing tunes (incl. text)**
  - Power consumption: approx 400uA
  - Lifetime (playing 24 hours a day): approx 2 month

- **Presenting text in the LCD**
  - Power consumption: approx 35-40uA (depends on whether the text is scrolling or not)
  - Lifetime (24 hours a day): over 1.5 year

- **In power save mode (only the RTC ticking)**
  - Power consumption: approx 9uA
  - Lifetime: approx 7 years
Atmel AVR Butterfly