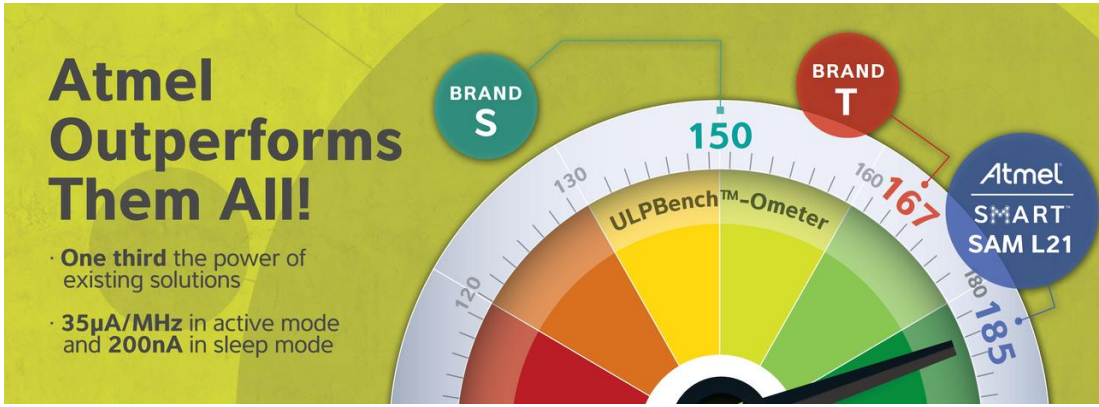
Atmel SAM L21

picoPower Cortex-M0+ Microcontrollers



SAM L21

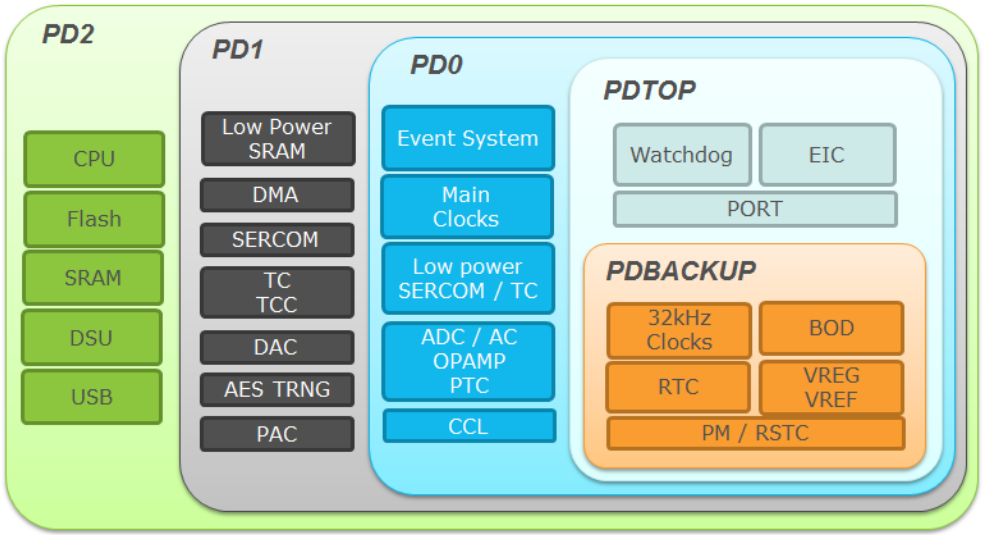
- New Ultra Low Power Atmel | SMART Cortex-M0+ Based microcontroller family
- Targeted for Battery powered applications
- Industries first Ultra Low Power Large Flash and SRAM Cortex-M0+
- Designed with emphasis on
  - Low active mode power consumption
  - Smart Low power peripherals
  - Industry leading RAM retention numbers
- Leveraging two decades of Atmel Ultra Low power ARM, AVR and AVR32 know how
- Easy migration from existing SAM D families
- Code compatible to existing families with ASF

The worlds lowest power Cortex-M0+ Micro

Design methodology for picoPower devices

- Regulators & oscillators
  - Multiple power sources and clocking options
- Flexible sleep modes
  - Scale performance & power consumption
- Event System and Sleepwalking
- Multiple Domains
  - Power & clock gating
- picoPower peripherals
  - SERCOM, PTC & TC
- Low power analog
- Ultra Low power Process

Overview of SAM L21 Power Domains



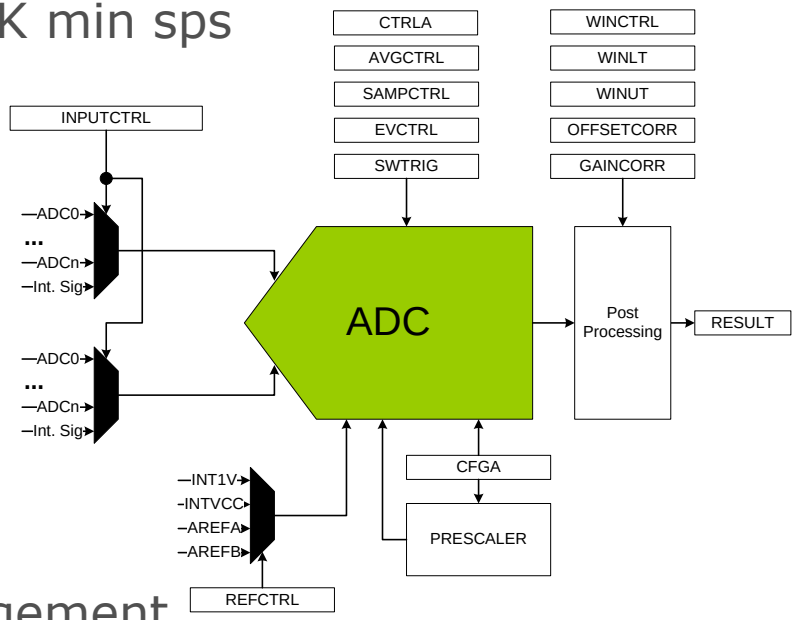
SAM L21 compared to SAM D21

- SAM D21 active mode running coremark 103uA/MHz
- SAM L21 **35uA/MHz**
  - Most competitors are in the 120-160 uA/MHz range for their comparable devices
- SAM D21 sleep mode with RAM retention and RTC: 3.8uA
- SAM L21 **0.9uA**
  - No other vendors offer large SRAM low leakage CM0+

Updated Peripherals

ADC

- From 350 Ksps (D20/21) to 1Msps / 10K min sps
- 3 new internal inputs
  - OPAMP01
  - OPAMP2
  - Scaled VBAT



- No fixed gain stage
  - OPAMP can be used for Gain
- Flexible Power / Throughput rate management
- Input scan is changed to Sequencing
  - More flexible than input scan
  - Inputs do not need to be in a continuous sequence (input 3,4,5,6...)
  - It is possible to select specific inputs to scan from lowest to highest (inputs 3,5,6 14...)

Updated Peripherals

DAC

- 1Msps (350Ksps in D20/21)
- 12-bit DAC (10 in D20/21)
- 4-bit Dithering mode to reduce quantization error / extend resolution
  - Can max be performed at 1Msps/16 (62500 sps)
  - Will have to use one event channel and one TC in order to work
  - If you are converting a 44Ksps 16-bit signal this can give you a 16-bit conversion over the standard 12-bits
- 2 DACs or single DAC in differential mode
- DMA support (dedicated trigger line)

Updated Peripherals

NVM

- Support for write while read (WWR)
  - Less overhead for emulated EEPROM
  - Makes FW upgrades easier

Updated Peripherals

Peripheral Touch Controller (PTC)

- The touch performance of the SAM L21 PTC is identical to that of the SAM D series, but
  - A touch accelerator was added to reduce CPU load and reduce overall power consumption
  - Overall power consumption of the module was reduced
- The PTC is located in the low power domain and can remain powered while the rest of the system is sleeping

Wake up from touch on less than 2uA!

Updated Peripherals

Full Speed USB host and Device

- Sleep mode
  - The USB module can put the microcontroller in any sleep mode when the USB bus is idle and a suspend condition is given.
  - Upon bus resume the USB module can wake the microcontroller from any sleep mode

New Peripherals

Configurable Custom Logic (CCL)

- Glue logic for general purpose PCB design
- Up to four programmable three input Look Up Table units (LUT)
- Combinatorial Logic Functions
  - AND, NAND, OR, NOR, XOR, XNOR, NOT
- Sequential Logic Functions
  - Gated D Flip-Flop, JK Flip-Flop, gated D Latch, RS Latch
- Flexible LookUp Table Inputs Selection
  - I/Os
  - Events
  - Internal Peripherals
  - Subsequent LUT Output
- Output can be connected to IO pins or Event System
- Optional synchronizer, filter or edge detector available on each LUT output

New Peripherals

AES – Advanced Encryption Standard

- Decrypt and Encrypt
- 128 bit block of input data
- 128/192/256 bit keys supported
- Encryption time of 57/67/77 cycles with 128-bit/192-bit/256-bit cryptographic key

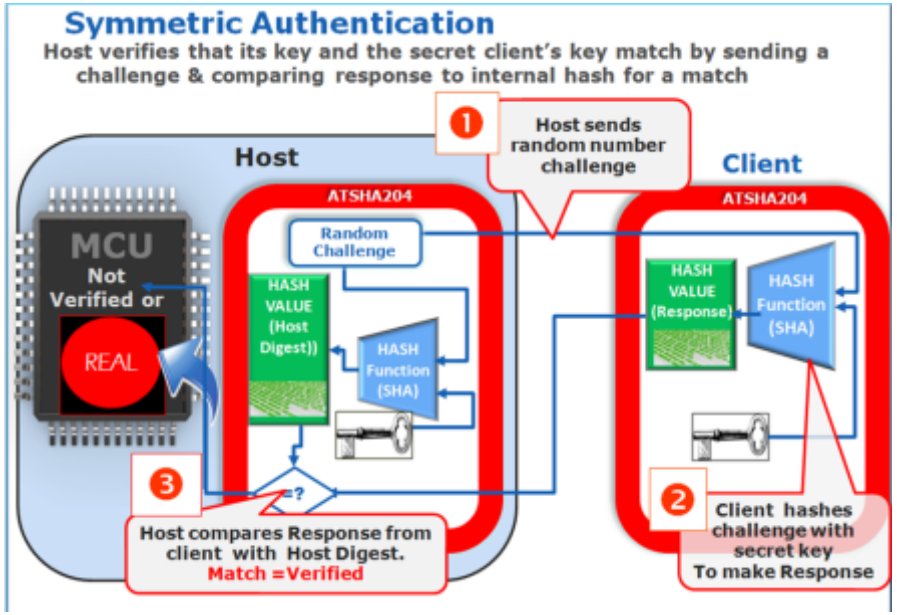
- Automatic or manual start
  - Automatic conversion starts when input register is filled with the correct amount of data

New Peripherals

TRNG – True Random Number Generator

- (TRNG) passes the American *NIST Special Publication 800-22 and Diehard RandomTests Suites*
- When enabled generates a new 32-bit random number every 84 CLK_TRNG_APB cycles.
- Optional Interrupt when a new random number is available

- Can be used to generate inputs for Authentication challenges



New Peripherals

Op-Amp

- 3 Individually configurable low power OpAmps
  - Can be interconnected
- Rail to Rail inputs
- No need for external components with internal feedback resistors
  - Internal resistors are muxable to form different resistor-OpAmp circuits
- Inputs available
  - GPIO pins
  - DAC
  - Ground
- Output available:
  - On GPIO pins
  - Can be used as Input for AC and ADC
- Low power configuration options
  - Performance/latency vs power
  - On demand start-up for ADC and AC operations

New low power features

picoPower SerCom

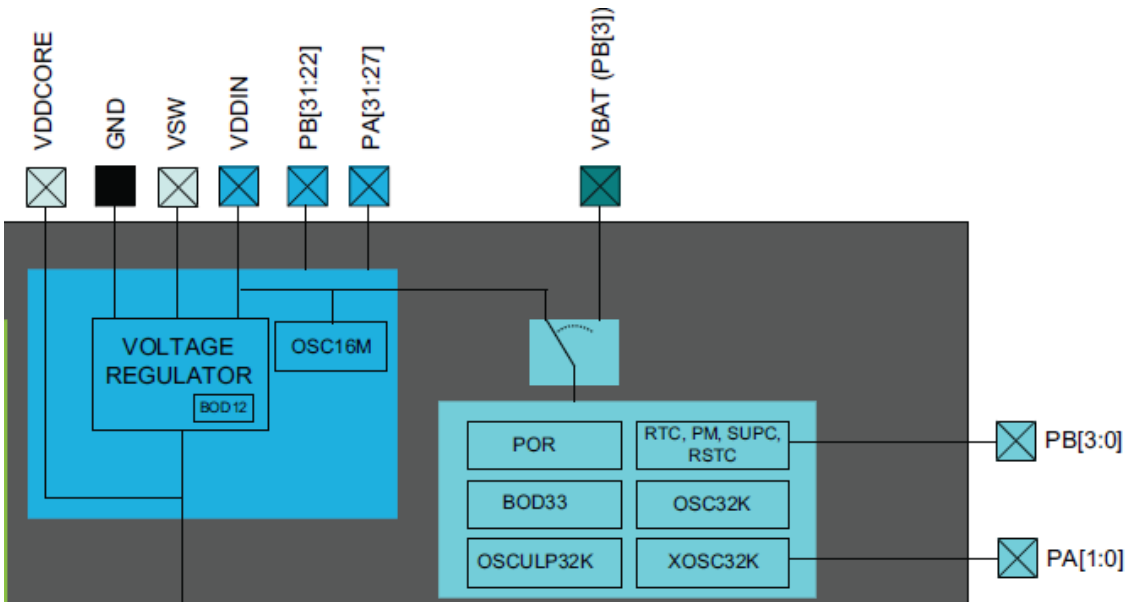
- UART with wake-up from standby sleep
  - auto-baud detection up to 115.2kbps
- Functional in sleep mode
  - Connected to DMA
  - Message reception in standby
- Operational in standby sleep
  - Limit DMA or CPU resources used = lower power
  - Built in logic
  - Built in buffer
- picoPower SEROM is Optimized for low power consumption not high performance

New low power features

Battery backup mode

- BOD33 or Automatic Power Switch can switch the backup domain to VBAT pin automatically
- Retains battery backup registers and RTC

- Backup domain can be forced to run from VBAT pin

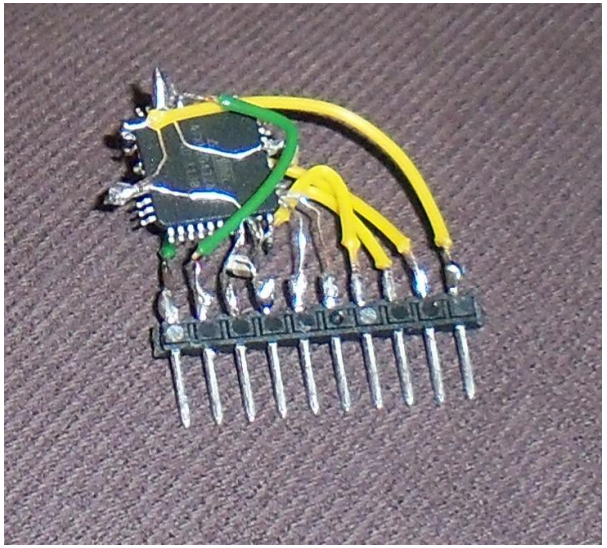


New low power features

Sleep modes BACKUP and OFF

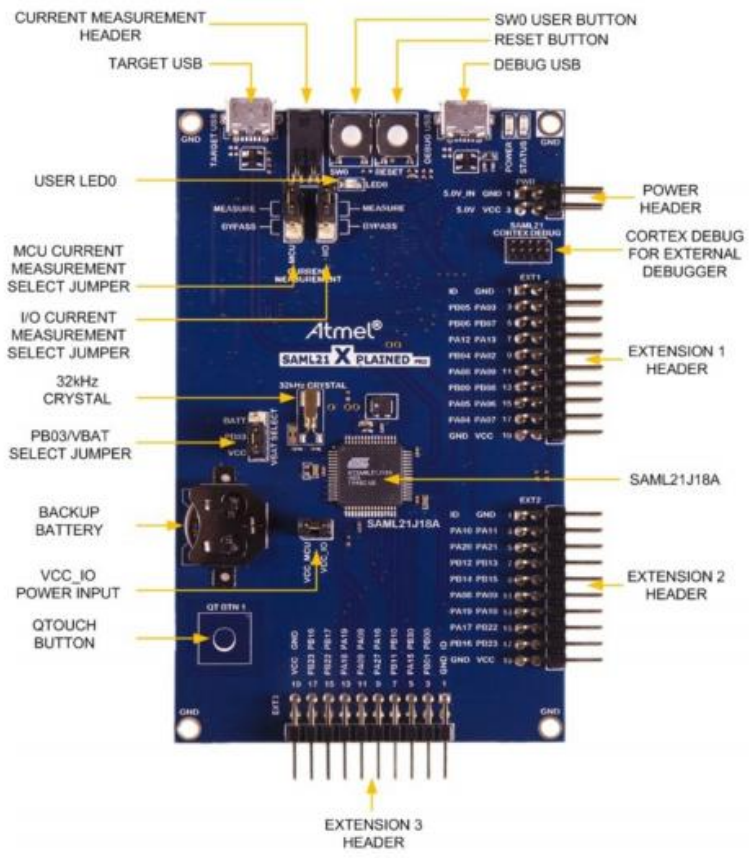
- BACKUP Mode
  - Most of logic and analog cells are powered off. The backup domain is kept powered (RTC, BOD, WDT, 32kHz clock sources and wake-up from external pins).
- OFF
  - Core and backup domains are powered off.
  - Cannot be entered if WDT is running
  - Reset pin only source of wakeup
- Regulators
  - On the Fly selection of LDO and Buck regulator

SAM L21 Tools



Tools for SAM L21

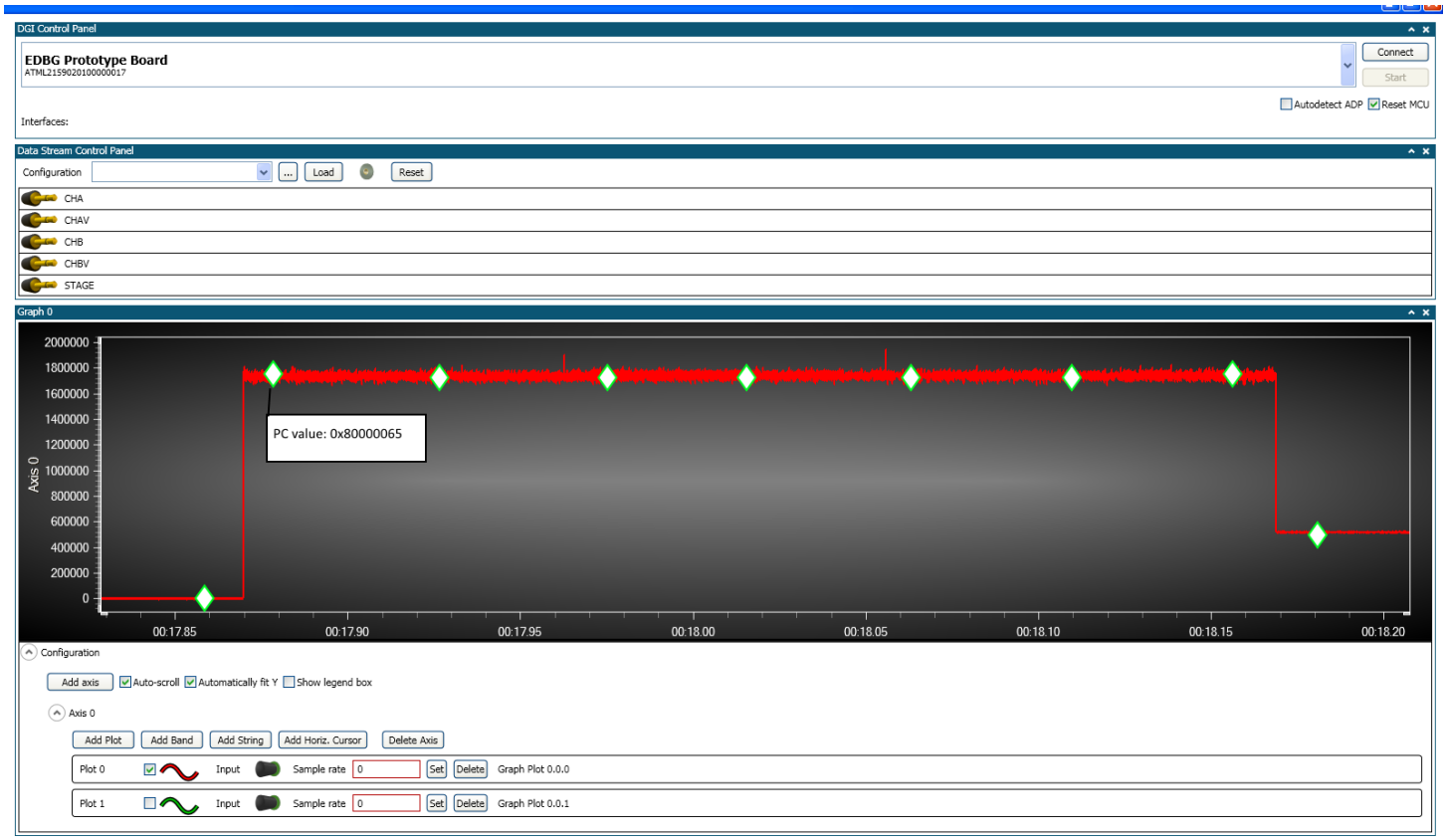
- Xplained Pro with power measurements
- Full support in Atmel Studio and ASF
- Appnotes
- Example code and projects
- QTouch support for
  - Buttons
  - Slider
  - Wheels
  - Surface



SAM L21 tools

Added features in Atmel Tools for picoPower Atmel|SMART

- **Power consumption measurement and visualization**
  - Support power profiling on SAML21 using SAML21-XPRO board.
  - Demonstrate low power modes of SAML21
  - Program Counter values included to track power consumers in your application



Introduction

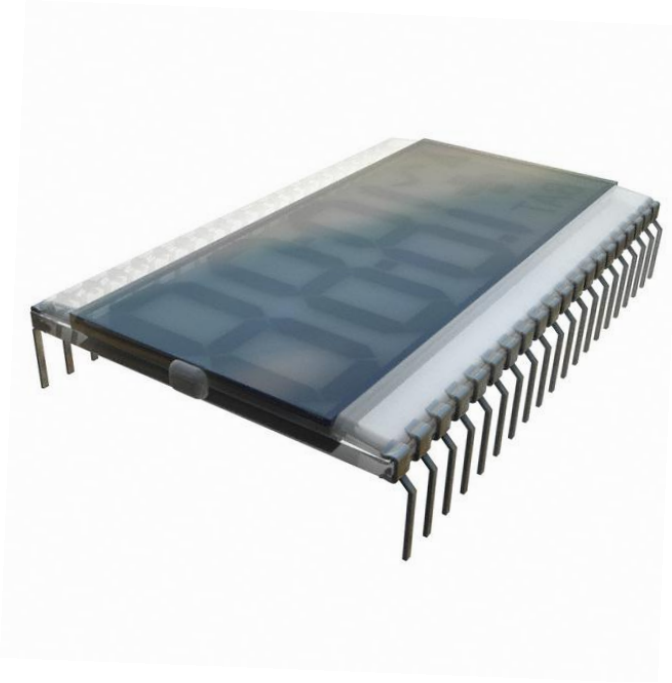
SAM L21 Series

Flash / SRAM / LP SRAM	Sub-Series		
256KB / 32KB / 8KB	SAM L21E 3x 16b T/C 4x SERCOM 10-ch ADC 2-ch DAC 2x An.comp	SAM L21G 3x 16b T/C 6x SERCOM 14-ch ADC 2-ch DAC 2x An.comp	SAM L21J 5x 16b T/C 6x SERCOM 20-ch ADC 2-ch DAC 2x An.comp
128KB / 16KB / 8KB			
64KB / 8KB / 4KB			
32KB / 4KB / 2KB			
Package	32-pin QFN and TQFP	48-pin QFN and TQFP	64-pin QFN and TQFP

Main Features and Functions in all devices:

ARM Cortex M0+ CPU at 48 MHz, 1.62-3.6V operation, -40°C – 85°C temp grade
Ultra low power analog: 12-bit 1 Msps ADC, 12-bit DAC, 2 analog comparators, **3x op-amp**
Peripheral Touch Controller, 32-bit RTC with calendar mode, **AES, TRNG**
12-ch Event system, and 16-ch DMA controller with **next generation SleepWalking**
USB host/device, SERCOM supports USART, UART with autobaud,
SPI, I^2C up to 3.4MHz, PM/SMBus, IrDA
3 Timer/Counters for Control applications, **Ultra low power SERCOM and Timer/Counter**

Atmel® | SMART SAM L22 Ultra-low power segment LCD Controller



Atmel | SMART™

SAM L22 - Introduction

Advantages and Features System and Core

- Atmel | SMART ARM® based Cortex-M0+ Controller, 32MHz
  - supported by Atmel Studio®, ASF®, Atmel Xplained Pro boards and other 3rd party compilers/IDE/SW/Tools inlcuding IAR® and Keil®
- Targeted for segment LCD and/or Battery powered applications
- Industries first Ultra Low Power Large Flash and SRAM Cortex-M0+ segment LCD Controller
- Pin and Code compatible with all SAMRT ARM Cortex-M0+ Controller (except for SLCD pins)

SAM L22 - Low Power consumption

Ultra Low Power Atmel | SMART microcontroller

- Active mode: <50µA/MHz
- Standby with RTC and LCD = 3uA
  - Inclusive logic and SRAM retention and LCD
  - <3.4 µs wake-up time
- Standby with RTC: <1.5uA
  - Inclusive logic and SRAM retention
  - <3.4 µs wake-up time
- Backup with RTC: <600nA
  - No SRAM retention
  - 4x32-bit backup registers
  - <95 µs wake-up time

SAM L22 - Segment LCD Controller

Advantages and Features

- Up to 8 common terminals
- up to 40 (44) segment terminals
- Bias: static, 1/2, 1/3, 1/4
- Duty: static, 1/1, 1/2, 1/3, 1/4, 1/6, 1/8

- Flexilibity for different segment LCDs
  - All SLCD Pins can also be used as GPIOs
    - On the 100Pin device, 8 SLCD Pins are only GPI
  - Of 52 SLCD I/O lines the user can select up to 48 SLCD Pins
    - 100Pin: 8 com max 320 (8x40), 4 com max 176 (4x44) segments
    - 64Pin: 8 com max 184 (8x23), 4 com max 108 (4x27) segments
    - 48Pin: 8 com max 120 (8x15), 4 com max 76 (4x19) segments

SAM L22 - Segment LCD Controller

Additional Features

- Shadow display memory for full freedom in segment update
- Software contrast adjustment control

- Lower the power consumption trough
  - DMA
  - Sleepwalking
  - Interrupt request and event output for display update
  - Switch from regular to low power waveform
  - Blinking
  - Automated Character Mapping (ACM)
  - Automated Bit Mapping (ABM)

- Lower BOM
  - On-chip LCD power supply
  - need only one external capacitor (typ 1uF)

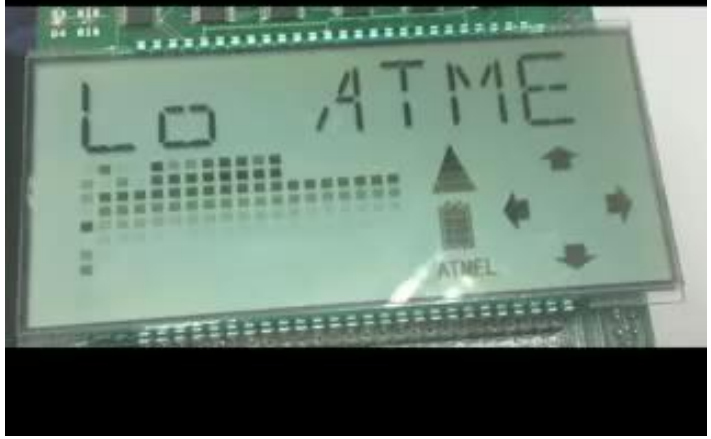
SAM L22 - Segment LCD Controler

Advantages and Features

- Automated Character Mapping (ACM) uses DMA
- Automated Bit Mapping (ABM) uses DMA
- Blinking

ACM & ABM

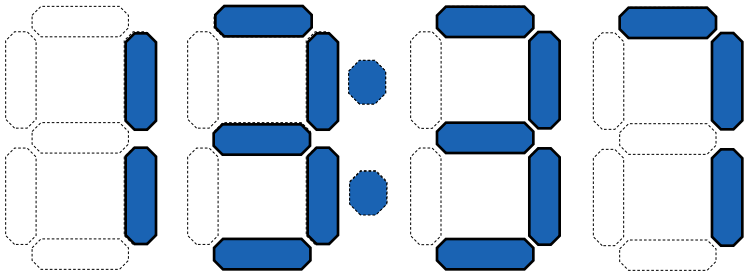
ACM & ABM & Blink



SAM L22 - Segment LCD Controller

Segment Blinking

- 2 options for blinking
  - Blink all segments
  - Blink selected segments
    - Up to 16 segments (connected to SEG0, SEG1 and COM0 to COM7)
- Available in Sleep and Active mode
- Selectable blink frequency
- Reduce interrupt frequency
- Reduce power consumption



SAM L22 - Series Differences Overview

Development

Atmel | SMART Ultra Low Power segment LCD Controller series

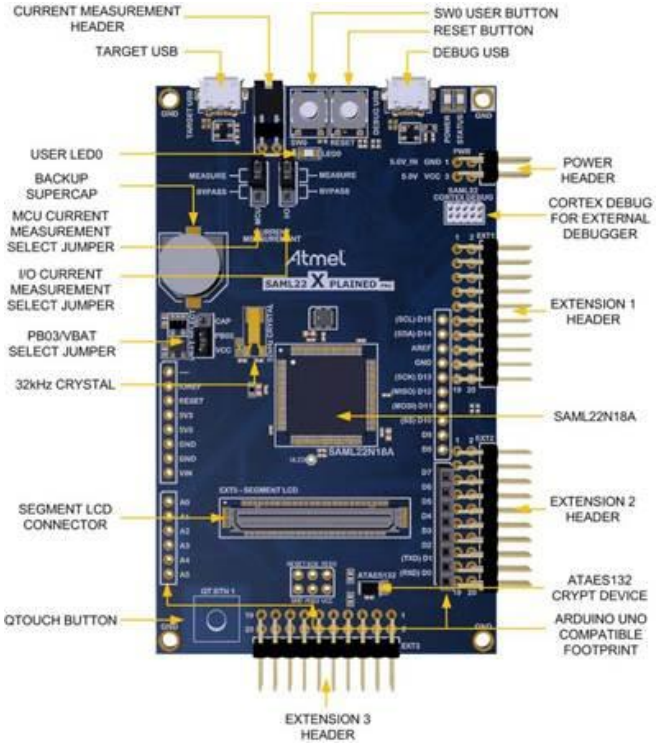
Flash / SRAM	Sub-Series		
256KB / 32KB	SAML22G18	SAML22J18	SAML22N18
128KB / 16KB	SAML22G17	SAML22J17	SAML22N17
64KB / 8KB	SAML22G16	SAML22J16	SAML22N16
LCD controller	0 –120 segments	0 – 184 segments	0 – 320 segments
SERCOM	3xSERCOM	4xSERCOM	6xSERCOM
ADC	8ch-ADC	10ch-ADC	20ch-ADC
PTC Pins Mutual X x Y / Self-Cap Y	10x11 / 13	13x14 / 19	16x16 / 24
GPIOs	Up to 36 GPIOs	Up to 50 GPIOs	Up to 82 GPIOs
Package	48-pin TQFP and QFN	64-pin TQFP and QFN	100-pin TQFP and VFBGA

SAM L22 Tools

Tools for SAM L22

ATSAML22-XPRO w/ SLCD1-XPRO

- Display extension with SLCD1-XPRO
- Full support in Atmel Studio and ASF
- Appnotes
- Example code and projects
- QTouch support for
  - Buttons
  - Slider
  - Wheels
  - Surface



Demonstration : Data Visualizer