Introduction to ARM

(Advanced RISC Machine)

ARM History

- Originally designed in 1983 by UK-based Acorn which eventually became ARM Ltd.
- It started as a more powerful replacement to the 6502 (found in BBC computers and the Commodore 64)
- As of 2007, 98% of new cell phones sold had an ARM processor (Wikipedia)
- As of 2009, 90% of all embedded 32-bit processors was an ARM (Wikipedia)
- Licensed by ARM Ltd. as IP to chip makers such as ATMEL, Freescale, LG, NEC, NXP (former Philips), Samsung, Sharp, ST, Texas Instruments

ARM Versions

- 32-bit processor with 16-bit Thumb option for reduced size
- ARM7, ARM9, ARM11, Cortex
- What is the difference between ARM7 and ARM9 ?
  - ARM9 has Harvard architecture with separate instruction and data bus. ARM7 has Von Neumann architecture.
  - ARM9 is faster than ARM7
  - ARM9 is more suitable for high-level operating systems
- What is Cortex?
  - Faster, more power efficient
  - Cortex-A for Applications (iPad uses Cortex-A8)
  - Cortex-R for Real-Time
  - Cortex-M for Microcontroller

Upgrade to ARM

- Why ARM (versus 8-bit processors such as 8051, AVR and PIC) ?

- Pros:
  - ARM is the industry standard for 32-bit microcontrollers
  - 32-bit performance compared to 8-bit, faster clock speeds
  - Comparable price
  - Wealth of peripherals
  - Larger memory, larger address space
  - High level operating system support (Linux, Android, Windows CE)
  - USB host support
  - Advanced development tools
  - Advanced debugging

- Cons:
  - Surface Mount package
  - Low voltage I/O (typically 3.3V or 1.8V)
  - More stringent power requirements

Advantages of ARM

- ARM is the industry standard for the 32-bit embedded controllers
- No need to switch and learn a new architecture for every new project
- Extended range of products and feature sets
- Full code compatibility across the line

  (ARM7 -> ARM9)
- Existing software library including communication stacks and RTOS's reduces the development cycle

CISC vs. RISC

CISC (Complex Instruction Set Computing)

- Several clock cycles to decode and execute one instruction
- A greater emphasis on hardware
- Extensive instruction set leading to larger silicon areas

RISC (Reduced Instruction Set Computing)

- Pipelined operation, decodes more instructions in fewer cycles
- Emphasis on software, since RISC code is often larger than CISC code
- Simpler but more powerful instruction set
- Became more popular as memory prices decreased

ARM Instruction Extensions

- Thumb – 16 bit instructions
- Thumb2 – Additions to Thumb and ARM sets
- DSP Instructions
- Jazelle (Java Byte Code)
- Vector Floating Point
- NEON for high speed audio/video processing
- TrustZone for security applications

ARM Development Tools

- C compilers: GCC (free from BiPOM), Keil, IAR, Imagecraft
- Graphical Programming: Flowcode for ATMEL ARM7’s (AT91SAM7 family)
- Linux tools for ARM9
- Operating Systems:
  - FreeRTOS, Micrium µC/OS-III, ucLinux
  - ARM Linux, Debian, Windows CE, Android on ARM9
- QEMU: Machine emulator. It allows to run ARM code on a PC and vice versa.

JTAG Debugging JEM-ARM

- PC hosted and powered via a USB 2.0 compatible port
- Supports debugging and programming for
  ARM 7 and ARM 9-based devices from a variety of silicon vendors
- Automatically programs flash memory when debugging
- Smart programming algorithm reduces flash memory writing time, prevents flash memory against premature wearing out
- Supports operations with external program and data memory devices
- Supports real-time and single step program execution
- Enables two hardware breakpoints
- Enables access to all target microcontroller resources when halted at breakpoint or after single step
- JTAG clock frequency up to 8 MHz
- Automatically adjusts a built-in clock generator to match the RTCK frequency, if cannot detect the RTCKI sets Fclk to maximum
- Software tracer records and displays preprogrammed set of parameters when emulation is halted or after a single step
- JTAG logical I/O lines tolerate target input/output signals in the 1 to 5.5V range
- Conveniently controllable from the Phyton CodeMaster integrated development environment
- The software set includes a C-like script language for hardware testing and device programming

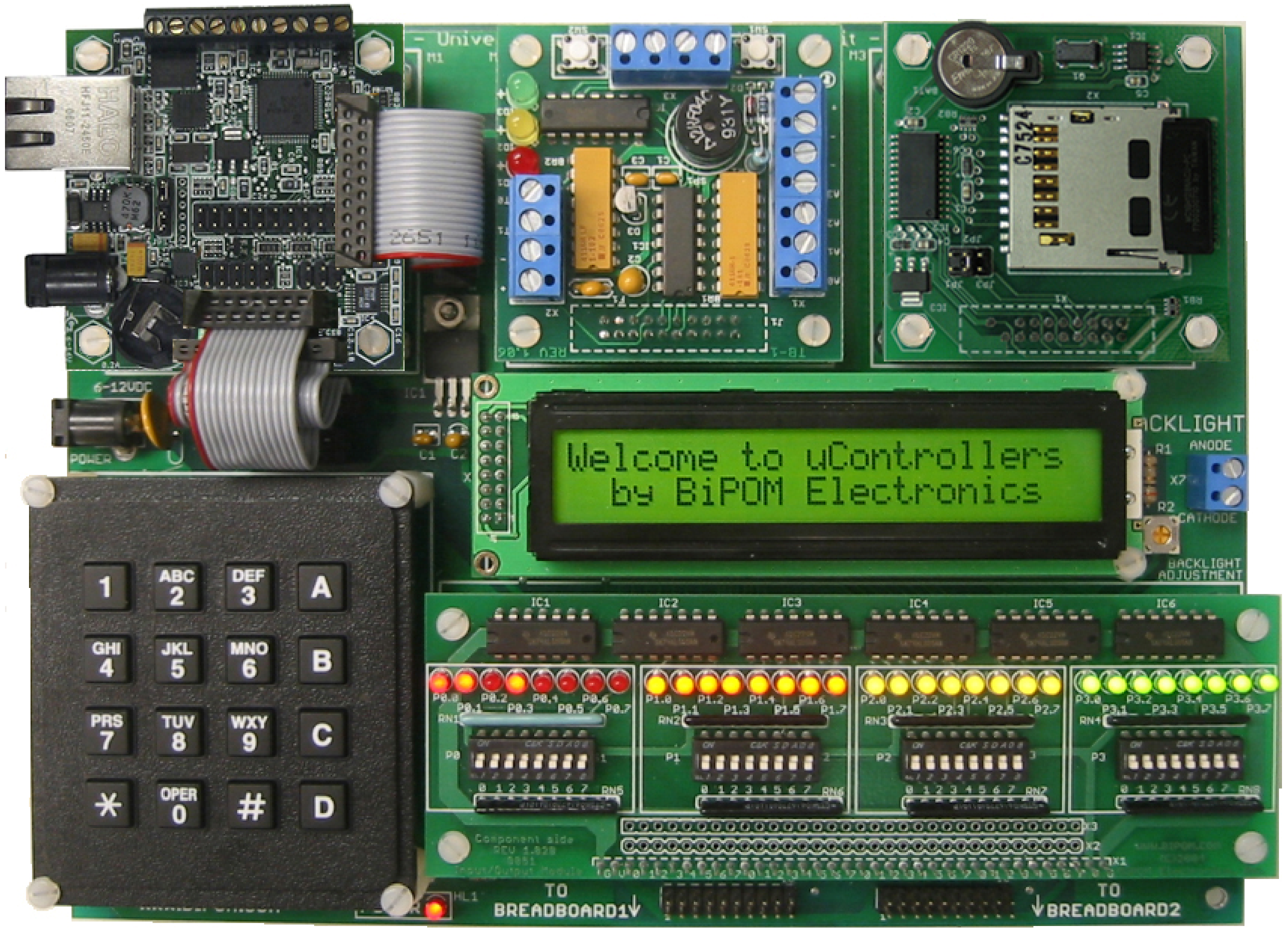
JTAG Debugging – SAM-ICE by ATMEL

- Any ARM7/ARM9/Cortex-M3 Atmel core supported, i
- Serial Wire Debug (SWD) support
- Serial Wire Viewer (SWV) support
- J-Link compatible mode
- RDI compliant
- Download speeds up to 720KByte/sec
- Powered from USB port
- Maximum JTAG speed up to 12 MHz
- Auto speed recognition
- All JTAG signals and target voltage can be monitored
- Fully plug and play compatible
- USB and 20-pin flat cables included
- J-Link server (connects to SAM-ICE via TCP/IP) include
- GDB Server included
- USB 2.0, full speed

JTAG Debugging - JLink

- Connects and powers via USB to the PC host running Windows.
- Integrates seamlessly into [IAR Embedded Workbench](#) for ARM
- Supports all ARM7 and ARM9 architectures
- Download speed up to 50 KB/sec
- JTAG speed 8 MHz, auto speed recognition
- All JTAG signals and target voltage can be monitored
- 20-pin standard JTAG connector
- USB and 20-pin flat cable included

ARM Development and Training Kits Customized MicroTRAK platforms



MicroTRAK/ARM-E Complete (shown here) is based on ARM7

Frequently Asked Questions

- Why can ARM9 not run Windows ?

  There are too many ARM variants. Microsoft has to add support.

  Windows CE (Windows Mobile) runs on ARM.

  Microsoft announced support for ARM in Windows 8.

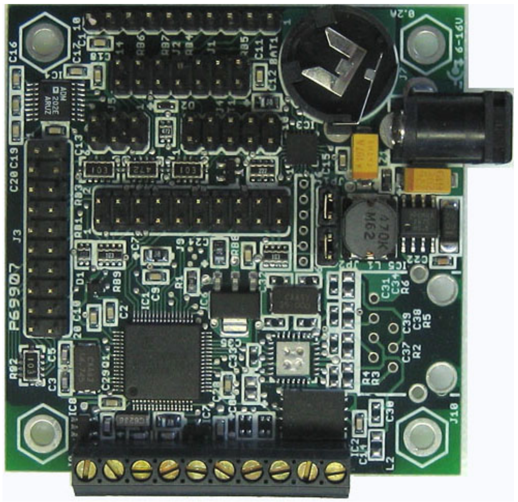
- Are ARM7 and ARM9 code compatible ?

  Yes.

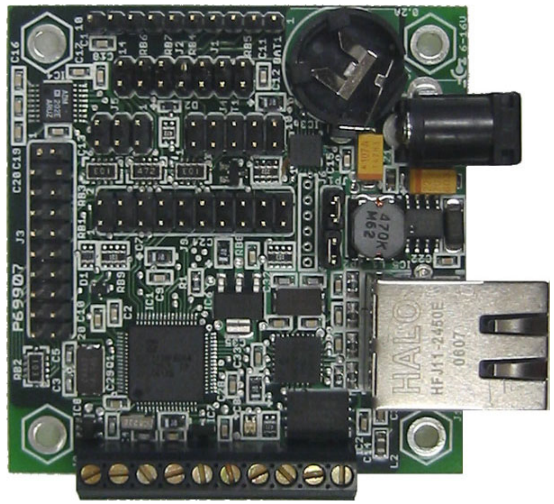
- Does BiPOM offer ARM design services ?

  Yes, we are a certified ATMEL consultant

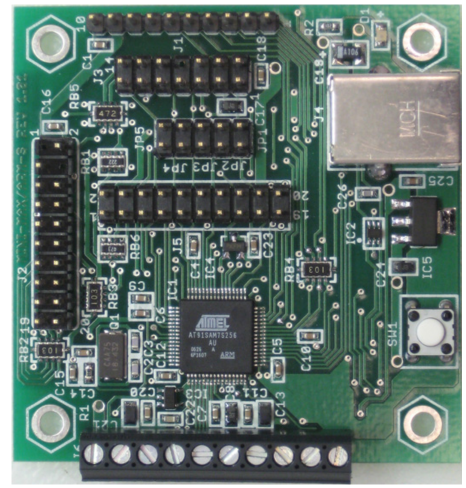
BiPOM ARM7 Support



MINI-MAX/ARM-C
Low power,
Philips LPC2138



MINI-MAX/ARM-E
Ethernet,
Philips LPC2138



MINI-MAX/ARM-S
USB,
ATMEL
AT91SAM7S256

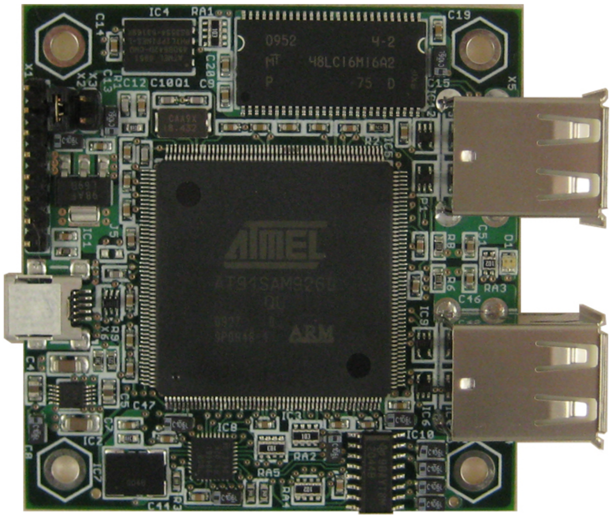
BiPOM ARM7 Support

WebCatPlus

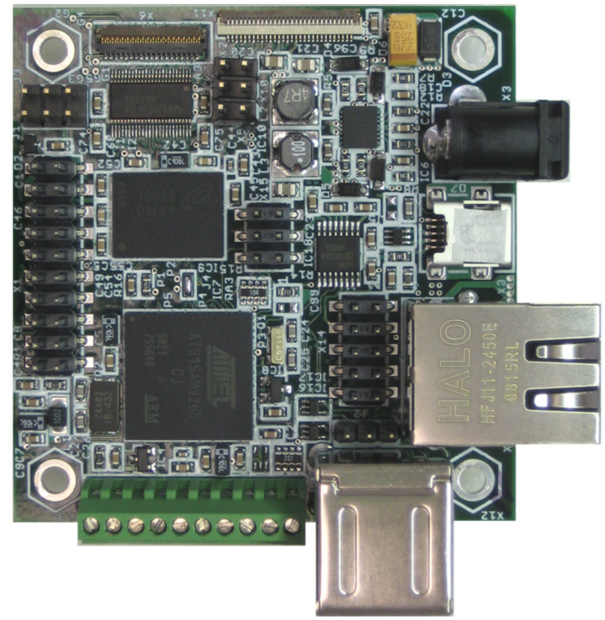
Small, Efficient, Flexible Web Server

•Based on BiPOM's [MINI-MAX/ARM-E board]
•32-bit ARM7 microcontroller
•Second 8-bit AVR CPU (ATTINY2313,8 MHz)
512KB Flash, 32KB RAM, 1MB DataFlash Expansion
bus interface to low-cost peripherals
•JTAG programming interface
•LCD connector
•10Mbit (10Base-T) Ethernet port
• Current consumption 110 mA
•Dimensions: 2.4" x 2.35" x 1.2"
•31 Digital I/O's
•Two RS-232 Serial port
•I2C (2-wire) bus

BiPOM ARM9 Support



GadgetPC
5 USB ports,
ATMEL AT91SAM9260



MINI-MAX/ARM9260-E
Ethernet, 2 USB ports,
ATMEL AT91SAM9260

Future BiPOM ARM Support

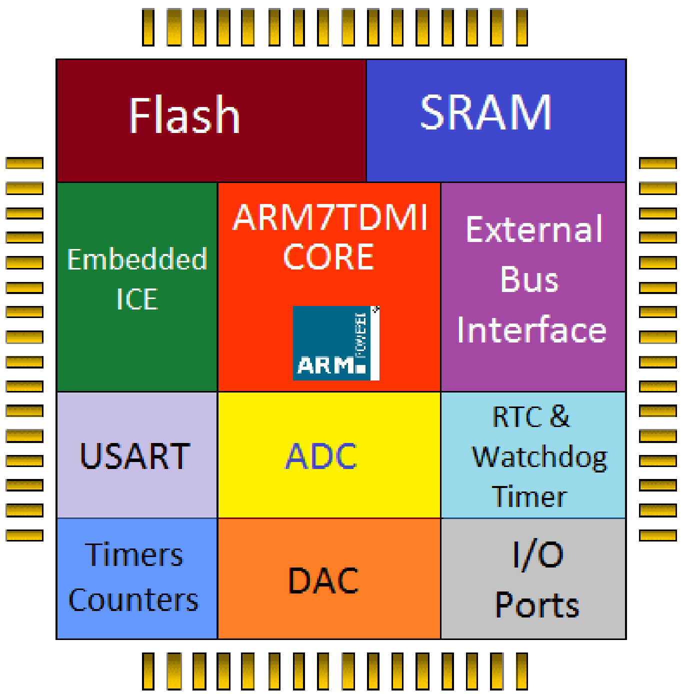
- Robot board with motor controller, Wi-Fi and Webcam using Freescale ARM i.MX233
- WebCatPlus based on Cortex-M4
- Version of GadgetPC with display port

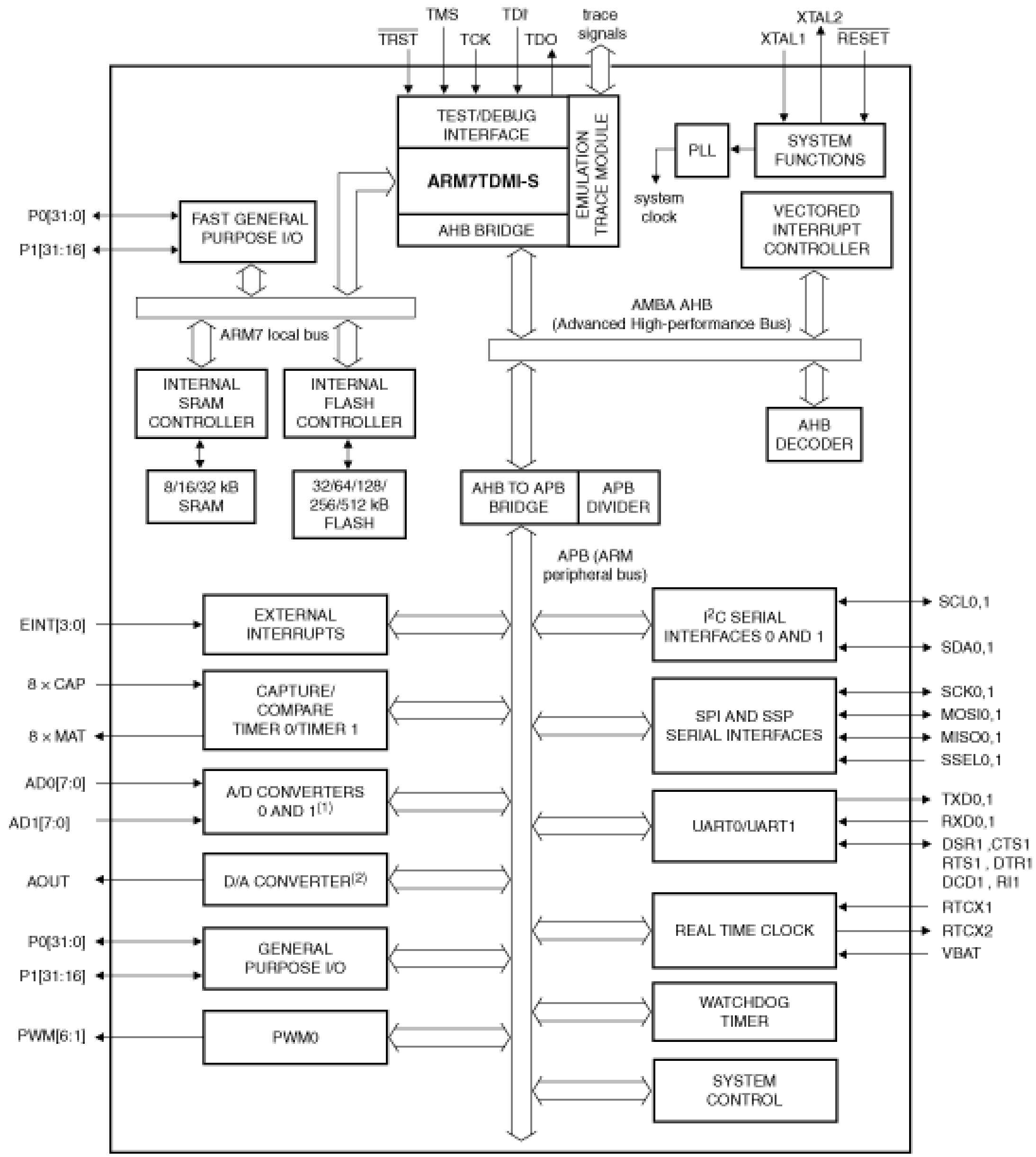
Anatomy of an ARM7 Microcontroller: LPC2138 from NXP

- Based on 16/32 bit ARM7TDMI-S core
- ARM7TDMI
- T - “Thumb” 16-bit high-code density instruction set
- D - Debug Extensions Included In Core
- M – Math core with 32X8 Hardware Multiplier
- I - ICE Macrocell (for JTAG debugging)

- 32-bit Advanced System Bus, 32-bit Advanced Peripheral Bus
- 37 32-bit registers
- 512K high speed Flash memory, 32K RAM
- 128-bit wide memory interface and a unique accelerator for fast 32-bit code execution
- 16-bit Thumb Mode reduces code by more than 30 % with minimal performance penalty.
- Real-time emulation and embedded trace support

LPC2138 Functional Blocks





LPC2138 Flash Memory

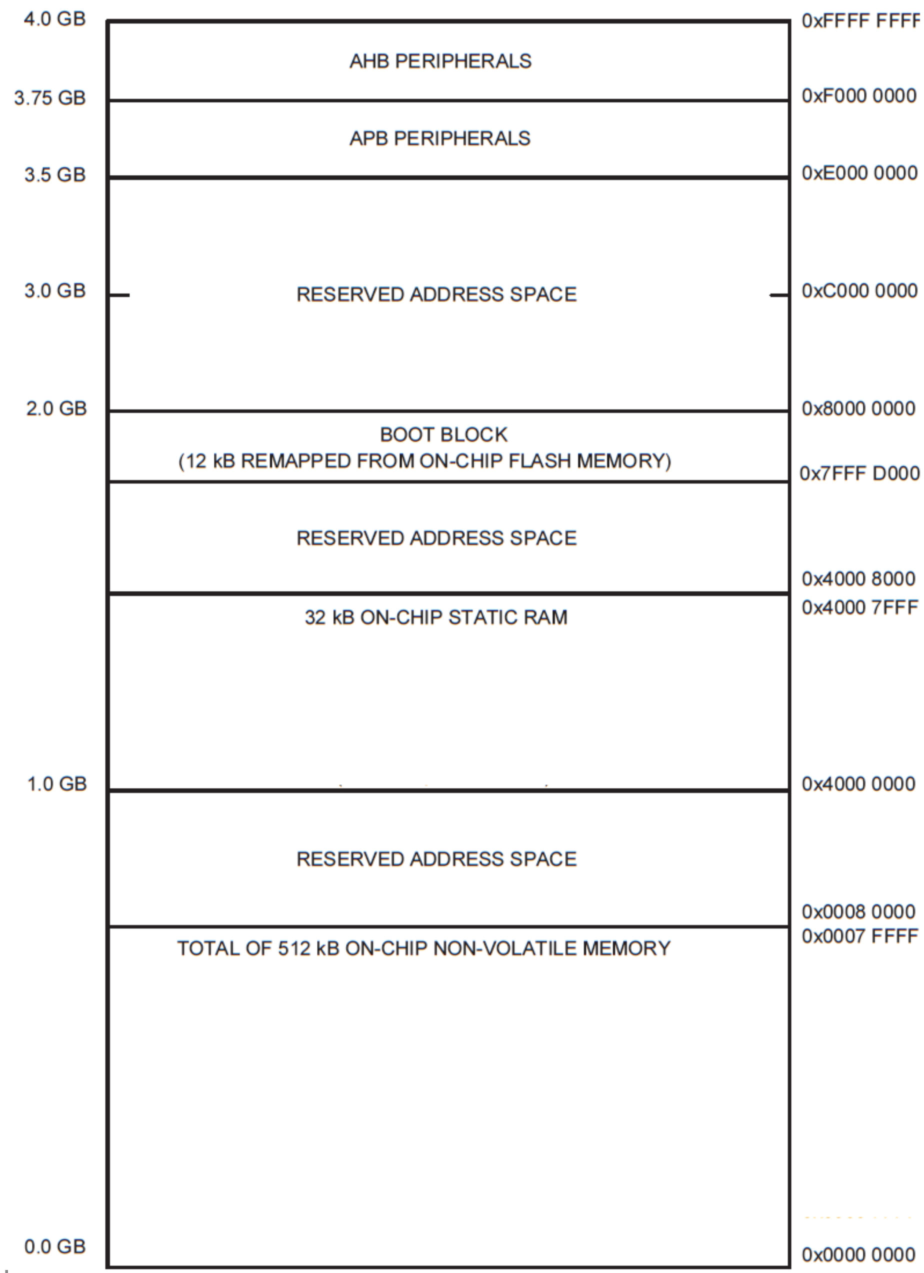
- 512 Kilobytes
- Programmable via
  - JTAG Interface
  - In-System Programming (ISP) over UART0
  - In-Application Programming (IAP)
- Minimum of 100,000 erase/write cycles
- 20 years of data retention

LPC2138 RAM

- 32 Kilobytes of Static RAM (SRAM)
- Byte (8-bit), word (16-bit),
  double word (32-bit) addressable
- SRAM contents are battery backed up

LPC2138 Memory Map

- Boot Block resides in Flash
- Large address space allows external memory
- Peripherals are memory mapped



LPC2138 Clock & Power Management

- 60 MHz maximum CPU clock available from programmable on-chip PLL
- On-chip integrated oscillator operates with external crystal from 1 MHz to 25 MHz
- Low power Real-time Clock with independent power and dedicated 32 kHz clock
- Power saving modes include Idle and Power-down
- Individual enable/disable of peripheral functions as well as peripheral clock scaling down for additional power optimization
- Wake-up from Power-down mode via external interrupt or Real-time Clock
- Single power supply chip with Power-On Reset and Brown-Out Detection
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O
- Idle mode current at 10MHz and 25°C: Under 2.5mA
- Power down current at 25°C : 60uA
- Active current at 10MHz and 25°C: 10mA typical (40mA at 60MHz)

LPC2138 Peripheral Support

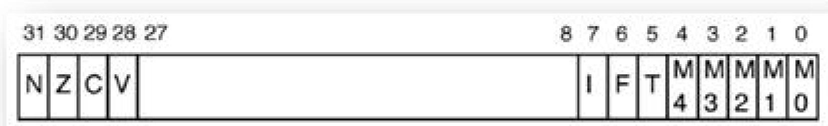
- 47 fast 5 Volt-tolerant GPIO lines with up to nine edge or level sensitive external interrupt pins
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C (400 Kbit/s), SPI and SSP with buffering and variable data length capabilities
- 16 channel 10-bit ADC, 2.44us conversion time
- 10-bit DAC, PWM
- Vectored interrupt controller with configurable priorities and vector addresses
- Up to nine edge or level sensitive external interrupt pins available

LPC2138 Peripheral Map

APB peripheral	Base address	Peripheral name
0	0xE000 0000	Watchdog timer
1	0xE000 4000	Timer 0
2	0xE000 8000	Timer 1
3	0xE000 C000	UART0
4	0xE001 0000	UART1
5	0xE001 4000	PWM
6	0xE001 8000	Not used
7	0xE001 C000	I^2C0
8	0xE002 0000	SPI0
9	0xE002 4000	RTC
10	0xE002 8000	GPIO
11	0xE002 C000	Pin connect block
12	0xE003 0000	Not used
13	0xE003 4000	10 bit AD0
14-22	0xE003 8000 - 0xE005 8000	Not used
23	0xE005 C000	I^2C1
24	0xE006 0000	10 bit AD1
25	0xE006 4000	Not used
26	0xE006 8000	SSP
27	0xE006 C000	DAC
28 - 126	0xE007 0000 - 0xE01F 8000	Not used
127	0xE01F C000	System control block

LPC2138 Registers

Register	Description
R0-R12	User Registers
R13	Stack Pointer
R14	Link Register
R15	Program Counter
CPSR	Current Program Status Register
SPSR	Saved Program Status Register (includes status of program & processor)



<u>Mode Bits</u>
Specifies the processor Modes

<u>Conditional Code Flags</u>
N - Negative Result from ALU
Z - Zero result from ALU
C - ALU operation carried out
V - ALU operation overflowed

<u>Interrupt Enable Bits</u>
I - IRQ, Interrupt Disable
F - FIQ, Disable Fast Interrupt

<u>T- Bit</u>
T=0, Processor in ARM Mode
T=1, Processor in THUMB Mode

LPC2138 Input/Output Ports

- Ports 0 and 1
- Minimum 4mA source and sink
- IODIR0 and IODIR1 registers control direction (1=output, 0=input)
- IOPIN0 and IOPIN1 registers read inputs
- IOCLR0 and IOCLR1 set port pin to 0 state
- IOSET0 and IOSET1 set port pin to 1 state

Useful Links

- www.at91.com
- www.nxp.com
- www.atmel.com
- BiPOM Forum: www.bipom.com
- Application Notes: www.bipom.com
- MINI-MAX/ARM-C Page: www.bipom.com/products/us/319526.html

Thank you !