

Module 2

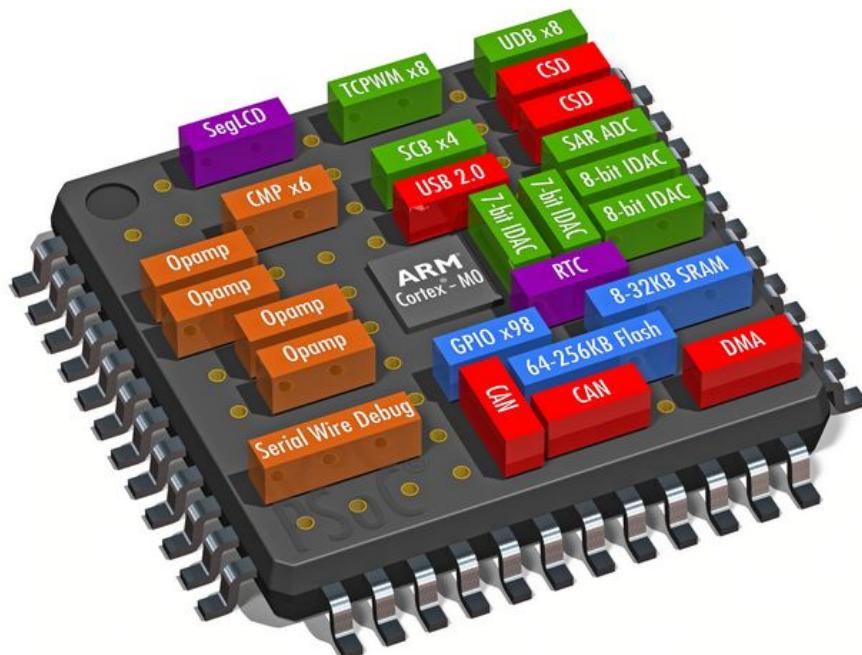
Microcontrollers

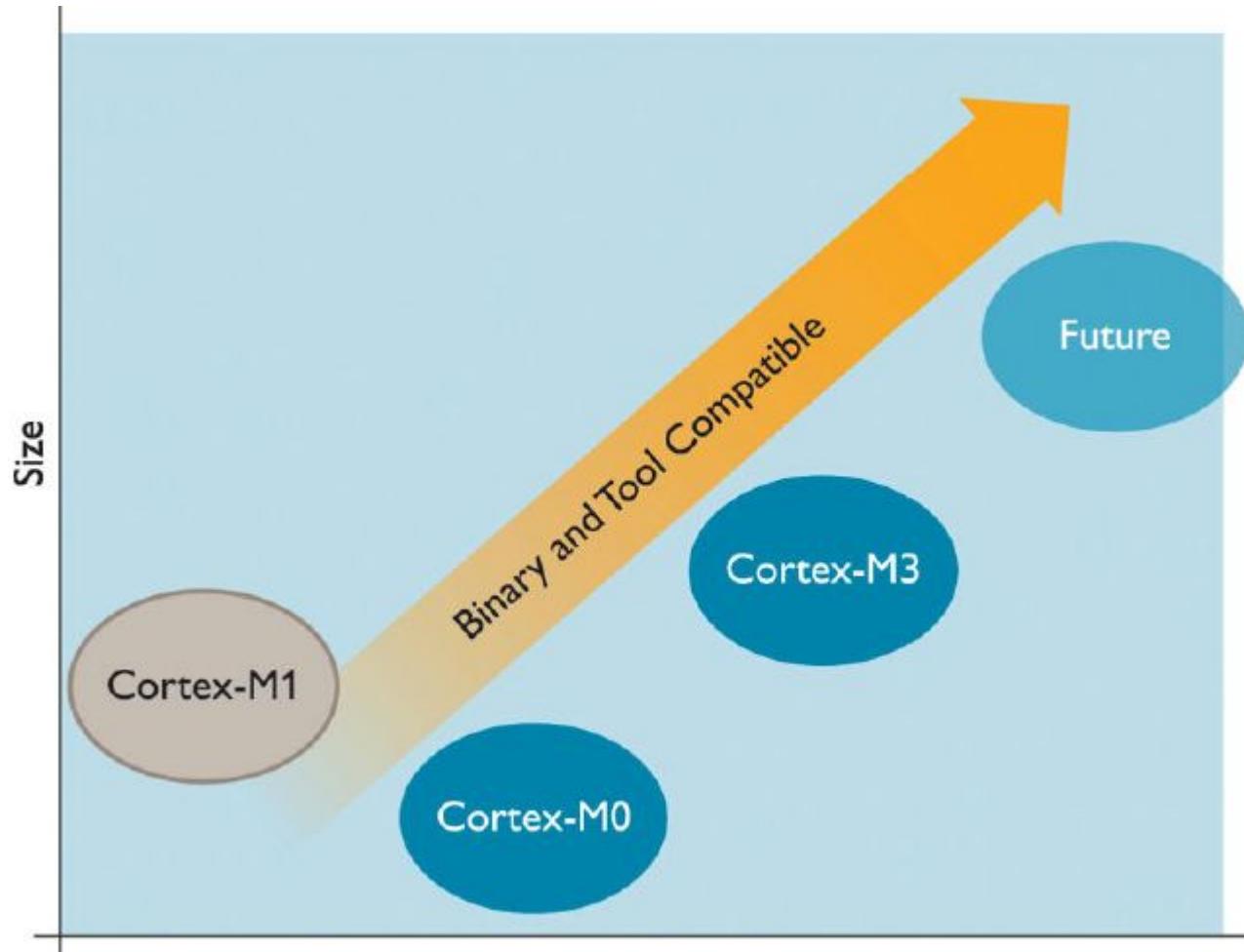
Topic 4

ARM0 Peripherals

Duration
1 hour

Instructor
Dr. Gilberto Ochoa Ruiz





ARM Cortex-A Series:

Applications processors for feature-rich OS and user applications

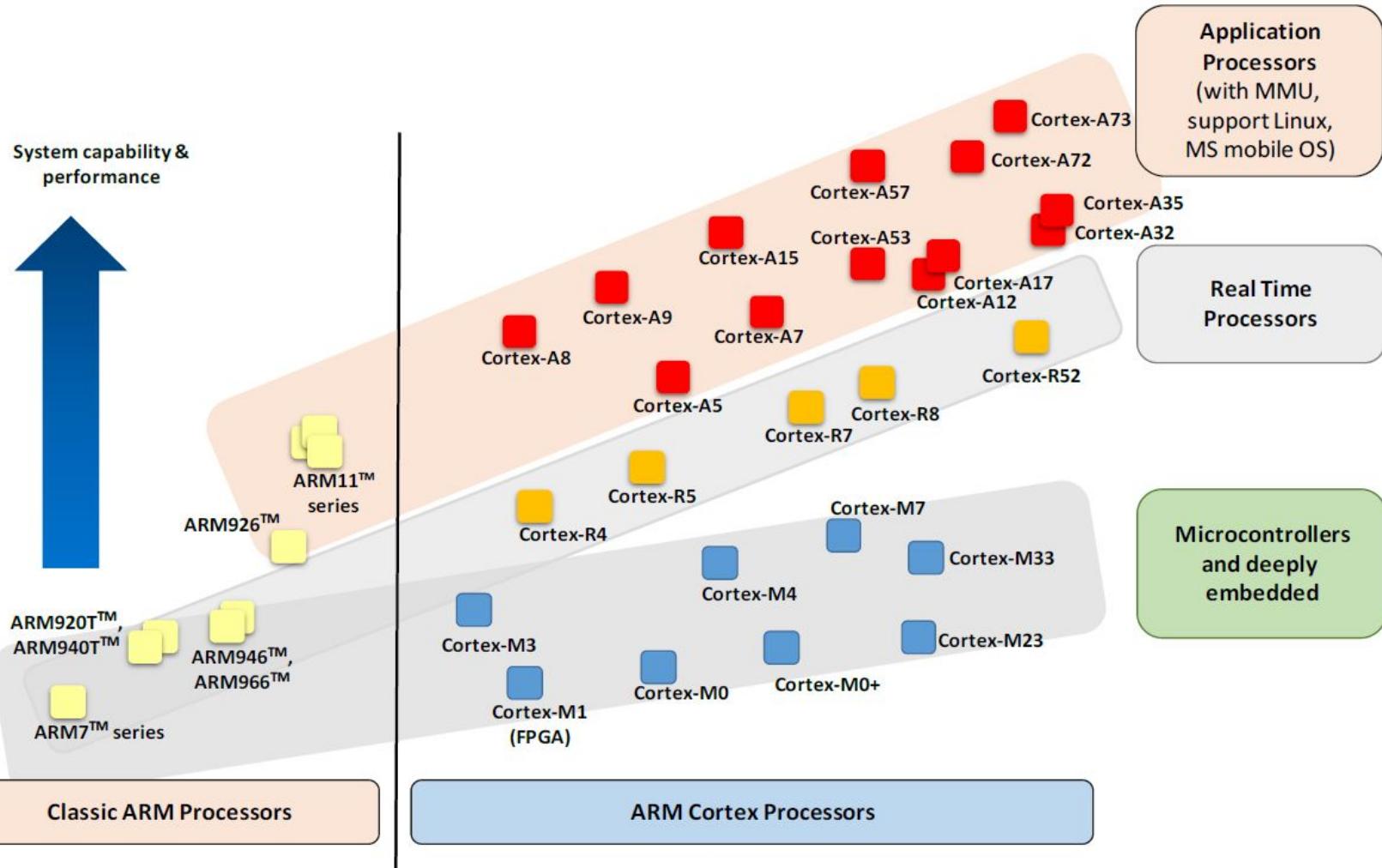
ARM Cortex-R Series:

Embedded processors for real-time signal processing and control applications

ARM Cortex-M Series:

Deeply embedded processors optimized for microcontroller and low-power applications

Fundamentals – ARM Cortex M0 Peripherals





Main characteristics of the three processor ranges.

	Application processors	Real-time processors	Microcontroller processors
Design	High clock frequency, Long pipeline, High performance, Multimedia support (NEON instruction set extension)	High clock frequency, Long to medium pipeline length, Deterministic (low interrupt latency)	Usually shorter pipeline, Ultra-low-power, Deterministic (low interrupt latency)
System features	Memory Management Unit (MMU), cache memory, ARM TrustZone® security extension	Memory Protection Unit (MPU), cache memory, Tightly Coupled Memory (TCM)	Memory Protection Unit (MPU), Nested Vectored Interrupt Controller (NVIC), Wakeup Interrupt Controller (WIC), ARM TrustZone® security extension in latest designs.
Target markets	Mobile computing, smart phones, energy-efficient servers, high-end microprocessors	Industrial microcontrollers, automotives, Hard disk controllers, Baseband modem	Microcontrollers, Deeply embedded systems (e.g. sensors, MEMS, mixed signal IC), Internet of Things (IoT)



Main characteristics of the three processor ranges.

Processor	Descriptions
Cortex-M0	A very small processor (starting from 12K gates) for low cost, ultra low power microcontrollers and deeply embedded applications
Cortex-M0+	The most energy-efficient processor for small embedded system. Similar size and programmer's model to the Cortex-M0 processor, but with additional features like single cycle I/O interface and vector table relocations
Cortex-M1	A small processor design optimized for FPGA designs and provides Tightly Coupled Memory (TCM) implementation using memory blocks on the FPGAs. Same instruction set as the Cortex-M0
Cortex-M3	A small but powerful embedded processor for low-power microcontrollers that has a rich instruction set to enable it to handle complex tasks quicker. It has a hardware divider and Multiply-Accumulate (MAC) instructions. In addition, it also has comprehensive debug and trace features to enable software developers to develop their applications quicker
Cortex-M4	It provides all the features on the Cortex-M3, with additional instructions target at Digital Signal Processing (DSP) tasks, such as Single Instruction Multiple Data (SIMD) and faster single cycle MAC operations. In addition, it also have an optional single precision floating point unit that support IEEE 754 floating point standard
Cortex-M7	High-performance processor for high-end microcontrollers and processing intensive applications. It has all the ISA features available in Cortex-M4, with additional support for double-precision floating point, as well as additional memory features like cache and Tightly Coupled Memory (TCM)

Fundamentals – ARM Cortex M0 Peripherals



Performance ↑



ARM Cortex-M4 powered

Kinetis K Series

Industry-first ARM Cortex-M4 MCU families from 50MHz / 32KB with low power, FlexMemory, mixed-signal and broad connectivity, HMI & security features.

Alpha Samples: Q4 2010
Production: Now

Kinetis L Series

Ultra-low power/cost ARM Cortex-M0+ MCU families from 32MHz / 8KB with mixed-signal, connectivity & HMI features in low pin-count packages. Compatible with 'K' Series & S08Px

Alpha Samples: Q3 2012
Production: Q4 2012

Kinetis E Series

Robust, low cost 5V ARM Cortex-M0+ MCU families for use in high electrical noise environments. Safety features for high-reliability applications. Compatible with S08Px and 'L' Series

Alpha Samples: Apr 2013
Production: July 2013



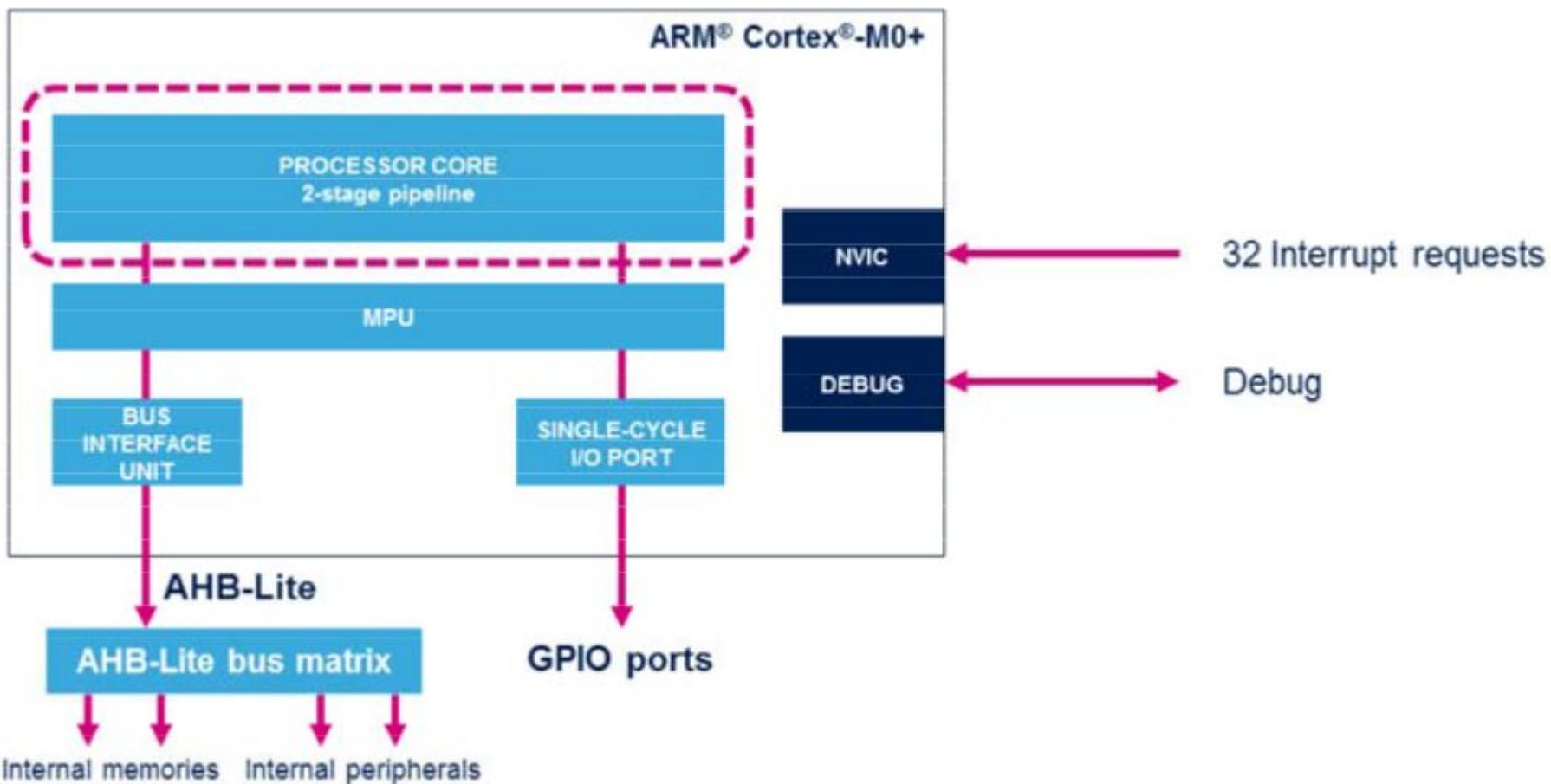
ARM Cortex-M0+ powered

Integration →

Leading Performance - Low Power - Scalability - Industrial-grade reliability & temp

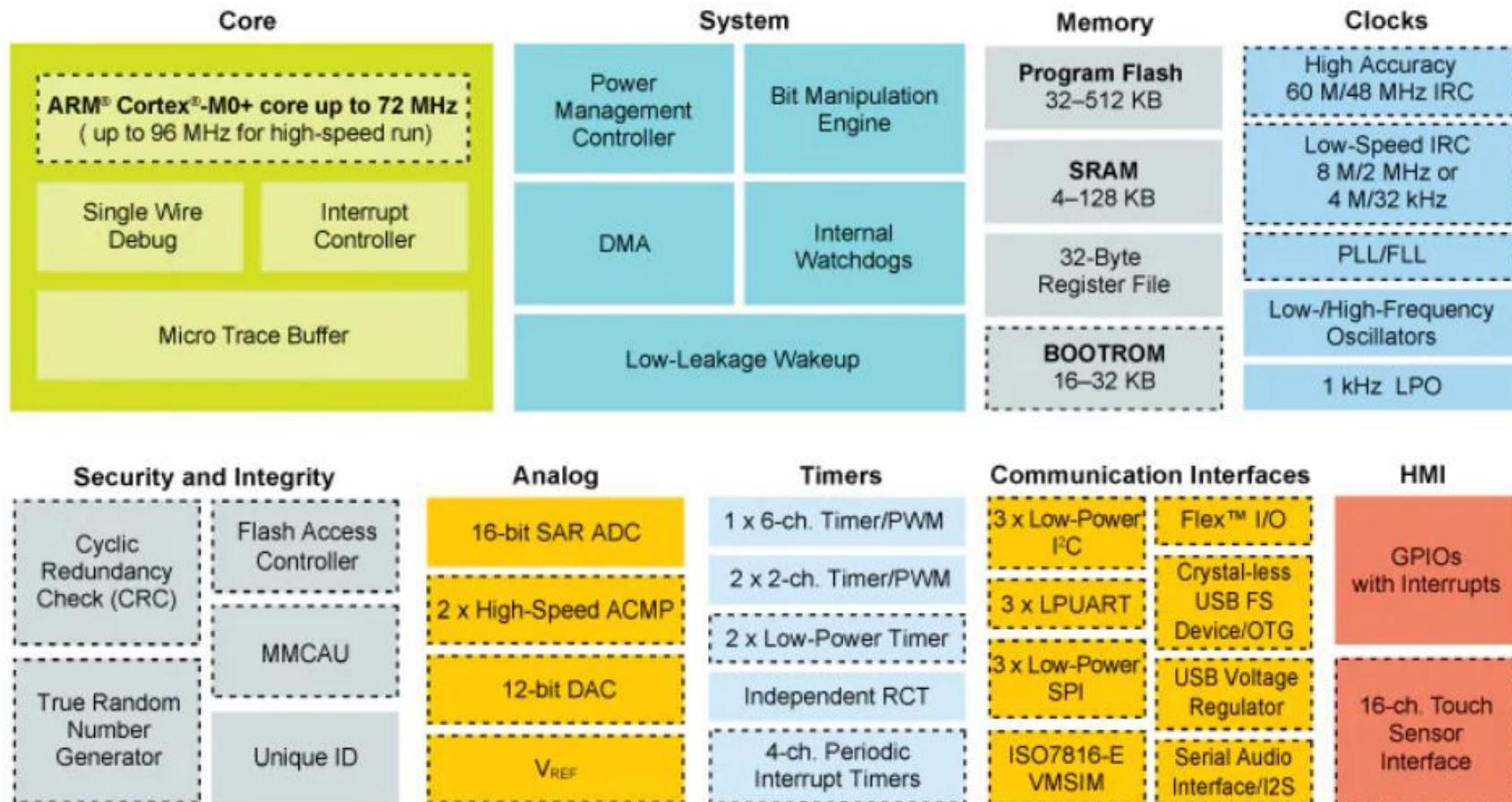
Freescale Bundled IDE, RTOS & Middleware - Rapid prototyping Platform - Broad ARM Ecosystem Support

Fundamentals – ARM Cortex M0 Peripherals



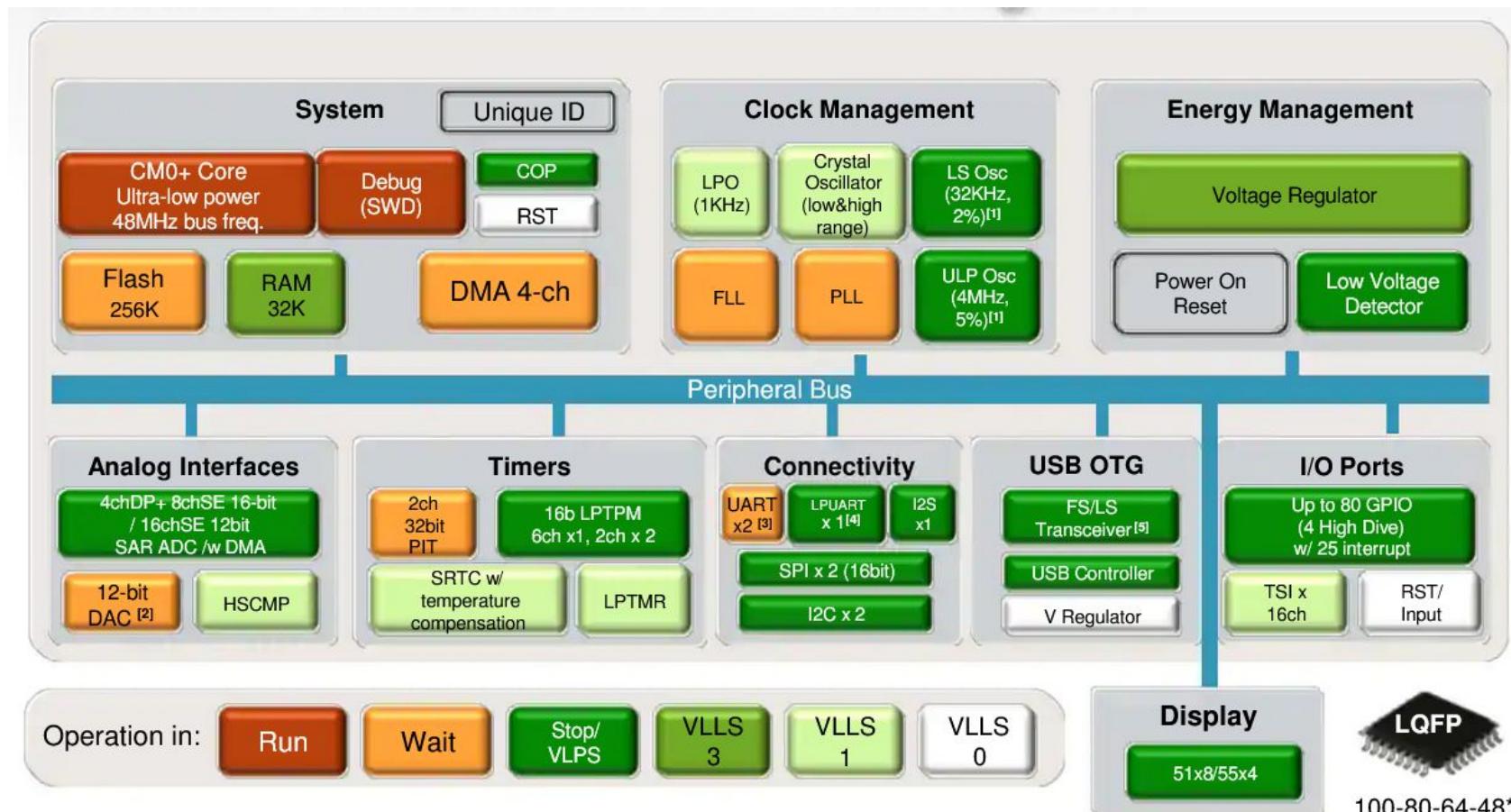


Kinetis KL2x MCU Family Block Diagram





Kinetis KL2x MCU Family Block Diagram





Kinetis KL2x MCU Main features

Operating characteristics	<ul style="list-style-type: none">• 1.71 V to 3.6 V• Temperature range (T_A) -40°C to 105°C• Flexible modes of operation
Core features	<ul style="list-style-type: none">• Next generation 32-bit ARM Cortex M0+ core• Support up to 32 interrupt request sources• Nested vectored interrupt controller (NVIC)• Debug & trace capability<ul style="list-style-type: none">• 2-pin serial wire debug (SWD)• Micro trace buffer (MTB)
System and power management	<ul style="list-style-type: none">• Software watchdog• Integrated bit manipulation engine (BME)• DMA controller• Low-leakage wake-up unit (LLWU)• Power management controller with 10 different power modes• Non-maskable interrupt (NMI)• 80-bit unique identification (ID) number per chip
Clocks	<ul style="list-style-type: none">• External crystal oscillator or resonator• DC- 48 MHz external square wave input clock• Internal clock references<ul style="list-style-type: none">• 31.25 to 39.063 kHz oscillator• 4 MHz oscillator• 1 kHz oscillator• Frequency-locked loop with the range of<ul style="list-style-type: none">• 20-25 MHz• 40-48 MHz• Phased-locked loop up to 100 VCO



Kinetis KL2x MCU Main features

Memory and memory interfaces	<ul style="list-style-type: none">Up to 128 KB with 64 byte flash cache for KL25 and up to 64 KB with 64 byte flash cache for KL24Up to 16 KB random-access memory for KL25 and up to 8 KB RAM for KL24
Security and integrity	<ul style="list-style-type: none">COP watchdog
Analog	<ul style="list-style-type: none">12-bit analog-to-digital converter(ADC) for KL24 and 16-bit ADC with DP channel for KL25High speed comparator (HSCMP)with internal 6-bit digital-to-analog converter (DAC)12-bit digital-to-analog converter (DAC) for KL25
Timers	<ul style="list-style-type: none">One 6-channel and two 2-channel 16-bit TPM modules32-bit Programmable interrupt timer (PIT)Real-time clock (SRTC)Low-power timer (LPTMR)System tick timer (SYSTIK)
Communications	<ul style="list-style-type: none">USB low speed/full-speed OTG/host deviceSPI with DMA supportI²C with DMA supportLow-power UART with DMA support
Human-machine interface	<ul style="list-style-type: none">GPIO with pin interrupt support, DMA request capability, and other pin control optionsCapacitive touch sensing inputs for KL25



Kinetis KL2x Family Options

Sub-Family	Part Number	CPU (MHz)	Memory								Features				
			Flash (KB)	SRAM (KB)	DMA	UART	SPI	I ² C	TSI	I ² S	RTC	12-bit DAC	16-bit ADC w/ DP Ch.	12-bit ADC	Total I/Os
KL24	MKL24Z32xxx4	48 MHz	32	4	✓	3	2	2			✓			✓	23~66
	MKL24Z64xxx4	48 MHz	64	8	✓	3	2	2			✓			✓	23~66
KL25	MKL25Z32xxx4	48 MHz	32	4	✓	3	2	2	✓		✓	✓	✓		23~66
	MKL25Z64xxx4	48 MHz	64	8	✓	3	2	2	✓		✓	✓	✓		23~66
	MKL25Z128xxx4	48 MHz	128	16	✓	3	2	2	✓		✓	✓	✓		23~66
KL26	MKL26Z32xxx4	48 MHz	32	4	✓	3	2	2	✓	✓	✓	✓	✓		23~50
	MKL26Z64xxx4	48 MHz	64	8	✓	3	2	2	✓	✓	✓	✓	✓		23~50
	MKL26Z128xxx4	48 MHz	128	16	✓	3	2	2	✓	✓	✓	✓	✓		23~80
	MKL26Z256xxx4	48 MHz	256	32	✓	3	2	2	✓	✓	✓	✓	✓		50~80

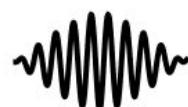


Kinetis KL2x Family Options

Family	Program Flash	Packages	Key Features			
KL4x Family	128-256KB	64-121pin				
KL3x Family	64-256KB	64-121pin				
KL2x Family	32-256KB	32-121pin				
KL1x Family	32-256KB	32-80pin				
KL0x Family	8-32KB	16-48pin				



Low power



Mixed signal



Segment LCD



Kinetis KL2x Package

Package Options



64MAPBGA
5 x 5 mm
0.5mm pitch
(K10/20)



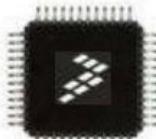
121MAPBGA
8 x 8 mm
0.65mm pitch
(K10/20/30/40/50/60)



144MAPBGA
13 x 13 mm
1.0mm pitch
(K10/20/30/40/50/60)



256MAPBGA
17 x 17 mm
1.0mm pitch
(K60/70)



48LQFP
7 x 7 mm
0.55mm pitch
(K10/20)



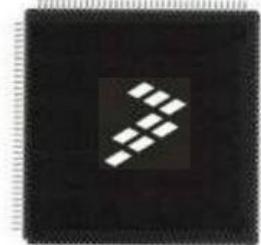
64LQFP
10 x 10 mm
0.5mm pitch
(K10/20/30/40/50)



80LQFP
12 x 12 mm
0.5mm pitch
(K10/20/30/40/50)



100LQFP
14 x 14 mm
0.5mm pitch
(K10/20/30/40/50/60)



144LQFP
20 x 20 mm
0.5mm pitch
(K10/20/30/40/50/60)

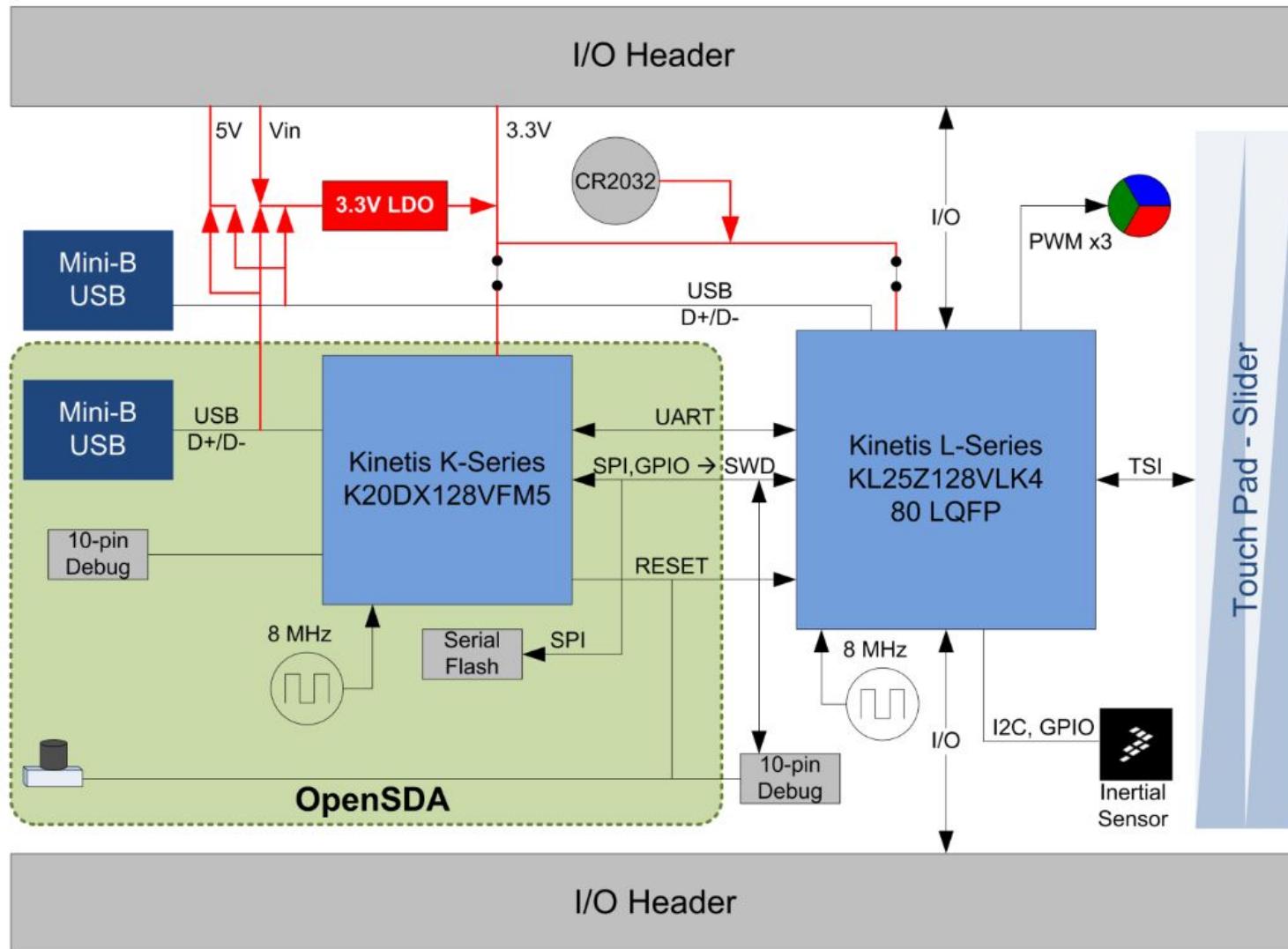


Kinetis KL25 Freedom Board



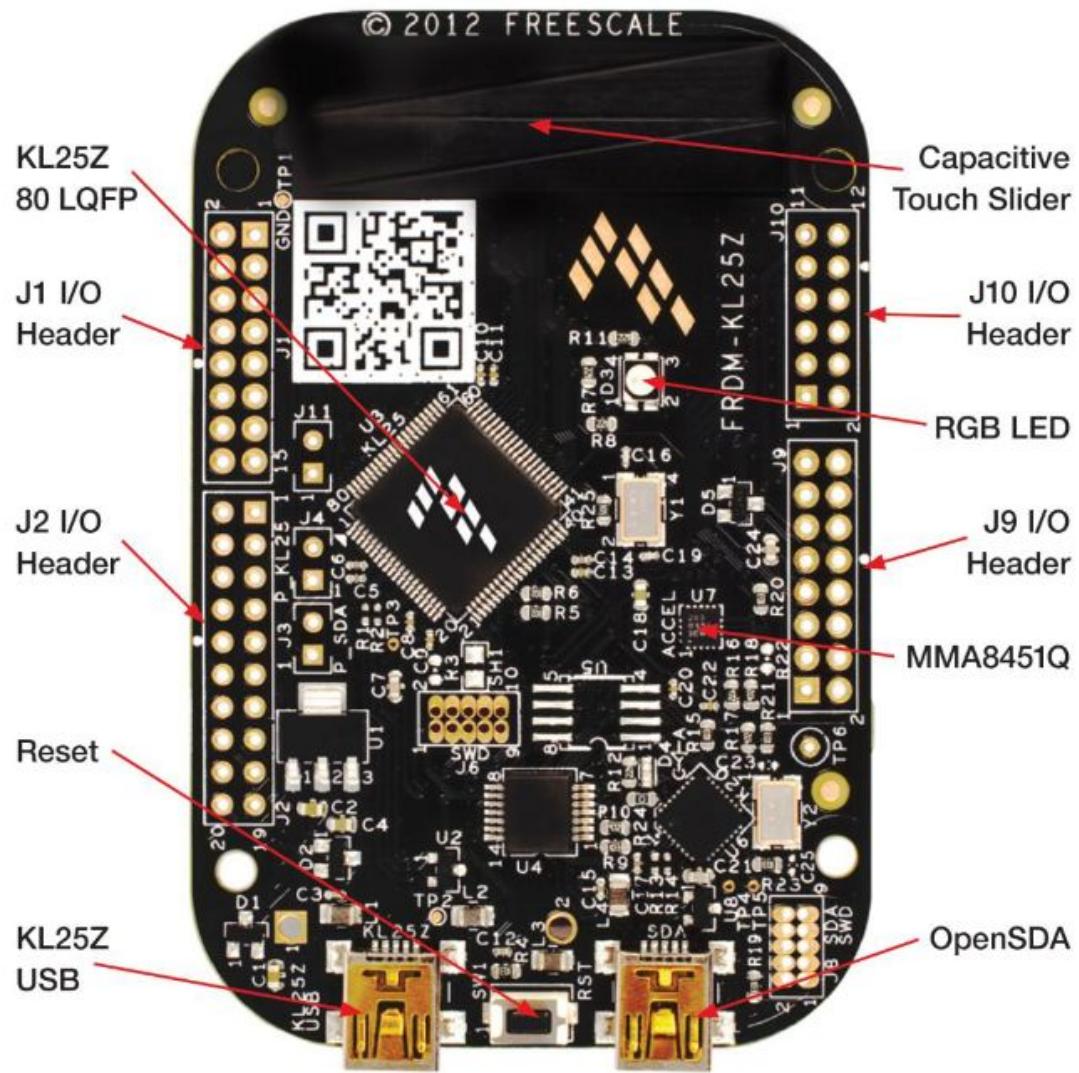
**MKL25Z128VLK4
in an
80 LQFP package**

Fundamentals – ARM Cortex M0 Peripherals



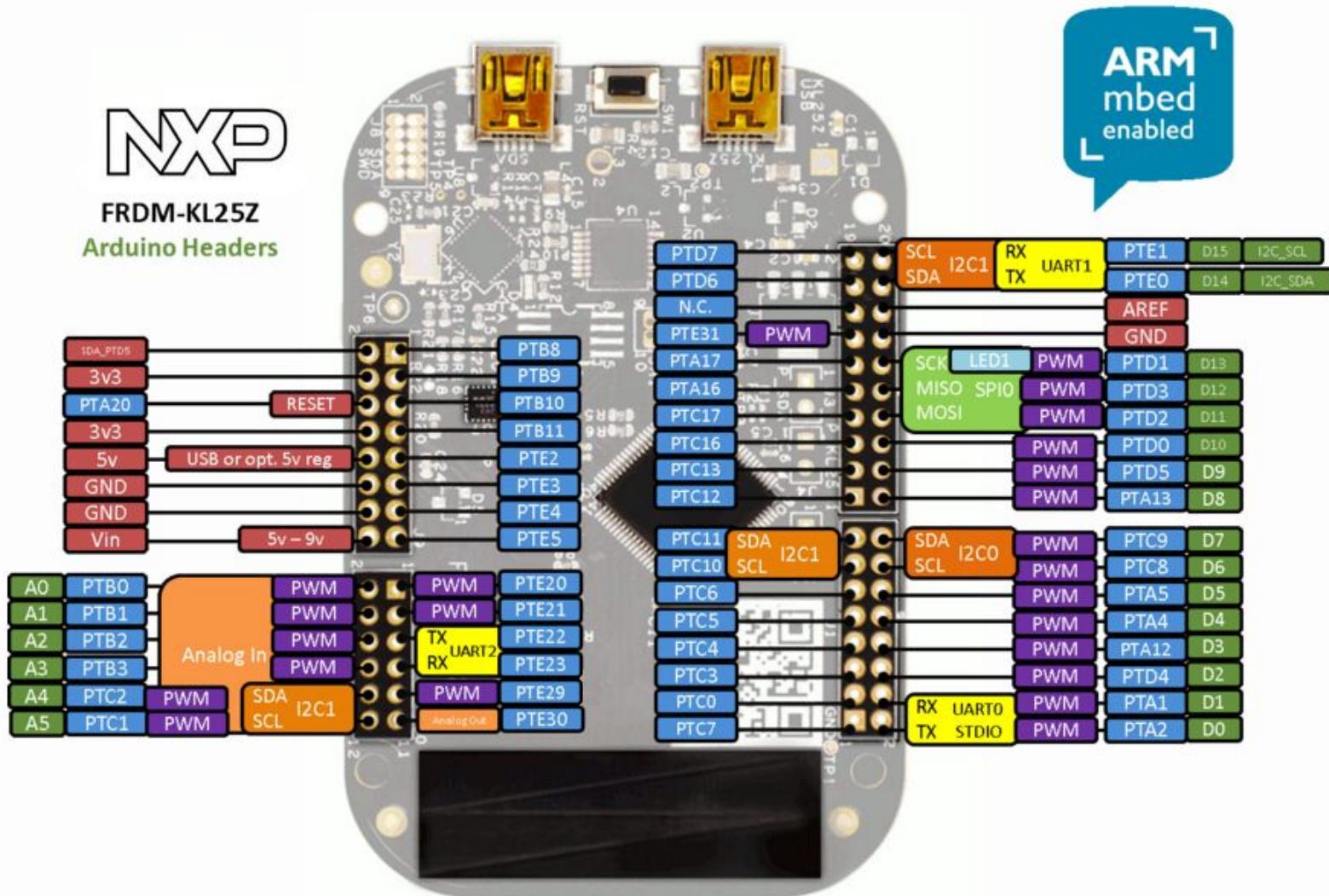


FRDM-KL25Z Feature Call-outs





FRDM-KL25Z Feature Call-outs



ARM
mbed
enabled

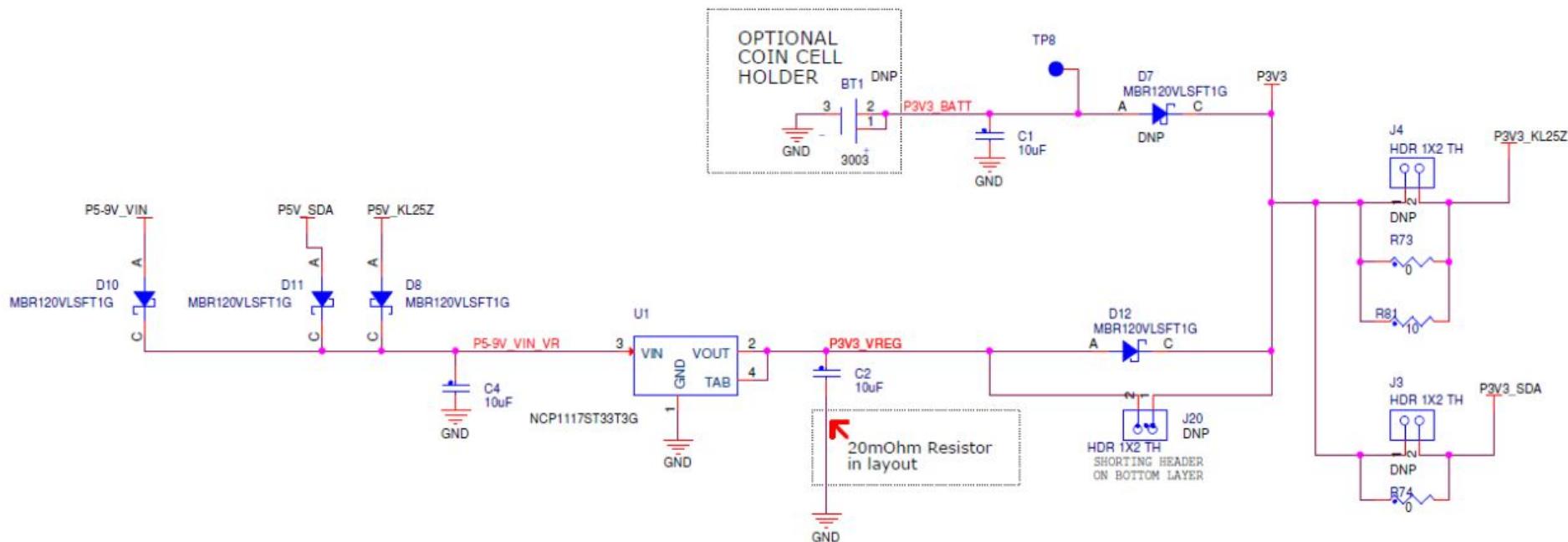


Power Supply Requirements

Supply Source	Valid Range	OpenSDA Operational?	Regulated on-board?
OpenSDA USB (J7)	5V	Yes	Yes
KL25Z USB (J5)	5V	No	Yes
V _{IN} Pin	4.3-9V	No	Yes
3.3V Pin	1.71-3.6V	No	No
Coin Cell Battery	1.71-3.6V	No	No



Power Supply Schematic



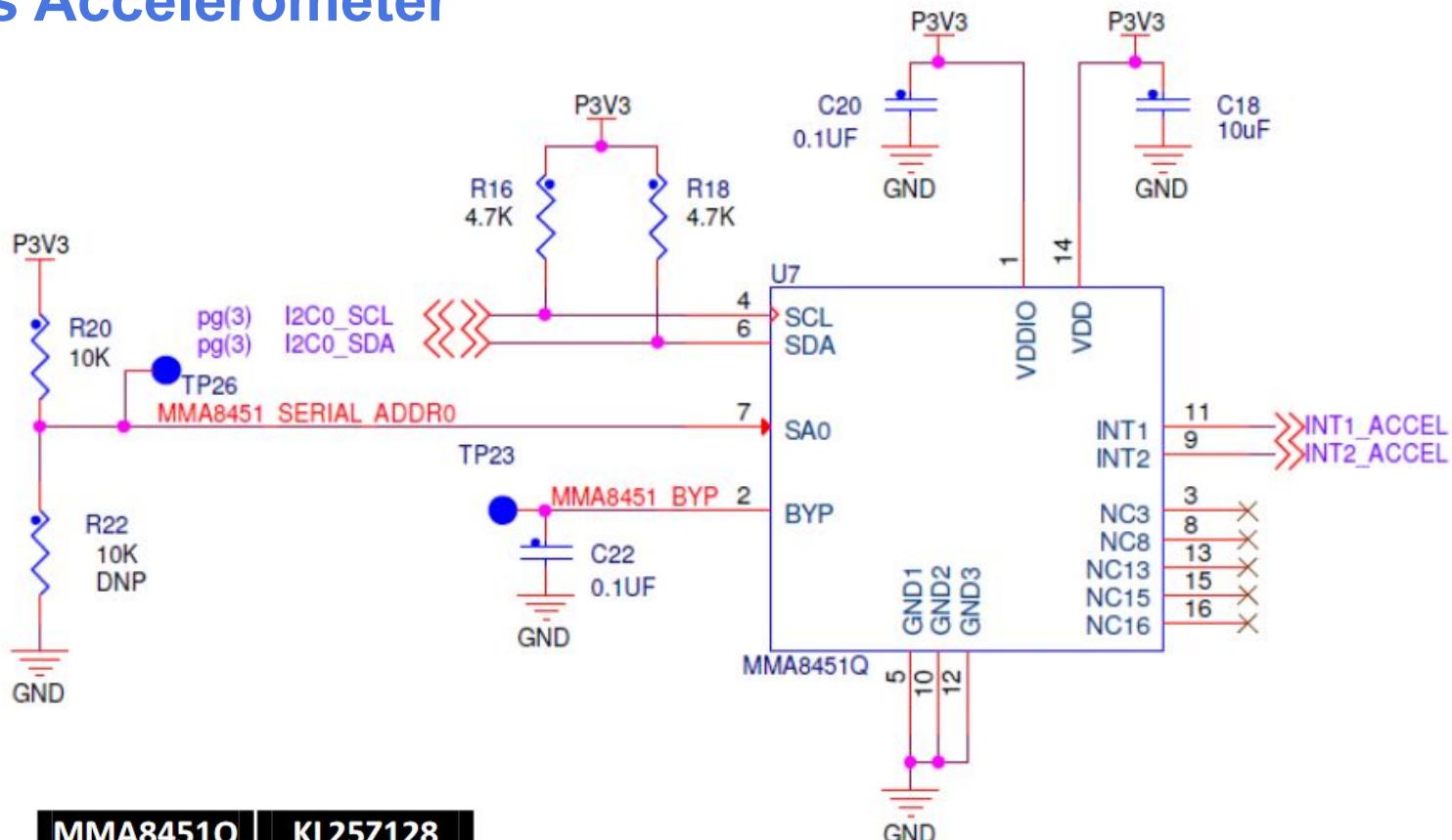


Power Supply Sources

Power Supply Name	Description
P5-9V_VIN	Power supplied from the V_{IN} pin of the I/O headers (J9 pin 16).
P5V_SDA	Power supplied from the OpenSDA USB connector (J7). A Schottky diode provides back drive protection.
P5V_KL25Z	Power supplied from the KL25Z USB connector (J5). A Schottky diode provides back drive protection.
P3V3_VREG	Regulated 3.3V supply. Sources power to the P3V3 supply rail with an optional back drive protection Schottky diode. ^{1,3}
P3V3_BATT	Coin cell battery supply voltage. Sources power to the P3V3 supply rail with the option of adding a back drive protection Schottky diode. ⁴
P3V3	Main supply rail for the FRDM-KL25Z assembly. May be sourced from P3V3_VREG, P3V3_BATT, or directly from the I/O headers (J9 pin 8)
P3V3_KL25Z	KL25Z MCU supply. Header J4 provides a convenient means for energy consumption measurements. ²
P3V3_SDA	OpenSDA circuit supply. Header J3 provides a convenient means for energy consumption measurements. ²
P5V_USB	Nominal 5V supplied to the I/O headers (J9 pin 10). Sourced from either the P5V_KL25Z or P5V_OSDA supply through a back drive protection Schottky diode.



3-axis Accelerometer



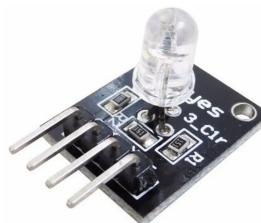
MMA8451Q	KL25Z128
SCL	PTE24
SDA	PTE25
INT1	PTA14
INT2	PTA15



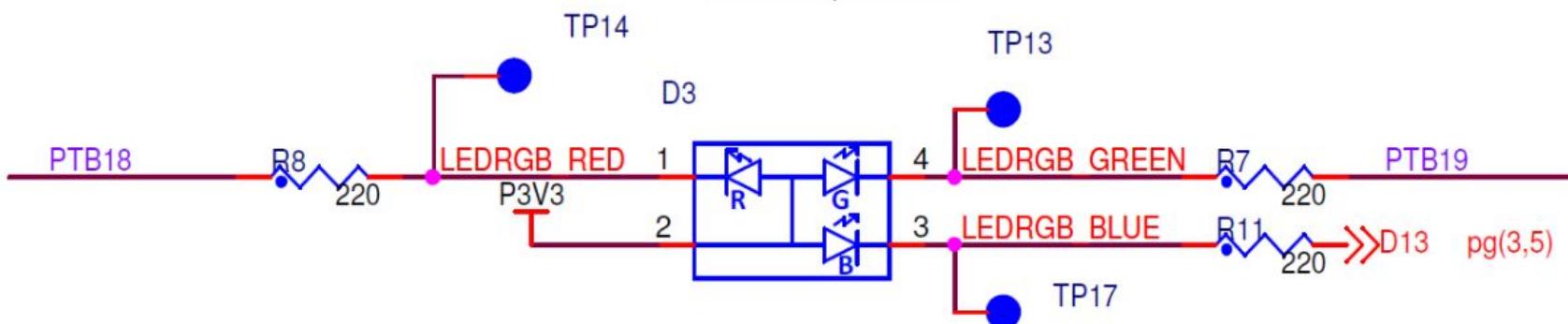
I2C interface!



RGB LED



Discrete components also exist!!!



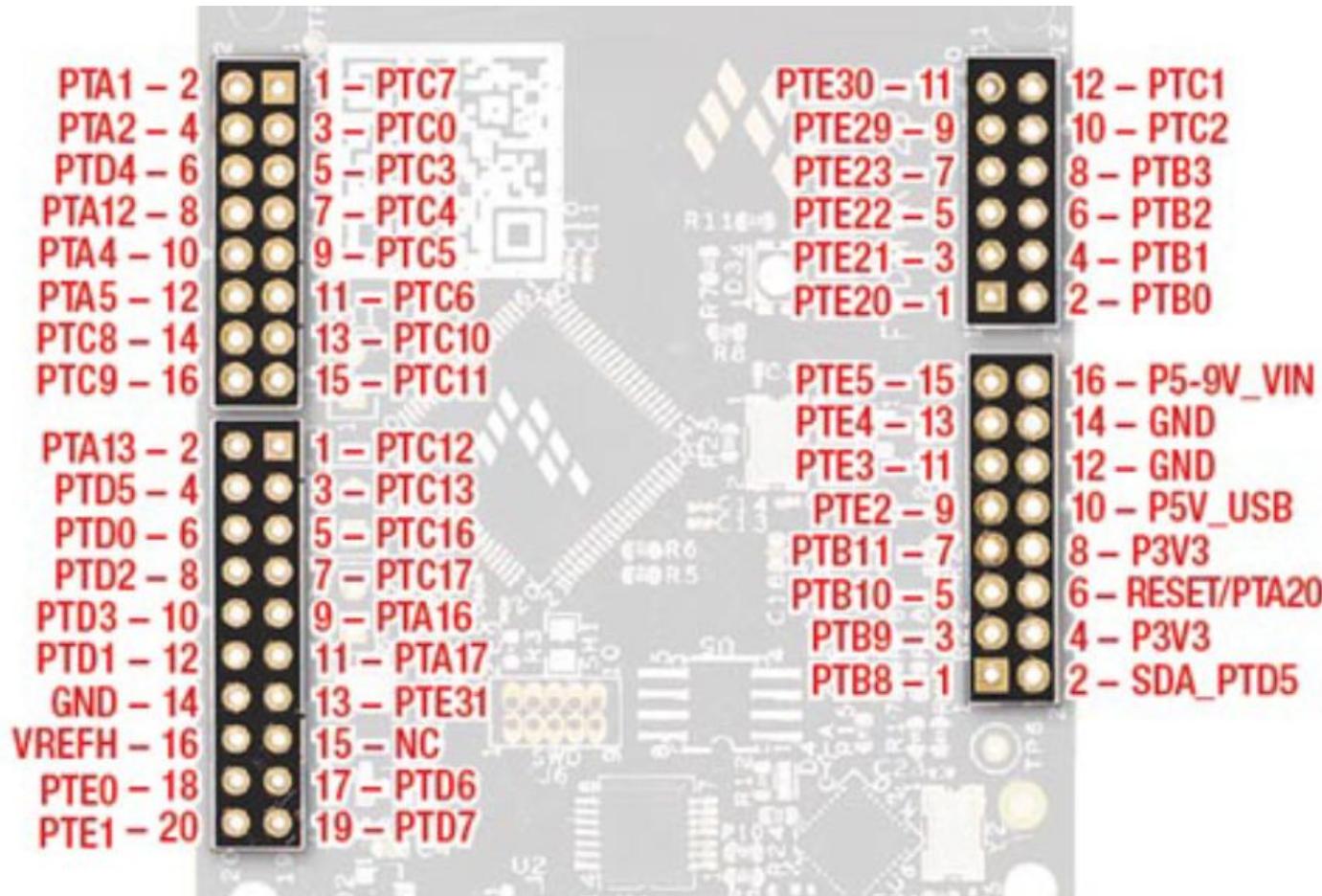
RGB LED	KL25Z128
Red Cathode	PTB18
Green Cathode	PTB19
Blue Cathode	PTD1 ¹



1) PTD1 is also connected to the I/O header on J2 pin 10(also known as D13)

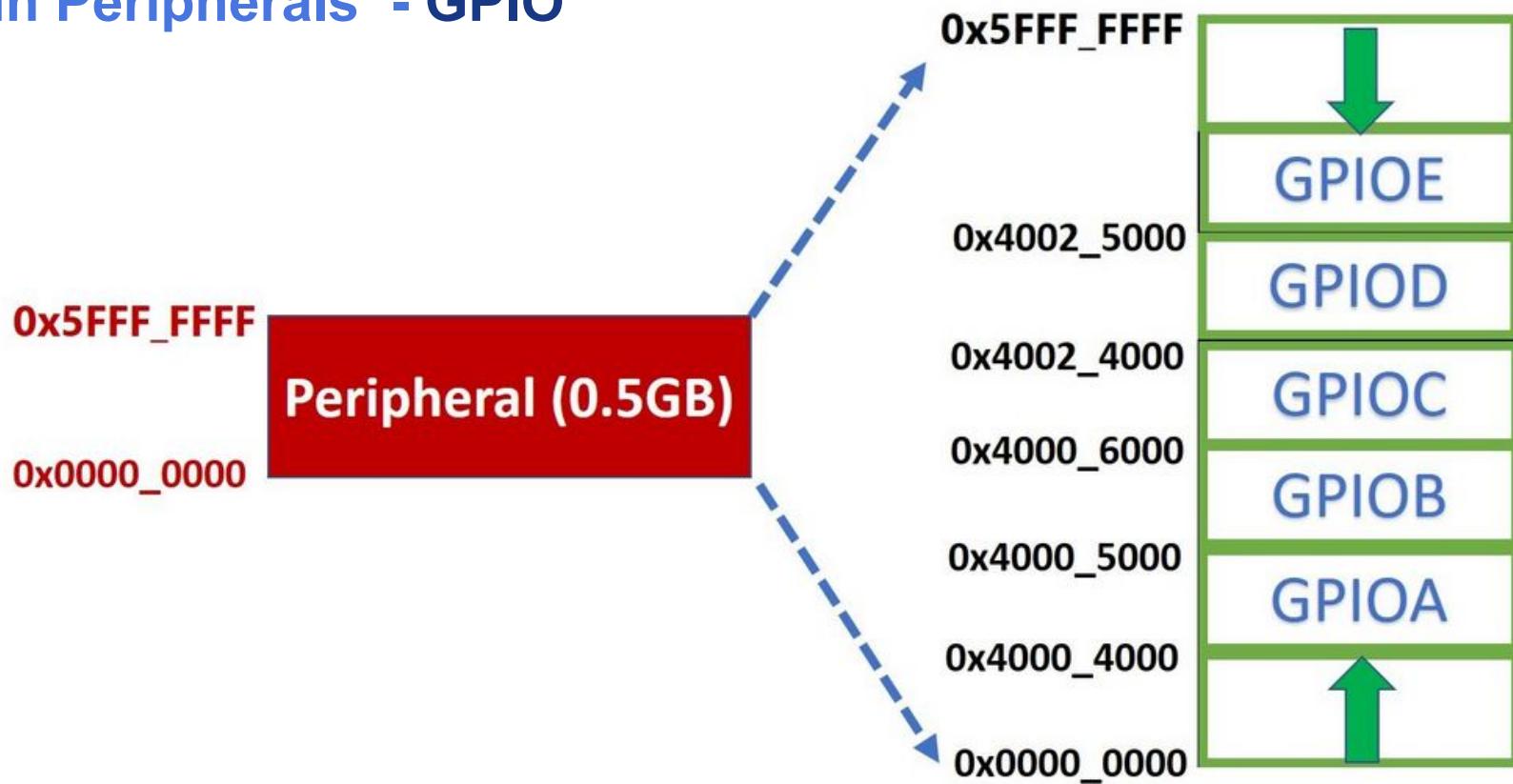


Input/Output Connectors



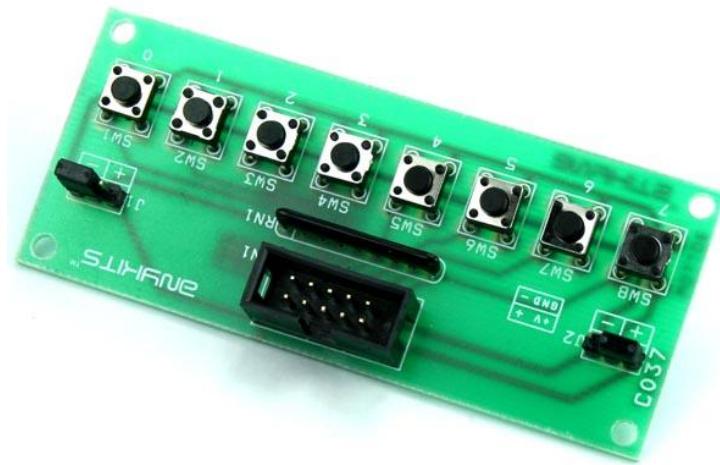
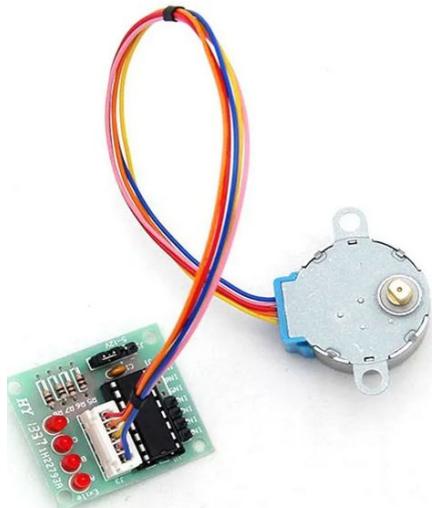
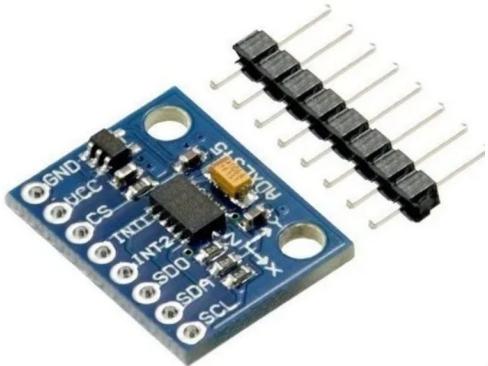


Main Peripherals - GPIO





Main Peripherals - GPIO





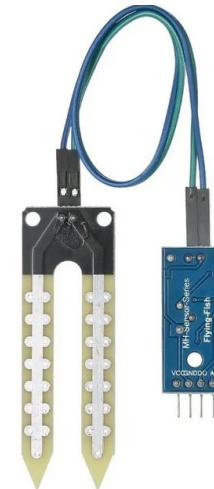
Main Peripherals - GPIO



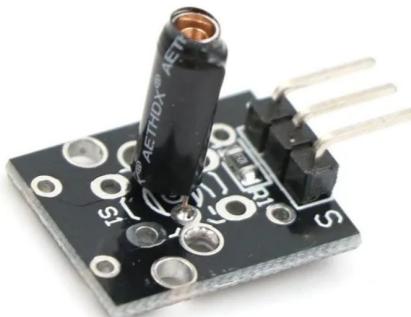
DTH11
Humidity



Ping
Ultrasonic



YI 69
Soil Moisture

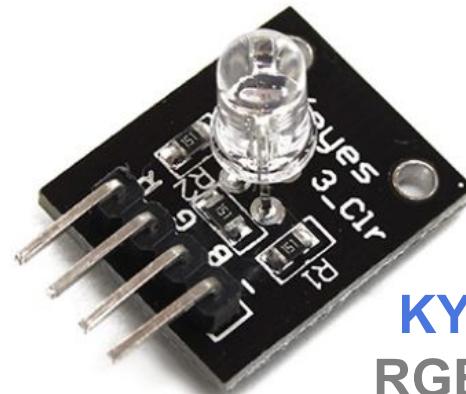




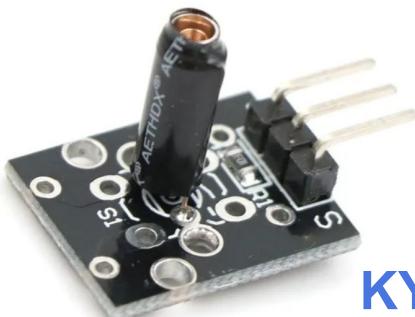
Main Peripherals - GPIO



KY-013
Temperature



KY-013
RGB Led



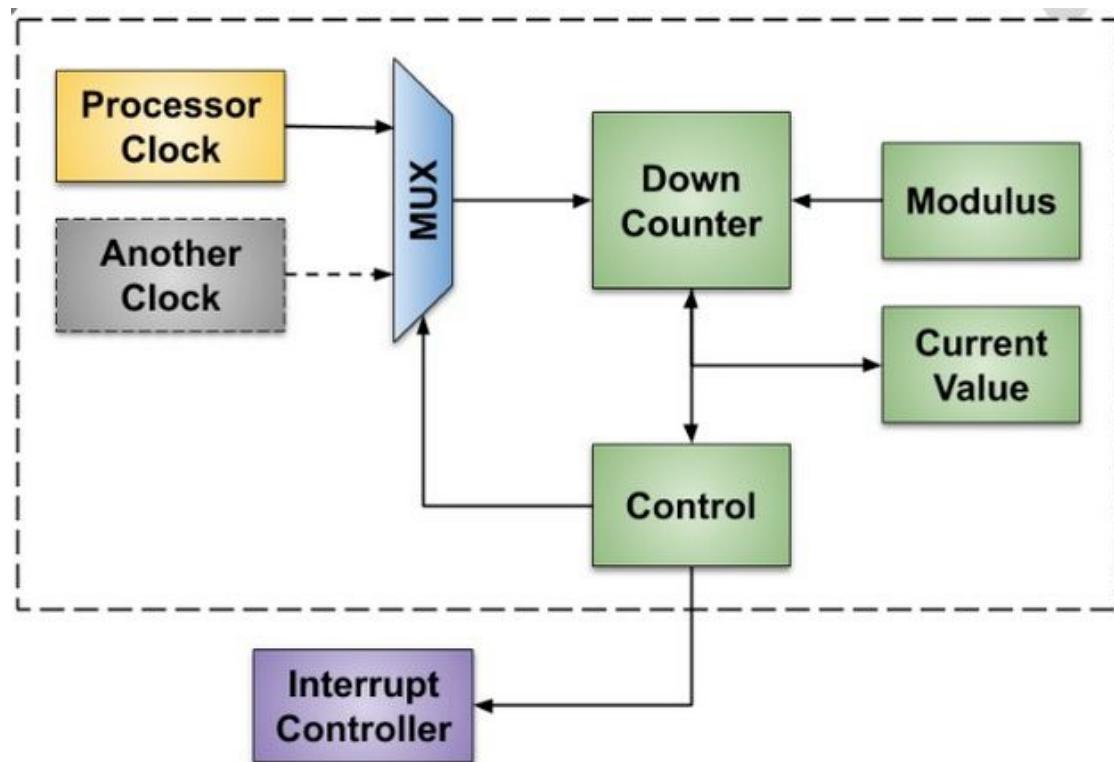
KY-002
Vibration



KY-012
Buzzer



Main Peripherals - Timers



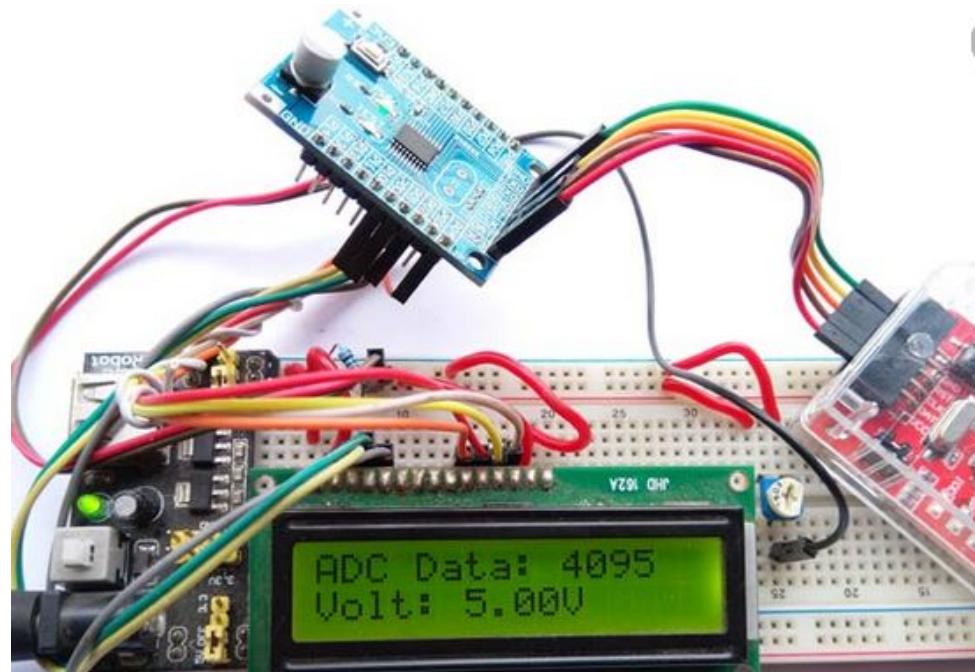
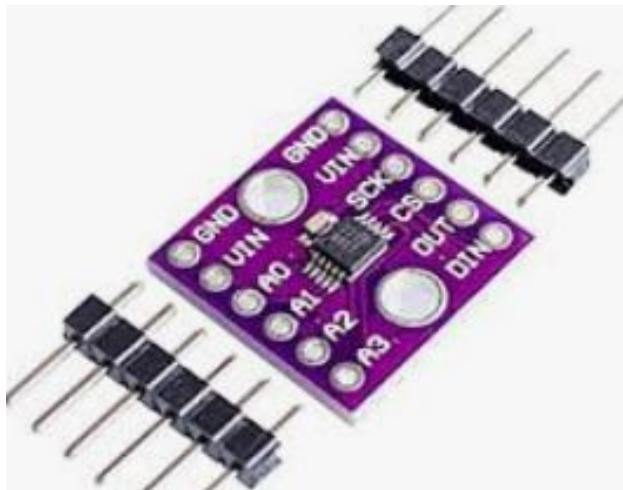


Main Peripherals - Timers



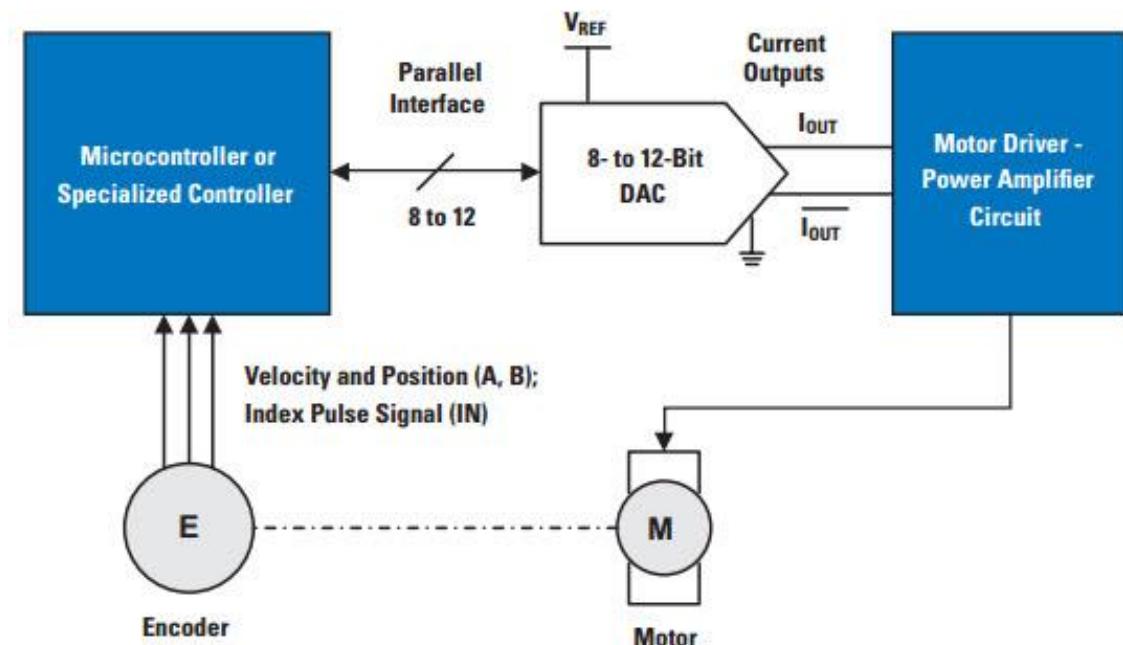
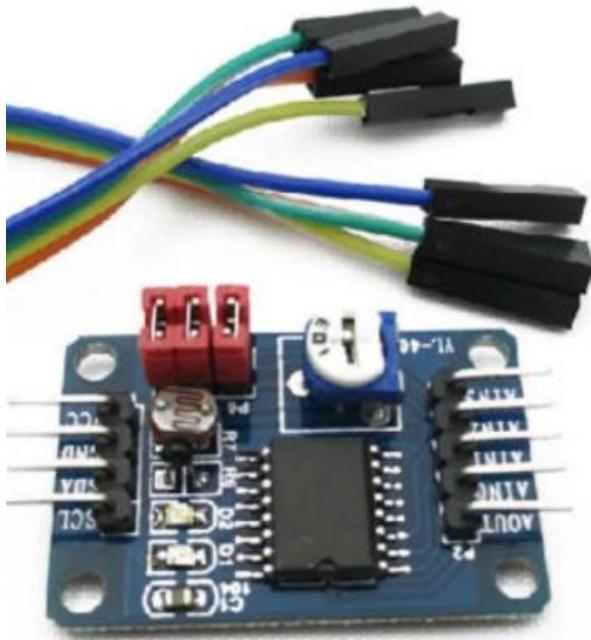


Main Peripherals - Analog to Digital Converter



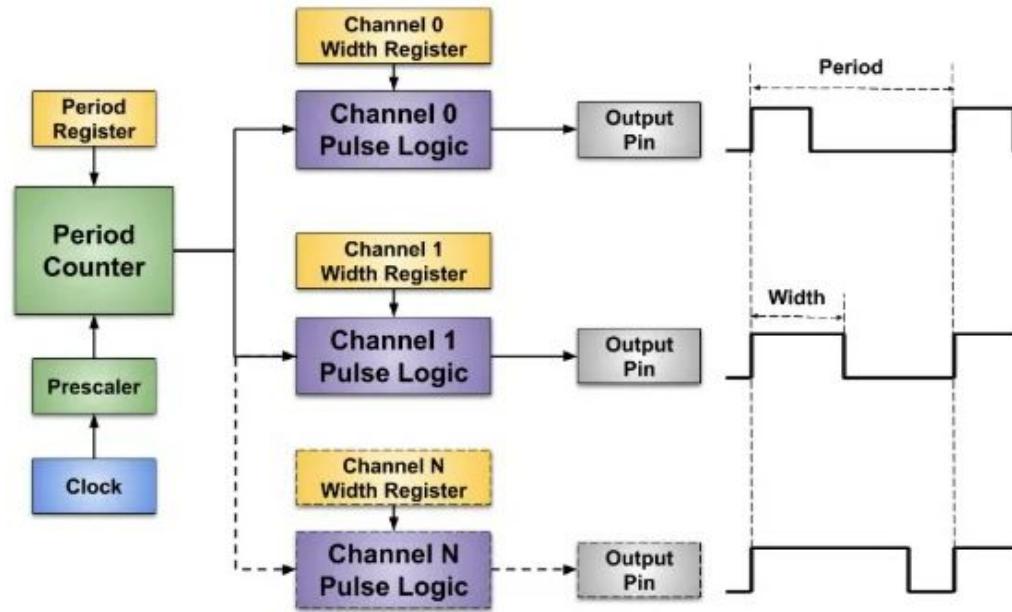
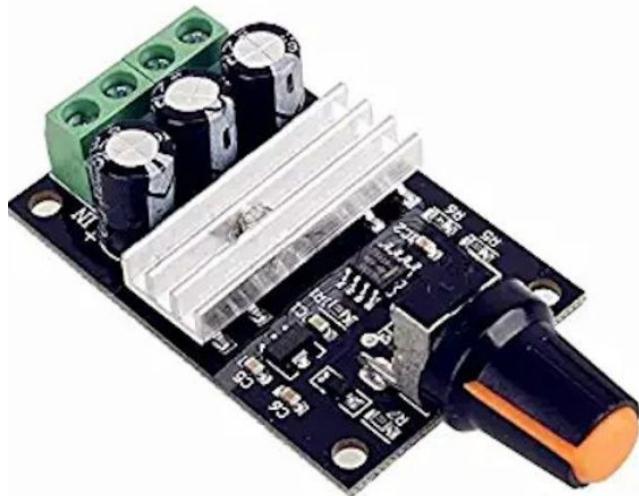
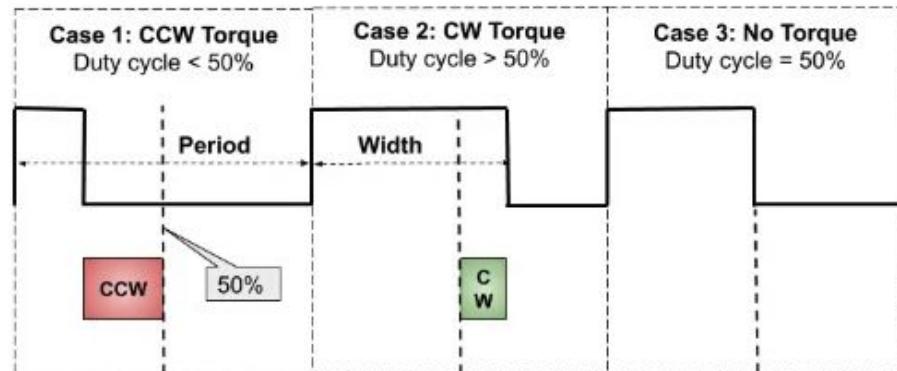


Main Peripherals - Digital to Analog Converter





Main Peripherals - Pulse Width Modulation





Main Peripherals - Pulse Width Modulation



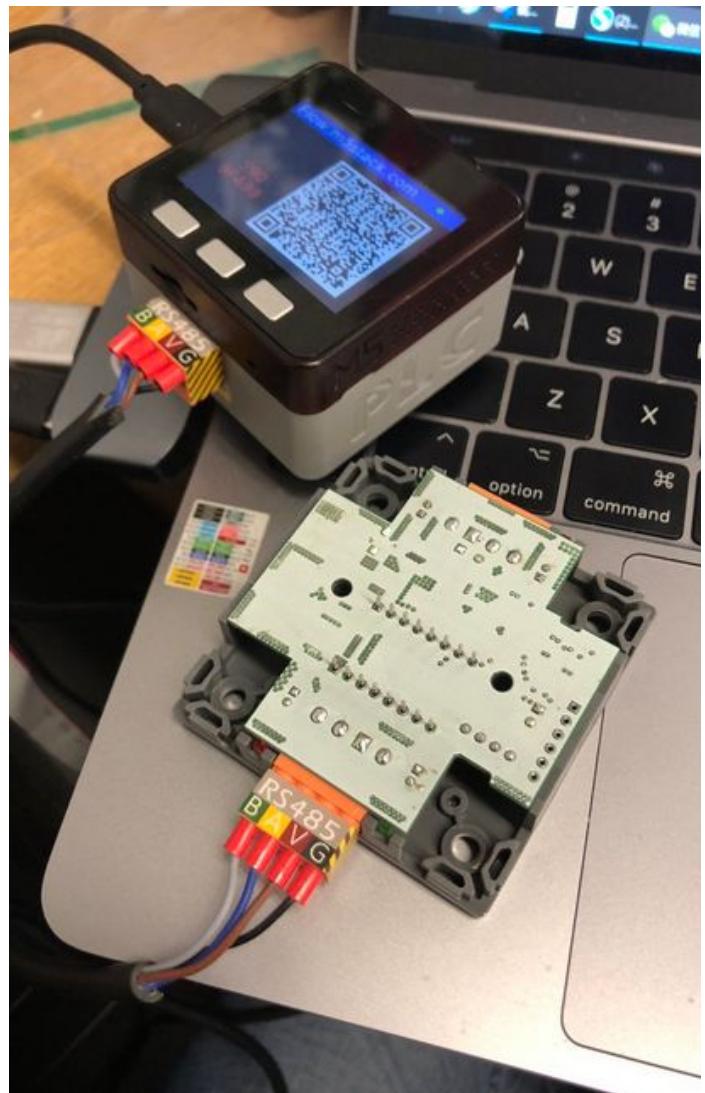


Main Peripherals - UART



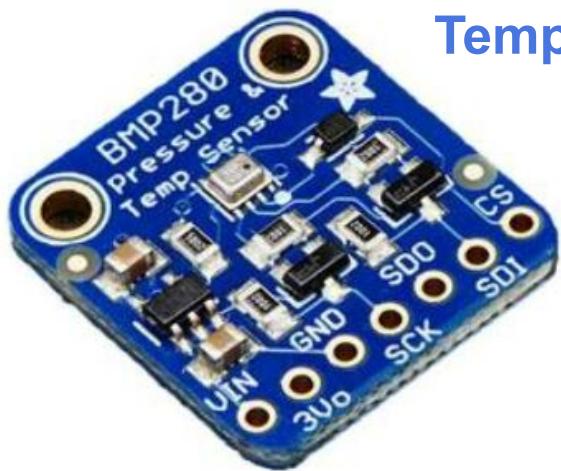


Main Peripherals - UART

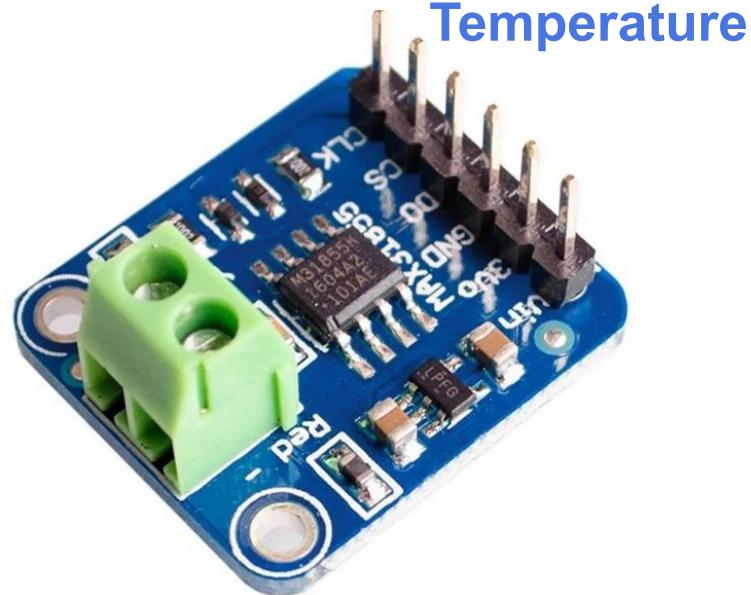




Main Peripherals - SPI

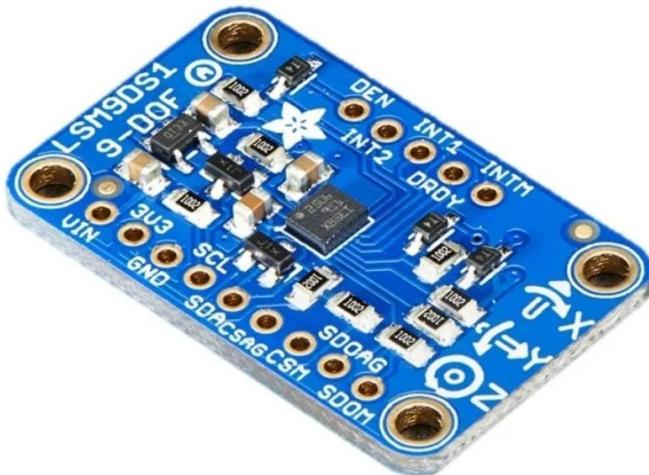


Pressure/
Temperature



Temperature

Accelerometer
Gyroscope
Magnetometer

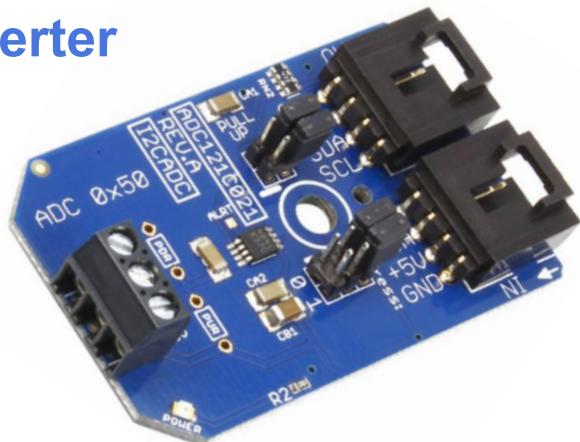




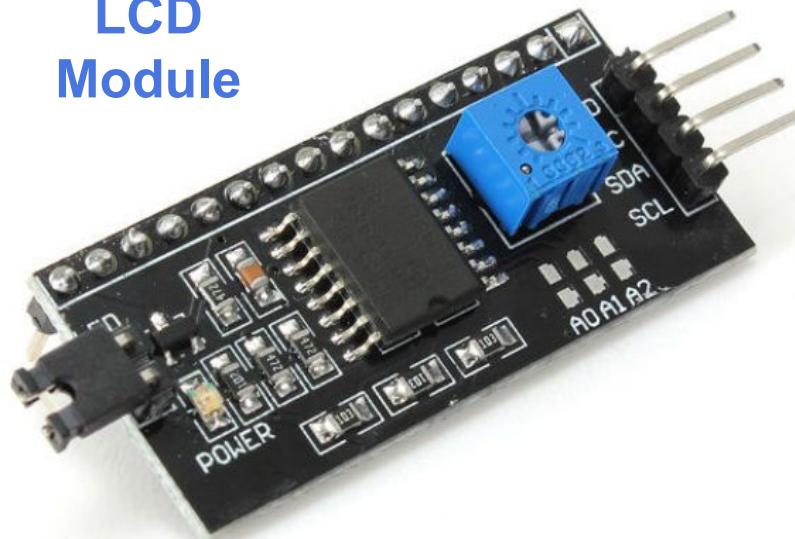
Main Peripherals - I2C



ADC
Converter



LCD
Module



8-channel
Relay Controller





Main Peripherals - Interrupts

