

# 32-bit PIC® and SAM Microcontrollers Peripheral Integration

## Quick Reference Guide

Product Family	Core	Max. Operation Freq. (MHz)	Program Flash Memory (KB)	RAM (KB)	Pin Count	Automotive (AEC-Q100 Grade 1 or Grade 2)	Peripheral Function Focus																																		
							Intelligent Analog				Waveform Control		Timing and Measurements		Safety and Monitoring		Communication								User Interface		Security			System Flexibility											
							ADC (channels/bits)	ADC Speed (sps)	DAC (channels/bits)	Analog Comparator (+Op Amp)	Output Compare/Input Capture/ Waveform Output Channels	Motor Control PWM Pairs/Single Ended MC PWM (3)	16-bit/32-bit Timer Channels (TC)	Quadrature Encoder/Decoder for Motor Control: QE/QDEC/PDEC(3)	Functional Safety Ready	Class B Safety Library	USB (FS/HS) + PHY (Transceiver)	CAN (2.0B or FD)	Ethernet (10/100)	UART	PC	SPI (3)	SDIO/SD/eMMC	PCC or PIO as CMOS Camera Interface	SQI/QSPI	I2S for Audio CODEC (3)	Peripheral Bus Interface EBI/PMP (3)	Hardware Peripheral Touch, PTC (channels/Driven Shield + ) (3)	Segment/Graphics LCD Controller LCD Controller (External, Low-Cost Controllerless, Integrated)	Crypto Engine (AES, SHA, ECC, RSA/DSA, TRNG)	TrustZone (3)	Secure Boot (3)	Tamper Detection	Dual Panel/Bank Flash (3)	Intelligent Low Power Peripheral Event System (channels) (3)	CLC/CCL (3)	DMA (channels)	Ultra Small Package (WLCSP)			
PIC32C Family (Arm® Cortex®-M)																																									
PIC32CM LX	CM0+	48	256-512	32-64	48-100	G1	24/12	1M	10-Feb	4	16/16/30	4/4	5/2	0			1F+P			6	6	6				1		P256			A,S,T	✓*	✓*	✓*		✓*	✓*	12			
PIC32CM MC (4)	CM0+	48	64-128	8-16	32-48		14/12	1M	1/10	2	16/16/30	4/4	5/2	1						4	4	4						E							12	✓	12				
PIC32CM JH	CM0+	48	256-512	32-64	32-100	G1	12/12	1M	1/10	4	16/16/30	4/-	4/-	1	✓				2FD*	8	8	8						P256		E	S	✓				12	✓	12			
PIC32M Family (MIPS32®)																																									
PIC32MM GPL	microAptiv™	25	16-64	4-8	20-36	G1	14/12	200k	1/5	2	3/3/3		7/3			✓				2	2					2											✓				
PIC32MM GPM	microAptiv	25	64-256	16-32	28-64	G1	24/12	200k	1/5	3	3/3/3		21/9			✓	1F+P			3	3	3				3										✓	4				
PIC32MX 1/2*/5+	M4K®	50	16-512	4-64	28-100		48/10	1M		3	5/5/5		5/2			✓	1F+P**	1+		5	2	4				4	✓			E								8			
PIC32MX 1/2* XLP	M4K	72	128-256	32-64	28-44		13/10	1M		3	5/5/5		5/2			✓	1F+P*			2	2	2				2	✓											4			
PIC32MX 3/4*	M4K	120	32-512	8-128	64-100		28/10	1M		2	5/5/5		5/2			✓	1F+P*			5	2	2				2	✓			E/L								4			
PIC32MX 5*/6*/7+	M4K	80	64-512	16-128	64-100		16/10	1M		2	5/5/5		5/2			✓	1F+P	1x/2+	1**	6	5	4				✓	✓		E/L									8			
PIC32MK GP/MC	microAptiv	120	128-1024	64-256	28-100		42/12	25M	3/12	504	16/16/16	12/12	9/8	6		✓	2F+P	4FD		6	4	6				6	✓			E/L					✓		✓	8			
PIC32MZ EF	M-Class	252	512-2048	128-512	64-144	G1	48/12	18M		2	9/9/9		9/4			✓	1H+P	2	1	6	5	6			✓	6	✓		E/L			A,S,T			✓			8			
PIC32MZ DA (2)	microAptiv	200	1024-2048	256-640	169-288	G2	45/12	18M		2	9/9/9		9/4			✓	1H+P	2	1	6	5	6	1		✓	6	✓			G	I	A,S,T			✓				8		
SAM Family (Arm Cortex-M)																																									
SAM D09	CM0+	48	8-16	4	14-24		10/12	350k			2/2/2		2/1							2	2	2															6	6			
SAM D10/D11*	CM0+	48	8-16	4	14-24		10/12	350k	1/10	2	6/6/10	4*/-	2/1				1F+P*			3	3	3						P72								6	6	✓			
SAM D20/D21*	CM0+	48	16-256	2-32	32-64	G1	20/12	350k	1/10	2	22/22/32	8*/-	5/2		✓*	✓	1F+P*			6	6	6				1*		P256		E						12	12*	✓			
SAM D21L	CM0+	48	32-128	4-16	32-48	G1	18/12	350k	1/10	4	22/22/32	8/-	5/2		✓	✓	1F+P			6	6	6						E								12	12				
SAM DA1	CM0+	48	16-64	4-8	32-64	G2	20/12	350k	1/10	2	18/18/24	8/-	5/2		✓	✓	1F+P			6	6	6				1		P256		E						12	12				
SAM L10/L11*	CM23	32	16-64	4-16	24-32	G1	10/12	1M	1/10	203	6/6/6		3/1			✓			3	3	3						P100, D+		E		A*,S*,T	✓*	✓*	✓		8	✓	8	✓		
SAM L21	CM0+	48	32-256	4-32	32-64		20/12	1M	2/12	203	12/12/12	4/-	5/2		✓		1F+P			6	6	6						P169		E		A,T				12	✓	16	✓		
SAM L22	CM0+	32	64-256	8-32	48-100		20/12	1M		2	12/12/12	4/-	4/2				1F+P			6	6	6						P256	S320	E		A,T			✓		8	✓	16	✓	
SAM C20/C21* (4)	CM0+	48	32-256	4-32	32-100	G1	12/12	1M	1/10*	4	16/16/30	4/4	8/4		✓*	✓			2FD*	8	8	8						P256		E						12	✓	12	✓		
SAM4N	CM4	100	512-1024	64-80	48-100		16/10	510k	1/10		6/6/10		6/-	2						7	3	4																23			
SAM4S	CM4	120	128-2048	64-160	48-100		16/12	1M	2/12	1	6/6/10		6/-	2			1F+P			4	2	3	1	✓		1	✓								✓	14	22	✓			
SAM4E	CM4F	120	512-1024	128	100-144		24/16	300k	2/12	1	9/9/13		-/9	3			1F+P	2	1	4	2	3	1	✓		✓						A			✓				33		
SAM4L	CM4	48	128-512	32-64	48-100		16/12	300k	1/12	4	6/6/6		3/-				1F+P			4	4	1		✓		1		P32	S160			A,T				4	16	✓			
SAM G	CM4F	120	256-512	64-176	49-100		8/12	500k			6/6/6		6/-				1F+P			8	8	8				2								✓		6	30	✓			
SAM D5x+/E5x*	CM4F	120	256-1024	128-256	48-128	G1	32/12	1M	2/12	2	33/33/39	8/13	8/4	1		✓	1F+P	2FD*	1*	8	8	8	2	✓	✓	1		P256		E		A,S,E,R,T		✓	✓	32	✓	32	✓+		
SAM S7x (2)/E7x	CM7	300	512-2048	256-384	64-144		24/12	1.7M	2/12	1	12/12/16	8	12/-	4			1H+P	2FD*	1*	8	3	5	1	✓	✓	2	✓			E/L		E/L		A,S,T		✓		12		24	
SAM V7x	CM7	300	512-2048	256-384	64-144	G2	24/12	1.7M	2/12	1	12/12/16	8	12/-	4			1H+P	2FD	1	8	3	5	1	✓	✓	2	✓			E/L			A,S,T		✓			12		24	

1: USARTs with SPI mode are taken into account 2: DRAM Memory Support: PIC32MZ DA with DDR2 (32 MByte embedded or 128 MB external) 3: Terminology in the back 4: SAM C20/C21 & PIC32CM MC are true 5V devices; SAM C21 & PIC32CM MC also come with 16-bit Sigma Delta ADC and integrated temp sensor

# Terminology

WAVEFORM CONTROL: PWM Drive and Waveform Generation	
Motor Control PWM Channel Pairs 24-bit TCC with Dead Time Insertion	In some datasheet, look for 24-bit TCC with Dead-Time Insertion (DTI) or PWM with Dead-Time Generator (also know as Dead-Band or Non-Overlapping Time). TCC (Timer/Counter for Control): Selected SAM products have TCCs for applications like Switch Mode Power Supplies (SMPS), lighting and motor control. The TCCs support up to 96 MHz and 24-bit resolution. 24-bit TTC channels with Dead Time Insertion are considered as Motor Control PWM channel.
TIMING AND MEASUREMENTS: Signal Measurement with Timing and Counter Control	
QEI: Quadrature Encoder Interface QDEC: Quadrature Decoder PDEC: Position Decoder	QEI to increment encoders for obtaining mechanical position data typical for automation or motor control applications. QDEC performs the input lines filtering, decoding of quadrature signals and connects to the timers/counters in order to read the position and speed of the motor through the user interface. The PDEC consists of a Quadrature/Hall decoder, following by a counter, with two compare channels. The counter can be split into two parts to report the angular position and the number of revolutions.
COMMUNICATIONS: General, Industrial, Lighting and Automotive	
SERCOM: Serial Communication Module	A SERCOM is a configurable peripheral that may be used to operate as I <sup>2</sup> C, SPI or USART, giving you extended flexibility to mix serial interfaces and greater freedom in PCB layout. Each SERCOM instance can be assigned to different I/O pins through I/O multiplexing, further increasing versatility.
CMOS Camera Interface PCC: Parallel Capture Controller PIO: Parallel Input/Output	PCC: The Parallel Capture Controller can be used to interface an external system, such as a CMOS digital image sensor, ADC, or DSP, and capture its parallel data. PIO: The Parallel Input/Output Controller (PIO) manages up to 32 fully programmable input/output lines. An 8-bit Parallel Capture mode is also available which can be used to interface a CMOS digital image sensor, an ADC, a DSP synchronous port in Synchronous mode, etc.
I2S: Inter-IC Sound Controller	The Inter-IC Sound Controller provides a bidirectional, synchronous digital audio link with external audio devices.
EBI: External Bus Interface PMP: Parallel Master Port	EBI: The External Bus Interface (EBI) is designed to ensure the successful data transfer between several external devices and the embedded Memory Controller of an Arm-based device. Data transfers are performed through a 16-bit or 32-bit data bus. PMP: The PMP (mostly seen in PIC32M) is a parallel 8-bit/16-bit input/output module specifically designed to communicate with a wide variety of parallel devices, such as communications peripherals, LCDs, external memory devices and microcontrollers.
SAFETY AND MONITORING: Hardware Monitoring and Fault Detection	
Functional Safety Ready	Complete collateral ready, including FMEDA, Safety Manual, Diagnostic Software (in development) and third Party Tools.
USER INTERFACE: Capacitive Touch Sensing and LCD Control	
PTC: Peripheral Touch Controller	An embedded peripheral touch controller makes it easy to add capacitive touch buttons, sliders, wheels and proximity. By offering superb sensitivity and noise tolerance as well as self-calibration, the PTC eliminates the need for external components and minimizes CPU overhead. PTC with Driven Shield + can achieve better noise immunity and moisture tolerance.

SYSTEM FLEXIBILITY: System Peripherals and Interconnects	
CLC/CCL: Configurable Custom Logic	The CCL is a programmable logic peripheral which can be connected to the device pins, events or to other internal peripherals. This allows you to eliminate logic gates for simple glue logic function on the PCB.
Dual Panel/Bank Flash	Dual Bank Flash allows live field firmware/program update on one bank while CPU can continue executing code from another Flash bank.
EVSYS /PEVC: Event System	The Event System allows autonomous, low-latency and configurable communication between peripherals. Several peripherals can be configured to generate and/or respond to signals known as events. Communication is made without CPU intervention and without consuming system resources such as Bus or RAM bandwidth. This reduces the load on the CPU and power consumption, compared to a traditional interrupt-based system.
SECURITY: Chip-Level Security, Crypto Acceleration, Secure Key Provisioning & Storage, and Tamper Detection	
TrustZone	TrustZone® for ARMv8-M provides hardware-enforced security isolation between trusted and the untrusted resources on a Cortex™-M23 based device, while maintaining the efficient exception handling.
Secure Boot	Secure Boot authenticates the Flash content at startup and ensures the desired code is executed.

## Development Tools

Tools	Description
MPLAB® X Integrated Development Environment (IDE)	MPLAB X IDE is an expandable, highly configurable software program that incorporates powerful tools to help you discover, configure, develop, debug and qualify embedded designs for most of Microchip's microcontrollers and digital signal controllers. MPLAB X IDE works seamlessly with the MPLAB development ecosystem of software and tools, many of which are completely free.
MPLAB Harmony v3	MPLAB Harmony v3 is a fully integrated embedded software development framework that provides flexible and interoperable software modules to simplify the development of value-added features and reduce your product's time to market. Key benefits: <ul style="list-style-type: none"> <li>• Core agnostic supporting both MIPS® and Arm® Cortex® core architectures</li> <li>• Code portability with consistent APIs that can be used across different device families</li> <li>• Easily configurable using MPLAB Harmony Configurator's (MHC's) Graphical User Interface (GUI)</li> <li>• Optimized peripheral libraries to simplify device setup and peripheral usage</li> <li>• Supports multiple development models with application examples and demos</li> </ul>
MPLAB Harmony Configurator	MPLAB Harmony Configurator (MHC) is an easy to use development tool with a Graphical User Interface (GUI) that simplifies device setup, library selection, and configuration, and application development. The MHC is available as a plugin that directly integrates with the MPLAB X IDE or as a separate Java executable for standalone use with other development environments.
MPLAB Harmony Graphics Suite (MHGS)	MPLAB Harmony Graphics Suite (MHGS) is Microchip's industry leading embedded GUI (Graphical User Interface) development tool for 32-bit MCUs and MPUs. Available within the MPLAB Harmony embedded software development framework, this tightly integrated system of tools and software allows you to quickly and easily add GUIs, animation and imagery to a graphical display.

Note: Existing Arm® Cortex®-M based SAM products are also supported by Atmel Studio 7 IDE, Atmel START configuration tool and ASF software framework. For new projects, please start with MPLAB® X IDE and MPLAB Harmony v3.