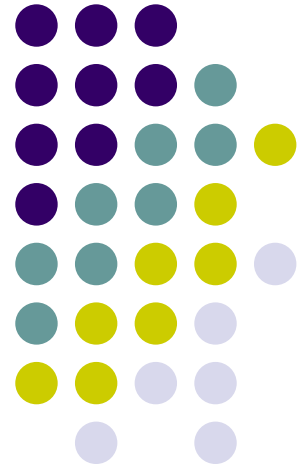


Choosing a Micro for an Embedded System Application

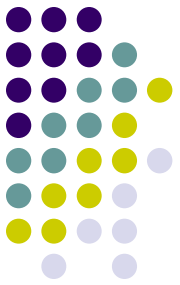


Dr. Manuel Jiménez

UPRM - Spring 2012

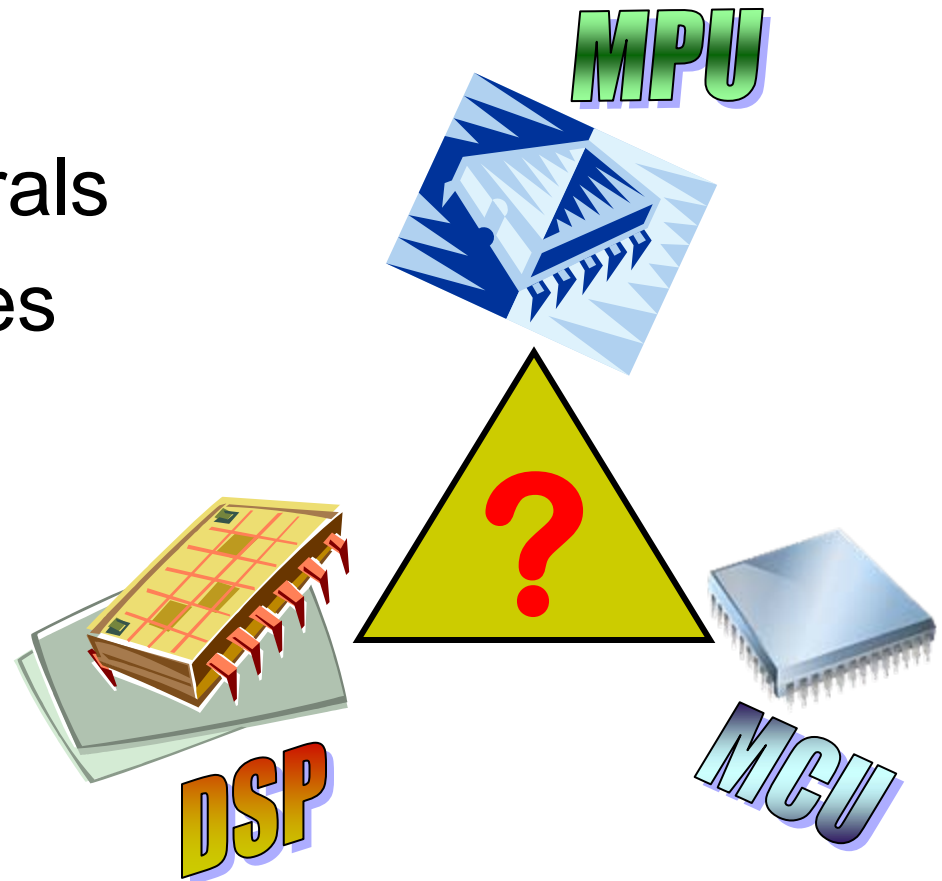


With contributions by:
L. Francisco

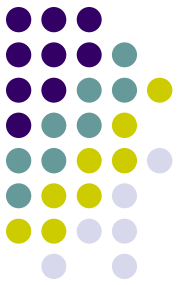


Outline

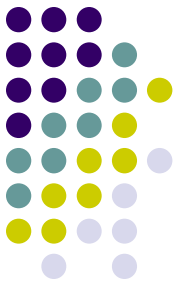
- MCU Vs. CPU Vs. DSP
- Selection Factors
- Embedded Peripherals
- Sample Architectures
- Selection Guides
- Development Tools
 - Hardware
 - Software



Introduction

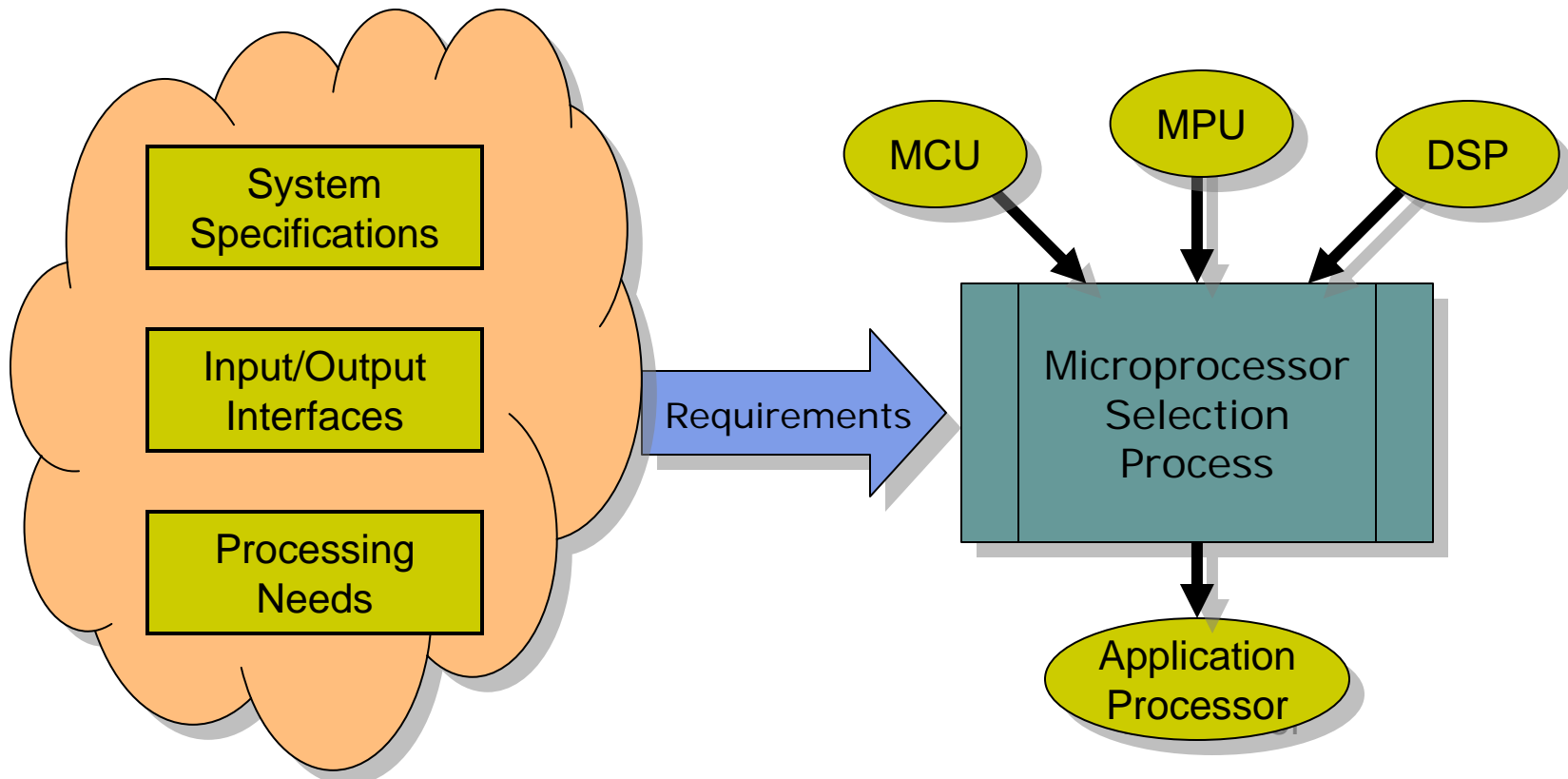


- Challenges in Selecting the right MCU
 - Wide Selection of Vendors
 - Large Number of Alternatives
 - CPU Architecture/Programming
 - Embedded peripherals
 - Cost
 - Power
 - Packages
- Try a **Search** in the DigiKey on-line Catalog
 - More than 16,000 entries for “Microcontroller”

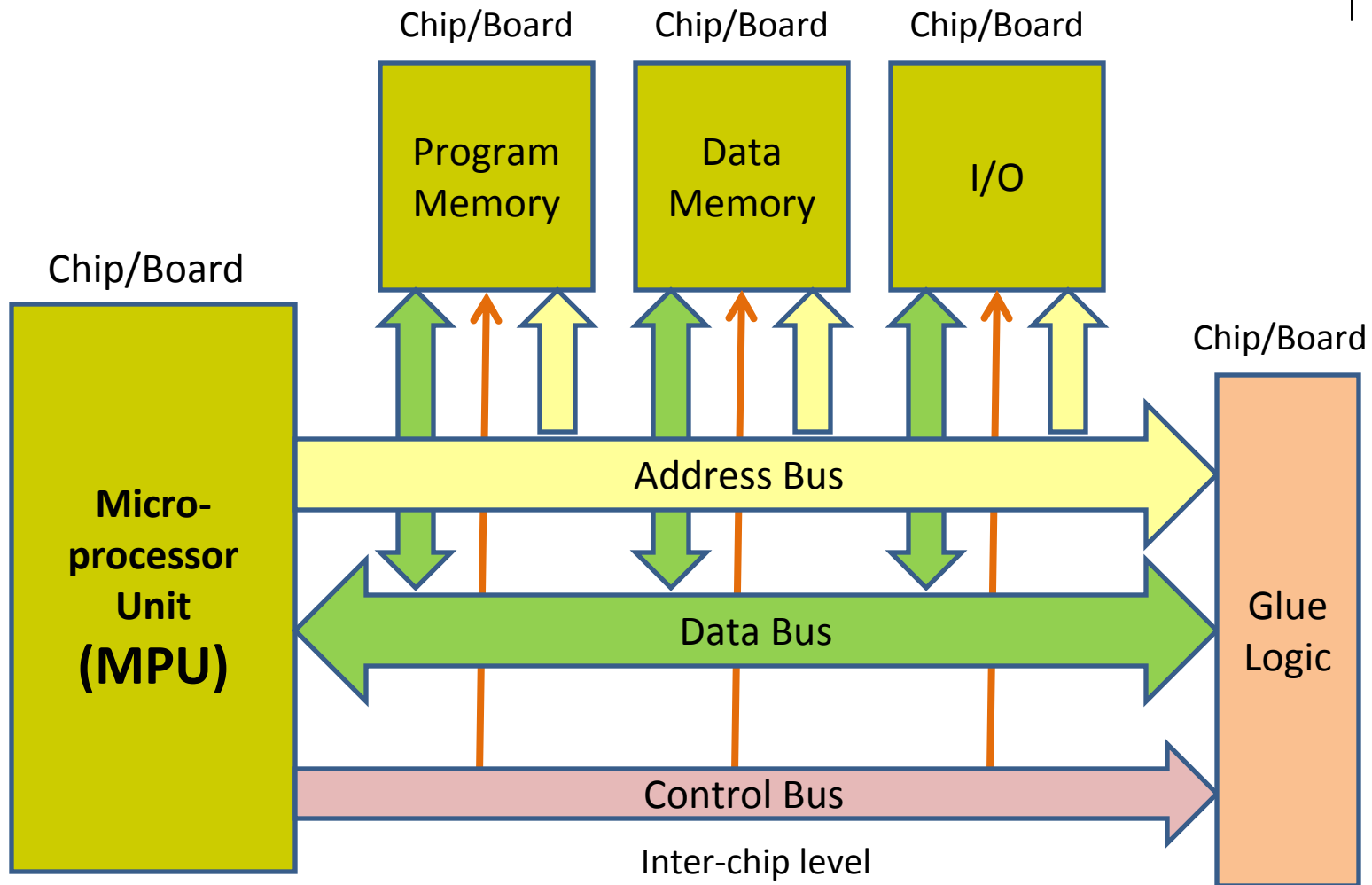
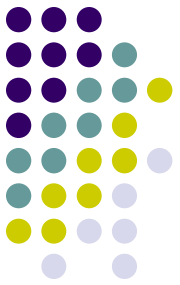


MCU, MPU, or DSP?

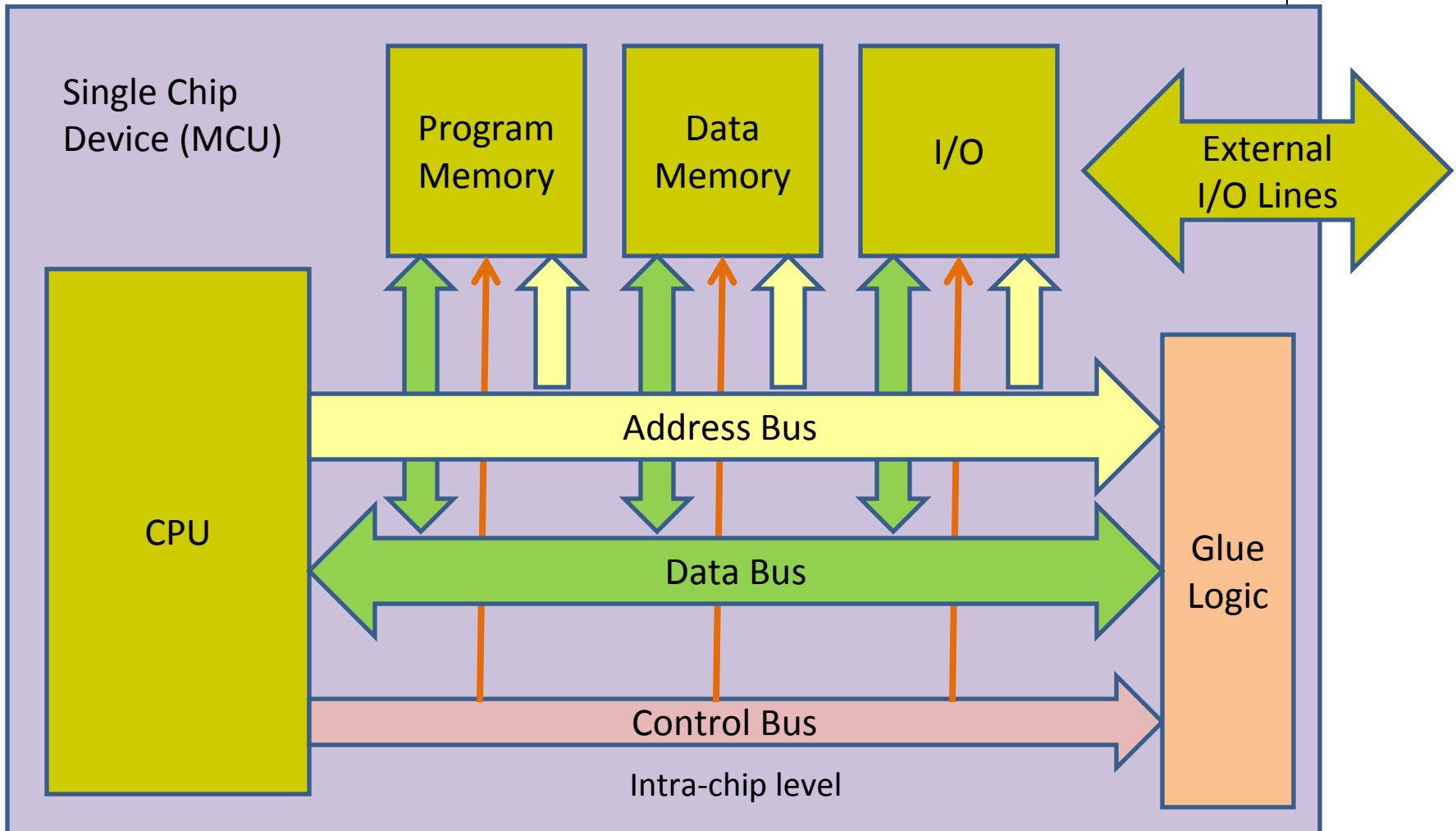
- Let your application dictate the needs & requirements for the system CPU



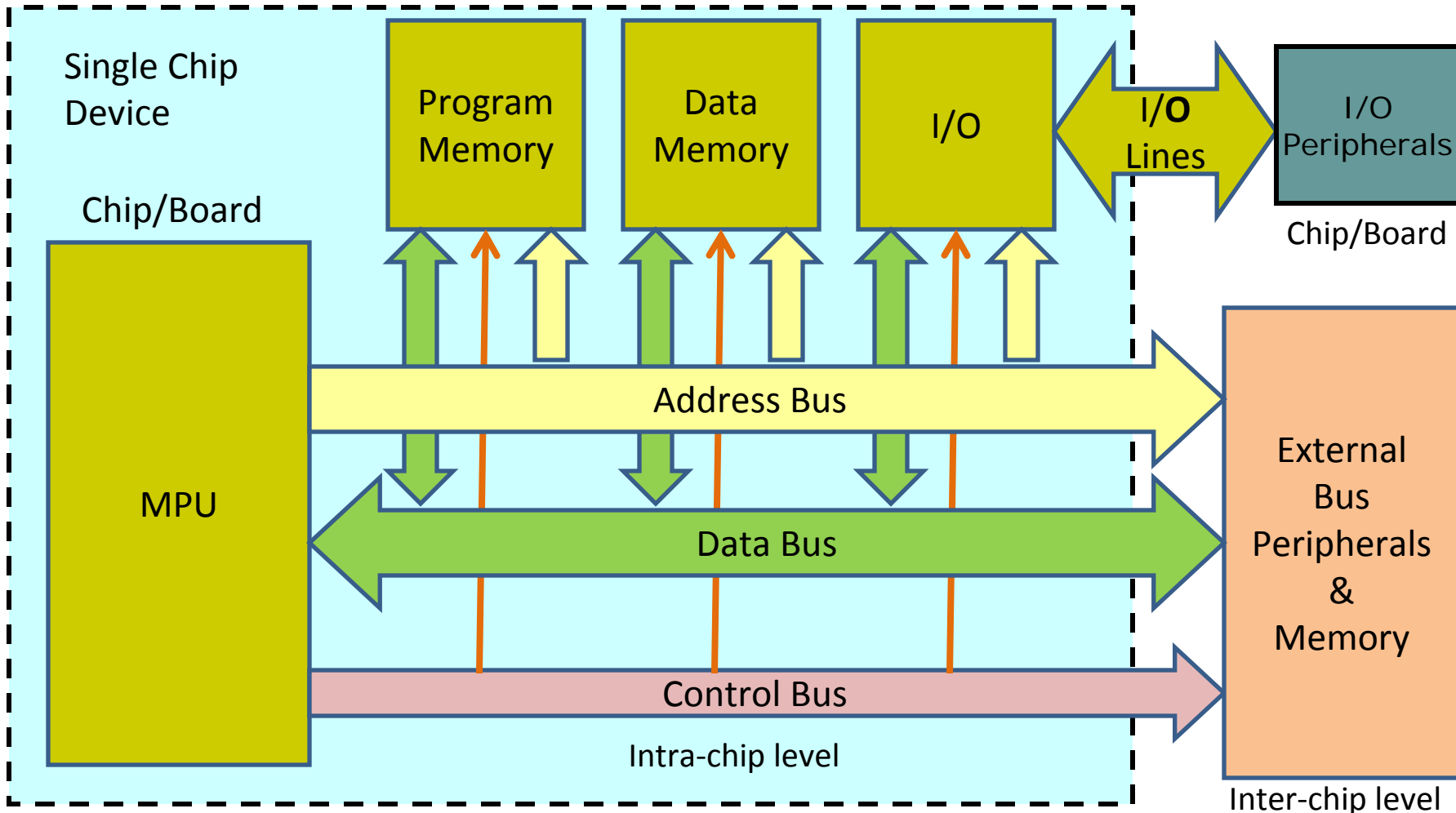
Classic Microprocessor-based Systems (MPU)



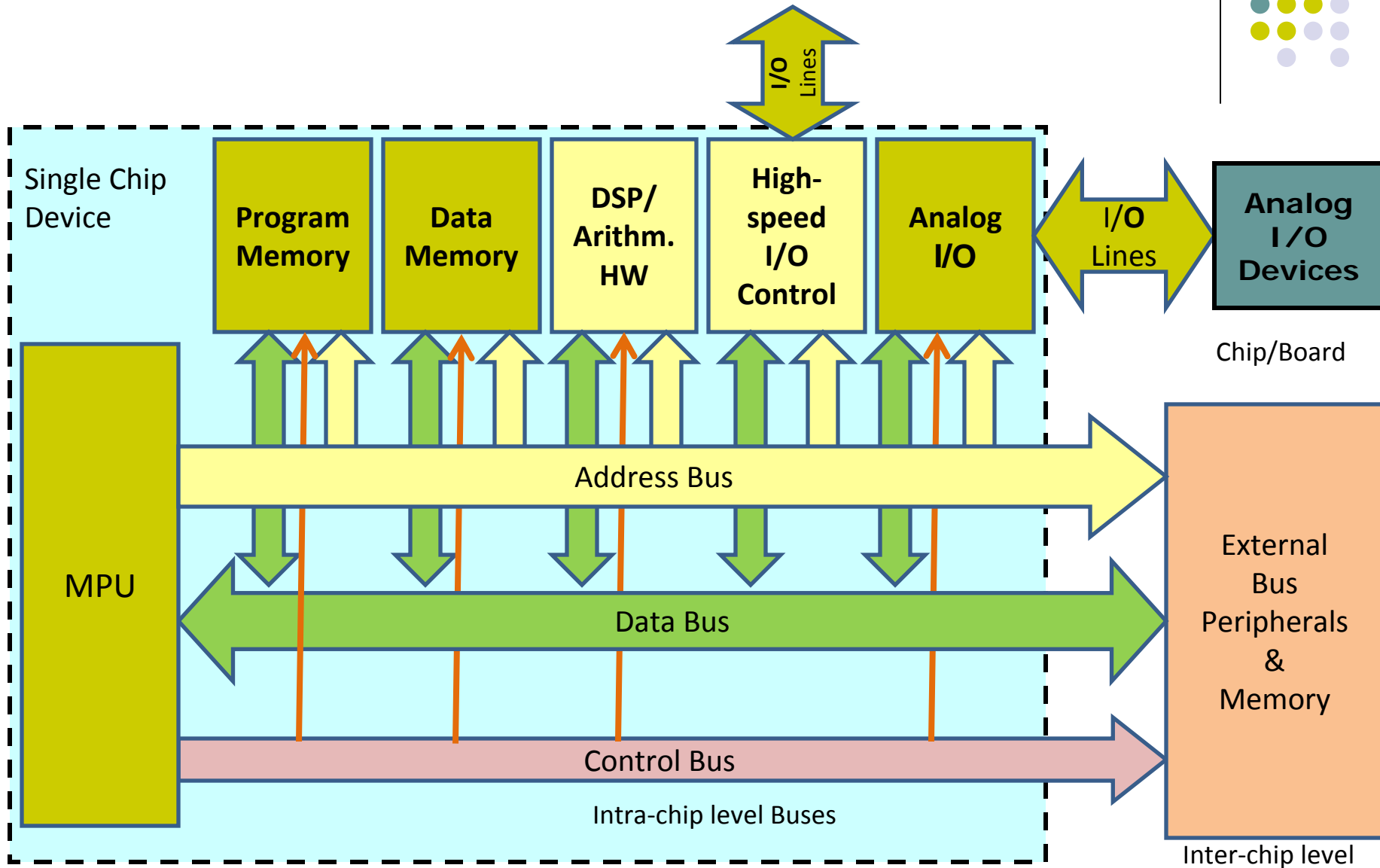
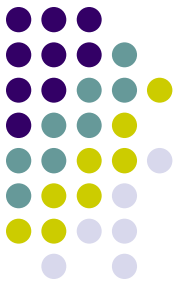
Microcontroller-based Systems (MCU)



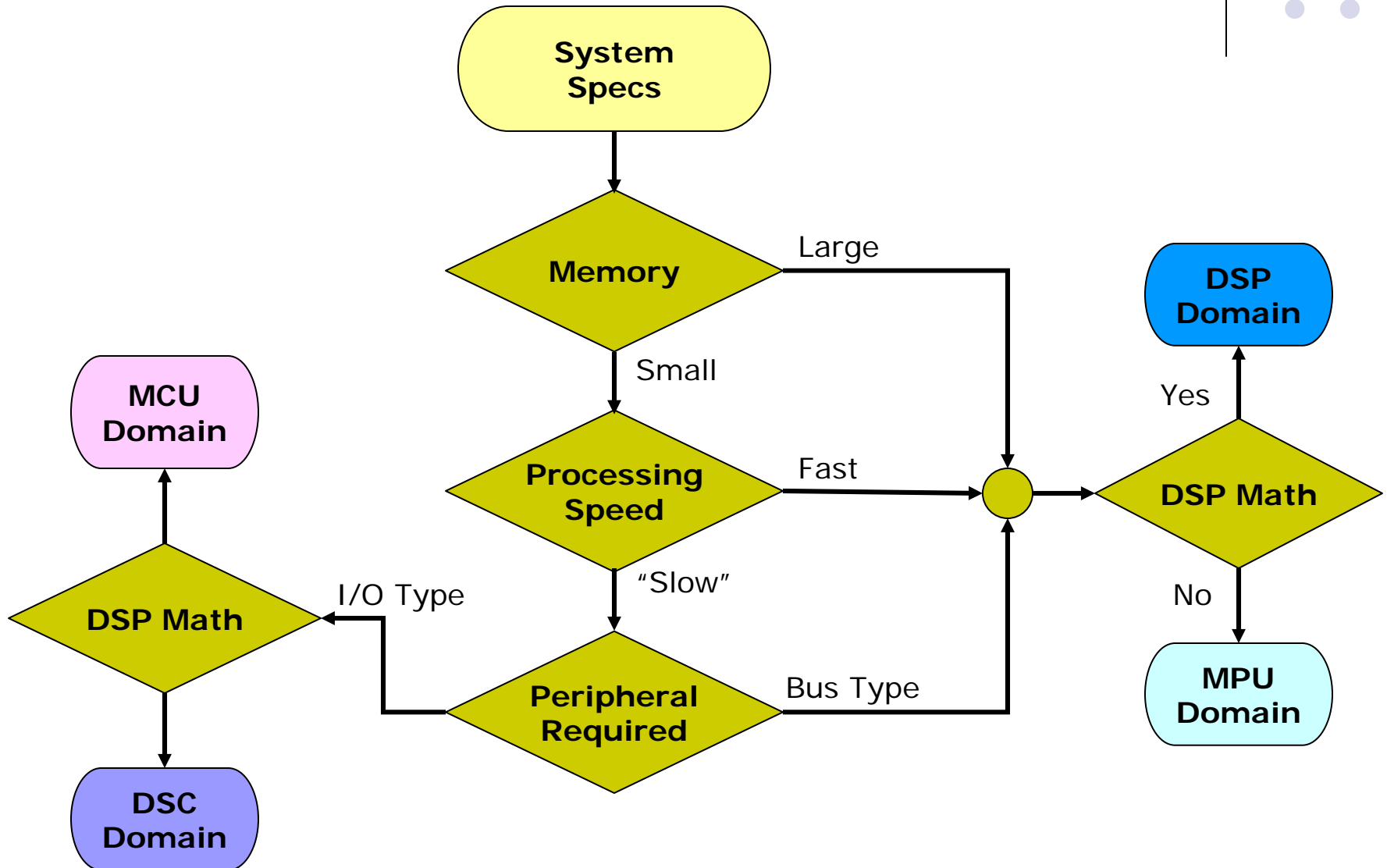
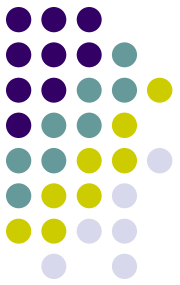
Embedded Microprocessors Systems

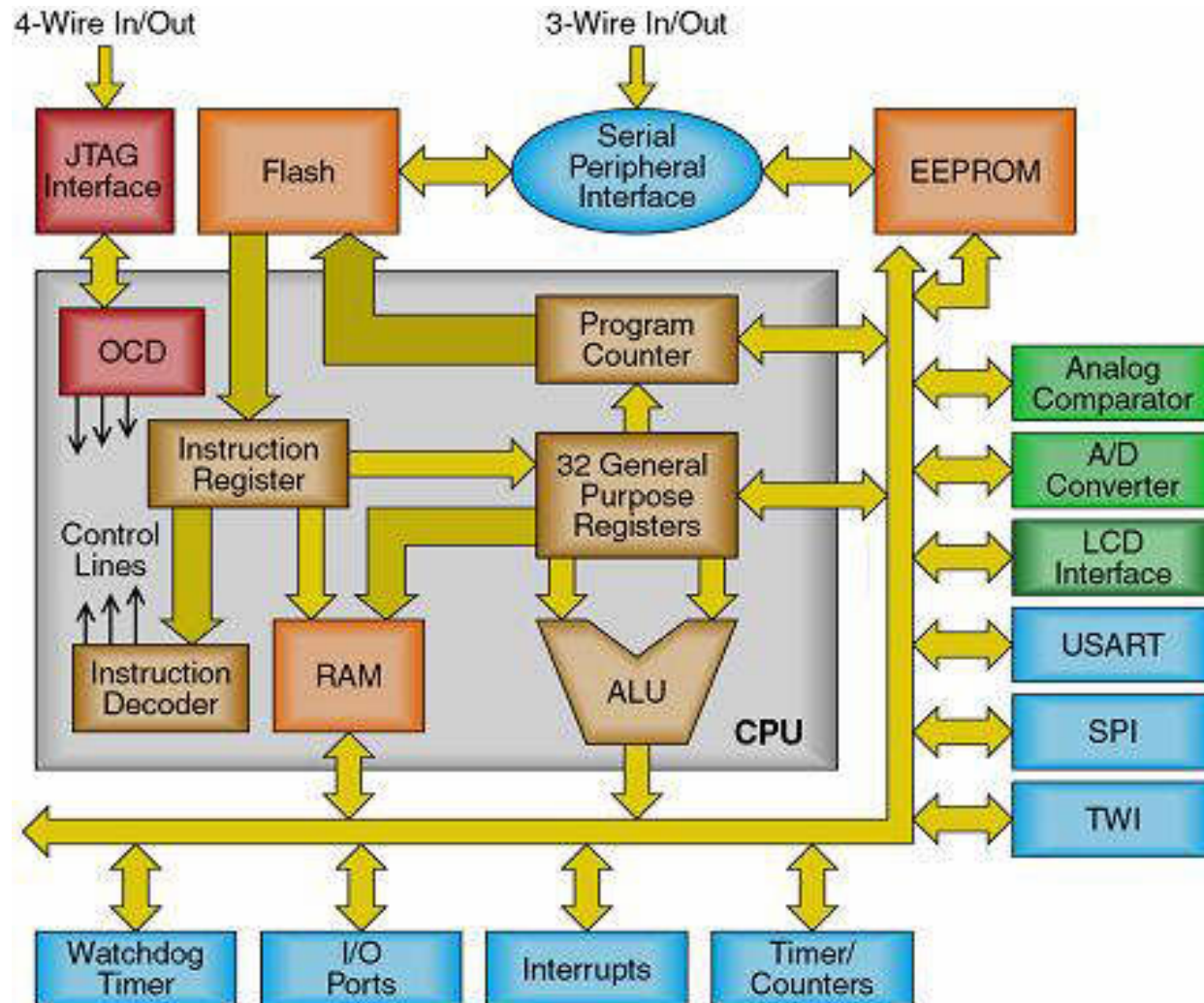


Embedded DSP / DSC Systems



Critical Indicators

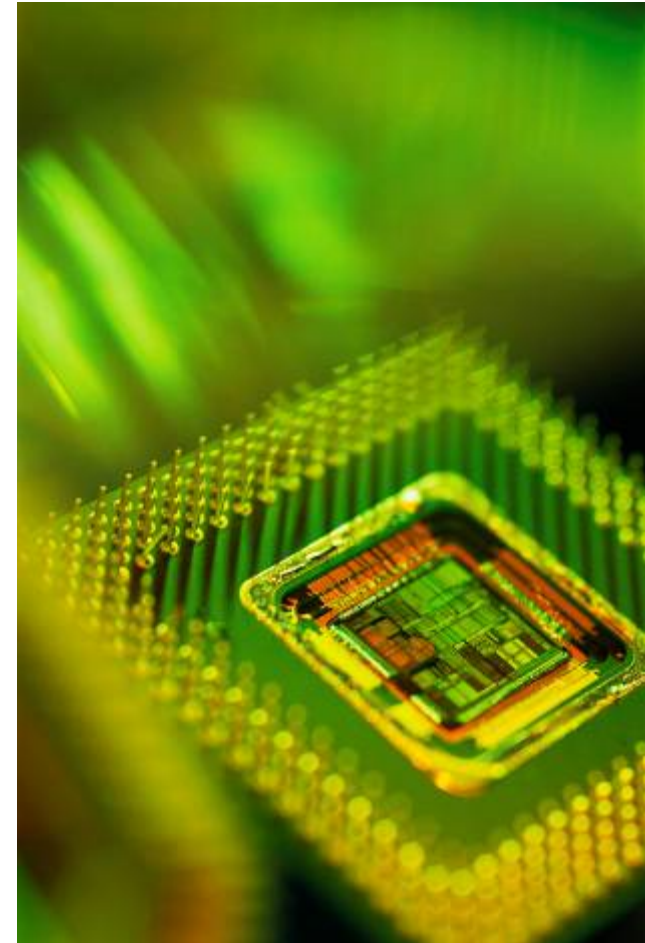




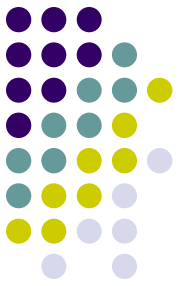
Core CPU Architecture



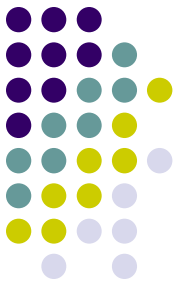
- Word Width
 - Data resolution
 - Computing power
- Register Structure
 - How many?
 - Register types
 - Accumulator Vs. Register File
 - Stack type and depth
- Assembly Language Structure
 - CISC Vs. RISC
- Bus Architecture
 - Harvard Vs. Stanford (Von Neuman)
 - Internal Vs. External



Digital Signal Processor Architecture Characteristics



- MPU designed to perform Digital Signal Processing operations
 - Multiply and accumulate (MAC)
 - Digital Filters: IIR & IIF
 - FFT
 - MAC instructions in a single cycle
- Multiple access to memory in a single instruction cycle
- Operations with fixed- or floating-point data



DSP vs. DSC

- DSP

- High speed processing
- High speed external peripherals
- Lots of external memory
- Image & Video processing, powerful DSP algorithms

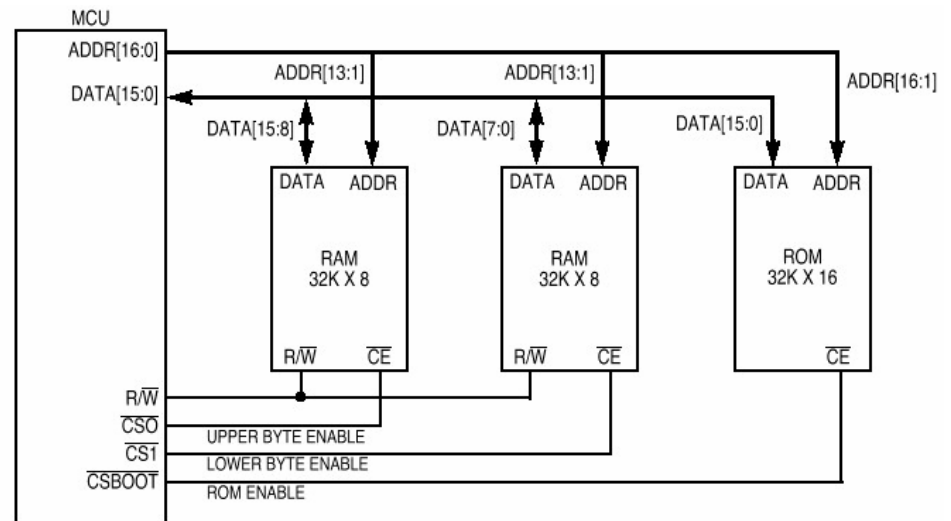
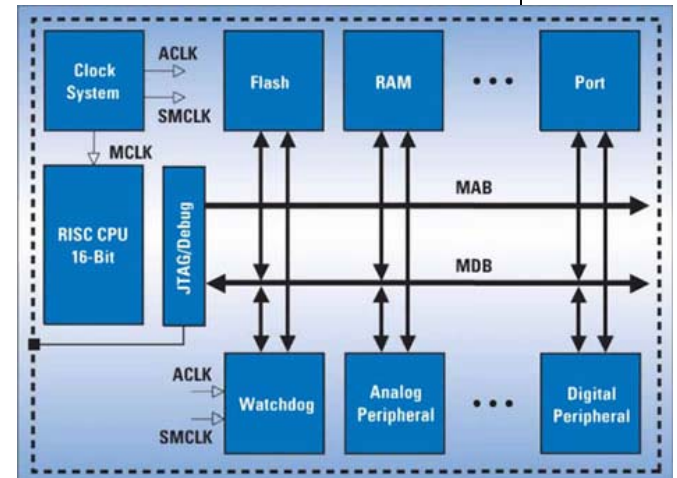
- DSC

- Low to mid speed processing
- I/O type peripherals
- Applications: Consumer electronics applications, motors controls, power electronics controllers, etc.

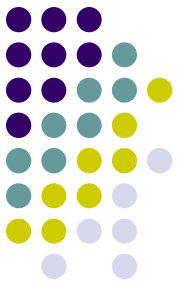
Programmability



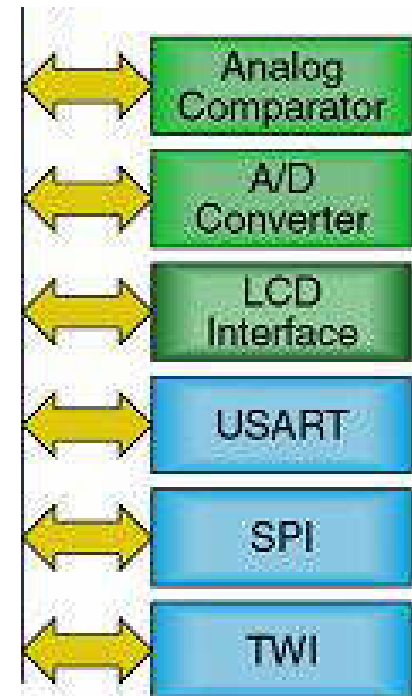
- Programmability
 - Prefer FLASH devices
 - Many erase/reprogram cycles
 - On-board reprogrammable
 - Other types:
 - EEPROM
 - EPROM
 - OTP
 - External Memory
 - FLASH/EEPROM
 - RAM
 - EPROM



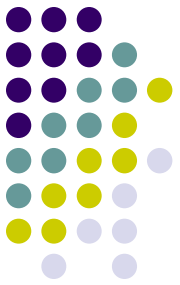
On-chip MCU Peripherals (1/2)



- I/O ports
 - Number of I/Os
 - Individually or byte programmable
 - Driving capability
- Timers
 - Number of Timers
 - Counting bits
 - Prescaler(s)
 - Operating modes:
 - Event/timer
 - Watchdog



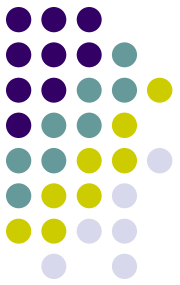
On-chip MCU Peripherals (2/2)



- UARTs/USARTs
 - Clocking sources
 - Baud rate generation
- Data Converters
 - Resolution (No. of bits)
 - Analog Channels
 - Conversion Method
 - Speed
 - Referencing
- Other
 - PWM
 - Comparators
 - I²C, CAN, USB, etc.
 - JTAG, BlueTooth, 802.11



Other Considerations



- Physical Packaging
 - Important for prototyping
 - PLCC, QFP, BGA, DIP
- Supply voltage
 - Compatibility with add-on components
- Memory
 - Program memory
 - Data memory
 - Application requirements
 - Word width
- Power Down Modes
 - Power Consumption
 - Sleep/wake-up time



Embedded MPU Examples

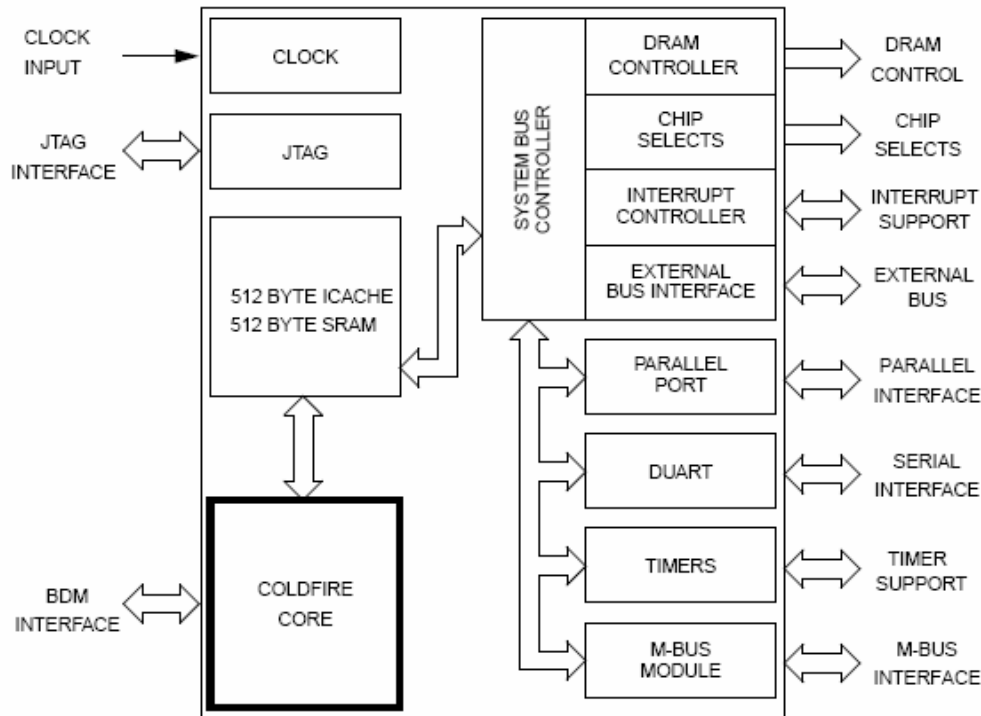
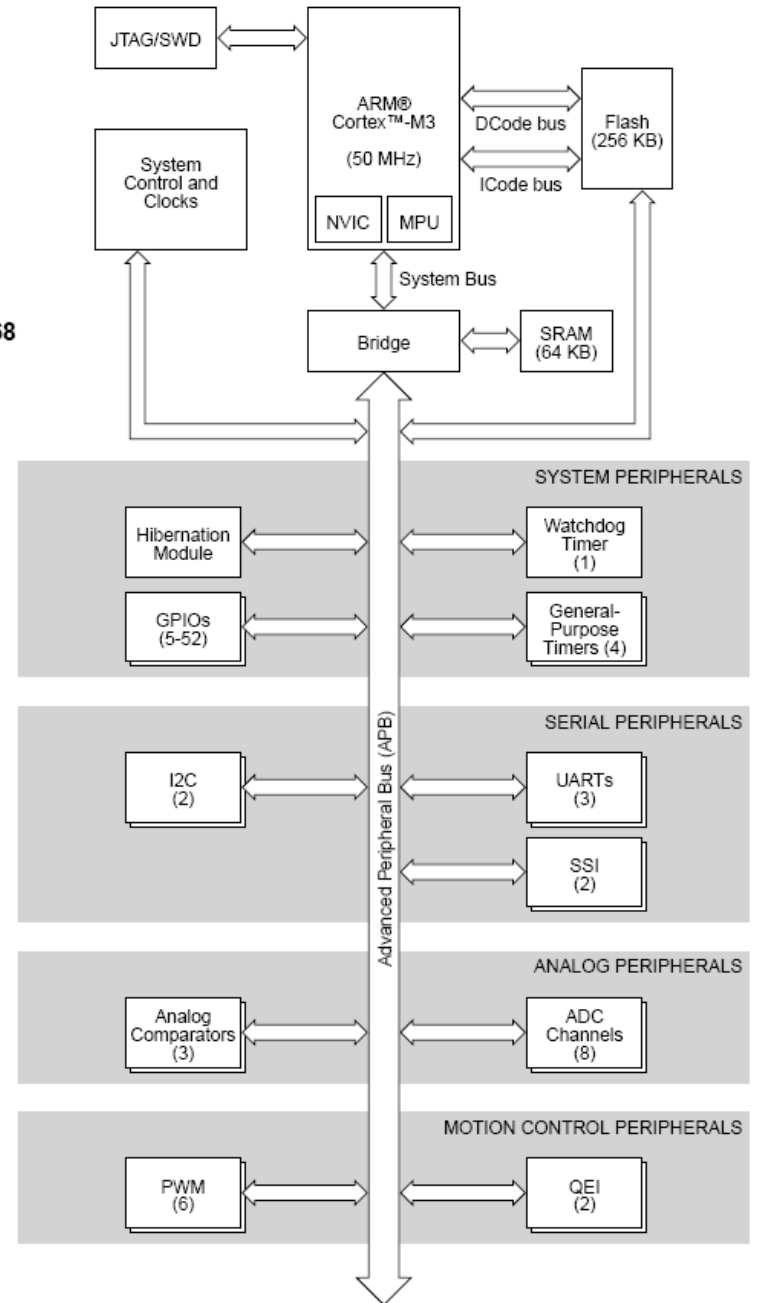
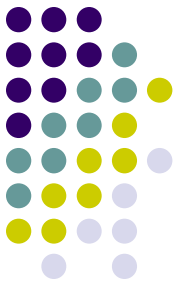


Figure 1. MCF5206 Block Diagram

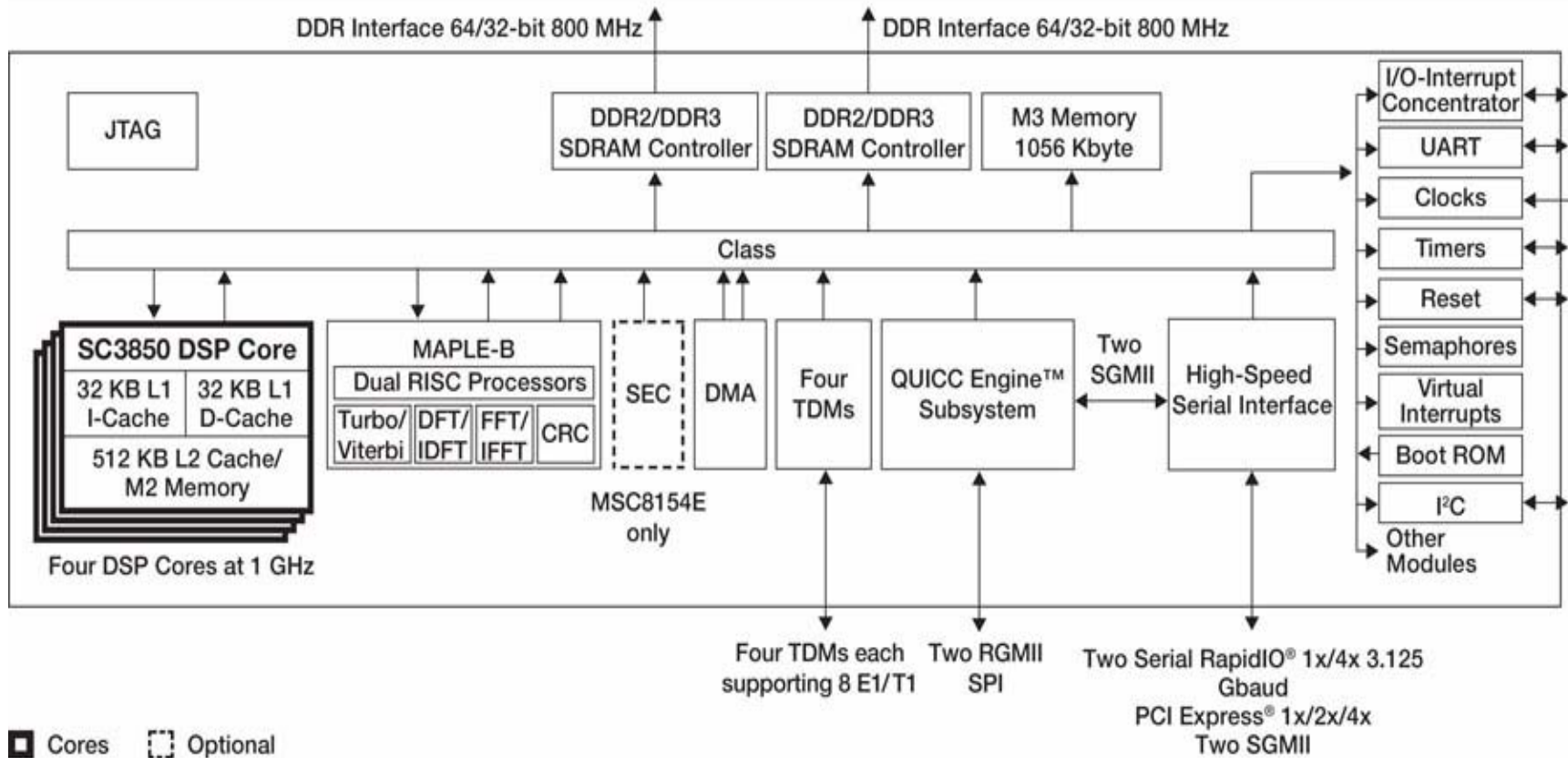
LM3S1968

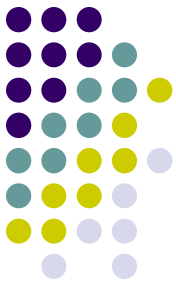


Embedded DSP Example



MSC8154/MSC8154E Block Diagram





Product Selection Guides

- Allow choosing specific members within a family

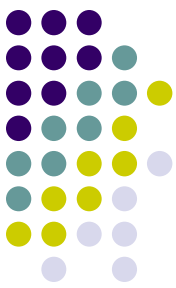
Table 1.1. Product Selection Guide

Ordering Part Number	MIPS (Peak)	Flash Memory (Bytes)	RAM	Calibrated Internal Oscillator	Low Frequency Oscillator	USB with 1k Endpoint RAM	Supply Voltage Regulator	SMBus/I2C	Enhanced SPI	UARTs	Timers (16-bit)	Programmable Counter Array	Digital Port I/Os	External Memory Interface (EMIF)	10-bit 200kps ADC	Temperature Sensor	Voltage Reference	Analog Comparators	Package
C8051F340-GQ	48	64k	4352	✓	✓	✓	✓	✓	✓	2	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F341-GQ	48	32k	2304	✓	✓	✓	✓	✓	✓	2	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F342-GQ	48	64k	4352	✓	✓	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F342-GM	48	64k	4352	✓	✓	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F343-GQ	48	32k	2304	✓	✓	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F343-GM	48	32k	2304	✓	✓	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F344-GQ	25	64k	4352	✓	✓	✓	✓	✓	✓	2	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F345-GQ	25	32k	2304	✓	✓	✓	✓	✓	✓	2	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F346-GQ	25	64k	4352	✓	—	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48
C8051F346-GM	25	64k	4352	✓	—	✓	✓	✓	✓	1	4	✓	40	✓	✓	✓	✓	2	TQFP48

6

MSP430 Microcontrollers

Flash/ROM-Based x4xx MCU Platform (V _{CC} 1.8-3.6V), Up to 16 MIPS (See www.ti.com/msp430 for additional information)																						
	(C) ROM (F) Flash	Program (KB)	SRAM (B)	I/O	16-Bit Timers			Watchdog and Basic Timer	BOR	SVS	USART (UART/ SPI)	USCI		LCD Segments	DMA	HPY (16 x 16)	Comp. A	Temp Sensor	ADC Ch/Res	Additional Features	Package(s)	1 k/1 Price ¹
					Total	A ²	B ³					Ch A: UART/LIN/ I2C/SPI	Ch B: PC/SPI									
F42xx	MSP430F423	8	256	48	2	3.5	—	✓	✓	✓	—	—	—	96	—	—	✓	—	slope	SCAN F	64 PM	3.75
	MSP430F425	16	512	48	2	3.5	—	✓	✓	✓	—	—	—	96	—	—	✓	—	slope	SCAN F	64 PM	4.05
	MSP430F427	32	1024	48	2	3.5	—	✓	✓	✓	—	—	—	96	—	—	✓	—	slope	SCAN F	64 PM	4.45
F42xx	MSP430F423A	8	256	14	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(3) SD16	ESP430	64 PM	3.90
	MSP430F425A	16	512	14	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(3) SD16	ESP430	64 PM	4.40
	MSP430F427A	32	1024	14	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(3) SD16	ESP430	64 PM	4.95
	MSP430F4232	8	256	14	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(2) SD16	ESP430	64 PM	3.50
	MSP430F4242	12	512	14	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(2) SD16	ESP430	64 PM	3.70
	MSP430F4252	16	512	32	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(2) SD16	ESP430	64 PM	3.95
	MSP430F4272	32	1024	32	1	3	—	✓	✓	✓	1	—	—	128	—	✓	—	✓	(2) SD16	ESP430	64 PM	4.30
F42xx	MSP430F4250	16	256	32	1	3	—	✓	✓	—	—	—	—	56	—	—	✓	5ch, SD16_A	DAC12	48 DL, R32	3.10	
	MSP430F4260	24	256	32	1	3	—	✓	✓	—	—	—	—	56	—	—	✓	5ch, SD16_A	DAC12	48 DL, R32	3.45	
	MSP430F4270	32	256	32	1	3	—	✓	✓	—	—	—	—	56	—	—	✓	5ch, SD16_A	DAC12	48 DL, R32	3.80	

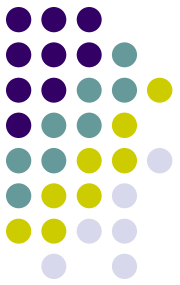


Product Selection Guides

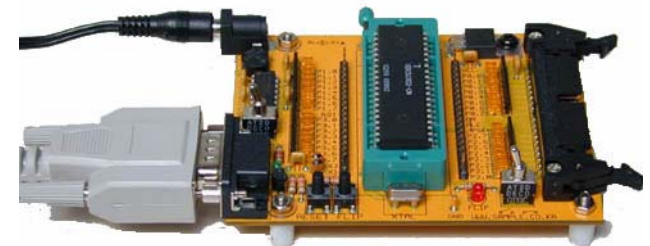
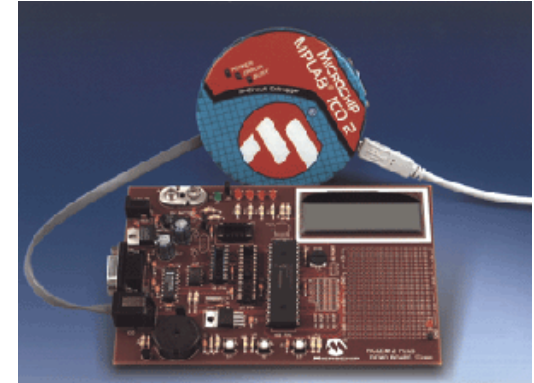
TMS320C55x™ DSP Generation

Part Number	RAM (Bytes)	ROM (Bytes)	I-Cache (Bytes)	EMIF (Bits)	DMA (ch)	DAT/PRO (ADDR) (Words)	USB ²	ADC ³	UART	I ² C	RTC	McBSP ⁴	MMC/ SD	LCD	Voltage (V)		COM	Timers ⁵	MHz	MIPS	Packaging	1-KU Price ¹
TMS320VC5501GZZ300 ⁶	32 K	32 K	16	32	6	8 M	–	–	Y	Y	–	2	–	–	1.26	3.3	HPI18	3 ⁷	300	600	201 BGA ⁸	4.50
TMS320VC5501PGF300 ⁶	32 K	32 K	16	32	6	8 M	–	–	Y	Y	–	2	–	–	1.26	3.3	HPI18	3 ⁷	300	600	176 LQFP	4.50
TMS320VC5501ZZZ300 ⁶	32 K	32 K	16	32	6	8 M	–	–	Y	Y	–	2	–	–	1.26	3.3	HPI18	3 ⁷	300	600	201 BGA ⁸	4.50
TMS320VC5502GZZ200 ⁶	64 K	32 K			6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	200	400	201 BGA ⁸	6.26
TMS320VC5502PGF200 ⁶	64 K	32 K			6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	200	400	176 LQFP	6.26
TMS320VC5502ZZZ200 ⁶	64 K	32 K	16	32	6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	200	400	201 BGA ⁸	6.26
TMS320VC5502PGF300 ⁶	64 K	32 K			6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	300	600	176 LQFP	8.08
TMS320VC5502GZZ300 ⁶	64 K	32 K			6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	300	600	201 BGA ⁸	8.08
TMS320VC5502ZZZ300 ⁶	64 K	32 K	16	32	6	8 M	–	–	Y	Y	–	3	–	–	1.26	3.3	HPI16/8	3 ⁷	300	600	201 BGA ⁸	8.08
TMS320VC5503GHH ⁶	64 K	64 K	–	16	6	8 M	–	–	–	Y	Y	3	–	–	1.2/1.35/ 1.6	2.7–3.6	HPI16	2 ⁷	108/144/ 200 (max)	400	179 BGA	6.75
TMS320VC5503PGE ⁶	64 K	64 K	–	16	6	8 M	–	–	–	Y	Y	3	–	–	1.2/1.35/ 1.6	2.7–3.6	HPI16	2 ⁷	108/144/ 200 (max)	400	144 LQFP	6.75
TMS320VC5503ZHH ⁶	64 K	64 K	–	16	6	8 M	–	–	–	Y	Y	3	–	–	1.2/1.35/ 1.6	2.7–3.6	HPI16	2 ⁷	108/144/ 200 (max)	400	179 BGA ⁸	6.75
TMS320VC5506GHH108 ⁶	128 K	–	–	16	6	8 M	Y1	–	–	Y	Y	3	–	–	1.2	2.7–3.6	–	2 ⁷	108	216	179 BGA	6.50
TMS320VC5506GHH108 ⁶	128 K	–	–	16	6	8 M	Y1	–	–	Y	Y	3	–	–	1.2	2.7–3.6	–	2 ⁷	108	216	179 BGA	6.50
TMS320VC5506PGE108 ⁶	128 K	–	–	16	6	8 M	Y1	–	–	Y	Y	3	–	–	1.2	2.7–3.6	–	2 ⁷	108	216	144 LQFP	6.50
TMS320VC5506ZHH108 ⁶	128 K	–	–	16	6	8 M	Y1	–	–	Y	Y	3	–	–	1.2	2.7–3.6	–	2 ⁷	108	216	179 BGA ⁸	6.50
TMS320VC5506ZHH108 ⁶	128 K	–	–	16	6	8 M	Y1	–	–	Y	Y	3	–	–	1.2	2.7–3.6	–	2 ⁷	108	216	179 BGA ⁸	6.50
TMS320VC5507GHH ⁶	128 K	64 K	–	16	6	8 M	Y1	Y1	–	Y	Y	3	–	–	1.2/1.35/ 1.6	2.7–3.6	HPI16	2 ⁷	108/144/ 200 (max)	400	179 BGA	9.41

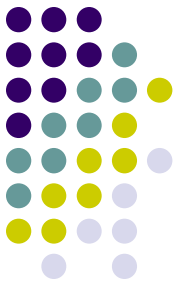
Hardware Development Tools



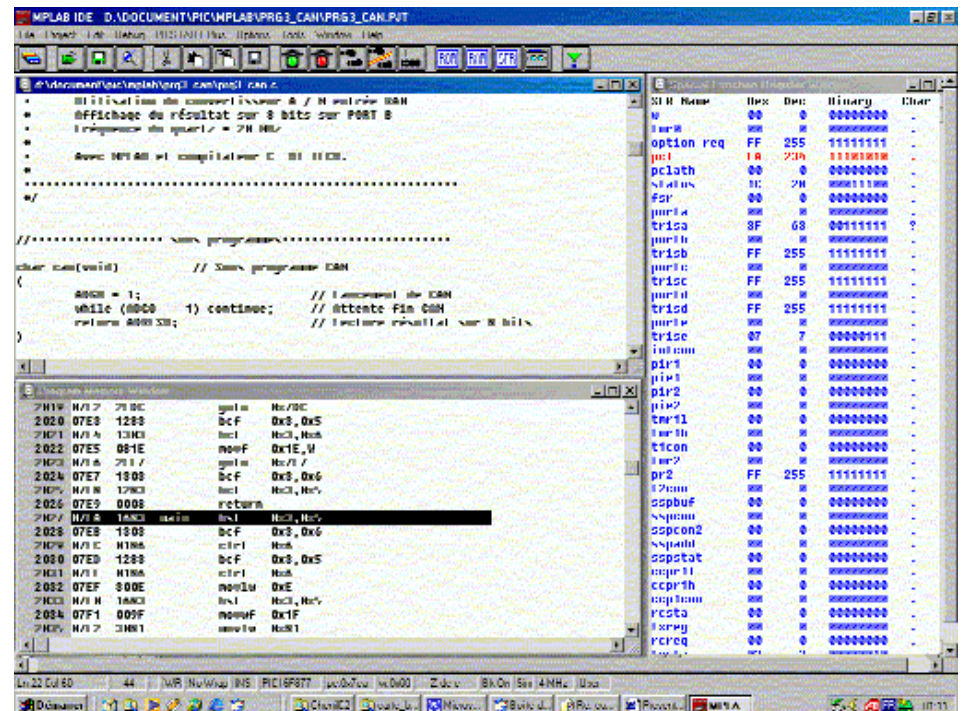
- Availability of Development Kits
 - Most Kits sold for \$50 or less
 - Ask for samples or student discount
- Minimum HW Contents
 - Development Board
 - JTAG debugger or Emulator
 - Power supply
 - Spare chips
 - Cables



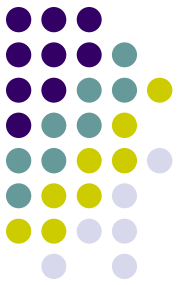
Software Development Tools



- Allow for Software Development
 - Programming
 - Debugging
 - Downloading
 - Testing
- Minimum Support
 - Integrated Development Environment (IDE)
 - Emulator
 - Assembler
 - C-Compiler (Demo)



Resources



- <http://www.instructables.com>
- http://www.freescale.com/files/microcontroller/doc/app_note/AN1057.pdf
- <http://www.microchip.com/stellent>
- <http://archive.chipcenter.com/circuitcellar/march01/c0301cg1.htm>