University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292

Lab 6: New Microcontroller Setup.

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Requirements & Comments

- Lab #6 requirements are the same as Lab #4 (for ELEC291 students) but microcontroller system must not be 8051!
- Programmed in C.
- Work with a partner.
- Good start for Project #2

Getting the Parts for Lab #6 and Project #2

- Buy the kit (one per team, CAD 80$) by visiting:
  - https://eng-services.ece.ubc.ca/course-support/2022-winter-term-2/elec291/
  - Password: ee291-3_2023
- Bring proof of payment to EECE stores (MCLD 1032) to pick up you kit.

Getting Started with a New Microcontroller System

1. Obtain/assemble the hardware. Also documentation: datasheets & manuals.
2. Obtain/install the development environment. Also documentation like manuals.
3. Obtain/install a means of putting the 'firmware' in the hardware ("Flash Load"). May require additional hardware tools and software.
4. Settle a workflow. Also: examples, application notes, and forums.

Getting Started with a New Microcontroller System

- In this course is not too difficult. Instructions provided for:
  - PIC32MX130: DIP-28. 64k flash. Microchip. MIPS architecture.
  - MSP430G2553: DIP-20. 16k flash. Texas Instruments. MSP430 architecture.
  - ATMEGA328P: DIP-28. 32k flash. Formerly Atmel, now Microchip. AVR architecture.
  - STM32L051: LQFP32. 64k flash. ST Microelectronics. ARM architecture.
  - LPC824: TSOP28. 32k flash. NXP. ARM architecture.

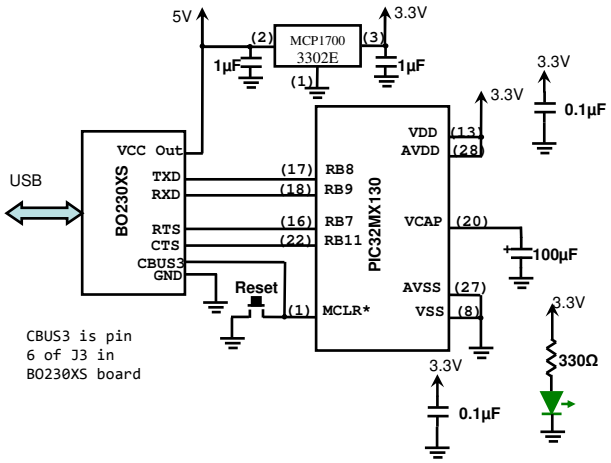
ARM Cortex Processors

- For the ARM processors included in your kit a surface mount adapter and soldering is required.
- Adapters, pins, and de-soldering braid (for cleaning after soldering) are included in both the project #1 and #2 kits.

The PIC32 Microcontroller System

1. Hardware: Bare IC in breadboard.
2. Development environment: XC32 from Microchip. (Derived from GCC but…)
3. Flash Loader: Pro32 via BO230XS board by yours truly.
4. Workflow: via Makefiles in CrossIDE or VS code. Examples in Canvas.

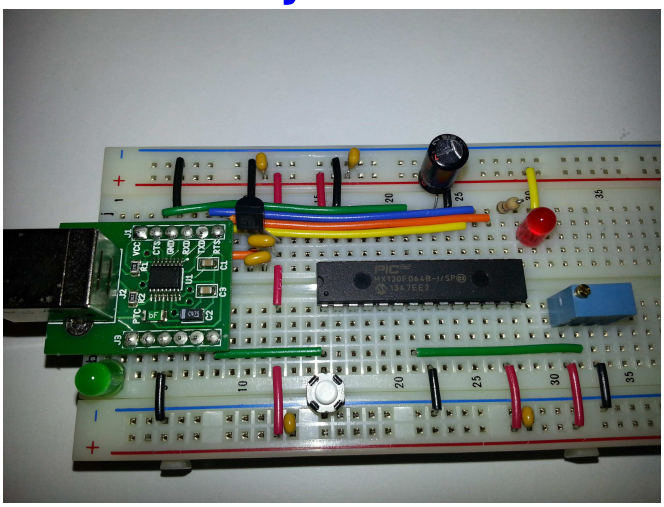
The PIC32 Microcontroller System



The PIC32 Microcontroller System

Qty	Supplier's#	Man's #	Description
2	**BC1148CT-ND**	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL
2	BC1157CT-ND	K105Z20Y5VE5TH5	CAP CER 1UF 25V Y5V RADIAL
2	330QBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL
1	67-1102-ND	SSL-LX5093HD	LED RED DIFF 5MM ROUND T/H
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H
1	MCP1700-3302E/TO-ND	MCP1700-3302E/TO	IC REG LDO 3.3V 0.25A TO92-3
1	PIC32MX130F064B-I/SP-ND	PIC32MX130F064B-I/SP	IC MCU 32BIT 64KB FLASH 28SDIP
1	493-1548-ND	UHE1E101MED	CAP ALUM 100UF 20% 25V RADIAL
2	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V

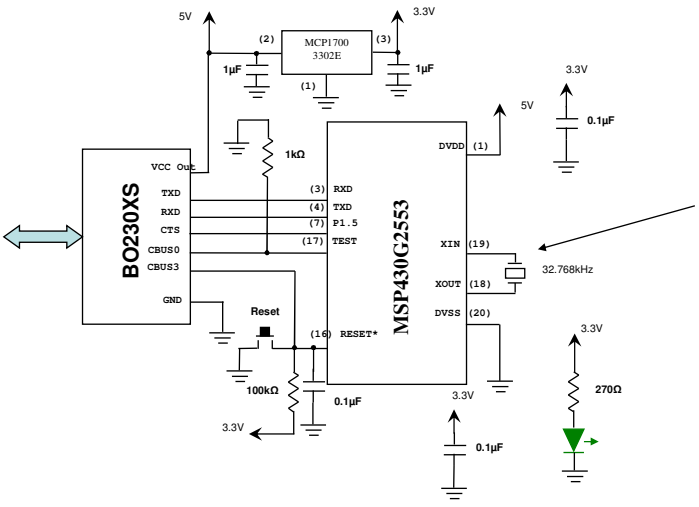
The PIC32 Microcontroller System



The MSP430 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for MSP430.
3. Flash Loader: MSP430_prog via BO23XS board by yours truly.
4. Workflow: via makefiles in CrossIDE or VS code. Examples in Canvas.

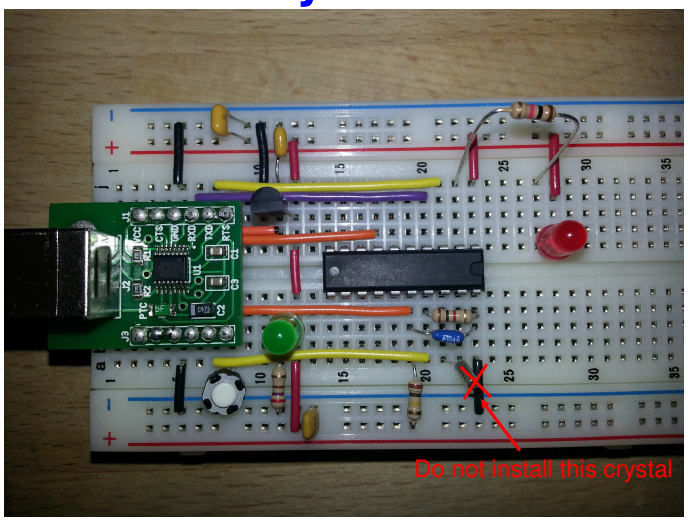
The MSP430 Microcontroller System



The MSP430 Microcontroller System

Quantity	Digi-Key Part #	Description
3	BC1148CT-ND	0.1uF ceramic capacitors
2	BC1157CT-ND	1uF ceramic capacitor
2	270QBK-ND	270Ω resistor
1	1.0KQBK-ND	1kΩ resistor
1	100KQBK-ND	100kΩ resistor
1	MCP1700-3302E/TO-ND	IC REG LINEAR 3.3V 250MA TO92-3
1	67-1108-ND	LED 5MM GREEN
~~1~~	~~300-8842-ND~~	~~CRYSTAL 32.7680KHZ 7PF T/H~~
1	296-28429-5-ND	MSP430G2553
1	P8070SCT-ND	Push button switch

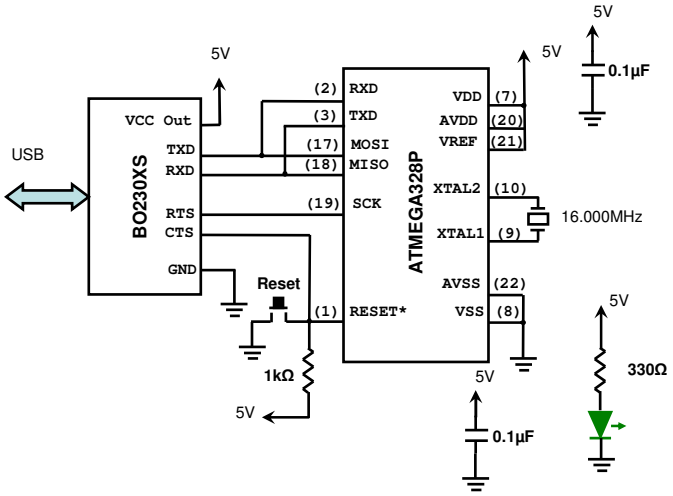
The MSP430 Microcontroller System



The ATMEGA328P Microcontroller System

1. Hardware: Bare IC in breadboard.
2. Development environment: Atmel AVR 8-bit Toolchain for Windows.
3. Flash Loader: spi_atmega328 via BO230XS board by yours truly.
4. Workflow: via Makefiles in CrossIDE or VS code. Examples in Canvas.

The ATMEGA328P Microcontroller System



The ATMEGA328P Microcontroller System

Qty	Supplier's#	Man's #	Description
3	BC1148CT-ND	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL
1	1.0KQBK-ND	CFR-25JB-52-1K	RES 1K OHM 1/4W 5% AXIAL
2	330QBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL
1	67-1102-ND	SSL-LX5093HD	LED RED DIFF 5MM ROUND T/H
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H
1	CTX1085-ND	ATS16B	CRYSTAL 16.0000MHZ 18PF T/H
1	ATMEGA328P-PU-ND	ATMEGA328P-PU	IC MCU 8BIT 32KB FLASH 28DIP
1	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V

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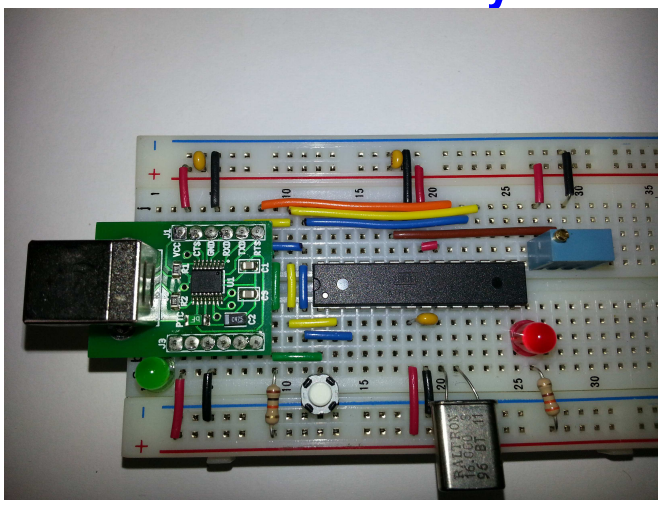
The ATMEGA328P Microcontroller System



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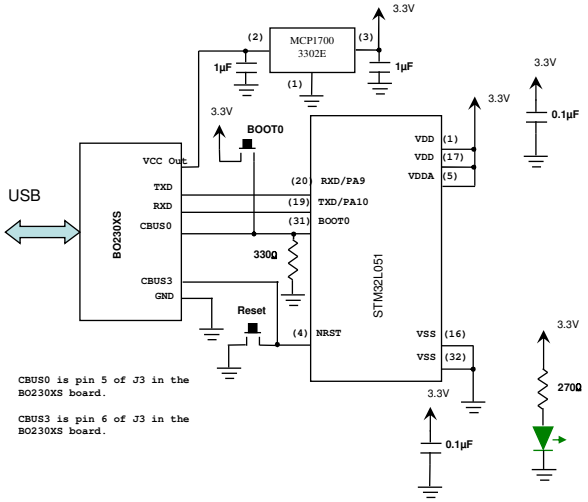
The STM32L051 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for ARM.
3. Flash Loader: stm32flash.
4. Workflow: via Makefiles in CrossIDE. Examples in Connect.

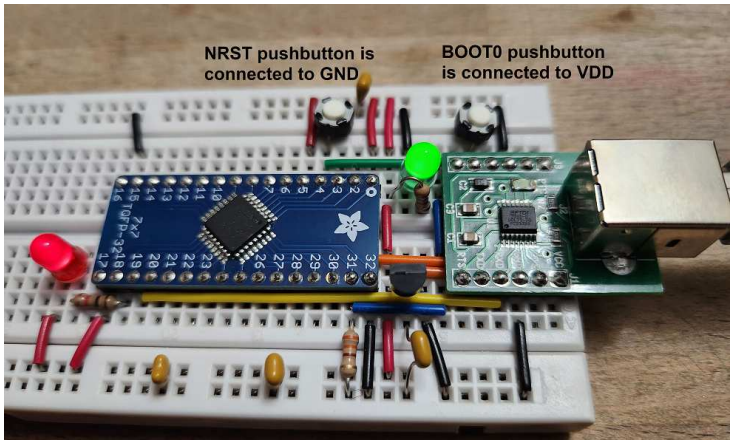
The STM32L051 Microcontroller System



The STM32L051 Microcontroller System

Quantity	Digi-Key Part #	Description
2	BC1148CT-ND	0.1uF ceramic capacitors
2	BC1157CT-ND	1uF ceramic capacitors
2	270QBK-ND	270Ω resistor
1	330QBK-ND	330Ω resistor
1	67-1102-ND	LED 5MM RED
1	67-1108-ND	LED 5MM GREEN
1	MCP1700-3302E/TO-ND	MCP17003302E 3.3 Voltage Regulator
1	N/A	BO230XS USB adapter
1	497-14901-ND	STM32L051K8T6
1	1528-1065-ND	LQFP32 to DIP32 adapter board
2	A26509-16-ND	16-pin header connector
1	P8070SCT-ND	Push button switch

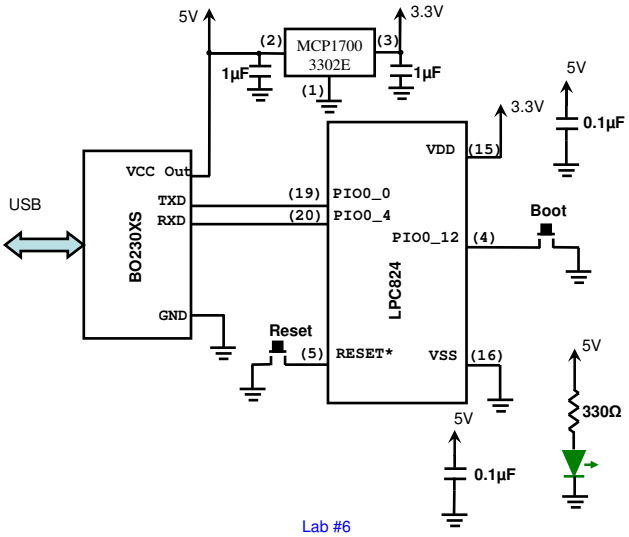
The STM32L051 Microcontroller System



The LPC824 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for ARM.
3. Flash Loader: Port of lpc21isp via BO23XS board.
4. Workflow: via makefiles in CrossIDE. Examples in Connect.

The LPC824 Microcontroller System

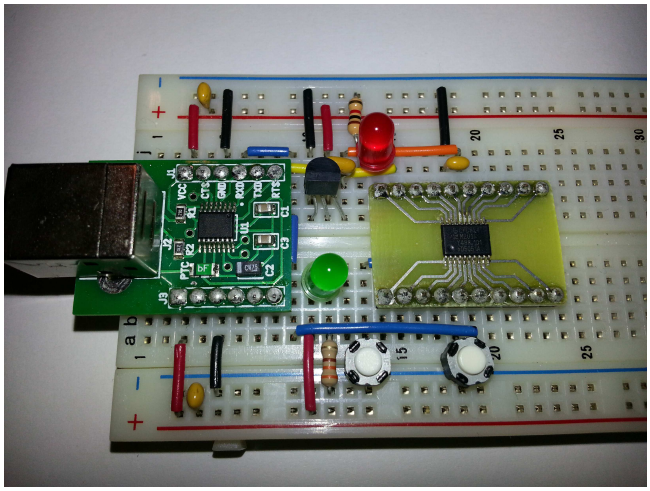


The LPC824 Microcontroller System

Qty	Supplier's#	Man's #	Description
2	BC1148CT-ND	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL
2	BC1157CT-ND	K105Z20Y5VE5TH5	CAP CER 1UF 25V Y5V RADIAL
1	1.0QBK-ND	CFR-25JB-52-1R	RES 1 OHM 1/4W 5% AXIAL
1	330QBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL
1	67-1102-ND	SSL-LX5093HD	LED RED DIFF 5MM ROUND T/H
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H
1	MCP1700-3302E/TO-ND	MCP1700-3302E/TO	IC REG LDO 3.3V 0.25A TO92-3
1	568-11619-1-ND	LPC824M201JDH20J	IC MCU 32BIT 32KB FLASH 20TSSOP
0.33	1528-1066-ND	1206	SMT ADAPTERS 3 PACK 20SOIC/TSSOP
2	A26509-10-ND	4-103741-0-10	CONN HEADR BRKWAY .100 10POS STR
2	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V

Total

The LPC824 Microcontroller System



Which one to Pick?

- Size of the documentation:
  - ATMega328P: 294 pages
  - MSP430: 644+76 pages
  - PIC32: 1138+344 pages
  - LPC824: 487+82 pages
  - STM32L051: 784+133 pages
- Quality of the documentation (personal opinion):
  - ATMega328P: ok
  - MSP430: ok
  - PIC32: Excellent
  - LPC824: Excellent
  - STM32L051: Very good.

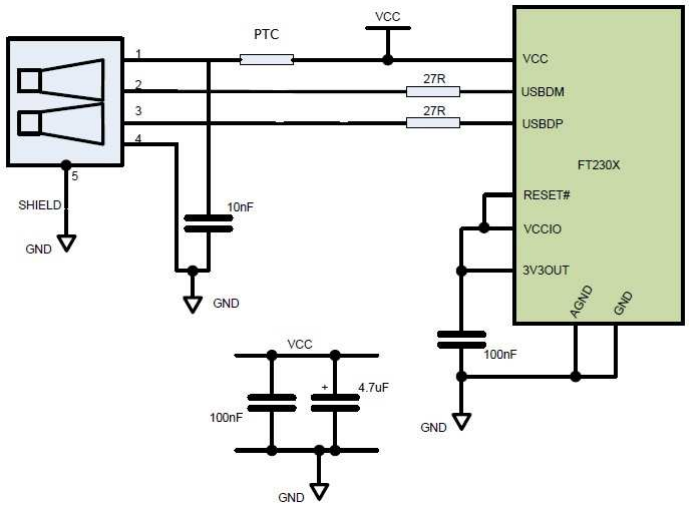
Which one to Pick?

- Raw power:
  - ATMega328P: ok
  - MSP430: Good
  - PIC32: Excellent
  - STM32L051: Excellent
  - LPC824: 60MHz! The fastest of the bunch.
- Examples:
  - ATMega328P: Excellent. Everywhere!
  - MSP430: Good
  - PIC32: Good (in the manual!)
  - STM32L051: Good (in the manual!)
  - LPC824: Good (in the manual!)
- Number of timers (I may be wrong):
  - ATMega328P: 1 x 16-bits, 2 x 8-bits.
  - MSP430: 2 x 16-bit (each with two channels)
  - PIC32: 5 x 16-bit
  - STM32L051: 4 x 16 bit, 1 x 24 bit. TIM2 has four channels. TIM21 and TIM22 have two channels. TIM6 has one channel. SysTick.
  - LPC824: 4 x 16 bit + SCTimer + SysTick.

The BO230XS Board

- The BO230XS is a minimal system around the FT230XS IC that allows for communication between a Computer (using USB) and a microcontroller system.
- It can be used as serial port interface or a SPI interface using libraries and drivers provided by the manufacturer.
- Permits the implementation of simple flash memory programmers via boot loaders and SPI.

The BO230XS Board Schematic



The FT230XS Board

Qty	Supplier's#	Man's #	Description
1	768-1135-1-ND	FT230XS-R	IC USB SERIAL BASIC UART 16SSOP
2	A26509-06-ND	4-103741-0-06	CONN HEADR BRKWAY .100 06POS STR
1	ED2983-ND	USB-B1HSB6	CONN USB TYPE B R/A BLACK
2	399-1170-1-ND	C0805C104K5RACTU	CAP CER 0.1UF 50V X7R 0805
2	P27ACT-ND	ERJ-6GEYJ270V	RES SMD 27 OHM 5% 1/8W 0805
1	478-8222-1-ND	F931A475MAA	CAP TANT 4.7UF 10V 20% 1206
1	507-1797-1-ND	0ZCJ0020FF2E	PTC RESTTBLE 0.20A 30V CHIP 1206
1			PCB from PCBCart

BO230XS replacement

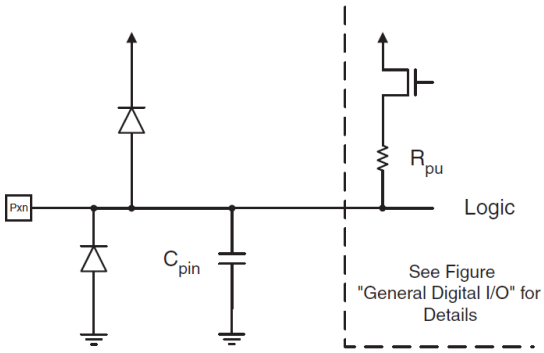
- Boards that use either the FT230XS or FT231XS ICs are ok.
- Inexpensive option from DigiKey ($14.27):
  - **LC231X.**
  - Digi-Key Part Number: 768-1316-ND.
  - You'll need to solder the header pins.

Examples Relevant to Lab #6

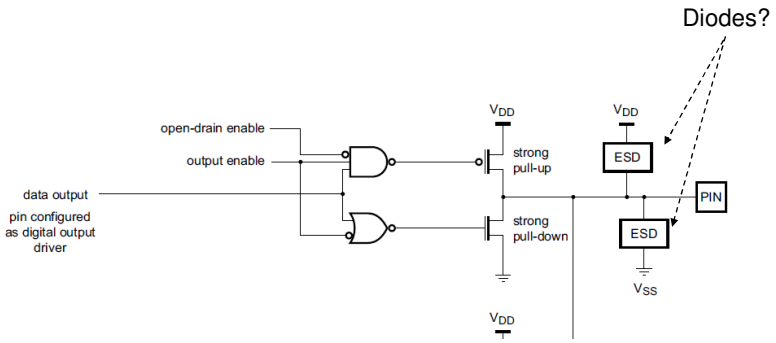
- ATMega328:
  - LCD and Period.
- MSP430:
  - LCD and Period.
- PIC32MX130:
  - LCD and Period.
- STM32L051:
  - LCD and Period.
- LPC824:
  - LCD and Period.

ATMega328P Pin Equivalent Circuit

Figure 14-1. I/O Pin Equivalent Schematic

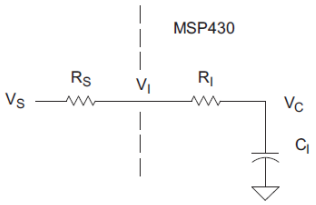


LPC824 Pin Equivalent Circuit



Page 15 of "Product data sheet"

MSP430 Pin Equivalent Circuit



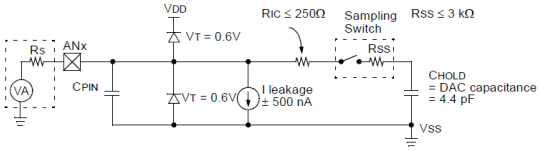
V_I = Input voltage at pin Ax
V_S = External source voltage
R_S = External source resistance
R_I = Internal MUX-on input resistance
C_I = Input capacitance
V_C = Capacitance-charging voltage

Figure 22-4. Analog Input Equivalent Circuit

No diodes?

PIC32MX130 Pin Equivalent Circuit

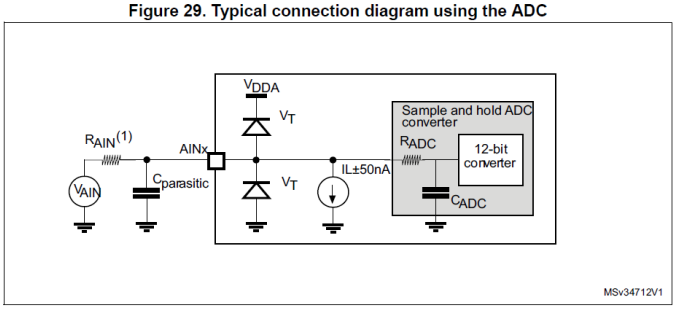
Figure 17-22: 10-Bit A/D Converter Analog Input Model



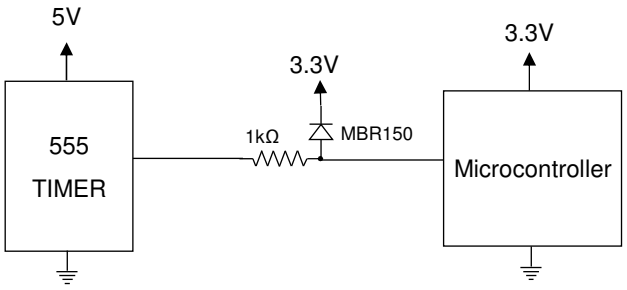
Note: CPIN value depends on device package and is not tested. Effect of CPIN negligible if RS ≤ 5 kΩ.

STM32L051 Pin Equivalent Circuit

Figure 29. Typical connection diagram using the ADC



Recommended Circuit for Lab #6



Since the ATMega328P power is 5V, no protection circuit is needed.

The diode is only needed if using the MSP430G2553.

macOS support

- As of the moment of writing this, the only processors supported in macOS are the LPC824 and STM32L051. Instructions posted on Canvas.
- The LPC824 and the STM32L051 are the only ones that come with a proper serial boot loader from factory.
- (The MSP430 has also a serial boot loader, but the programming pins are a mess! Therefore it doesn't work on macOS.)