University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292

# Lab 6: New Microcontroller Setup.

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March 11, 2022




# Requirements & Comments

- Lab #6 requirements are the same as Lab #4 but microcontroller system must not be 8051!
- Programmed in C.
- Work with a partner.
- Compared to Lab #5, this lab is easy as cake!
- Good start for Project #2

# Getting the Parts for Lab #6 and Project #2

- Form a team of six students.
- Complete the team form. It is available on Canvas.
- Buy the kit(s) by visiting:
  - https://eng-services.ece.ubc.ca/course-support/2021-winter-term-2/elec291/
  - Password: ee291-2_2022
- Bring the team form and proof of payment to EECE stores (CEME 1057) to pick up you kit(s).




# Two kits available (per team)

- Required: "Project 2 - Robot Kit", it costs 126$. It has 5 microcontroller, robot parts, magnet wire, screws, etc. You need this ASAP for Lab #6 and Project #2.
- Not required but recommended: "Project 2 - Passive Components Kit", it costs 70$. Just capacitors and resistors, lots of them! Useful for ELEC291/292 and future courses as well. Split it in 6 equal parts, one part per team member.

# 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. 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.
  - ATSAMD20E16: LQFP32. 64k flash. Formerly Atmel, now Microchip. ARM architecture.
  - LPC824: TSOP28. 32k flash. NXP. ARM architecture.

## ARM Cortex Processors

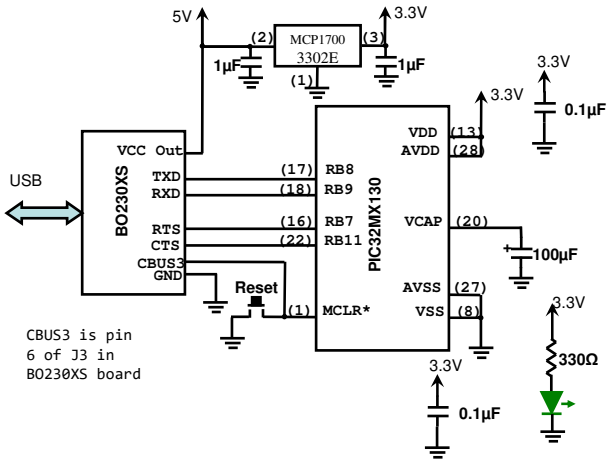
- For the ARM processors included in your kit a surface mount adapter and soldering is required.
- Adapters, pins, and de-soldering braid (for cleaning after soldering) is included in the project #2 kit.




## 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







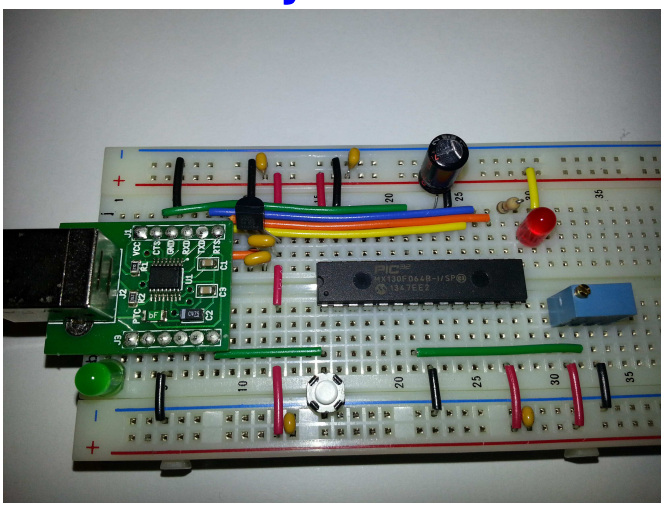



# The PIC32 Microcontroller System

| Qty | Supplier's# | Man's # | Description | Price |
|---|---|---|---|---|
| 2 | **BC1148CT-ND** | K104Z15Y5VE5TL2 | CAP CER 0.1UF 25V Y5V RADIAL | 0.54 |
| 2 | BC1157CT-ND | K105Z20Y5VE5TH5 | CAP CER 1UF 25V Y5V RADIAL | 0.94 |
| 2 | 330QBK-ND | CFR-25JB-52-330R | RES 330 OHM 1/4W 5% AXIAL | 0.30 |
| 1 | 67-1102-ND | SSL-LX5093HD | LED RED DIFF 5MM ROUND T/H | 0.55 |
| 1 | 67-1108-ND | SSL-LX5093LGD | LED GRN DIFF 5MM ROUND T/H | 0.62 |
| 1 | MCP1700-3302E/TO-ND | MCP1700-3302E/TO | IC REG LDO 3.3V 0.25A TO92-3 | 0.57 |
| 1 | PIC32MX130F064B-I/SP-ND | PIC32MX130F064B-I/SP | IC MCU 32BIT 64KB FLASH 28SDIP | 4.23 |
| 1 | 493-1548-ND | UHE1E101MED | CAP ALUM 100UF 20% 25V RADIAL | 0.41 |
| 2 | P8070SCT-ND | EVQ-11A04M | SWITCH TACTILE SPST-NO 0.02A 15V | 0.70 |

Total 8.86

# The PIC32 Microcontroller System

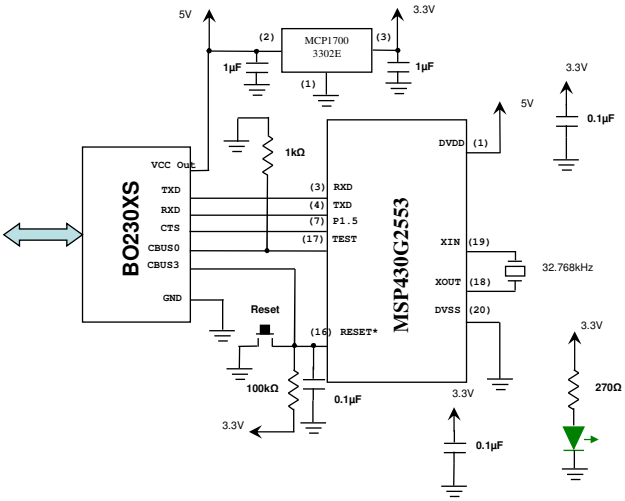





# The MSP430 Microcontroller System

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







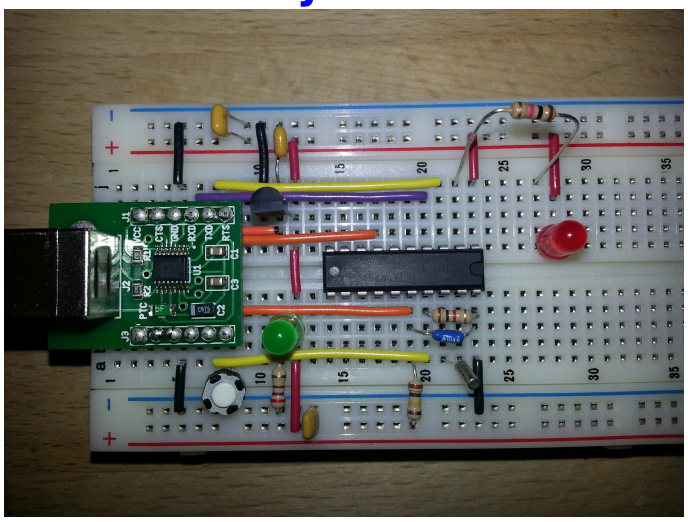



# The MSP430 Microcontroller System

| Quantity | Digi-Key Part # | Description | |
|---|---|---|---|
| 3 | BC1148CT-ND | 0.1uF ceramic capacitors | 0.73 |
| 2 | BC1157CT-ND | 1uF ceramic capacitor | 0.90 |
| 2 | 270QBK-ND | 270Ω resistor | 0.30 |
| 1 | 1.0KQBK-ND | 1kΩ resistor | 0.15 |
| 1 | 100KQBK-ND | 100kΩ resistor | 0.15 |
| 1 | MCP1700-3302E/TO-ND | IC REG LINEAR 3.3V 250MA TO92-3 | 0.57 |
| 1 | 67-1108-ND | LED 5MM GREEN | 0.59 |
| 1 | 300-8842-ND | CRYSTAL 32.7680KHZ 7PF T/H | 0.35 |
| 1 | 296-28429-5-ND | MSP430G2553 | 3.93 |
| 1 | P8070SCT-ND | Push button switch | 0.34 |

$8.01

# The MSP430 Microcontroller System

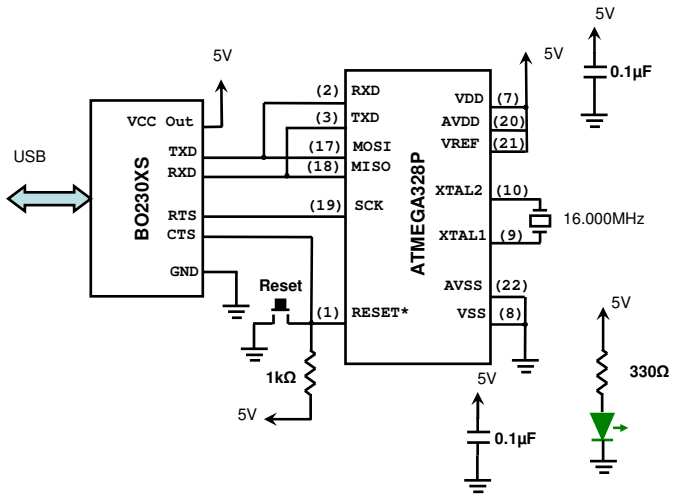





# The ATMEGA328P Microcontroller System

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





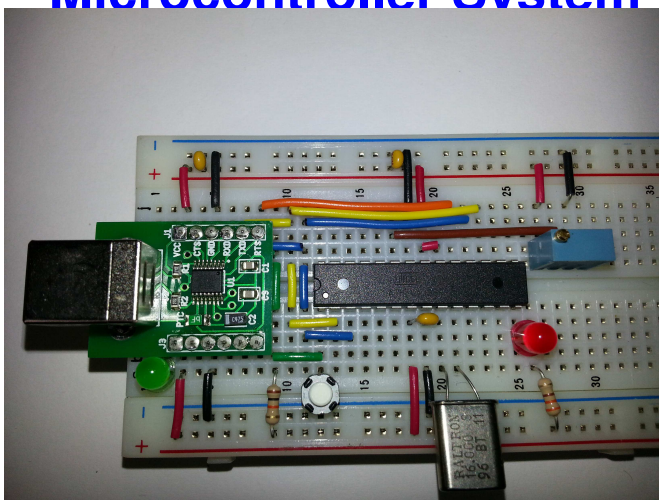





# The ATMEGA328P Microcontroller System

| Qty | Supplier's# | Man's # | Description | Price |
|---|---|---|---|---|
| 3 | BC1148CT-ND | K104Z15Y5VE5TL2 | CAP CER 0.1UF 25V Y5V RADIAL | 0.81 |
| 1 | 1.0KQBK-ND | CFR-25JB-52-1K | RES 1K OHM 1/4W 5% AXIAL | 0.15 |
| 2 | 330QBK-ND | CFR-25JB-52-330R | RES 330 OHM 1/4W 5% AXIAL | 0.30 |
| 1 | 67-1102-ND | SSL-LX5093HD | LED RED DIFF 5MM ROUND T/H | 0.55 |
| 1 | 67-1108-ND | SSL-LX5093LGD | LED GRN DIFF 5MM ROUND T/H | 0.62 |
| 1 | CTX1085-ND | ATS16B | CRYSTAL 16.0000MHZ 18PF T/H | 0.54 |
| 1 | ATMEGA328P-PU-ND | ATMEGA328P-PU | IC MCU 8BIT 32KB FLASH 28DIP | 3.24 |
| 1 | P8070SCT-ND | EVQ-11A04M | SWITCH TACTILE SPST-NO 0.02A 15V | 0.35 |
| | | | Total | 6.56 |

# The ATMEGA328P Microcontroller System



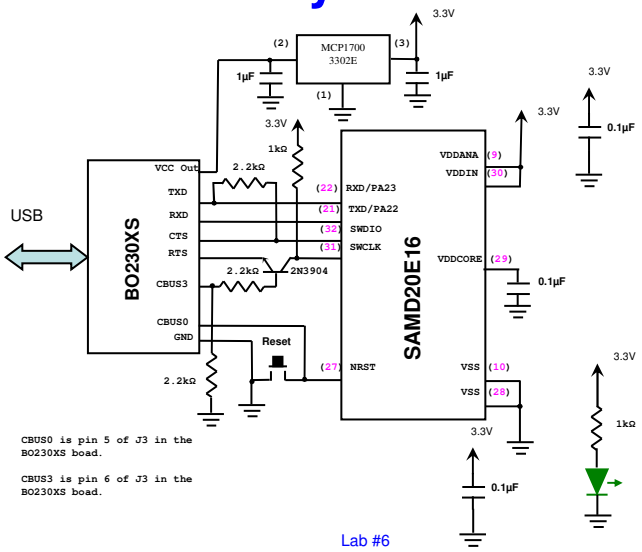





# The SAMD20E16 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for ARM.
3. Flash Loader: Custom loader via BO23XS board.
4. Workflow: via Makefiles in CrossIDE. Examples in Connect.

# The SAMD20E16 Microcontroller System





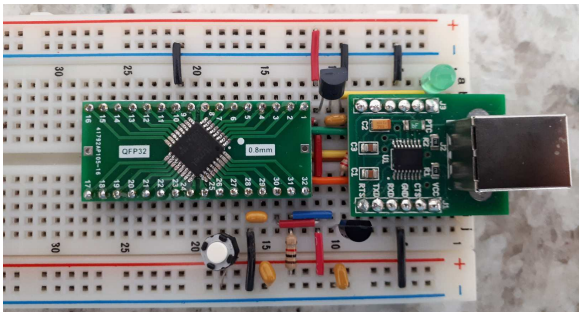



# The SAMD20E16 Microcontroller System

| Qty | Supplier's# | Man's # | Description | Price |
|---|---|---|---|---|
| 3 | BC1148CT-ND | K104Z15Y5VE5TL2 | CAP CER 0.1UF 25V Y5V RADIAL | 0.54 |
| 2 | BC1157CT-ND | K105Z20Y5VE5TH5 | CAP CER 1UF 25V Y5V RADIAL | 0.94 |
| 3 | 2.2kQBK-ND | CFR-25JB-52-270R | RES 270 OHM 1/4W 5% AXIAL | 0.45 |
| 2 | 1.0kQBK-ND | CFR-25JB-52-330R | RES 330 OHM 1/4W 5% AXIAL | 0.30 |
| 1 | 67-1108-ND | SSL-LX5093LGD | LED GRN DIFF 5MM ROUND T/H | 0.62 |
| 1 | MCP1700-3302E/TO-ND | MCP1700-3302E/TO | IC REG LDO 3.3V 0.25A TO92-3 | 0.57 |
| 1 | ATSAMD20E16B-AUTCT-ND | ATSAMD20E16B-AUT | IC MCU 32BIT 64KB FLASH 32LQFP | 2.88 |
| 0.33 | 1528-1065-ND | 1163 | SMT ADAPTERS 3 PACK 32QFN/TQFP | 2.82 |
| 2 | A26509-16-ND | 4-103741-0-16 | CONN HEADR BRKWAY .100 16POS STR | 3.12 |
| 1 | 2N3904-AP | 2N3904 | TRANS NPN 40V 0.2A TO92 | 0.27 |
| 1 | P8070SCT-ND | EVQ-11A04M | SWITCH TACTILE SPST-NO 0.02A 15V | 0.35 |

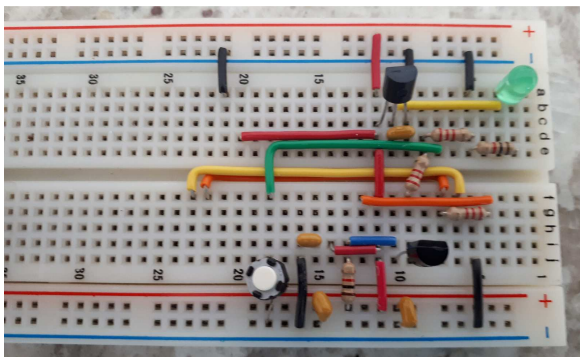
Total 12.86

# The SAMD20E16 Microcontroller System






# The SAMD20E16 Microcontroller System

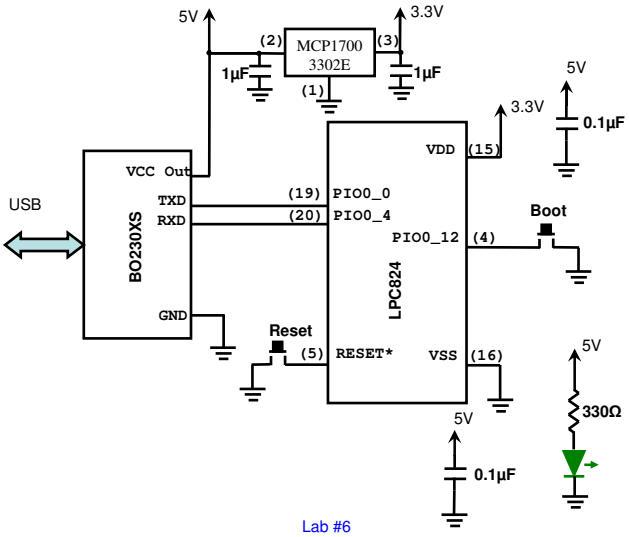


# The LPC824 Microcontroller System

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



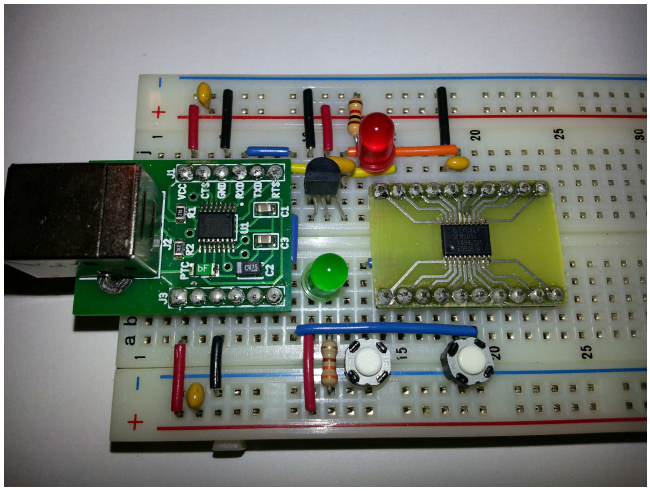
# The LPC824 Microcontroller System

| Qty | Supplier's# | Man's # | Description | Price |
|---|---|---|---|---|
| 2 | BC1148CT-ND | K104Z15Y5VE5TL2 | CAP CER 0.1UF 25V Y5V RADIAL | 0.54 |
| 2 | BC1157CT-ND | K105Z20Y5VE5TH5 | CAP CER 1UF 25V Y5V RADIAL | 0.94 |
| 1 | 1.0QBK-ND | CFR-25JB-52-1R | RES 1 OHM 1/4W 5% AXIAL | 0.15 |
| 1 | 330QBK-ND | CFR-25JB-52-330R | RES 330 OHM 1/4W 5% AXIAL | 0.15 |
| 1 | 67-1102-ND | SSL-LX5093HD | LED RED DIFF 5MM ROUND T/H | 0.55 |
| 1 | 67-1108-ND | SSL-LX5093LGD | LED GRN DIFF 5MM ROUND T/H | 0.62 |
| 1 | MCP1700-3302E/TO-ND | MCP1700-3302E/TO | IC REG LDO 3.3V 0.25A TO92-3 | 0.57 |
| 1 | 568-11619-1-ND | LPC824M201JDH20J | IC MCU 32BIT 32KB FLASH 20TSSOP | 2.74 |
| 0.33 | 1528-1066-ND | 1206 | SMT ADAPTERS 3 PACK 20SOIC/TSSOP | 2.13 |
| 2 | A26509-10-ND | 4-103741-0-10 | CONN HEADR BRKWAY .100 10POS STR | 2.32 |
| 2 | P8070SCT-ND | EVQ-11A04M | SWITCH TACTILE SPST-NO 0.02A 15V | 0.70 |

Total 10.71




# The LPC824 Microcontroller System



# Which one to Pick?

- Due to pandemic, availability may be a very important factor. ATMega328P is everywhere! You can order all chips from Digi-Key or Mouser. They usually arrive the next day.
- Size of the documentation:
  - ATMega328P: 294 pages
  - MSP430: 644 pages
  - PIC32: 1138 pages
- Quality of the documentation:
  - ATMega328P: ok
  - MSP430: ok
  - PIC32: Excellent




# Which one to Pick?

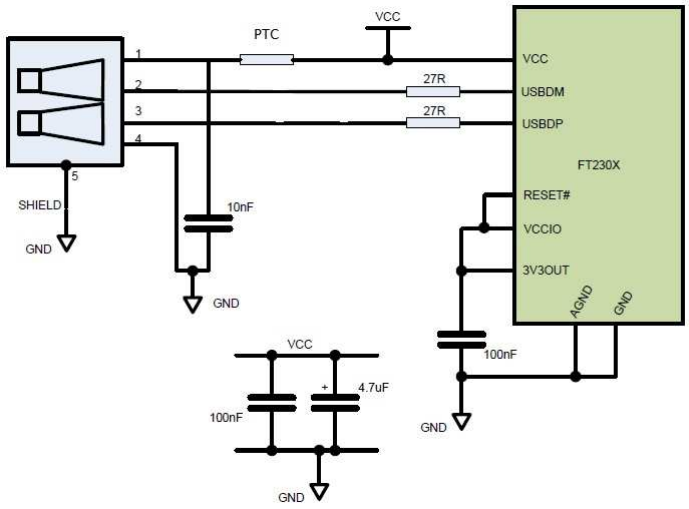
- Raw power:
  - ATMega328P: ok
  - MSP430: Good
  - PIC32: Excellent
- Examples:
  - ATMega328P: Excellent
  - MSP430: Good
  - PIC32: Good (in the manual!)
- Number of timers (I may be wrong):
  - ATMega328P: 1 x 16-bits, 2 x 8-bits.
  - MSP430: 2 x 16-bit (each with two channels)
  - PIC32: 5 x 16-bit

# 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 | Price |
|---|---|---|---|---|
| 1 | 768-1135-1-ND | FT230XS-R | IC USB SERIAL BASIC UART 16SSOP | 3.60 |
| 2 | A26509-06-ND | 4-103741-0-06 | CONN HEADR BRKWAY .100 06POS STR | 1.78 |
| 1 | ED2983-ND | USB-B1HSB6 | CONN USB TYPE B R/A BLACK | 0.82 |
| 2 | 399-1170-1-ND | C0805C104K5RACTU | CAP CER 0.1UF 50V X7R 0805 | 0.28 |
| 2 | P27ACT-ND | ERJ-6GEYJ270V | RES SMD 27 OHM 5% 1/8W 0805 | 0.30 |
| 1 | 478-8222-1-ND | F931A475MAA | CAP TANT 4.7UF 10V 20% 1206 | 0.41 |
| 1 | 507-1797-1-ND | 0ZCJ0020FF2E | PTC RESTTBLE 0.20A 30V CHIP 1206 | 0.18 |
| 1 | | | PCB from PCBCart | 0.67 |
| | | | Total | 8.04 |




# BO230XS replacement

- Board that use the FT230XS or FT231XS ICs are ok.
- Inexpensive option from DigiKey ($13.36):
  - **LC231X.**
  - Digi-Key Part Number: 768-1316-ND.
  - You'll need to solder the header pins.

# Examples Relevant for Lab 6

- ATMega328:
  - ADCTest (more efficient versions available)
- MSP430:
  - ADC (more efficient versions available)
- PIC32MX130:
  - ADCTest
- ATSAMD20:
  - ADC
- LPC824:
  - PrintADC , PrintADCeff1 , PrintADCeff2




# macOS support

- As of the moment of writing this, the only processor supported in macOS is the LPC824. Instruction posted on Canvas.
- The LPC824 is the only one in the bunch that comes with a proper serial boot loader.
- (The MSP430 has also a serial boot loader, but the programming pins are a mess! Therefore it doesn't work on macOS yet.)