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Arduino Microcontrollers

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Microcontrollers

- Microprocessors first appeared in the late 1970s
  - Integrated an entire central processing unit (CPU) onto one chip
  - I used an Intel 8051 as a RTTY code/speed converter in the early 1980s (see QST 1982)
- Microcontrollers evolved from microprocessors when memory and other peripheral functions were integrated onto the chip
  - RAM, ROM, EEPROM
  - ADC/DACs
  - ….
- You will find a microcontroller in most modern appliances
- Modern phase locked loop (PLL) ICs require a microcontroller for control
- Some PLL boards include a embedded, pre-programmed microcontroller
  - e.g., ZL boards, DigiLO, Orion (Orion based on 8051!)
- Others PLL boards require an external microcontroller
  - e.g., Chinese ADF4351 development boards

Why “User” Programmable Microcontrollers?

- That is; Arduinos, Raspberry Pi, WeMos, etc.
- Highly flexible and can be programmed for a wide variety of functions
  - Bus control
    - Serial Peripheral Interface (SPI), I2C bus, discrete lines
  - Morse code generator/beacon
  - Relay control
  - Position indication.....
- Inexpensive
- Wide range of supporting hardware extensions available
  - Displays
  - Switches
  - Relays……
- Very large user base with an abundance of open source software

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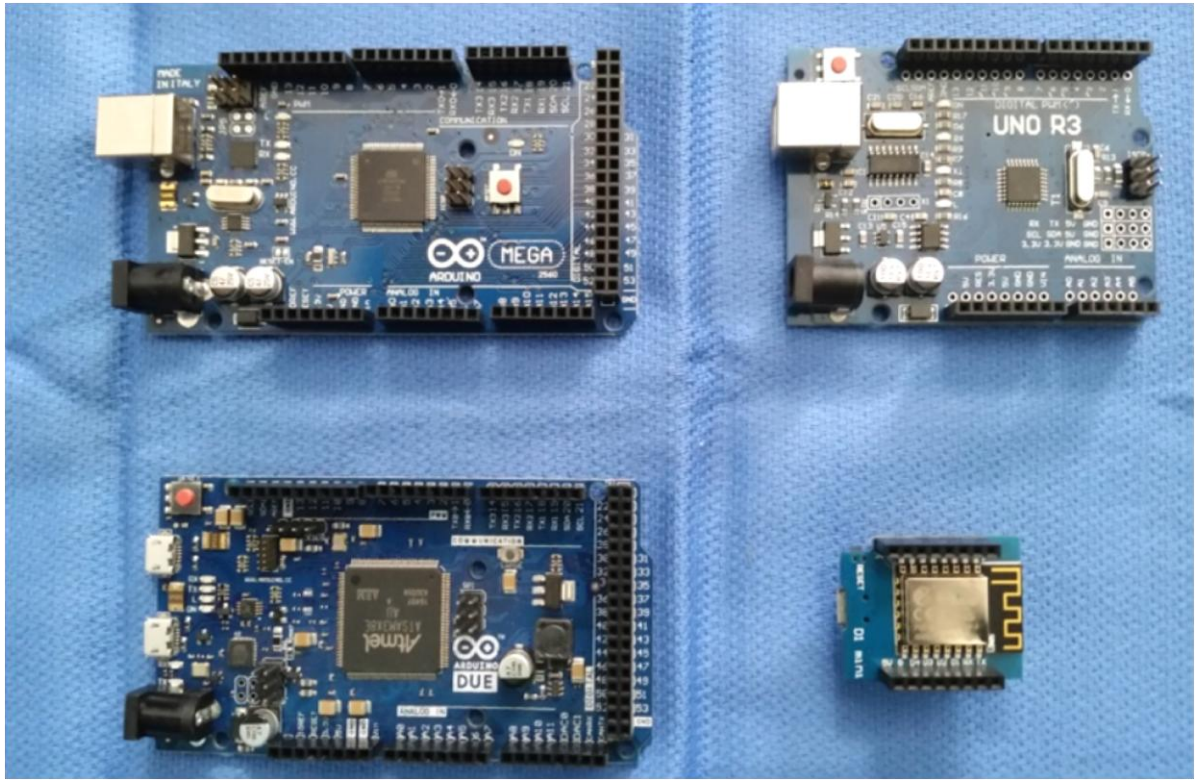
Example Microcontrollers

Arduino Mega 2560



Arduino Uno R3

Arduino Due

WeMos D1 Mini

Specifications

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Board	Mega 2560	Uno	Due	D1 Mini
Processor	ATmega2560	ATmega328P	ATSAM3X8E	ESP8266
Clock Speed (MHz)	16	16*	84	80/160
Word Length (bits)	32	8	32	32
I/O Logic Voltage	3.3	5	3.3	3.3
Analog I/O (in/out)	16/0	6/0	12/2	1/0
Digital (I/O or PWM)	54/15	14/6	54/12	11
EEPROM (KB)	4	1	0	512 bytes
SRAM (KB)	8	2	96	4 MB
Flash (KB)	256	32	512	4 MB
SPI Bus Interfaces	1	1	2	1
USB Interface	1-Regular	1-Regular	2-Micro	1-Micro

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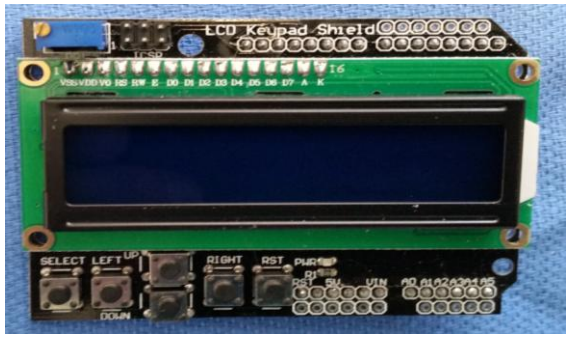
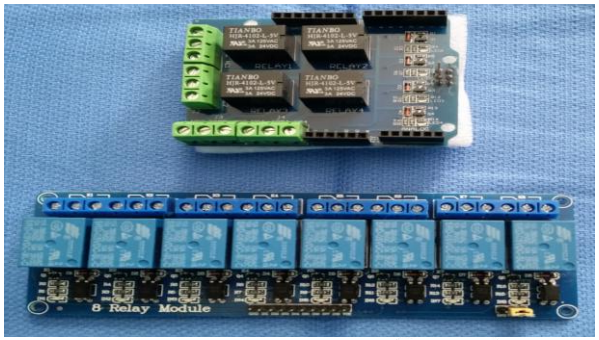
Shield Examples

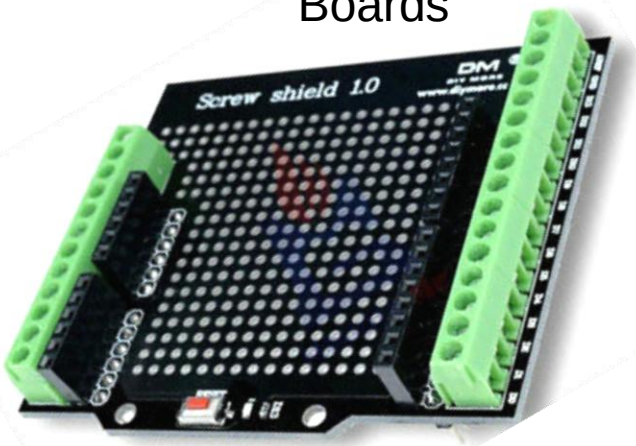


LCD Display With Switches and I/O Breakouts



Four and Eight Relay Boards

Ethernet with SD Card Reader



Prototyping Boards

Programming

- You don’t need to be a software engineer to write code for popular microcontrollers
- A lot of already programmed library functions available, for example
  - SPI bus
  - EEPROM
  - Ethernet
  - LCD display
  - Servo
  - WiFi
  - I2C…….
- Lots of open source software available
  - Often you can start with existing code and modify for your application
- The software task can be mostly one of integration
- On the other hand, the Arduino instruction set is very powerful and you can design very sophisticated programs.

Firmware

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- Firmware for Arduino microcontrollers is developed using the Arduino Integrated Development Environment (IDE)
- The Arduino IDE is freeware located at:
  https://www.arduino.cc/en/main/software
- Current version is 1.8.12
- The coding language is very much like C++
- Programs are called sketches
- The IDE facilitates:
  - Writing the sketch
  - Compiling the sketch
  - Uploading the firmware (compiled sketch) to the target Arduino Board
- A USB-A to USB-B (or micro-USB) cable from your computer to the microcontoller is used to upload the firmware

Framework for an Arduino Sketch

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1. Comments
   - Anything between /* and */
   - After // for a single line comment
   - Use to document details on how to use the sketch
2. Variables
   - A place for storing a piece of data
3. Functions
   - A procedure or subroutine that can be called from elsewhere in the sketch
4. Setup
   - Called once when the sketch starts
5. Loop
   - Repeatedly executed

Comments & Variable


```
//  ****************************************** HARDWARE IMPORTANT*************************************************
//  With an Arduino UN0 : use a resistive divider to reduce the voltage, MOSI (pin 11) to
//  ADF DATA, SCK (pin13) to ADF CLK, Select (PIN 3) to ADF LE
//  Resistive divider 560 Ohm with 1000 Ohm to ground on Arduino pins 11, 13 et 3 to adapt from 5V
//  to 3.3V the digital signals DATA, CLK and LE send by the Arduino.
//  Arduino pin 2 (for lock detection) directly connected to ADF5355 card MUXOUT.
#include <LiquidCrystal.h>
#include <SPI.h>
#define ADF4351_LE 3
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);
byte poscursor = 0; //position cursor common 0 to 15
byte line = 0; // display line in progress on LCD in cours 0 to 1
byte memoire,RWtemp; // number the EEPROM memory
uint32_t registers[6] = {0x00AA0020, 0x08008029, 0x00004E42, 0x000004B3, 0x0085003C, 0x00580005}; //3408 MHz with 10 MHz
reference
int lcd_key = 0;
int adc_key_in  = 0;
int timer = 0,timer2=0; // use to measure the time a key is pressed
unsigned int i = 0;
double RFout, REFin, INT, PFDRFout, OutputChannelSpacing, FRACF;
double RFoutMin = 35, RFoutMax = 4400, REFinMax = 250, PDFMax = 32;
unsigned int long RFint,RFintold,INTA,RFcalc,PDRFout, MOD, FRAC;
byte OutputDivider;byte lock=2;
unsigned int long reg0, reg1;
```

Functions


```
void WriteRegister32(const uint32_t value)   //Program register 32bits
{
  digitalWrite(ADF4351_LE, LOW);
  for (int i = 3; i >= 0; i--)          // loop on 4 x 8bits
  SPI.transfer((value >> 8 * i) & 0xFF); // Offset, hiding the byte and sending via SPI
  digitalWrite(ADF4351_LE, HIGH);
  digitalWrite(ADF4351_LE, LOW);
}

void SetADF4351()  // Program all the registers of the ADF4351
{ for (int i = 5; i >= 0; i--)  // program ADF4351 starting with R5
    WriteRegister32(registers[i]);
}
```

Setup & Loop

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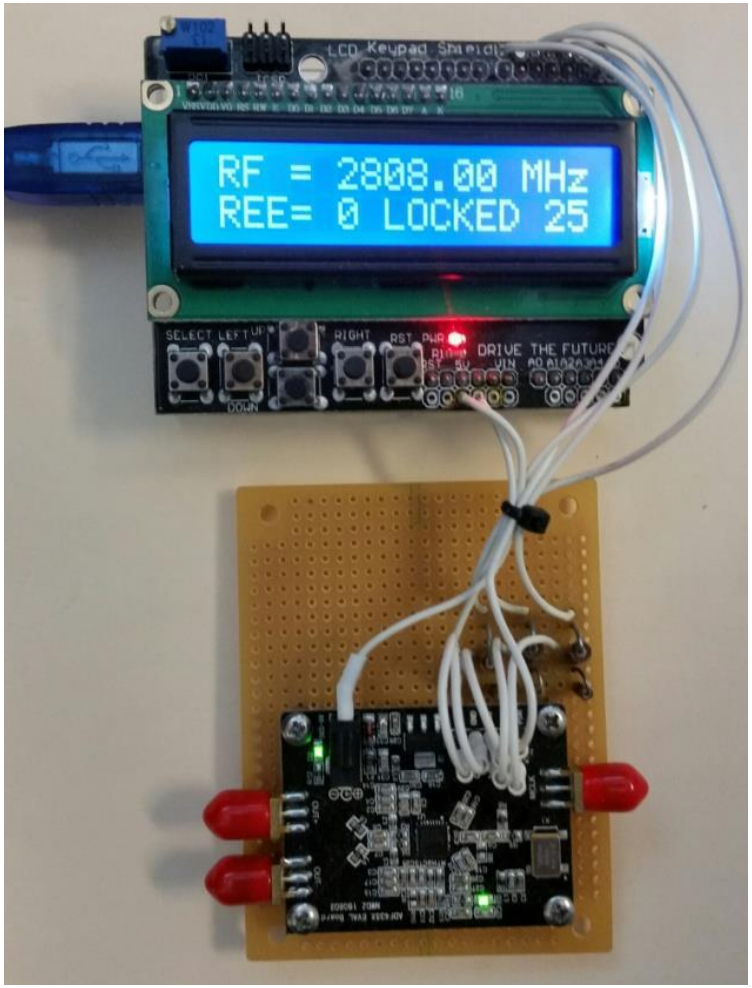
```
//********************************** Setup ***************************************
void setup() {
  lcd.begin(16, 2); // two 16 characters lines
  lcd.display();
  analogWrite(10,255); //LCD brightness
  Serial.begin (19200); //  Serial to the PC via Arduino "Serial Monitor"  at 9600
  delay(1000);
  pinMode(2, INPUT);  // PIN 2 in enter to lock
  pinMode(ADF4351_LE, OUTPUT);          // Setup pins
  digitalWrite(ADF4351_LE, HIGH);
  SPI.begin();                          // Init SPI bus
  SPI.setDataMode(SPI_MODE0);           // CPHA = 0 et Clock positive
  SPI.setBitOrder(MSBFIRST);            // poids forts in head
  SetADF4351();  // Program all the registers of the ADF4351
// End setup for ADF4351 code
  lcd.begin(16, 2);
  lcd.setCursor(0,0);
  lcd.write("AA5C RF=2556 MHz");
  lcd.setCursor(0,1);
  lcd.write("    Ref=25 MHz ");
}
// End setup
//**********************************Loop*********************************
void loop()
 {
  }   // end loop
```

ADF4351 Controller

- Analog Devices ADF4351
  - 35 MHz to 4.4 GHz Synthesizer
  - SPI Bus Controlled
  - Programmable features
- Evaluation Board
  - Mounted part
  - 3.3V Regulator
  - On-board reference oscillator
- Interface Board
  - 5V to 3.3V logic conversion
  - Breadboard space
- Arduino Uno R3 Controller
  - SPI bus control
  - Frequency selection
  - Reference selection
  - Display



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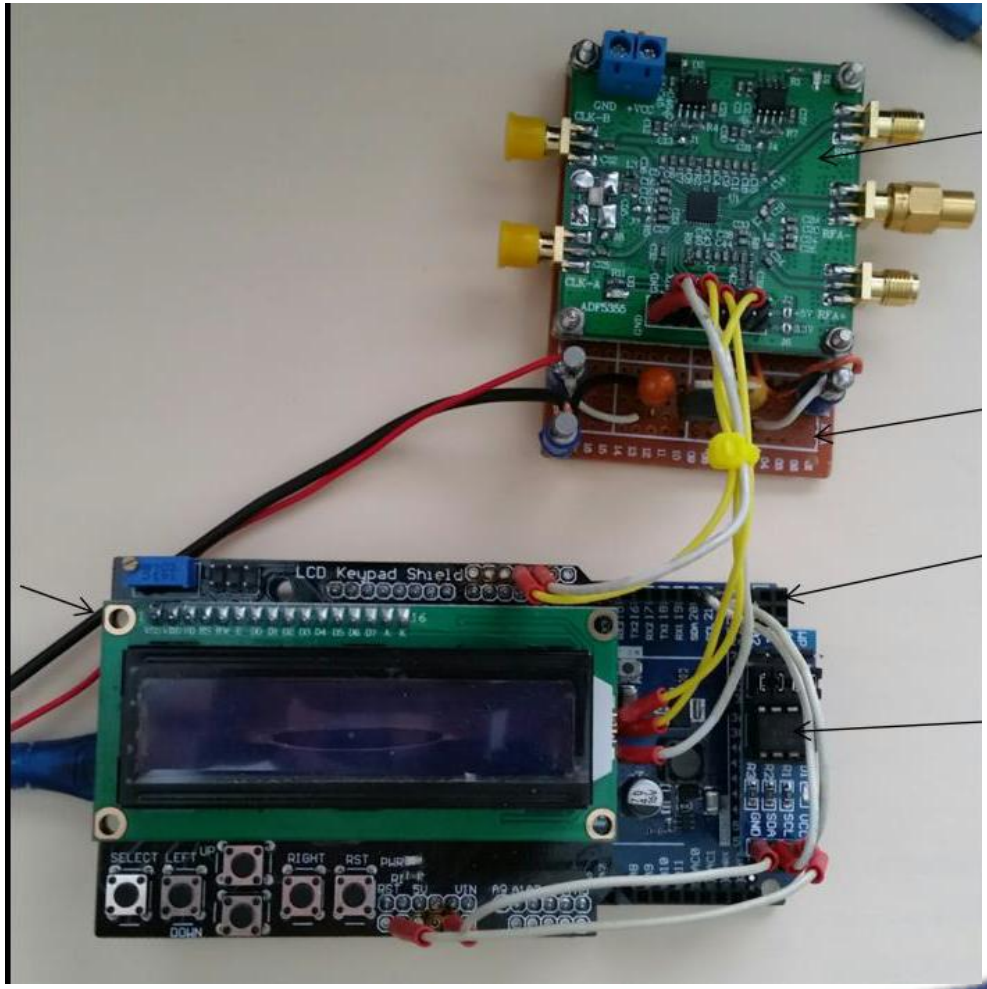
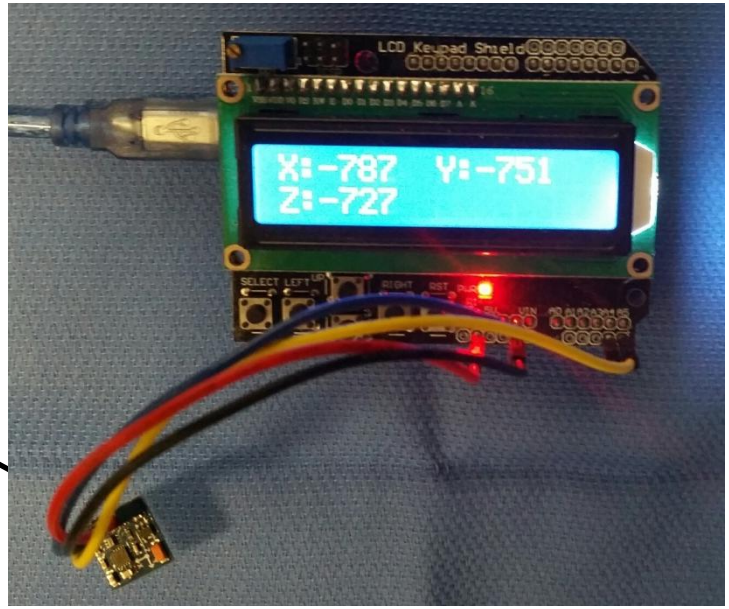
ADF5355 Controller

- Analog Devices ADF5355
  - 54 MHz to 13.4 GHz Synthesizer
  - SPI Bus Controlled
  - Programmable features
- Evaluation Board
  - Mounted part
  - 3.3V and 5V Regulators
  - On-board reference oscillator
- Interface Board
  - Regulator
  - Breadboard space
- Arduino Due Controller
  - SPI bus control
  - Frequency selection
  - Reference selection
  - Display



Position Indication

- HMC5388L 3 Axis Magnetic Compass
  - GY-271 module
- UNIK MPU-9250 9DOF Module
  - Nine-axis Attitude Gyro
  - Compass Acceleration
  - Magnetic Field Sensor
- Both Modules Controlled via an I2C Interface



Calibration in the Target Application Required
- Sensitive to Ferrous Materials

Summary

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- Low Cost Microcontrollers Can Be Used for a Wide Range of Functions
  - Controllers
  - Indicators
  - Sensors
- Many Different Supporting Hardware Devices/Shields Available
- Large base of Open Source Software Available
  - Minimizes the Amount of Unique Programming Required
  - Generic Functions, e.g.,
    - SPI bus control, I2C bus control
    - External EEPROM
  - Application Specific Functions, e.g.,
    - Synthesizer Control
    - Rotor Control
    - Az/El Indicators

Next Meeting – NanoVNA V2

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