International Journal of Innovative Research in Engineering
Volume 4, Issue 2 (March-April 2023), PP: 336-347.
www.theijire.com **ISSN No: 2582-8746**

Voice Controlled Home Automation System Using Alexa

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How to cite this paper:
Datchinamoorthi M[1], JuttigaNishant[2], Dinesh Kanna B[3], Keerthana Devi G[4], "Voice Controlled Home Automation System Using Alexa", IJIRE-V4I02-336-347.

Abstract: *The perky voice of Amazon's digital assistant Alexa can now be heard across millions of homes. The company's Echo smart speaker range and other Alexa devices have expanded rapidly in just a few years, spawning countless fans. While Alexa is useful alone if you need urgent questions answered or want to place an Amazon order there's a whole world of opportunities if you pair it with a compatible device or two. We have rounded up the best Alexa-compatible devices on the market, including add-on products and those that come with the digital assistant built-in. The Alexa "skill" takes over handling of the command; normally it results in a response being sent back to the Alexa device, causing it to say something to the user in response. In the case of Alexa IoT, the command gets routed to a "device shadow" on Amazon's cloud, which in the end results in a response being sent to some other device in your home. We are bypassing all that with our hack. We want to make the Alexa device talk directly to our ESP8266 chip, inside of our home, without sending anything out to the cloud and back. We want the Alexa to directly send a request to our ESP8266, over and inside of our home Wi-Fi network only. Ere we will Amazon's digital assistant install in the wi-fi module and esp8266 will be attached with a mike which takes all the voice commands through which it will automatically control the home alliances. As the user give the voice command to the mike according to that the home appliances can be switched ON/OFF accordingly.*

Key Word: *Smart Home; Microcontrollers; Alexa; ESP8266.*

I.OBJECTIVE

To design and implement an automated load control system for smart home management using digital Alexa assistant.

II.PROPOSED SYSTEM

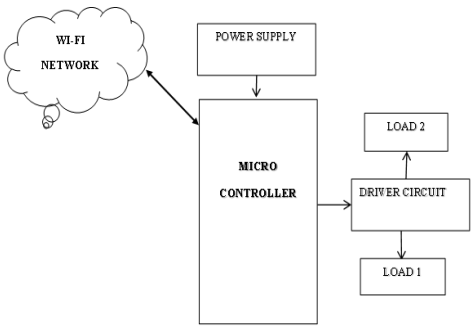
In this proposed system, we are using Alexa will respond to our voice commands. According to the voice inputs we can able to communicate with the Alexa assistant and we can control the home appliances through voice commands.Esp32 is linked with Alexa account which is connected to the amazon cloud. Home appliances like BULB, FAN and MOTOR are connected to the driver circuit. Connect power supply for esp8266. And also Alexa will able to communicate with internet for all in one Alexa application.

III.ADVANTAGES

- Control your smart home
- Control your lights. You can ask Alexa to turn lights on or off.
- Open or close your garage door. Smart garage door openers.
- Get the news
- Learn about more features

IV.BLOCK DIAGRAM

Control Home Section:



V.HARDWARE REQUIRED

- ESP32
- USB MIKE
- BULB
- MOTOR

VI.SOFTWARE REQUIRED

- ARDUINO IDE
- ALEXA ASSISTANT.
- EMBEDDED C

VII.HARDWARE DESCRIPTION

Microcontroller
ESP32
Introduction

Arduino is a great platform for beginners into the World of Microcontrollers and Embedded Systems. With a lot of cheap sensors and modules, you can make several projects either as a hobby or even commercial.

As technology advanced, new project ideas and implementations came into play and one concept is the Internet of Things or IoT. It is a connected platform, where several "things" or devices are connected over internet for exchange of information.

In DIY community, the IOT projects are mainly focused on Home Automation and Smart Home applications but commercial and industrial IoT projects have far complex implementations like Machine Learning, Artificial Intelligence, Wireless Sensor Networks etc.

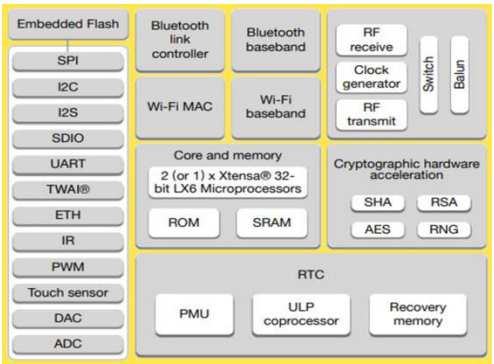
The important thing in this brief intro is whether it is a small DIY project by a hobbyist or a complex industrial project, any IoT project must have connectivity to Internet. This is where the likes of ESP8266 and ESP32 come into picture.

If you want to add Wi-Fi connectivity to your projects, then ESP8266 is a great option. But if you want build a complete system with Wi-Fi connectivity, Bluetooth connectivity, high resolution ADCs, DAC, Serial Connectivity, and many other features, then ESP32 is the ultimate choice.

What is ESP32?

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espress if Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth.

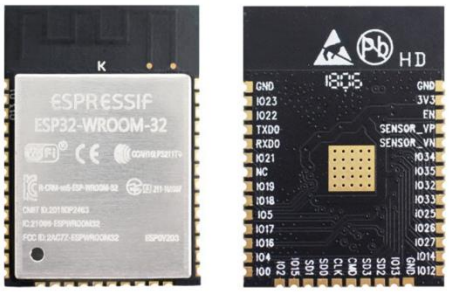
The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as you require very few external components.



Another important thing to know about ESP32 is that it is manufactured using TSMC's ultra-low-power 40 nm technology. So, designing battery operated applications like wear ables, audio equipment, baby monitors, smart watches, etc., using ESP32 should be very easy.

General Description:

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a TensilicaXtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process.



Specifications of ESP32

ESP32 has a lot more features than ESP8266 and it is difficult to include all the specifications in this Getting Started with ESP32 guide. So, I made a list of some of the important specifications of ESP32 here. But for complete set of specifications, I strongly suggest you to refer to the Datasheet.

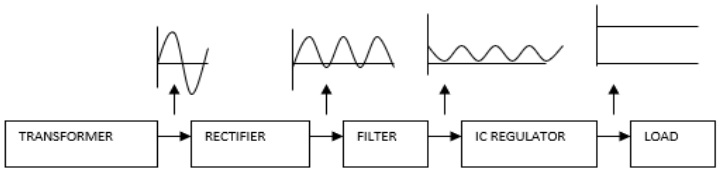
- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.
- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

Power Supply

Block Diagram

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.



Block Diagram of Power supply

Working principle

Transformer

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

Bridge rectifier

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. The positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow the path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. This path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and

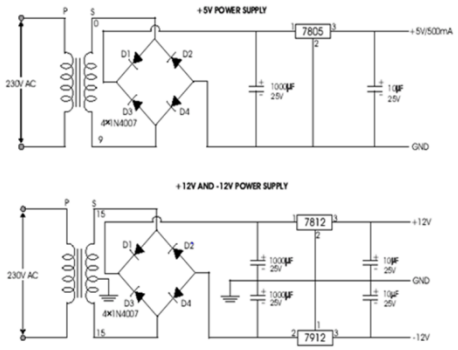
reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier. One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. In the conventional full-wave circuit shown—in view A, the peak voltage from the center tap to either X or Y is 500 volts. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts.

The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 v0lts, as result of the small voltage drop across the diode. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage, which is 1000 volts. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit.

IC voltage regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.



Circuit Diagram of Power Supply

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

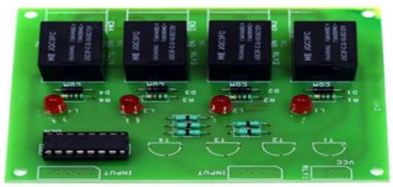
Relay Board

General Description

Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. They were used to switch the signal coming from one source to another destination. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors.

Product Description

A relay is an electromechanical switch which is activated by an electric current. A four relay board arrangement contains driver circuit, power supply circuit and isolation circuit. A relay is assembled with that circuit. The driver circuit contains transistors for switching operations. The transistor is use for switching the relay. An isolation circuit prevents reverse voltage from the relay which protects the controller and transistor from damage. The input pulse for switching the transistor is given from the microcontroller unit. It is used for switching of a four device.



Features
- Input voltage: 12VDC
- Driver unit: ULN2003A
- Isolation unit: In4007
- Fast switching
- Motor forward and reverse operation

Applications
- Ac load Switching applications
- Dc load Switching applications
- Motor switching applications

Dc Motor:

General Description

The relationship between torque vs speed and current is linear as shown left; as the load on a motor increases, Speed will decrease. The graph pictured here represents the characteristics of a typical motor. As long as the motor is used in the area of high efficiency (as represented by the shaded area) long life and good performance can be expected. However, using the motor outside this range will result in high temperature rises and deterioration of motor parts. A motor's basic rating point is slightly lower than its maximum efficiency point. Load torque can be determined by measuring the current drawn when the motor is attached to a machine whose actual load value is known.

Product Description

Geared dc motors can be defined as an extension of dc motors. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. A DC motor can be used at a voltage lower than the rated voltage. But, below 1000 rpm, the speed becomes unstable, and the motor will not run smoothly.

Features
- Supply voltage: 12VDC
- Speed: 60rpm
- Long Lifetime, Low Noise, Smooth Motion
- Equipped with high efficiency

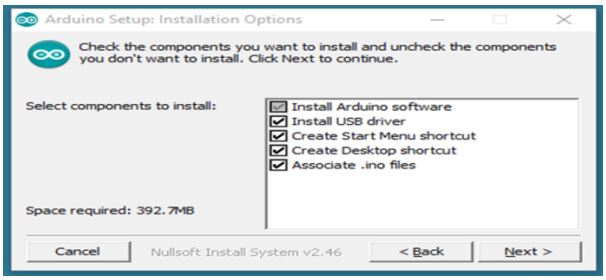
Applications
- Coin Changing equipment
- Peristaltic Pumps
- Damper Actuators
- Fan Oscillators
- Photo copier
- Ticket printer

Software Description

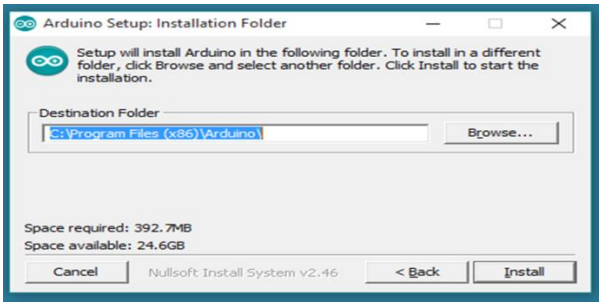
Arduino Software (IDE)

Get the latest version from the download page. You can choose between the Installer (.exe) and the Zip packages. We suggest you use the first one that installs directly everything you need to use the Arduino Software (IDE), including the drivers. With the Zip package you need to install the drivers manually. The Zip file is also useful if you want to create a portable installation.

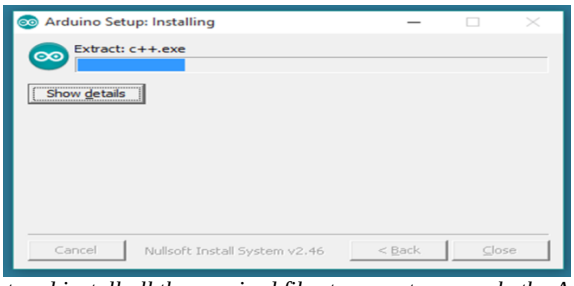
When the download finishes, proceed with the installation and please allow the driver installation process when you get a warning from the operating system.



Choose the components to install



Choose the installation directory (we suggest to keep the default one)



The process will extract and install all the required files to execute properly the Arduino Software (IDE)

Arduino Boot loader Issue

The current boot loader burned onto the Arduino UNO is not compatible with ROBOTC. In its current form, you will be able to download the ROBOTC Firmware to the Arduino UNO, but you will not able to download any user programs.

The reason for this is because there is a bug in the Arduino UNO firmware that does not allow flash write commands to start at anywhere but the beginning of flash memory (0x000000). See the bottom of this page for more technical details.

Because ROBOTC is not able to burn a new bootloader as of today, you will need to use the Arduino's Open Source language with a modified boot loader file to re-burn your bootloader on your Arduino UNO boards. The enhanced boot loader is backwards compatible with the original one. That means you'll still be able to program it through the Arduino programming environment as before, in addition to ROBOTC for Arduino.

Hardware Needed

To burn a new version of the Arduino boot loader to your UNO, you'll need an AVR ISP Compatible downloader.
Using an AVR ISP (In System Programmer)

- Your Arduino UNO (to program)
- An AVR Programmer such as the AVR Pocket Programmer
- An AVR Programming Cable (the pocket programmer comes with one)

If you have extra Arduino boards, but no ISP programmer, SparkFun.com has a cool tutorial on how to flash a boot loader using an Arduino as an ISP.

Using another Arduino as an ISP

- Your Arduino UNO (to program)
- A Working Arduino (doesn't matter what kind)
- Some Male-to-Male Jumper Cables

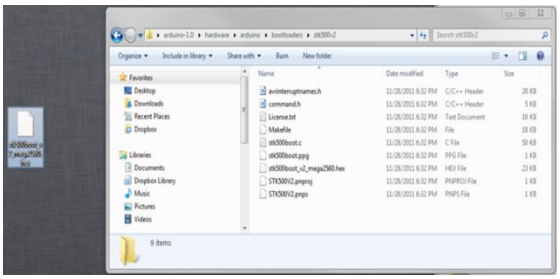
For instructions on this method, take a look at the SparkFun.com website: http://www.sparkfun.com/tutorials/247

Software Needed

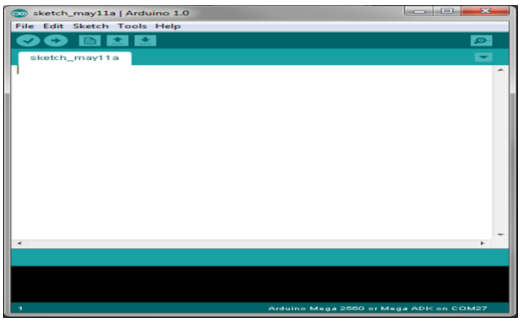
ROBOTC is not currently able to burn a boot loader onto an Arduino board, so you'll need to download a copy of the latest version of the Arduino Open-Source programming language.

- Arduino Official Programming Language - Download Page
  In addition, you'll need the ROBOTC modified boot loader. You can download that here:

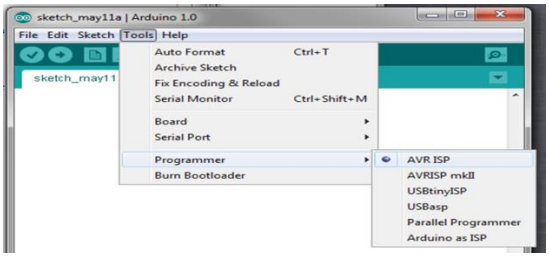
- ROBOTC Modified UNO Boot loader - Modified Boot loader
  Boot load Download Instructions
- Download the Arduino Open Source Software and a copy of the Modified Boot loader File
- Copy the Modified Boot loader File into the /Arduino-1.0/hardware/arduino/boot loaders/stk500v2/ and overwrite the existing boot loader.



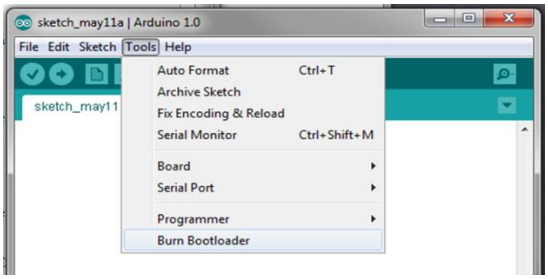
- Power up your Arduino UNO (either via USB or external power)
- Plug in your AVR ISP Programmer to your computer (make sure you have any required drivers installed)
- Connect your AVR ISP Programmer into your Arduino UNO Board via the ISP Header (the 2x3 header pins right above the Arduino Logo)
- Launch the Arduino Open Source Software



- Change your settings in the Arduino Software to look for an Arduino UNO
- Change your settings in the Arduino Software to select your ISP Programmer Type (Check your programmer's documentation for the exact model)



- Select the "Burn Boot loader" option under the "Tools" menu. The modified boot loader will now be sent to your Arduino. This typically take a minute or so.



- You should be all set to download ROBOTC firmware and start using your Arduino UNO with ROBOTC.

Technical Details

The Arduino Boot loader sets the "erase Address" to zero every time the boot loader is called. ROBOTC called the "Load Address" command to set the address in which we want to write/verify when downloading program.

When writing a page of memory to the arduino, the Arduino boot loader will erase the existing page and write a whole new page.

In the scenario of downloading firmware, everything is great because the Erase Address and the Loaded Address both start at zero.

In the scenario of writing a user program, we start writing at memory location 0x7000, but the Boot loader erases information starting at location zero because the "Load Address" command does not update where to erase.

Our modification is to set both the Load Address and the Erase Address so the activity of writing a user program does not cause the firmware to be accidentally erased.

Summary

Microcontroller	Arduino UNO
Operating Voltage	5V Input Voltage (recommended)
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40mA
DC Current for3.3VPin	50mA
Flash Memory	256 KB of which 8 KB used by boot loader
SRAM	8KB
EEPROM	4KB
Lock Speed	16MHz

The Arduino UNO can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

They differ from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the programmed as a USB-to-serial converter.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it is using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via a non-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3.A3.3voltsupplygeneratedbytheon-boardregulator.Maximumcurrentdrawis50mA.
- GND. Ground pins.

The ATMEGA has 256 KB of flash memory for storing code (of which 8 KB is used for the boot loader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Each of the 54 digital pins on the Mega can be used as an input or output, using pin Mode (), digital Write (), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50k Ohms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATMEGA USB-to-TTL Serial chip.
- External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a changing value. See the attach Interrupt() function for details.
- PWM: 0to13. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- I2C: 20 (SDA) and 21 (SCL). Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove.

The Arduino UNO has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analog Reference() function.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analog Reference().
- eset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino UNO has a few facilities for communicating with a computer, another Arduino, or other microcontrollers. The Arduino UNO provides four hardware UARTs for TTL (5V) serial communication.

An ATMEGA on the board channels one of these over USB and provides a virtual comport to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and1).

A Software Serial library allows for serial communication on any of the digital pins.

The Arduino UNO also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. To use the SPI communication, please see the Arduino UNO datasheet.

Programming

The Arduino UNO can be programmed with the Arduino software (download). For details, see the reference and tutorials.

The Arduino UNO on the Arduino UNO comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino UNO is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the Arduino UNO via a 100 nano-farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Arduino UNO is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the UNO. While it is programmed to ignore malformed data (i.e., anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It is labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110-ohm resistor from 5V to the reset line; see this forum thread for details.

USB Over current Protection

Physical Characteristics and Shield Compatibility

The Arduino UNO has a resettable poly fuse that protects your computer's USB ports from shorts and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. Ifmore than500mAisappliedtotheUSBport, the fuse will automatically break the connection until the short or overload is removed.

The maximum length and width of the UNO PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

The UNO is designed to be compatible with most shields designed for the Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega and Duemilanove / Diecimila.

Please note that I2C is not located on the same pins on the Mega (20and21) as the Duemilanove / Diecimila (analog inputs 4 and 5).

How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g., Flash, Processing, MaxMSP).

Arduino is a cross-platform program. You will have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. http://arduino.cc/en/Guide/HomePage

Once you have downloaded/unzipped the arduino IDE, you can plug the Arduino to your PC via USB cable.

Embedded C

About Embedded C

High-level language programming has long been in use for embedded-systems development. However, assembly programming still prevails, particularly for digital-signal processor (DSP) based systems. DSPs are often programmed in assembly language by programmers who know the processor architecture inside out. The key motivation for this practice is performance, despite the disadvantages of assembly programming when compared to high-level language programming.

If the video decoding takes 80 percent of the CPU-cycle budget instead of 90 percent, for instance, there are twice as many cycles available for audio processing. This coupling of performance to end-user features is characteristic of many of the real-time applications in which DSP processors are applied. DSPs have a highly specialized architecture to achieve the performance requirements for signal processing applications within the limits of cost and power consumption set for consumer applications. Unlike a conventional Load-Store (RISC) architecture, DSPs have a data path with memory-access units that directly feed into the arithmetic units. Address registers are taken out of the general-purpose register file and placed next to the memory units in a separate register file.

A further specialization of the data path is the coupling of multiplication and addition to form a single cycle Multiply-accumulate unit (MAC). It is combined with special-purpose accumulator registers, which are separate from the general-purpose registers. Data memory is segmented and placed close to the MAC to achieve the high bandwidths required to keep up with the streamlined data path. Limits are often placed on the extent of memory-addressing operations. The localization of resources in the data path saves many data movements that typically take place in a Load-Store architecture.

The most important, common arithmetic extension to DSP architectures is the handling of saturated fixed-point operations by the arithmetic unit. Fixed-point arithmetic can be implemented with little additional cost over integer arithmetic. Automatic saturation (or clipping) significantly reduces the number of control-flow instructions needed for checking overflow explicitly in the program. Changes in technological and economic requirements make it more expensive to continue programming DSPs in assembly. Staying with the mobile phone as an example, the signal-processing algorithms required become increasingly complex. Features such as stronger error correction and encryption must be added. Communication protocols become more sophisticated and require much more code to implement. In certain markets, multiple protocol stacks are implemented to be compatible with multiple service providers. In addition, backward compatibility with older protocols is needed to stay synchronized with provider networks that are in a slow process of upgrading.

Today, most embedded processors are offered with C compilers. Despite this, programming DSPs is still done in assembly for the signal processing parts or, at best, by using assembly-written libraries supplied by manufacturers. The key reason for this is that although the architecture is well matched to the requirements of the signal-processing application, there is no way to express the algorithms efficiently and in a natural way in Standard C. Saturated arithmetic.

For example, is required in many algorithms and is supplied as a primitive in many DSPs. However, there is no such primitive in Standard C. To express saturated arithmetic in C requires comparisons, conditional statements, and correcting assignments. Instead of using a primitive, the operation is spread over a number of statements that are difficult to recognize as a single primitive by a compiler.

Description

Embedded C is designed to bridge the performance mismatch between Standard C and the embedded hardware and application architecture. It extends the C language with the primitives that are needed by signal-processing applications and that are commonly provided by DSP processors. The design of the support for fixed-point data types and named address spaces in Embedded C is based on DSP-C. DSP-C [1] is an industry-designed extension of C with which experience was gained since 1998 by various DSP manufacturers in their compilers. For the development of DSP-C by ACE (the company three of us work for), cooperation was sought with embedded-application designers and DSP manufacturers.

The Embedded C specification extends the C language to support freestanding embedded processors in exploiting the multiple address space functionality, user-defined named address spaces, and direct access to processor and I/O registers. These features are common for the small, embedded processors used in most consumer products. The features introduced by Embedded C are fixed-point and saturated arithmetic, segmented memory spaces, and hardware I/O addressing. The description we present here addresses the extensions from a language-design perspective, as opposed to the programmer or processor architecture perspective.

Multiple Address Spaces

Embedded C supports the multiple address spaces found in most embedded systems. It provides a formal mechanism for C applications to directly access (or map onto) those individual processor instructions that are designed for optimal memory access. Named address spaces use a single, simple approach to grouping memory locations into functional groups to support MAC buffers in DSP applications, physical separate memory spaces, direct access to processor registers, and user-defined address spaces.

The Embedded C extension supports defining both the natural multiple address space built into a processor's architecture and the application-specific address space that can help define the solution to a problem.

Embedded C uses address space qualifiers to identify specific memory spaces in variable declarations. There are no predefined keywords for this, as the actual memory segmentation is left to the implementation. As an example, assume that X and Y are memory qualifiers. The definition:

X int a[25] ;

Means that a is an array of 25 integers, which is located in the X memory. Similarly (but less common):

X int * Y p ;

Means that the pointer p is stored in the Y memory. This pointer points to integer data that is located in the X memory. If no memory qualifiers are used, the data is stored into unqualified memory.

For proper integration with the C language, a memory structure is specified, where the unqualified memory encompasses all other memories. All unqualified pointers are pointers into this unqualified memory. The unqualified memory abstraction is needed to keep the compatibility of the void * type, the NULL pointer, and to avoid duplication of all library code that accesses memory through pointers that are passed as parameters.

Named Registers

Embedded C allows direct access to processor registers that are not addressable in any of the machine's address spaces. The processor registers are defined by the compiler-specific, named-register, storage class for each supported processor. The processor registers are declared and used like conventional C variables (in many cases volatile variables). Developers using Embedded C can now develop their applications, including direct access to the condition code register and other processor-specific status flags, in a high-level language, instead of inline assembly code.

Named address spaces and full processor access reduces application dependency on assembly code and shifts the responsibility for computing data types, array and structure offsets, and all those things that C compilers routinely and easily do from developers to compilers.

I/O Hardware Addressing

The motivation to include primitives for I/O hardware addressing in Embedded C is to improve the portability of device-driver code. In principle, a hardware device driver should only be concerned with the device itself. The driver operates on the device through device registers, which are device specific. However, the method to access these registers can be very different on different systems, even though it is the same device that is connected. The I/O hardware access primitives aim to create a layer that abstracts the system-specific access method from the device that is accessed. The ultimate goal is to allow source-code portability of device drivers between different systems. In the design of the I/O hardware-addressing interface, three requirements needed to be fulfilled:

1. The device-drive source code must be portable.
2. The interface must not prevent implementations from producing machine code that is as efficient as other methods.
3. The design should permit encapsulation of the system-dependent access method.

The design is based on a small collection of functions that are specified in the <iohw.h> include file. These interfaces are divided into two groups; one group provides access to the device, and the second group maintains the access method abstraction itself.

To access the device, the following functions are defined by Embedded C:

```
unsigned int iord(  ioreg_designator );
void iowr (  ioreg_designator, unsigned int value );
void ioor (  ioreg_designator, unsigned int value );
void ioand ( ioreg_designator, unsigned int value );
void ioxor ( ioreg_designator, unsigned int value );
```

These interfaces provide read/write access to device registers, as well as typical methods for setting/resetting individual bits. Variants of these functions are defined (with buf appended to the names) to access arrays of registers. Variants are also defined (with l appended) to operate with long values.

All of these interfaces take an I/O register designator ioreg_designator as one of the arguments. These register designators are an abstraction of the real registers provided by the system implementation and hide the access method from the driver source code. Three functions are defined for managing the I/O register designators. Although these are abstract entities for the device driver, the driver does have the obligation to initialize and release the access methods. These functions do not access or initialize the device itself because that is the task of the driver. They allow, for example, the operating system to provide a memory mapping of the device in the user address space.

```
void iogroup_acquire( iogrp_designator );
void iogroup_release( iogrp_designator );
void iogroup_map( iogrp_designator, iogrp_designator );
```

The iogrp_designator specifies a logical group of I/O register designators; typically, this will be all the registers of one device. Like the I/O register designator, the I/O group designator is an identifier or macro that is provided by the system implementation. The map variant allows cloning of an access method when one device driver is to be used to access multiple identical devices.

Embedded C Portability

By design, a number of properties in Embedded C are left implementation defined. This implies that the portability of Embedded C programs is not always guaranteed. Embedded C provides access to the performance features of DSPs. As not all processors are equal, not all Embedded C implementations can be equal for example, suppose an application requires 24-bit fixed-point arithmetic and an Embedded C implementation provides only 16 bits because that is the native size of the processor. When the algorithm is expressed in Embedded C, it will not produce outputs of the right precision.

In such a case, there is a mismatch between the requirements of the application and the capabilities of the processor. Under no circumstances, including the use of assembly, will the algorithm run efficiently on such a processor. Embedded C cannot overcome such discrepancies. Yet, Embedded C provides a great improvement in the portability and software engineering of embedded applications. Despite many differences between performance-specific processors, there is a remarkable similarity in the special-purpose features that they provide to speed up applications.

Writing C code with the low-level processor-specific support may at first appear to have many of the portability problems usually associated with assembly code. In the limited experience with porting applications that use Embedded C extensions, an automotive engine controller application (about 8000 lines of source) was ported from the eTPU, a 24-bit special-purpose processor, to a general-purpose 8-bit Free scale 68S08 with about a screen full of definitions put into a single header file. The porting process was much easier than expected. For example, variables that had been implemented on the processor registers were ported to unqualified memory in the general-purpose microprocessor by changing the definitions in the header definition and without any actual code modifications. The exercise was to identify the porting issues and it is clear that the performance of the special-purpose processor is significantly higher than the general-purpose target.

VIII.CONCLUSION

This project covers most important feature, in which it could provide the complete smart home environment. The voice controlled home automation using ESP32 is projected for the easy use and control of electronic devices by old age and disabled people. This project provides a basic system of home automation which can be easily implemented and used effectively.

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