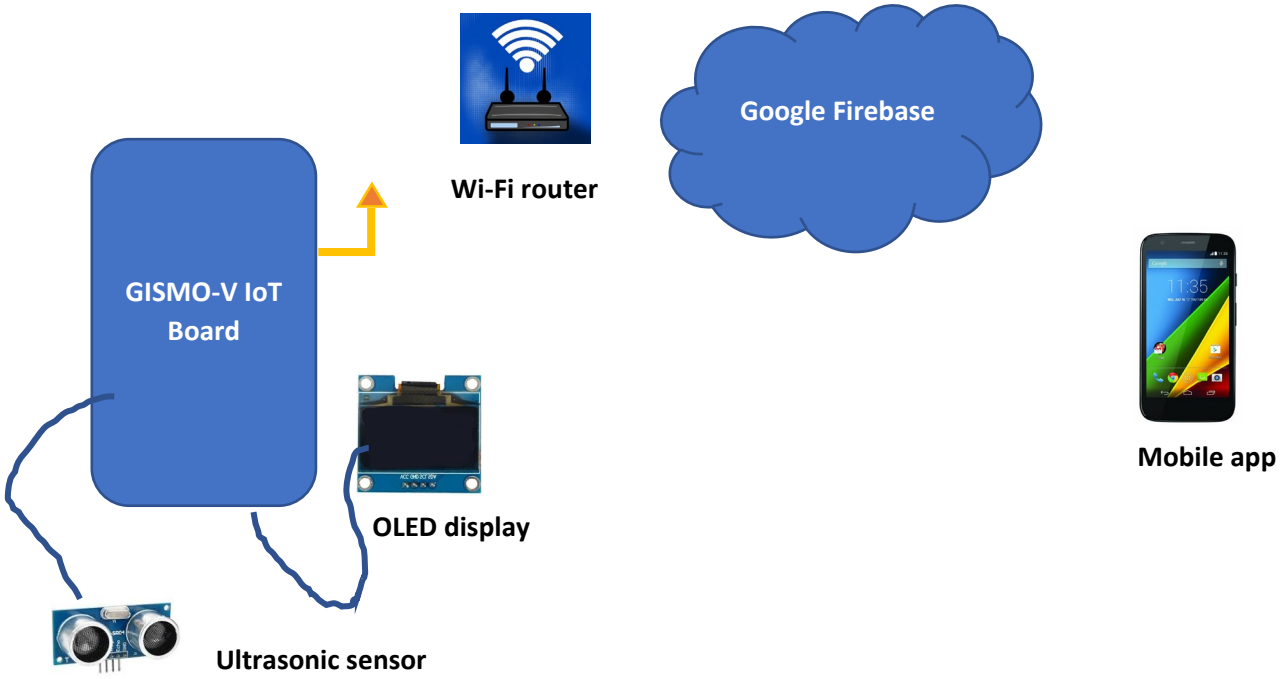
Project: Remote Range Meter using IoT

Document: Design Document

Description

The project aims to display the distance between the unit and an obstacle, the range at which the obstacle is located remotely on the mobile phone of the user. The project uses an ultrasonic sensor module HC-SR04 to transmit and receive ultrasonic waves reflected off an obstacle and based on the time elapsed compute the range. The ultrasonic sensor will be interfaced with an ESP32 controller. The ESP32 controller is a 32-bit dual core processor with Wi-Fi and Bluetooth capabilities built on-chip. The Wi-Fi capability is used to join a Wi-Fi network and connect to the Internet. The range parameter is pushed to a cloud database – Google's Firebase which is created for the project. The database credentials – the host URL and the database authentication key are to be fed into the firmware. The Firebase database is a key-value based database and using the Firebase credentials and the key the values are accessed and displayed in the mobile app of the user.

The different components in the project are:



Hardware

The hardware for the project consists of:

- GISMO-V board with:
    - ESP32 dual-core 32-bit processor with Wi-Fi and BLE
    - HC-SR04 Ulrasonic Distance Sensor Module
    - 0.96” OLED display with 128x64 resolution

The HC-SR 04 ultrasonic sensor module has an ultrasonic transmitter and receiver. It operates on 5V supply and has the following pins:

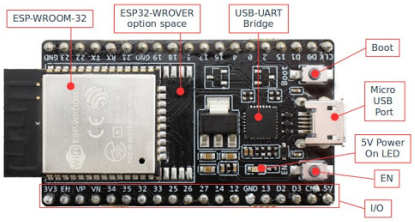
- VCC :5V
- Trigger: A trigger pulse of 10 microseconds needs to be sent to the trigger pulse. This will make the module transmit a train of ultrasonic pulses
- Echo: The echo pin will go high when the ultrasonic pulses are transmitted and will go low when the echoed ultrasonic pulses are received back
- GND

The trigger pin is connected to GPIO25 of ESP32

The echo pin will be at 5V level and will need to be level translated before connecting to the ESP32. This level translation is done using a potential divider circuit with 10K and 5.6K resistors in the two legs of the potential divider. The junction of the potential divider circuit is connected to GPIO26 of ESP32

The OLED display is a graphic display with I2C interface to the microcontroller. The SCL and SDA lines of the OLED display are connected to GPIO22 and GPIO21 pins of the ESP32. These are the I2C pins of the ESP32. The supply voltage for the OLED display is 3.3V

The ESP32 development board used is the ESP32 Dev Kit. The ESP32 board has a micro USB for programming, powering up and for transfer of data on serialline to and from the laptop. It has an on-board LED connected to GPIO2 which can be used for debugging purposes. It has a RESET and a BOOT button. The BOOT button needs to be kept pressed while downloading the program to the board. The Dev Kit also has 4 MB of external flash memory.



Firmware

The Arduino IDE is used to develop the firmware. The ESP32 board support package is downloaded and added to the existing boards in the IDE. The particular board to be selected is the ESP32 Dev Kit. The firmware can be divided into the following blocks:

- Sensor interface
- OLED display interface
- Internet connectivity
- Cloud database interface

Sensor interface:

No library is used for the interface to the ultrasonic sensor. GPIO25 to which the trigger pin is connected is made an output and a 10-microsecond pulse is sent on the trigger pin.

GPIO26 connected to the echo pin is declared as an input and the pulseIn Arduino function is used to measure the pulse width of the pulse on the echo pin

The pulseIn returns the pulse width in microseconds. Using this timing value, and the speed of sound, the distance to the obstacle is calculated

OLED display interface:

The two libraries used for the OLED display interface are:

Wire,h : For basic I2C interface

SSD1306.h: For display specific functions

The SSD1306 library provides a SSD1306 class. An object belonging to that class is created with the following initialization parameters:

- 7-bit I2C address of the display (0x3c)
- SCL pin of microcontroller (22)
- SDA pin of microcontroller (21)

The functions supported by the SSD1306 class are:

- init(): For initialization
- setFont(); Takes the font as a parameter. The font will decide the size of the text that will be displayed. The fonts supported are:
    - ArialMT_Plain_10
    - ArialMT_Plain_16
    - ArialMT_Plain_24
- clear(): For clearing the display
- drawSring(0,0,"fgfhgfhfhfh"): Takes three parameters – the x, y co-ordinates of the strat of the string and the string to be displayed
- display(): No parameters. The memory buffer is transferred to display

Internet connectivity

The in-built WiFi object is used to connect to the WiFi network. The WiFi object has the following functions:

- begin(): Takes two parameters:
    - SSID of the WiFi network to which we want to connect
    - Password of the WiFi network
- status(): Tells us whether the ESP32 is connected to the WiFi network or not.
- localIP(): The IP address dynamically assigned to the ESP32 by the access point (router)

Cloud database access

The cloud database used in the project is Google's Firebase. It is a No-SQL database in which data is stored as Key-Value pairs. The following are the credentials of the database required for access:

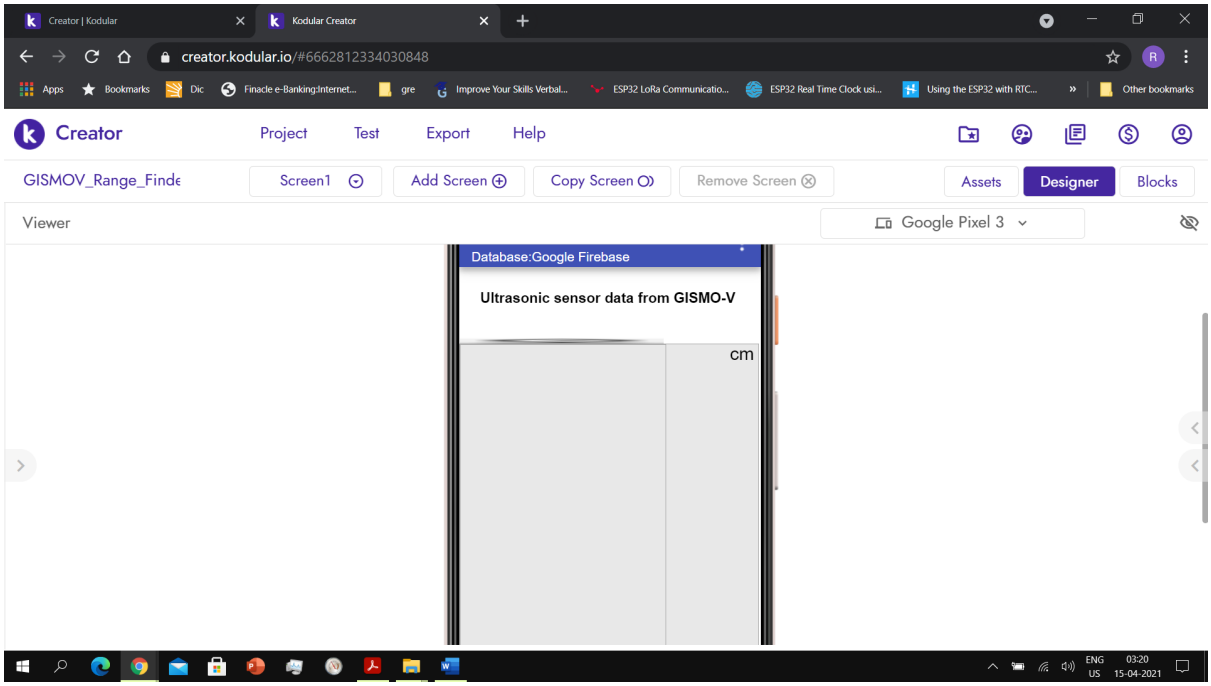
- Host URL
- Database authentication key

These credentials will be put in the ESP32 firmware to access the Google Firebase. The key used to store the range values in the project are:

- IOTLAB/Range_Meter/Range

Mobile App development

The Kodular rapid mobile app development utility is used for mobile app development. The utility has a Developer mode and a Blocks mode. In the Developer mode, there are different functional blocks available – User Interface, Sensors, Connectivity, Firebase, and so on. The UI gets defined in the Developer mode as under :



In the Blocks mode, a timer with timing set to 2 seconds will fetch the temperature and humidity values from the Firebase database and fill it in the appropriate place in the UI. To access the Firebase datase its credentials will be put in the Firebase component