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Practical engineering, electronics & SW

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Smart home - IOT Controller

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Smart Home - IOT Controller

06/06/19 Shavit class School of Engineering in Electronics (Software)

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משרד העבודה הרווחה
והשירותים החברתיים
האגף להכשרה מקצועית
ופיתוח כח אדם

Mahat - the government institute
for training professions

The national school
For the major engineers
for electronics

Subject description:

The project implements a home lighting system with 3 main layers:

1. Interior lighting - represents home lighting of rooms, realized through switches in the application and on the board.

2. Yard lighting - based on RTC and allows the lighting to be turned on and off according to the time of day (automatically).

3. Parking lighting - based on a proximity sensor, allows the lighting to be turned on and off with identification of a person/vehicle

in the parking lot The system is used through a SmartPhone application that is accessible to all residents of the house. The project implements the emerging trend these days of end devices connected to the Internet - IoT (Internet of Things).

We emphasize that several consumers can use the system at the same time as long as they are connected to the same home network (via a local web server).

Development Process:

The project will be developed in the C language. The project will be burned on the internal Flash memory of a C8051F380 microcontroller from SiliconLabs. During the development stages, the following actions were performed:

• Comprehensive research about the world of IoT and the layers of information included in it, in particular the layers of local communication (ie Server-Client within a home network).

• Writing code in the Vision Keil 5 development environment that allows for an extensive DEBUG and simulation process.

• Activation and programming of the RTC component and the ultrasonic sensor required UART and I2C serial communication protocols

• Extensive use of third-party applications (AT Commands communication, application activation and dedicated setting

• Activating smart lighting and planning different configurations for this lighting.

to the system - Configuration Wizard for initializing the controller, etc.).

Project goals:

How realized	purpose
The project is based on a micro-controller based on an 8051 processor - which was studied in detail in the course material, and was also tested on in the Mahait final exams.	Recognition and study of a SiliconLabs processor
Implemented in the project for defining the desired features from the microcontroller - UART protocol, timers, port initialization, clock frequency setting, etc.	Configuration Software activation 2 Wizard to determine initialization of the chips and units of the processor.
The I2C protocol was studied extensively as part of a programming lab in the curriculum, and the products we arrived at were incorporated into the project.	Recognition and implementation of the synchronous serial BUS protocol - I2C
The home server is available for the connections of several end users through an application installed on their cell phones. The information traffic from the moment it was received on the server is carried out between it and the microcontroller via UART.	Recognition and implementation of the asynchronous serial BUS protocol and activation of the serial URAT communication unit
A broad deepening of the layer model and planning in light of the model was carried out, focusing on the lower layers related to IP address identification and connection between client and server.	Recognition and implementation of the Internet's layered model with an emphasis on the TCP protocol and WIFI communication between client and server
Realized in the project - we will learn a wide set of commands beyond what is required. Communication is implemented both manually (for DEBUG purposes) and as an independent state machine listening to user requests.	Using the .WIFI command set to define the AT Commands module
The RTC component can set the time and date, and allows an autonomous function of the smart home to turn on the parking lights starting in the evening	Connecting an RTC component that uses the I2C protocol
A network controller that hosts a home server, available for the connections of several end users through an application installed on their cell phones, downloadable through the application store on Android-enabled devices.	ESP network controller connection using the TCP protocol

How realized	Achievements beyond what is required
Use of distance, temperature and humidity sensors that are sampled in fast+slow mode and provide information about the weather, inventions and the absence of the home vehicle and the home pet	Expanding the capabilities of the smart home
In order to operate the new sensors, it was necessary to deepen their features through the manufacturer's pages, independent learning of serial communication within a single or double data line.	Recognition and implementation of arbitrary protocols from manufacturer pages
All the hardware planning was carried out in an Altium 19 work environment and was actually built on a WireUp board that allows for an aesthetic presentation and quick replacement of faulty components.	Professional hardware planning and implementation

Technical specifications:

- C8051F380 microcontroller with upgraded .8051 core
- ESP8266 Ver.01 network module
- 3.95" LCD TFT touch screen
- 3.3V AMS1117 voltage stabilizer
- WireUp board - unique wiring to the system.
- .RTC DS1307 bar
- 1 humidity and temperature sensor 22-DHT
- 2 ultrasonic proximity sensors - HC .SR04
- 1 5V fan.
- A dedicated app on a device Android.
- LEDs - 3 RGB and 8 normal.
- USBOTTL for development purposes

Smart home features:

- Development - the system was developed in an Embedded C environment, it is easy to upgrade and add features according to the customer's order. Also, the interface is 'tailored' to the user and the sensors he chooses to use, and the running of the system can be monitored in real time, thereby locating faults.
- Connectivity - the system connects independent sensors to the "Internet of Things" world using the popular ESP8266 network module - which is a controller that can connect to the network within the reception range and in this case host a network server itself.
- Security - the smart home hermetically preserves the privacy of the residents of the home even in the event of a cyber incident and hacking into it, by means of a software monitoring system that is completely separate from the basic security of a password-based WiFi network. Each tenant has a personal password that can only be used to perform remote operations on the network.
- Lighting control - the system allows lighting control throughout the house, turning on and off specific bulbs and receiving an indication of the total number of bulbs that are on.
- Monitoring home parking and the living area of the home pet - the system allows for monitoring the presence of objects near a sensor, and in the current implementation allows for the presence of the home pet in the parking lot as well as the presence of the pet in the kennel - the sensors must be installed in these places.
- Climate control - the system allows monitoring the temperature and humidity in the space where the sensor was installed.
- Autonomous lighting and air conditioning system - the system allows the activation of parking lighting and a central air conditioning system in the house based on a specified time (for each) for example in the evening.
- Interface - The user interface is divided into two parts. A local interface required an LCD screen which is a touch screen (similar to a cell phone) and is built close to the controller. and a personal interface for all the residents of the house using their cell phones through an application that can be downloaded from the 'app store' on Android.
- Pulling information by a remote client - each tenant can independently pull information from the home server and get a real-time status of reading the sensors in the house.
- Controlling the status of the home server - the system allows you to remotely disable the home server, and to receive display information about the tenants who are connected in real time.
- Displaying a message sent from the cell phone on the display - the system allows all tenants to send messages from the cell phone to the home controller, which will be displayed on the screen on demand.
- Power consumption and duration of operation - if no request is made on the network within 5 minutes - a house tenant who is connected is automatically disconnected. The network controller is voltage stabilized, and should reset only once in about half an hour. The system requires a permanent connection to a regular household electrical outlet (230V) using a standard 9V transformer.

2. Introduction - "The Internet of Things"

The world of IOT has developed a lot in the last 5 years and includes within it the combination of technology, society and the economy. Almost every component that accompanies our lives is connected or can connect to the Internet and thus add information to assessment and analysis tools that are aimed at changing the way we work, live and play.

In this era, not only computers can communicate with each other and exchange information, now also components such as refrigerators, microwaves, lighting and audio sensors are able to function in this way, with as little intervention as possible on the part of the user.

Beyond the many personal applications that have developed in the field - such as smart homes, sports bracelets, and medical components (monitors), there are also uses and contributions on the public side such as smart transportation systems that know how to regulate traffic according to the load on the roads, and ecological systems that utilize natural resources for the benefit of the residents, From air conditioning to saving on municipal electricity consumption.

The connection between the various components, systems and sensors in their type and nature is carried out on the basis of one of the Back-End Data-Sharing, Device-to-Gateway, Device-to-Cloud, Device-to-Device infrastructures:

Of course, alongside the contribution of IoT applications, there are also weaknesses and shortcomings such as:

Security - components and servers with weak protection and encryption circuits endanger their environment and especially the information passing through them which could be routed for malicious purposes. For example, there are components that are able to automatically connect to components that are already connected to the network, thus opening a window of opportunity for hacking, tracking or deliberate slowing down (such as DOS attacks) in the entire network.

Apart from the personal commitment of the developers and users of the IOT network, there are no enforcement organizations whose sole purpose is policy development, and the eradication and prevention of these security deficiencies - these are capabilities that are usually reserved for countries and corporations with their own interests, which find it difficult to create broad regulation. And for that she asked for thought: "Where is the switch to disable the internet?".

Privacy - as soon as a component connects to the network, one or another information is collected regarding frequency of use, history The operations performed to databases that include additional identical data from other users. As mentioned at the beginning, analysis and evaluation of this information will ultimately lead to the optimization of the entire system and the user experience in particular. And therefore - the fact that there is a violation of the user's privacy for the development of the network cannot be ignored.

3. Important concepts from the world of networks

, in advance We will focus our project on the **Gateway to Device infrastructure.** The infrastructure allows components **that have not been programmed but have features and capabilities that enable a direct connection to the Internet** - to make their way with the help of applications on the phone The mobile and use of existing protocols such as HTTP, IP/TCP.

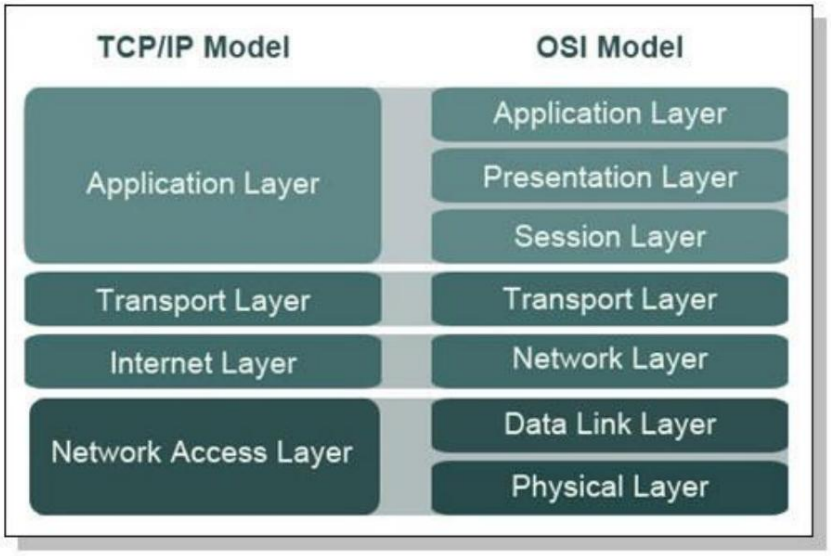
First we will explain that the concept of **protocol** is a collection of standards and rules that are important to follow in order to function Efficient, reliable and correct in transferring and exchanging information in the Internet space.

We will define the **Server or Host** - as a server whose role is to handle the client's requests, from transferring and exchanging information with Another client and a witness to transfer information from a web page (which is on another server) to the client.

We will define the **Client** - as a client that requests to send information to a Host located in the environment far from it - for example from a page Internet.

In order to fully understand how information is sent and exchanged from one component to another, we will present **the 'seven layers' model - Interconnect Systems Open OSI -** for communication on the Internet, and we will explain in detail about **the IP/TCP model** . From which the Transmission Control Protocol/Internet Protocol is derived

4. The seven-layer model - OSI



In the early 1980s, different networks consisted of hardware components from different manufacturers and different software familiar and adapted to their environment. This situation **caused great difficulty in communication** between computers from different networks.

As a result, the **OSI** model was developed by the International Organization for Standards (ISO). The model, like the protocol, defines A set of rules and regulations for proper operation and reliable information transfer (ie without loss of information) between internet networks.

We will review the model hierarchically (from top to bottom):

1. **The application layer** - the layer closest to the customer, where the customer uses Gmail or posts a picture on Facebook.
2. **The presentation layer** - the layer responsible for how the information will be visually presented to the client. messing around (. In conversions and encodings between the different types of information) (such as photo / video
3. **The conversation layer** - the layer that manages the functions of starting or ending a call between two clients / servers. As soon as we stay connected to Gmail or Facebook even though we have moved to browse other sites we Basically using the conversation layer.
4. **The traffic layer** - in order to send information through the network, this layer divides the information into small packets (segments) and takes care of reassembling the information in an orderly manner on the other side (client / server). In addition, this The layer where the exact identification is made between who the customer is and what is the application or service he is requesting, verification of the receipt of the information in the correct sequence and order and error checking for the various information packages is carried out.
5. **The network layer** - in order to identify the end users (clients / servers) this layer uses dedicated addresses on in order to route the information. A dedicated address, or as it is more commonly known, an IP address with more than four octets. For example: server X requests to transfer information to the computer at address 192.168.1.4. The network address is: 192.168.1.0 and in it i.e ,. End users and our specific client address is: 192.168.1. **4** For the purpose of the example, there are 255. The recipient is end user number 4.
6. **The link layer** - is responsible for linking the information between the end users and between the information packages themselves. I mean, all The information in the network passes, as mentioned, in small packets of information containing bits: 0 or 1. In this layer are the network cards and error control checks are performed at **the bit level.**
7. **Physical layer** - manages the information movement of bits at the level of voltages and digital and analog signals that come from the end users and sets standards for frequencies (that is, how many bits will be transferred per second 1 Mbs or .)Mbs20

In summary, **the first four layers** deal **with the transfer of information** between end users throughout the network. **three The last layers** deal with providing **service and routing** the information between the applications. Below are the details of **the protocols that operate within each of the layers** - the protocols implemented in our structure will be emphasized:

HTTP, SMTP, FTP, RTP, IRC, SNMP, SIP, DNS, **DHCP** - **the application layer**•

MIME, **ASCII**, Unicode, SSL **- the representation layer**•

ASP, PPTP, SSH, NFS, RPC, SOCKS - the call layer

TCP, UDP, SCTP, DCCP **- the traffic layer**•

IP (IPv4, IPv6), ICMP, IPX, **- the network routing layer**•

Ethernet, Token ring, FDDI - the link layer

E1, 10Base-T, RS-232, DSL, SON - the physical layer

Now that we understand the seven layer model we can easily understand how two of the protocols work The most significant in our design: IP/TCP and **DHCP.** One forms the **communication core** of the 01-ESP controller with all the customers connected to it, and the second is important for the operation **of the application** that is installed on cell phones and is responsible for communication with the 'smart home' controller.

TCP/IP - Transmission Control Program 5

The data **transfer control protocol** is built **from only four layers** and meets the requirements and characteristics of the OSI model.

The link layer - overlaps with the first and second layers in the OSI model and manages the data traffic through cards the network

The Internet layer - routes the traffic of packets throughout the network and uses additional protocols . Internet Control Message Protocol - and Internet Protocol: such as **the traffic layer** - overlaps with the traffic and conversation layer in the OSI model and actually manages and routes the transfer of information to the application layer. Two important protocols operate in this layer: • **Protocol Control**

Transmission - TCP - this is a protocol for transferring information between two end users and it knows how to divide the information into the most optimal sizes, verify confirmation of each packet sent and report in case of failure.

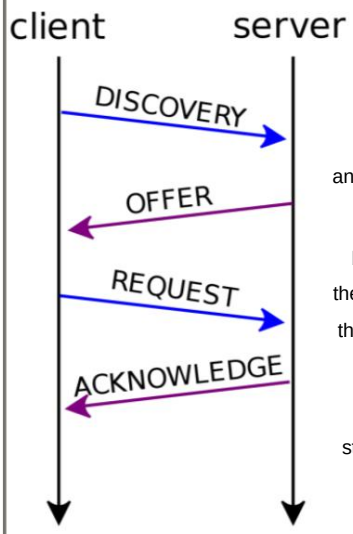
• **User Datagram Protocol - UDP -** this is a protocol for transferring information between two end users but it is not As reliable as TCP, that is, there is no verification and confirmation of each packet transmitted between users.

- Synchronizes the use between the various applications, such as using email or transferring **a message. The app layer :** for example, transferring photos, since each application has an adapted protocol for transferring information in the best way. Photos There is a protocol called Protocol Transfer File - FTP, for sending mail there is a protocol called - SMTP and so on . Simple Mail Transfer Protocol

DHCP - Dynamic Host Configuration Protocol 6

Dynamic Host Configuration Protocol is a communication protocol used to assign unique IP addresses to computers on a local area network (LAN) in addition to the IP address. A DHCP server will usually also provide the computer with data such as the subnet mask, DNS server address, and gateway address (so that the computer can start functioning in the network without the need for additional data.

DHCP functions **in the application layer** of the OSI model - and in the application layer of the IP/TCP model - it works above. As long as the client (client) and above the network protocol in IP, the UDP traffic protocol on ports 67-68 (server) and has not received an IP address, he **uses zeros** (0) to represent his address and is identified by the physical address.



The steps of the protocol: • The client sends a broadcast discovery packet to all computers in the local network in order to locate a DHCP server. In this packet, the computer does not enter the IP address of the destination, and therefore it will reach the computers on the LAN. only

• If there are DHCP servers in the local network that have a free address to distribute, the client will receive an offer packet with an IP address from each of them (assuming that there is no blocking of the passage of DHCP packets between the server and the client, for example by a firewall) • The client sends a request packet with the data he has chosen, also in a broadcast in order to update all the servers at the selected address This way, the servers whose offer was not accepted know that they can assign the address to another computer, and know the address that the computer received (so that they do not assign it to other computers).

• The server sends acknowledge - confirmation that it received the request. After this request the computer starts using the data he received. Beyond the address received by the customer, in this package are mostly sent the details that allow the computer to operate on the network - such as the subnet mask, the DNS server, the access gateway and more (see below).

7. Component 01- ESP from the 8266ESP family

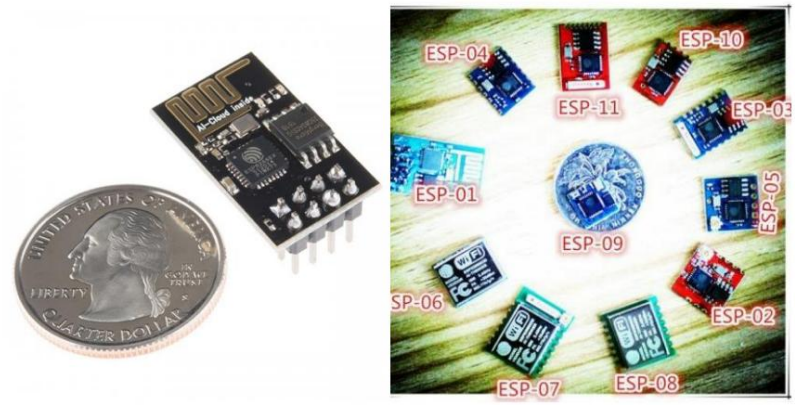
The communication component we used is a Fi-Wi module that allows microcontrollers to access the Fi-Wi network. This module is an independent controller (SOC), a system on a chip that communicates in the IP / TCP protocol and is able to host external network applications, and comes with a firmware **that supports Commands AT** - which are unique commands for communicating with it.

This means that the module can be used as an expansion card for an existing system but in addition it can be programmed to work as **a microcontroller on its own.** With the help of Fi-Wi communication, you can connect to the Internet as a client or alternatively host a web server with real web pages, thus connecting access points and connect to it with your smartphone.

There are many different modules of this component available, and many companies have even extended the existing configuration and ,different market it in the form of a complete development kit. Different controllers may have different pins, different Fi-Wi antennas or a amount of flash memory on the board.

and development , The use of the 8266ESP component is very common among Arduino enthusiasts using the Arduino IDU environment. This environment is indeed very friendly for **beginner developers,** and users who **are not looking to professionally program microcontrollers .**

However, we have chosen **to 'sewn'** a unique system, without facilitating learning, while developing through language and environment - thus **basically also summarizing the learned material.** A job we got to know during our studies



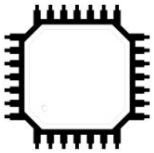
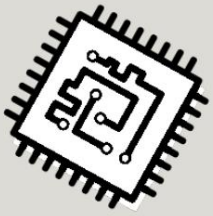
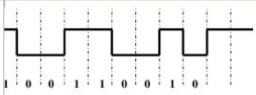
It is important to note that 8266ESP is a general name for a group of chips that includes **a series of components with additional characteristics and features** suitable for development in different environments. Different manufacturers market development packages with varying features, but the hardware common denominators of the boards are: 3.3 V regulator for connecting to the voltage, LEDs, antenna to extend the transmission range, etc.

In light of the characteristics presented earlier, the 01-ESP model was chosen to be used by us in the project, mainly because we saw before our eyes the **flexibility** it offers in the structure that we intended to embroider around it, taking into account that we will have to suffer from possible **instability** in the future **and provide an answer to the current consumption of all the sensors that we intended to implement in the structure.**

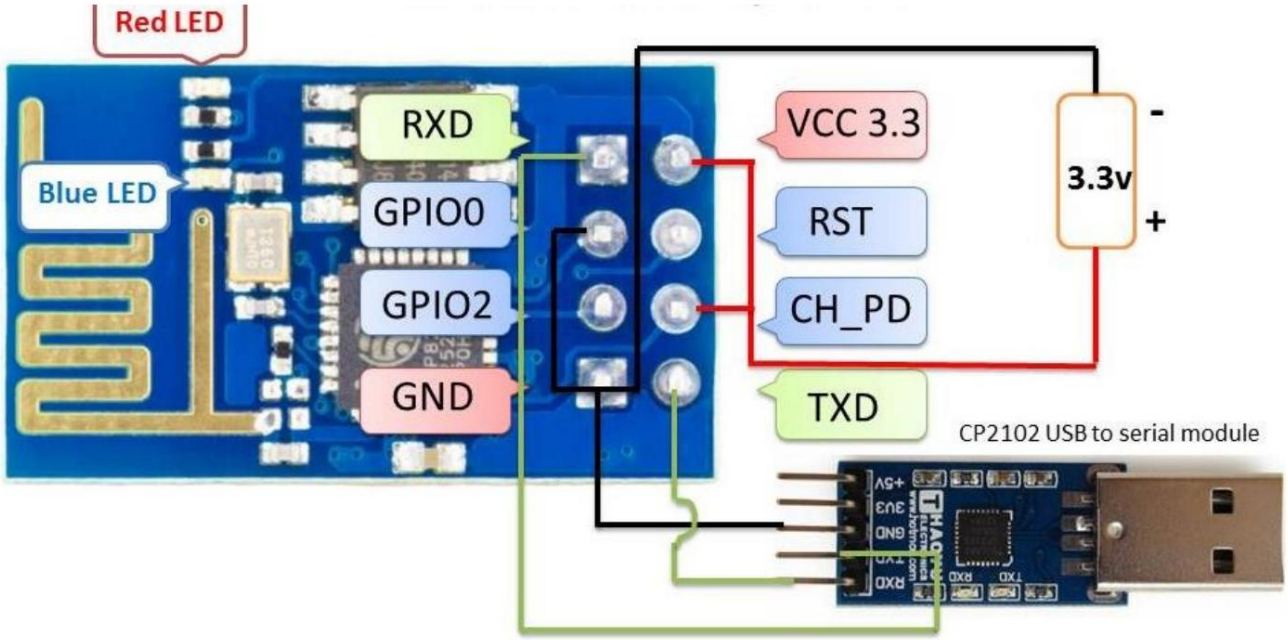
The low **price** compared to **the functionality** it offers was also taken into account , as well as the ability to use the component **as a client** that connects to a home server (in the project we use it as **a server)** - something that will allow future expansion of the project.

It is important to note that this is a final project **with a limited time** for its completion, and also the goals we sought to achieve were defined in advance so that **they would be achievable,** and the component allowed us to fulfill all of these - and to create a fairly independent home controller, with a relatively low number of compromises.

8. 8266ESP WiFi component characteristics

meaning	explanation	bit32
advantage	In regressive operation MHz 80 which is not 106L Tensilica RISC 32 8051 processor .we worked with Creates a bottleneck for cattle	processor characteristic 
advantage	Power Supply: +3.3V only, Current Consumption: 100mA, I/O Voltage: 3.6V (max), I/O source current: 12mA (max). These data make the component suitable for mobile devices, wearable electronics and IoT applications with extremely low power, which includes Three operating modes: active mode, sleep mode and deep sleep mode. Thus, it is possible Adjust the home controller to a 'standby' working mode when the users The potentials choose it.	architecture Energy saving 
disadvantage	The controller is able to operate consistently in industrial environments, due to the range The wide range of temperatures to which it is adapted. It is also characterized by tension Low activation, minimal size and limited number of minutes. However - throughout The forums on the net do not lack documentation about instability in drawing current and frustration A lot of users from his unexpected activity.	 Medium durability
allowing expansion future	kB 512 that allow the storage of temporary information that the component uses and Storage of recent network data to which the component is connected. to assemble a system A small file stored in memory - System Flash SPI (SPIFFS (System. We do not use it, but its existence allows page storage Internet on the component and thus run a full web server with HTML pages written in advance.	 Flash memory
advantage	The transmission rate for uploading to ESP by default is 115200 baud but It can be programmed even 921,600. We preferred to use the normal speed of light .Our 8051 Controller UART compatibility	 UART communication
Advantage + enables expansion future	Fusion in all the interfaces used today by consumers and network products: three working modes. b / g / n / d / e / i / k / r support 802.11 different: Fi-Wi station, Fi-Wi access point - and a third mode - Both in it- Temporarily at the accepted working frequency of 2.4 GHz. Hosting / connection capacity while maintaining common encryptions such as WPS and 2WPA / WPA . support	 WiFi working modes

9. Logical and electrical scheme



The start of work with the component will be integrated into the learning and the protocols presented earlier, we did by direct connection to a laptop through a popular **TTL to USB type controller,** which appears in the lower right.

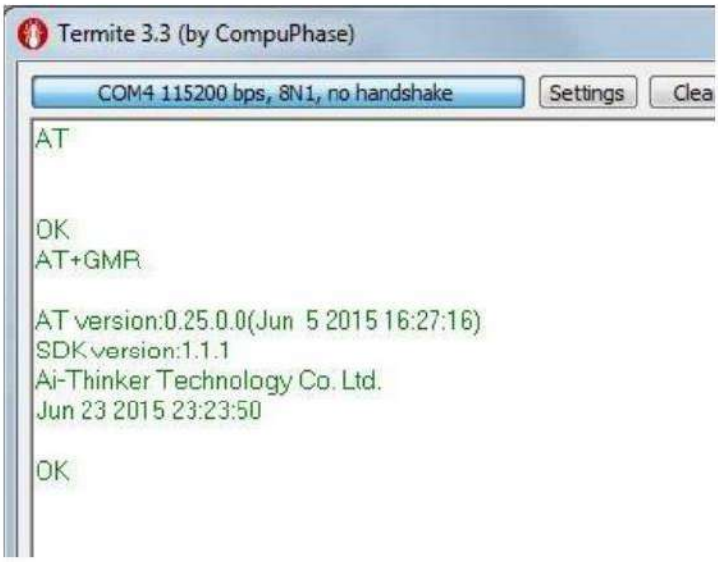
It can be seen that the component also provides external power to the component directly from the USB, and also **the 2 data lines** of the USB are connected respectively to the 'send' and 'receive' lines which **are the Rx and Tx pins of the ESP controller.** In this way, you can send commands to Riv and define its work modes, which we will expand on later.

It should be noted that throughout the development we encountered **problems with the current consumption** of the ESP, which required us to supply it with external power through the TTL to USB component. This situation **is not ideal** because it requires the controller to be connected to a computer (or to a battery with a USB port), so the final solution was to use a voltage stabilizer V> 5 V 3.3 as will be shown later.

Each Wifi communication component contains **a transmitter + receiver** and the normal operation involves the transmission of high frequency radio waves, which That is why we made sure to **calculate the total Zezrom consumption** throughout the development and ensure compatibility with **the design that may burden** the features of the main controller.

The console, the core application we used, is common in mass maintenance ('open source') on a network called **Termite.** Throughout the book we will accompany the explanations with screenshots from it. An example of the AT commands (which will be explained later) that we used to send to the controller:

During the development we used the auxiliary connection with a laptop in order to watch in real time the traffic received both in the network controller and in the main controller:

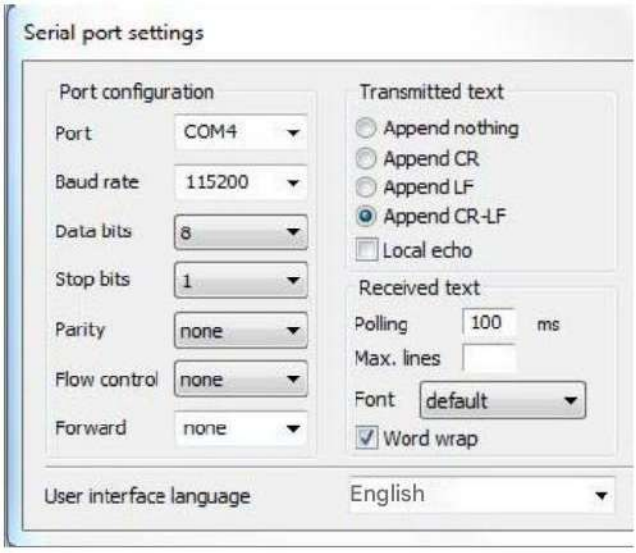


The connection of the USB converter to the laptop is wired to the controller on the development board. The network module is also connected to the controller. This is how three-way communication is carried out:

1. Computer communication - - network controller - enables surgical work in front of the network controller, sending commands Specificity and control response learning. An important process in the phase of learning the component. The responses are displayed in the console.

2. Network controller communication - - Microcontroller 8051 - actually enables the bulk of the smart home controller - independent work of the controller (using the software built into it) in front of the network module, without human intervention - Except for the needs of requests from the server - that's what it's meant for. 3. Microcontroller 8051 communication - computer - was used mainly for DEBUG needs and in the first stages of development - to listen to the strings produced by the microcontroller in the UART framework - and display them on the console.

It is needless to say that the normal operation of this connectivity requires a common 'talk' of all three at the same data sending rate - a fact that must be defined / verified in advance. For example, the rate was set to 115,200 BAUD in the console, in the microcontroller, and for the network controller it is a default rate - but the command to change it is as described:



Command AT+UART_CUR? will return the actual value of UART configuration parameters, which may have allowable errors compared with the set value because of the clock division.

For example, if the UART baud rate is set as 115200, the baud rate returned by using command AT+UART_CUR? could be 115273.

1. The configuration changes will NOT be saved in the flash.
2. The use of flow control requires the support of hardware:
   - MTCK is UART0 CTS
   - MTDO is UART0 RTS
3. The range of baud rates supported: 110~115200*40.

```
AT+UART_CUR=115200,8,1,0,3
```

10. As the power supply technology - expansion

The 8266ESP enables relatively low current consumption for its purpose - especially for portable devices such as electronics
'. This option is achieved by switching it between three modes: **'active mode', 'sleep mode' and deep sleep mode** ,the wearable

The controller can be programmed to wake up within a certain period of time by using RTC. The component will wake up in a manner
Automatic according to the set time, this feature can be applied to SOC for mobile devices, and to optimize more
the average current consumption of the system.

If the programmers refer **to the power of the network identified** by the component (existing option), it is also possible to determine whether
addition, **turn off/on the component** using the applied software, thus maintaining a continuous connection only with networks with reception
favor.

,3.3 The following data is based on manufacturer data, and was tested (according to his commitment) by connecting to an external V
power supply to WiFi and 90% cycle time (CD). Continuous transmission mode °C **antenna with connection**, At an ambient temperature of 25
can be **observed different current consumption depending on the strength of the communication and the transmission protocol** used, but the value
. with us **The typical one** is about that which is also measured

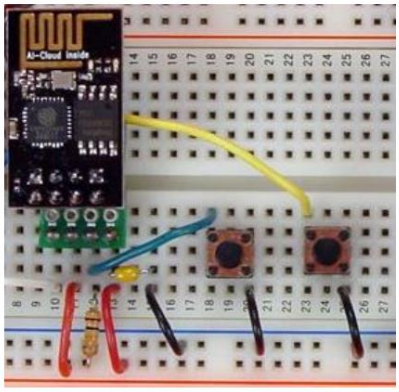
Mode	Typical	Units
802.11b, CCK 1Mbps, POUT=+19.5dBm 802.11b,	215	mA
CCK 11Mbps, POUT=+18.5dBm 802.11g, OFDM	197	mA
54Mbps, POUT=+16dBm 802.11n, MCS7, POUT	145	mA
=+14dBm 802.11b, packet size of 1024	135	mA
bytes, -80dBm 802.11b, packet size of 1024 bytes,	60	mA
-70dBm 802.11b, packet size of 1024 bytes, -65dBm	60	mA
Standby Deep sleep Saving mode DTIM 1 Saving	62	mA
mode	0.9	uA
DTIM 3	10	mA
Shutdown	1.2	mA
	0.86	mA
	0.5	uA

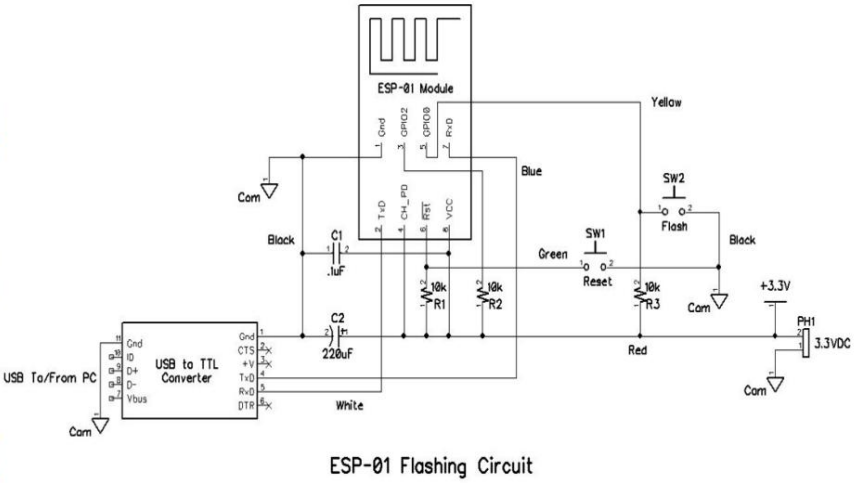
11. And fasten LEDs on the controller

trigger	name	alias	Description of use	Additional uses
1	**Ground**	-	Permanently connected to the ground in a way	-
2	**TX**	GPIO – 1	Used as a TX data trigger	Can be used as a trigger for use General, if not used as a trigger TX information
3	**-2GPIO**	-	The trigger for general use for connecting O/I	-
EN_CH 4		-	devices is permanently connected to DV voltage 3.3 V - for the purpose of enabling the component	-
5	**GPIO - 0**	Flash	General purpose trigger for connecting devices O/I	'holding' the trigger in a logic state low for a few seconds Puts the controller into position Firmware burning, as will be demonstrated in the next episode
6	**Reset**	-	Connecting it to ground resets the component and deletes all previous settings carried out in it. The component will immediately load default settings defaults to keep the memory of the FLASH, or settings configured as such Let them be loaded from memory on the next session.	-
7	3 - GPIO **RX**		Used as an RX data trigger	Can be used as a trigger for use General, if not used as a trigger RX information
8	**Vcc**	-	Connected to DV voltage 3.3 V permanently	It is important to emphasize that the board receives A voltage of V 3.3 and if you are mistaken and connect it to V 5 actually burn it.
LEDs	PWR **Red**		Emitters a constant red light as long as the controller receives power	-
LEDs	TXD **Blue**		Distributes a single pulse during Reset	-

12. Burning internal firmware of Commands AT

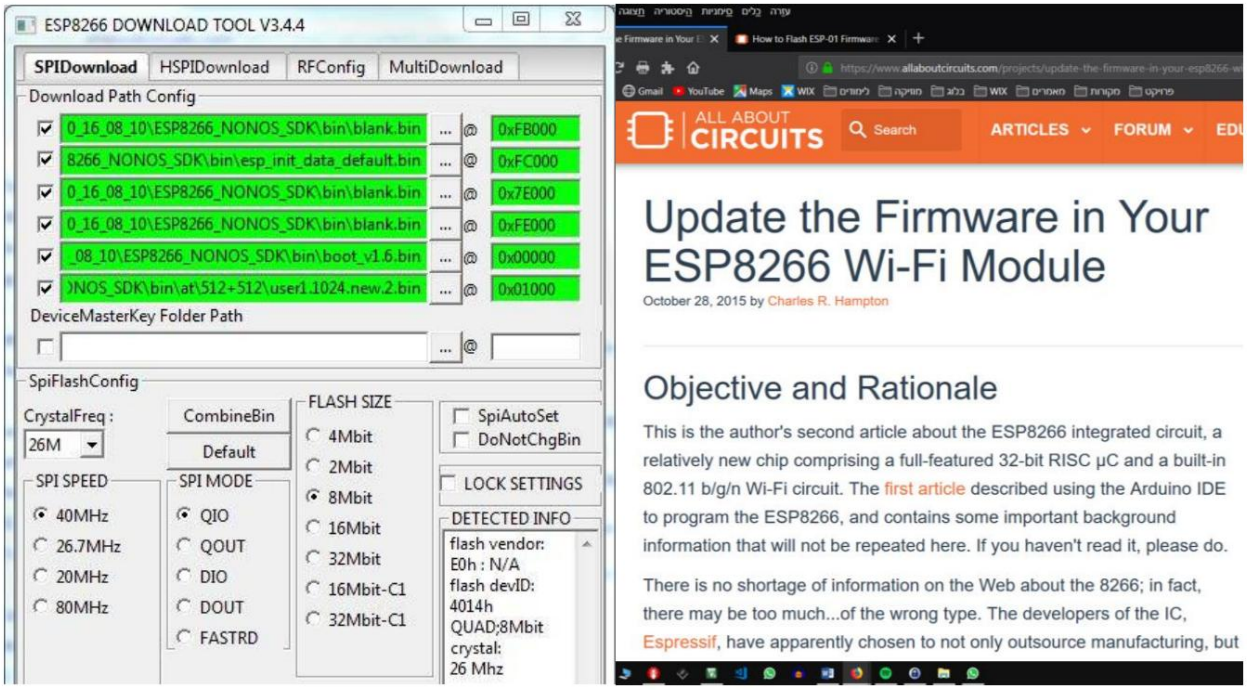
As mentioned, connecting the component and starting work is a simple matter, although it should be noted that the firmware installed on the component when we received **it was not up-to-date,** so the connection process was preceded by the above for **burning the most recent version** available on the network, which is from **August 2018.** For the purpose of burning, we were required to connect the burning connection component as described above, which included **adding the RST and PROGRAM buttons below :**





ESP-01 Flashing Circuit

Finally we flashed the latest firmware using a guide we found online:



13. Communication with the ESP controller - 'AT' commands

The 'Commands AT' system is a **command** language - unlike a conventional **programming** language . The commands are based They are based on a communication method **previously called 'set command Hayes** ', which was originally developed by Dennis Hayes, who founded and ran a company to create modems in the 1970s. -80 **The word AT is an abbreviation of Attention** - . from the component That is, **receiving attention**

The command line consists **of a series of short text strings** that can be combined to form executable commands and a definition of modems of the type used in the 80s and 90s (which were connected to the telephone line **using a dial-up method).** This system expanded as more manufacturers included it, but kept **the basic syntax.**

Modems are typically run on direct dial telephone lines that always begin and end with a known modem at each end. , but the microcomputer revolution of The modems operated in **"source"** or **"answer"** mode for a small network of computer customers. The 1970s led to the introduction of low-cost modems and the idea of **a point-to-point link was no longer adequate,** since **hundreds of thousands of users** might want to dial each other.

However, this method of communication remains popular, and is implemented in the component we have chosen since it is very easy to manipulate on strings that are received and sent to the component, and also the expected communication volume for IoT applications of the same type as the target audience of 8266ESP is limited anyway. (developers, students)

Below is the collection of commands relevant to the smart home controller project that we implemented, this collection is **an extract from a database** : **commands** we u **Even wider,** most of which was irrelevant for us. Below is **a general breakdown of the types of**

commands	type
AT+RST, AT , AT+GMR, ATE, AT+GSLP	**Basic**
AT+CWMODE , AT+CWJAP , AT+CWLAP , , AT+CWQAP AT+CWSAP , AT+CWLIF , AT+CWDHCP , AT+CIPSTAMAC , AT+CIPAPMAC , AT+CIPSTA , AT+CIPAP	**WiFi layer**
AT+CIPSTATUS , AT+CIPSTART , AT+CIPSEND , AT+CIPCLOSE , AT+CIFSR , AT+CIPMUX , AT+CIPSERVER , AT+CIPMODE , AT+CIPSTO , AT+CIUPDATE , +IPD	**TCPIP Layer**

Syntax and use of commands:

Similar to strings, **the commands contain repeating parameters and rules,** so for example at the end of each command there is to send a termination line termination Line that the 8266ESP component expects. The syntax for this ending is:

. LineFeed and CarriageReturn meaning > **CR><LF>**

while a command that requires ,A command **that stands on its own** (without parameters) will be sent as it is **with the end string. The transfer** ,in advance **of information in the form of parameters will be sent when the sign '=' is attached to it, followed by the information in a defined format.** For each command, we have attached the **answer received from the component,** which usually indicates as will be shown below. Also, success/failure of its execution.

14. Details of commands, parameters and controller response

• **Initial boot**

AT - Test AT startup

Variant	Command	Response	Function
Execute	AT	OK	Test if AT system works correctly

• **Secondary boot**

AT+RST - Restart module

Variant	Command	Response	Function
Execute	AT+RST	OK	Reset the module

ESP-01 Output after reset: ets
Jan 8 2013,rst cause:4, boot mode:(3,7) wdt reset
load

0x40100000, len 24444, room 16 tail 12
chksum

0xe0 ho 0 tail

12 room 4 load

0x3ffe8000, len 3168 , room 12 tail 4

chksum 0x93

load 0x3ffe8c60, len 4956, room 4 tail
8
chksum 0xbd

csum 0xbd

ready

• **Print firmware version installed on the component**

AT+GMR - View version info

Variant	Command	Response	Function
Execute	AT+GMR	version, OK	Print firmware version

Parameters:

• version: firmware version number

ESP-01 output:
00160901

• **Putting the component into 'sleep' mode**

AT+GSLP - Enter deep-sleep mode

Variant	Command	Response	Function
set	AT+GSLP=time	time OK	Enter deep sleep mode for time milliseconds

parameters: •

time: Time to sleep in milliseconds

Exampleÿ

- AT+GSLP=1500

Note:

- Hardware has to support deep-sleep wake up (Reset pin has to be High).

• Enable or cancel receiving an ECHO of the command we sent, before outputting the answer

ATE - Enable / Disable echo

Variant Command Response Function		
Execute ATE0	OK	Disable echo (Doesn't send back received command)
Execute ATE1	OK	Enable echo (Sends back received command before response)

• Setting work mode - server, client or both at the same time

AT+CWMODE - WIFI modeÿstation, AP, station + APÿ

Variant Command	Response	Function
Test AT+CWMODE=?	+CWMODE:(1-3) OK	List valid modes
Query AT+CWMODE?	+CWMODE: mode OK	Query AP's info which is connected by ESP8266.
Execute AT+CWMODE=mode OK		Set AP's info which will be connected by ESP8266.

Parameters:

- modeÿ An integer designating the mode of operation either 1, 2, or 3.
  - **1** = Station mode (client)
  - **2** = AP mode (host)
  - **3** = AP + Station mode (Yes, ESP8266 has a dual mode!)

• Connecting to the access point using a name and password known to us

AT+CWJAP - Connect to AP

Variant Command	Response	Function
Query AT+CWJAP?	+ CWJAP:ssid OK	Prints the SSID of Access Point ESP8266 is connected to.
Execute AT+CWJAP=ssid, pwd OK		Commands ESP8266 to connect an SSID with supplied password.

Parameters:

- ssidÿString, AP's SSID
- pwdÿString, not longer than 64 characters

Exampleÿ

AT+CWJAP="my-test-wifi","1234test"

Example AT+CWJAP?ÿ

+CWJAP:"my-test-wifi"

• Print all the communication networks that are in the reception range

AT+CWLAP - Lists available APs

Variant Command		Response	Function
Set	AT+CWLAP=ssid,mac,ch	+CWLAP:ecn,ssid,rssi,mac OK	Search available APs with specific conditions.
Execute	AT+CWLAP	AT+CWLAP:ecn,ssid,rssi,mac OK	Lists available Access Points.

Parameters:

- ECN:
  - o **0** = OPEN o **1** = WEP o **2** = WPA_PSK o **3** = WPA2_PSK o **4** = WPA_WPA2_PSK • ssid: String, SSID of AP • rssi: signal strength • mac: String, MAC address

Example AT+CWLAP:

+CWLAP:(3,"CVBJB",-71,"f8:e4:fb:5b:a9:5a",1)
+CWLAP:(3,"HT_00d02d638ac3",-90,"04:f0:21:0f:1f:61",1)
+CWLAP:(3,"CLDRM",-69,"22:c9:d0:1a:f6:54",1)
+CWLAP:(2,"AllSaints",-88,"c4:01:7c:3b:08:48",1)

• Disconnecting from the access number we are currently connected to

AT+CWQAP - Disconnect from AP

Variant Command	Response	Function	
Execute AT+CWQAP	OK		Disconnect ESP8266 from the AP it is currently connected to.

Note:

After running this command, if you run AT+CWJAP? it still shows the AP you were connected to before.

• Setting server status - access point hosted by the rival and setting name and password

AT+CWSAP - Configuration of softAP mode

Variant Command		Response	Function
Query	AT+CWSAP?	+CWSAP: ssid,pwd,ch,ecn OK	Query configuration of ESP8266 softAP mode.
Set	AT+CWSAP=ssid,pwd,ch,ecn OK		Set configuration of softAP mode.

Parameters:

- ssid: String, ESP8266's softAP SSID
- pwd: String, Password, no longer than 64 characters • ch: channel id
- ECN:
  - o **0** = OPEN o **2** = WPA_PSK o **3** = WPA2_PSK o **4** = WPA_WPA2_PSK

Example

AT+CWSAP="esp_123","1234test",5,3

AT+CWSAP? => +CWSAP:"esp_123","1234test",5,3

• Printing all the clients (Clients) who are connected to the access point we host

AT+CWLIF - List clients connected to ESP8266 softAP

Variant Command	Response		Function
Execute	AT+CWLIF [ip,other]	OK List information	on of connected clients.

Parameters:

ip: IP address of a client connected to the ESP8266 softAP other: Other info, look at example. I don't know what it means yet.

Example:

AT+CWLIF

192.168.4.100,3fff50b4:3fff50ba:3fff50c0:3fff50c6:3fff50cc:3fff50d2

OK

• Enable DHCP as explained in the chapter 'The Internet Layer Model'

AT+CWDHCP - Enable/Disable DHCP

Variant	Command	Response	Function
Set	AT+CWDHCP=mode,en	OK	Enable or disable DHCP for selected mode

Parameters:

- mode: o
  - **0 :** set ESP8266 as a softAP o **1 :** set ESP8266 as a station o **2 :** set both ESP8266 to both softAP and a station

en :

- o **0 :** Enable DHCP o **1 :** Disable DHCP

Note:

This command doesn't seem to work on firmware 00160901 (ESP-01) nor 0018000902-AI03 (ESP-12).

• Receiving general information about the current connection status

AT+CIPSTATUS - Information about connection

Variant Command		Response	Function
Test	AT+CIPSTATUS=? OK		
Execute	AT+CIPSTATUS	STATUS: status + CIPSTATUS: id, type, addr, port, type OK	Get information about connection.

Parameters:

• statusÿ

o 2: Got IP o
3: Connected o 4:
Disconnected

• idÿ id of the connection (0~4), for multi-connect • typeÿ

String, “TCP” or “UDP”

• addr: String, IP address. • portÿ

port number • typeÿ o **0** =

ESP8266

runs as a client o **1** = ESP8266 runs as
a server

• Establishing TCP communication in the case of a server or UDP in the case of a client

AT+CIPSTART - Establish TCP connection or register UDP port and start a connection

Variant Command		Response	Function
Set	AT+CIPSTART=type addr, port	OK	Start a connection as client. (Single connection mode)
Set	AT+CIPSTART=id,type, addr, port	OK	Start a connection as client. (Multiple connection mode)
Test	AT+CIPSTART=?	[+CIPSTART:)id()“type "(,)"ip address"(,)port(] OK	(List possible command variations)

Parameters:

• id: 0-4, id of connection •
type: String, “TCP” or “UDP”
• addr: String, remote IP •
port: String, remote port

• Preparation for sending free strings (like SMS 2) - possible modes

AT+CIPSEND - Send data

Variant	Command	Response	Function
Test	AT+CIPSEND=?	OK	
Set	AT+CIPSEND=length SEND	OK	Set the length of the data that will be sent. For normal sending (single connection).
Set	AT+CIPSEND=id, length SEND	OK	Set the length of the data that will be sent. For normal sending (multiple connection).
Execute	AT+CIPSEND		Send data. For unvarnished transmission mode.

Parameters:

• id: ID no. of transmit connection • length:

data length, MAX 2048 bytes

• Disconnecting TCP communication in the case of a server or UDP in the case of a client

AT+CIPCLOSE - Close TCP or UDP connection

Variant	Command	Response	Function
Test	AT+CIPCLOSE=? OK		
Set	AT+CIPCLOSE=id OK		Close TCP or UDP connection. For multiple connection mode
Execute	AT+CIPCLOSE OK		Close TCP or UDP connection. For single connection mode

Parameters:

• id: ID no. of connection to close, when id=5, all connections will be closed.

Note:

• In server mode, id = 5 has no effect!

• Obtaining a local IP address of the controller

AT+CIFSR - Get local IP address

Variant	Command	Response	Function
Test	AT+CIFSR=?	OK	
Execute	AT+CIFSR	+CIFSR:ip	OK Get local IP address.

Parameters:

• ip: IP address of the ESP8266 as a client.

Example AT+CIFSR:
10.101.10.134

• Enable the number of connections allowed to connect to the access point or a single connection in case of client mode

AT+CIPMUX - Enable multiple connections or not

Variant Command		Response	Function
Set	AT+CIPMUX=mode OK		Enable / disable multiplex mode (up to 4 connections)
Query AT+CIPMUX?		+CIPMUX:mode OK	Print current multiplex mode.

Parameters: •

mode: o 0:

Single connection o 1: Multiple connections (MAX 4)

Note:

This mode can only be changed after all connections are disconnected. If server is started, reboot is required.

• Server initialization is required after setting work mode

AT+CIPSERVER - Configure as server

Variant Command		Response	Function
Set	AT+CIPSERVER=mode[,port] OK		Configure ESP8266 as server

Parameters: •

mode: • 0:

Delete server (need to follow by restart) • 1: Create server

• port: port number, default is 333

NOTE:

1. Server can only be created when AT+CIPMUX=1 2. Server monitor will automatically be created when Server is created.

3. When a client is connected to the server, it will take up one connection, be given an id.

• Setting parameters for string sending mode

AT+CIPMODE - Set transfer mode

Variant Command		Response	Function
Query AT+CIPMODE?		+CIPMODE:mode OK	Set transfer mode, normal or transparent transmission.
Set	AT+CIPMODE=mode OK		Set transfer mode, normal or transparent transmission.

Parameters:

• mode: •

0: normal mode

• 1: unvarnished transmission mode

• Setting a period of time to disable the server

AT+CIPSTO - Set server timeout

Variant Command		Response	Function
Query	AT+CIPSTO?	+CIPSTO:time	Query server timeout.
Set	AT+CIPSTO=time	OK	Set server timeout.

Parameters:

• time: server timeout, range 0~7200 seconds

• Server output along with information received from it

+IPD - Receive network data

Variant	Command	Response	Function
Execute		+IPD,len:data	Receive network data from a single connection.
Execute		+IPD,id,len:data	Receive network data from multiple connections.

Parameters:

• id: id no. of connection

• len: data length •
data: data received

15. Demonstration of the operations for setting up a home server (access point)

In order to set up a home server to which all end users (residents of the house) can connect - the controller must be configured
Using a sequence of commands as described above, but while maintaining a certain order and inserting correct parameters.

Of course, **we do not intend to bother the residents of the house** to enter the AT commands to start the server, **every time**
And therefore the collection of commands that will be presented below - **has been embedded in the source code,** **The smart home** **that they want to use the controller ,**
as part of functions that run independently when activating the 8051 controller through which the design is implemented. **in the software**

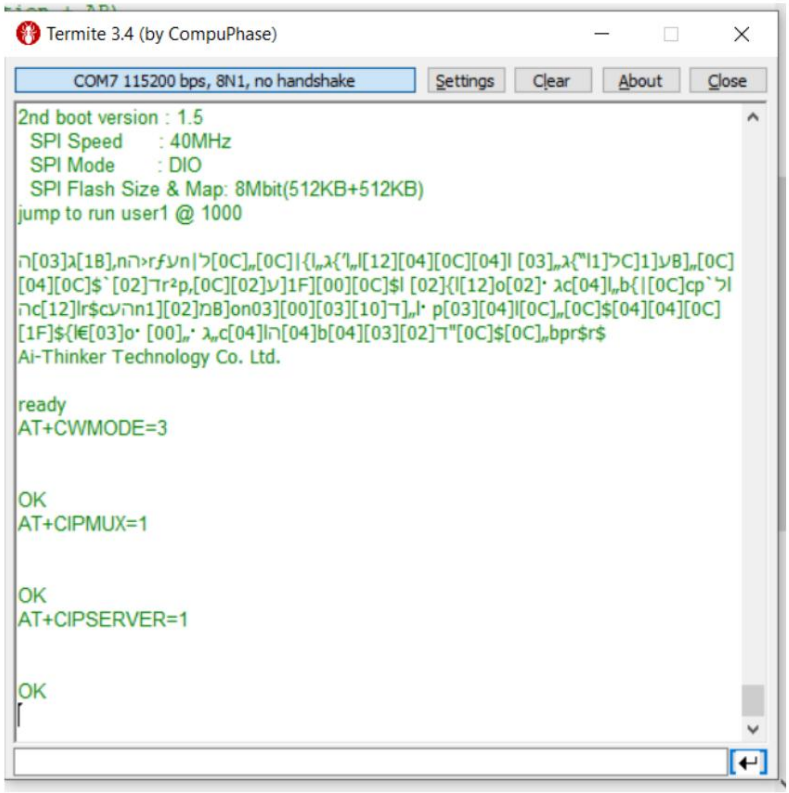
The commands were embedded **in a state machine** that the controller initializes and activates in an infinite loop, and so throughout the duration of its operation
The SmatPhone, and is ready to present to them **The controller 'listens' to requests from the** app users making an interface on
the local monitor - with which all operations can be performed even without the cell phones.

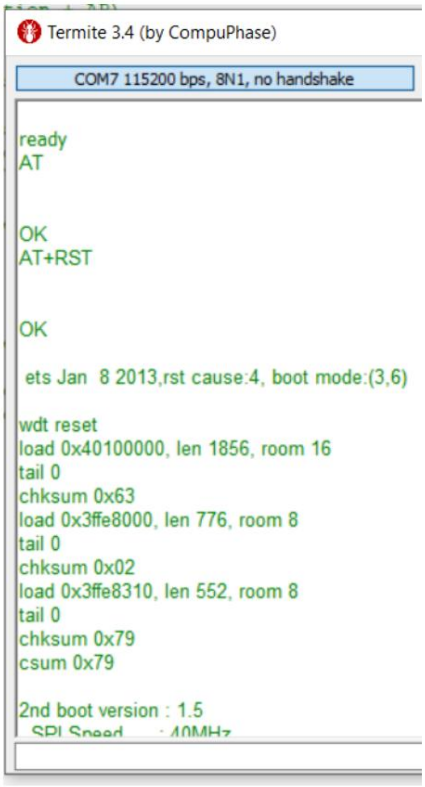
: Multiple Connections as TCP Server - on a multi-user hosting server

To allow several residents of a house **to connect to the server at the same time,** we will set the network controller to the working mode of an access point. there is
Note that there is **a limit of up to 4 clients** that are connected at the same time - a limit that originates from the component's hardware
(limited memory). Details about each of the commands can be found in detail in the AT commands chapter:

2. **Setting the station mode:** 3 = CWMODE + AT - (softAP), 1. **Initializing the component** - operating commands
The controller's response: confirmation
: Controller response ,3. **Allow multiple connections.** 1 = CIPMUX + AT
confirmation
Controller response: ,4. **Creating a TCP server:** 1 = CIPSERVER + AT
confirmation

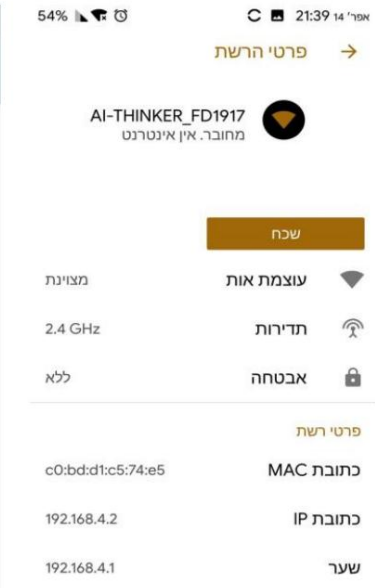
basicity.
We will sometimes receive ownership strings
'Garbage' values - normal condition that instructs on
Shred the beef.





16. Demonstration of the operations hang companies on the server as an end user

1. **Activating WiFi transmission** and connecting to the network on the access cell **phone** that the component distributes. ESP8266 softAP



2. Using a **WiFi** application **Controller** - **connect to** the TCP server that the server is currently hosting (IP must be entered once and the settings are saved for the next time).

3. It is important to note that the 'IP' address You can see the web page using the cell phone.
Another option is to send the CIFSR+AT command via the computer, and receive the information via the console screen.

In fact, the actions presented here are **one-time,** since **the WiFi network we connected to is saved in the cell phone for future uses,** and **the IP address is** also saved in the application to connect the next time.

It is important to note that **the Timeout mechanism** controls when the 8266ESP works as a TCP server. If a TCP client connected to the TCP 8266ECP server, but **no request was received** within 5 minutes - **the server will terminate the connection** with the timeout. To avoid such problems, **a data transfer cycle should be set every 5 seconds .** We did not make this setting in order to preserve the battery life time in cell phones and prevent data traffic that burdens the home network.

Of course, everything mentioned here is intended to present the communication protocol between the server, the end users, and the controller. 8051 **The intervention in the transfer of the information in the console - is intended to illustrate the processing of the commands presented in the previous chapte**

The network, as will be shown in the next chapter, is a direct result of an intermediate state in which a machineis to the controller, sending the state commands of the microcontroller, that is, it is automatic - and is **an outcome of all end-user requests** that are a trigger for changing the state of the machine.

Disabling the server, and terminating the connection proactively, is also a possible remote operation using a button in the application that holds the Kill command. After it has been sent and decoded in the software, the string " AT 0 = CIPCLOSE + " is sent to the network controller. This option is also provided through the local system (the touch screen) attached to the microcontroller

1. Upon connecting to the server - The indicator in the application will change **from 'red' to 'green' .**

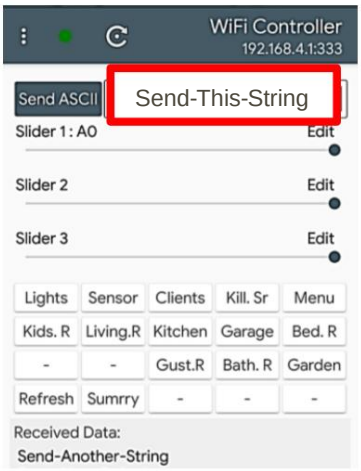
2. **A button interface now appears and sending text** to the server (also the buttons are actually a trigger for sending a string and are changeable). Choosing one of the sending options (text/ button) will publish the string on the server.

3. **The information saved on the server is transmitted Automatically** also via the **UART** protocol to the 8051 controller (because the ESP is wired to the Rx and Tx protocol lines). This can be proven by listening to the traffic on the server using the console. You can see an initial response to connecting to the server and immediately after receiving the string that was sent.

```
+CIFSR:APIP,"192.168.4.1"
+CIFSR:APMAC,"5e:cf:7f:fd:19:17"
+CIFSR:STAIP,"0.0.0.0"
+CIFSR:STAMAC,"5c:cf:7f:fd:19:17"

OK
0,CONNECT

+IPD,0,18:Send-This-String
AT+CIPSEND=0,50
```

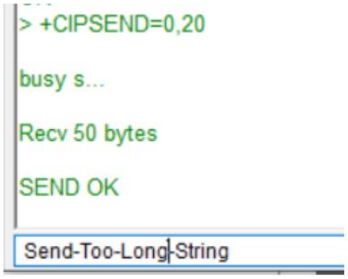


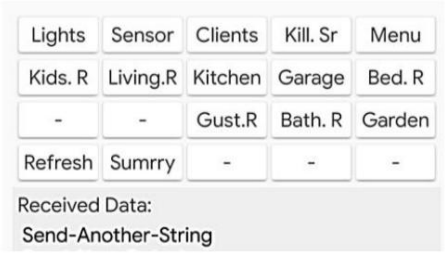
4. Conversely, **the server also publishes information to clients** connected to it.

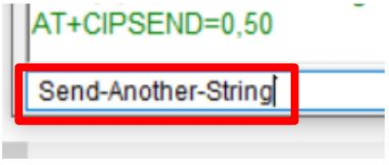
In order to trace the information - we will start a manual attempt to send a string using the console (as if the origin of the string is in the software from the 8051 microcontroller.)

AT + CIPSEND = 0, n. At the end of the command, the controller expects to receive strings that are transmitted at the bit rate at which it is set (BAUD selection). **Indeed,** a default of 115,200 will be received - **marking of input ">".** At the end of the sending, the controller's response: n RECV Bytes - confirmation of n bytes that we were notified in advance about sending. If the number of bits received is different from the defined size (n): the controller will reply 'Busy,'') to send only the n bytes After them he will inform , send that was actually successful 'OK.'

5. **Information sent from the server to the user will be printed at the bottom of the application.** The source of this information is in the 8051 microcontroller which sends users feedback about the state of the sensors in the house - This closes a circle that began with the end user's request for information from the network, and the return of the information to him from the network as well. Data reception: when 8266ESP received data from a client, it will generate a message as follows: that is, IPD, 0, n: xxxxxxxxxx + the controller received n bytes, the information itself = xxxxxxxxxxx

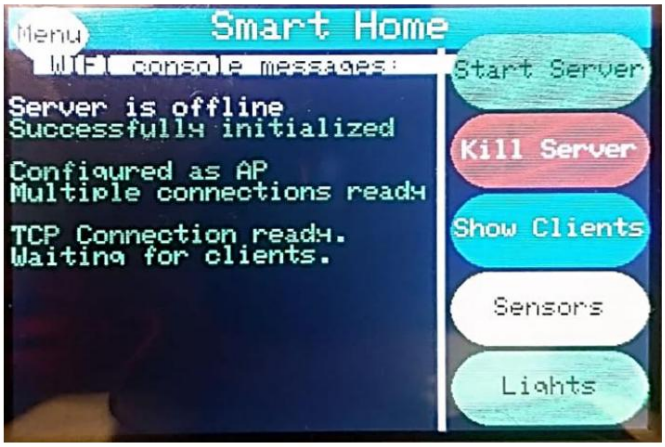






18. The 'smart home' - touch screen interface on the microcontroller

A major part of the project is also the realization of **a local interface that is accessible to the residents of the house,** and makes it possible to receive all the information coming from the sensors in one place, **without the need for an internet connection .** The implementation is on a touch screen - in the form of a status menu, with a fixed structure for each page, and the use of buttons for operation.



Main screen, appears when the microcontroller boots. In the menu on the right are buttons that enable **basic operations such as activating and deactivating the home server.**

You can also watch all **the clients that are connected** to the server in real time.

Buttons for **'Lighting' and 'Sensors'** allow you to go to the sub-menu related to them.

On the left side there is **a multi-Let's use** that shows the **information traffic** and the commands sent to the server.

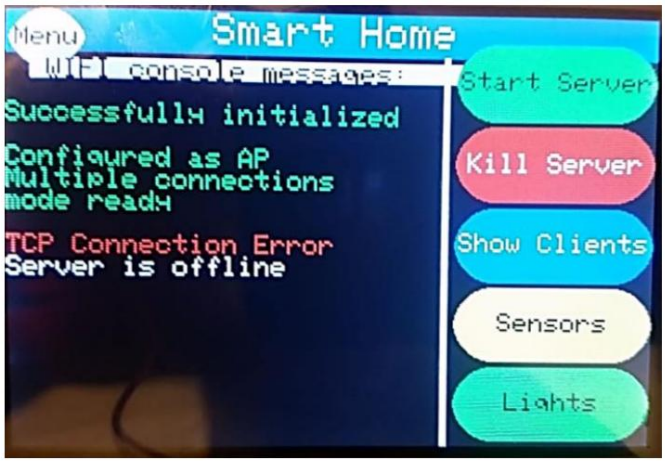
Home lighting control screen - enables turning on and off up to 8 light bulbs in different rooms in the house. Turning on the lighting turns the button green, and turning it off turns it back to red. A counter at the bottom of the screen gives **an indication of the total number of lights on** - and the main use of the message at the bottom of the screen is to hold a string **that will be sent to the end users' cell phones .**

LEDs on the development board represent the lights of the house. Activating lights in the lighting menu **causes them to be turned on and alternately to be turned off.** It should be noted that moving between menus **does not disable the selections made,** as would normally happen.

Control screen for sensors around the house - allows real-time reading of the state of the temperature and humidity in the house (bank where the sensor is located). Two other sensors indicate the presence or absence of the objects they are monitoring. **We chose to monitor the car in the parking lot and the domestic pet .**

The screen automatically refreshes the reading of the sensors, although an additional refresh is not automatic but **requires** pressing the refresh button **the sensors** into one string at a time

The string **is sent to all users** ,The click **·to the end server connected**

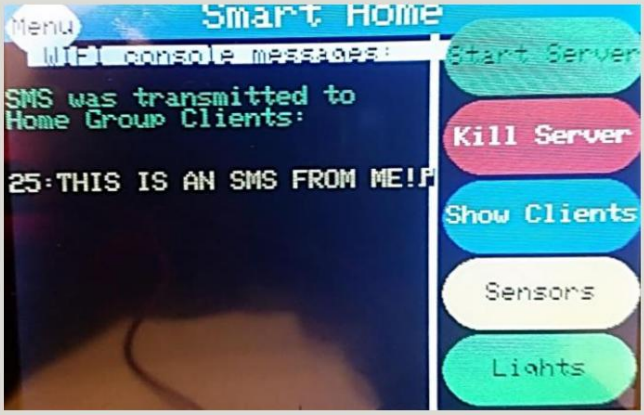


An example **of an indication of a fault** detected when connecting to the server. The indicator is one example **out of many** that have been embedded in the code, and are ready to be displayed as soon as such is reported by the network controller.

From the example of console prompts when **requesting to display all end users** (4) up to those connected to the server.

An example **of** a string containing **all the data gathered from the sensors,** after clicking the 'Summary' button in the sensors menu. It should be noted that the click also redirects back to the main screen so that you can view this communication with the server through the console.

The string is of course sent to the end users **and appears in the application .**



An example **of an SMS message** received from one of the residents of the house, which **was sent as part of the application on the cell phone.** The message is sent to the console and also to all other keyboard users, and this is how **a home chat group actually takes place.**

19. Hardware and sensors used in the 'smart home' design

As mentioned, the control of the system is carried out in 2 ways - **locally** (touch screen) **and wirelessly** (an application that communicates with **a network controller).** The following is a breakdown of the uses of all the hardware in the system: • **Microcontroller 380F8051C with an upgraded 8051 core -** the heart of the system, on which the software is written. • **Network module 01Ver 8266ESP –** communication component for hosting 4 house residents (users) and control In **the** remote controller. **-** for local control inside the house. • **1117AMS voltage stabilizer for** the system.

1307DS RTC component - time controller for autonomous lighting and home air conditioning • **Humidity and temperature sensor 22- DHT -** temperature monitor and humidity in the air in which it was assembled at home

Installed under the fan to show actual measurement capabilities.

• **2 ultrasonic proximity sensors 04SR-HC -** simulate sensors for monitoring the inventions of a pet in the area assigned to her and monitoring the family members' vehicles in the parking lot assigned to her.

• **V5 fan –** simulates a home air conditioner.

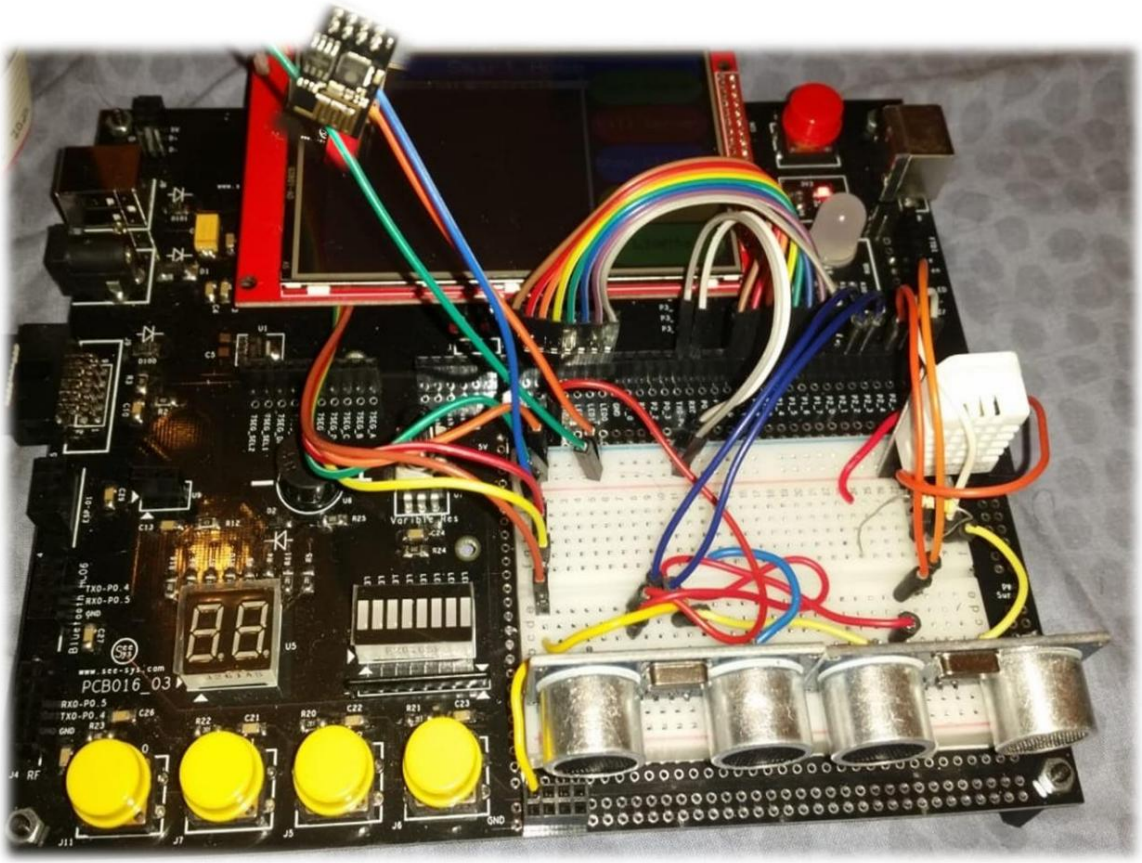
• **3 RGB type LEDs -** colored lights that indicate the status of the system's hourly automatic activation setting

The air conditioning and the parking light.

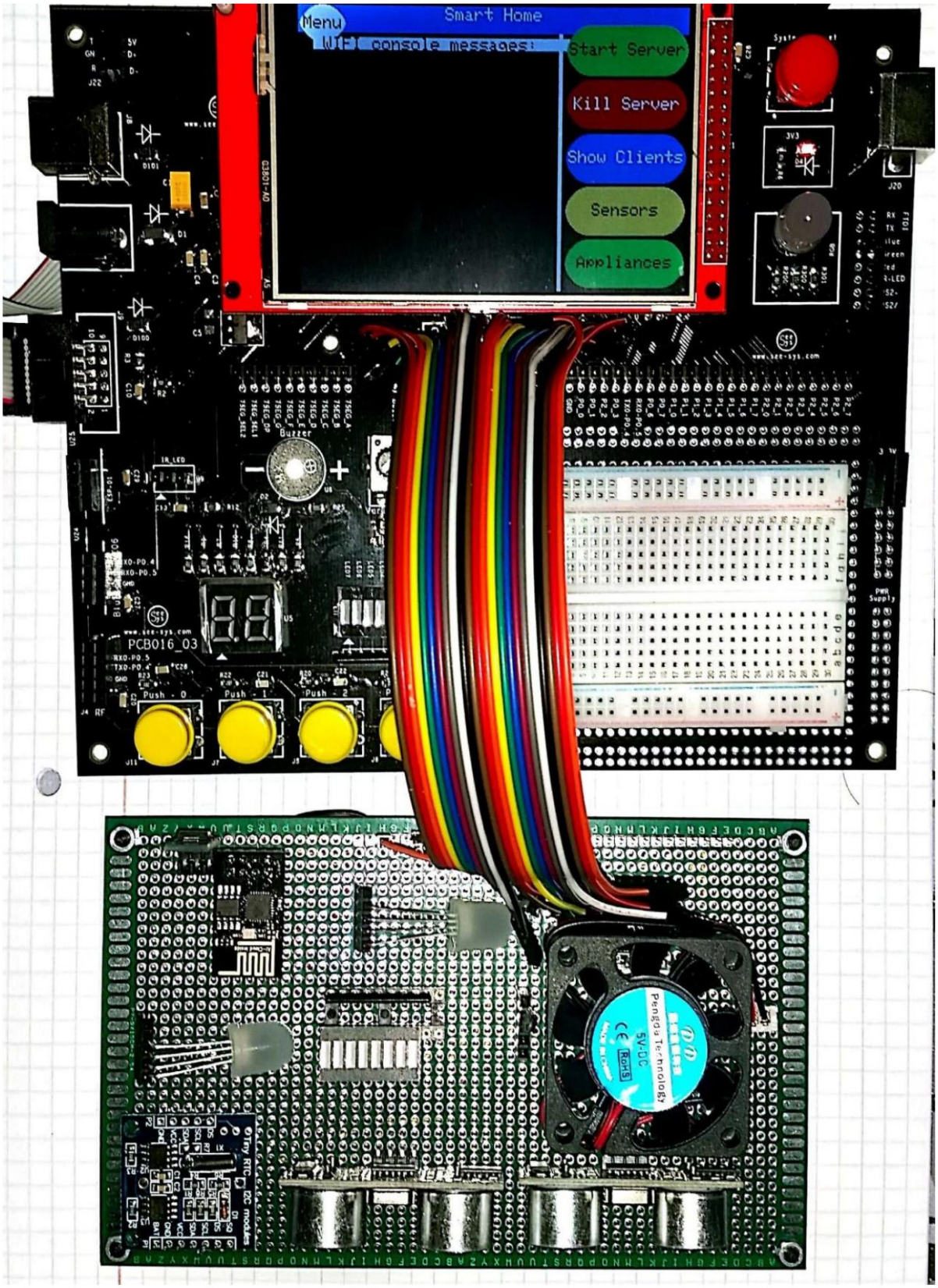
• **8 normal LEDs -** simulating 8 household consumers/bulbs around the house.

• **Cellphone with a dedicated application (Android)** - for remote control via Cellphone.

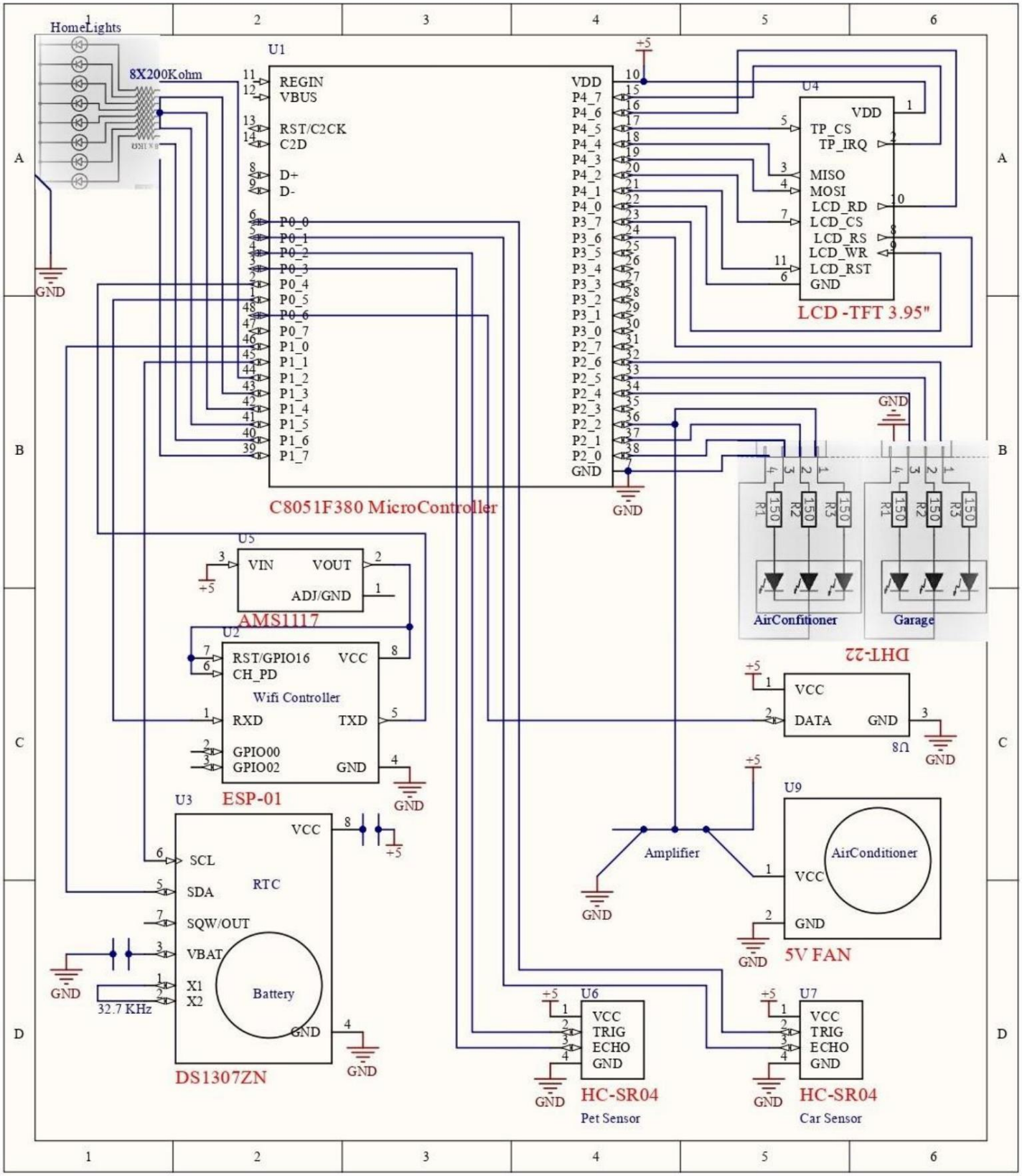
The micro controller in development configuration, before mounting the hardware on a dedicated board



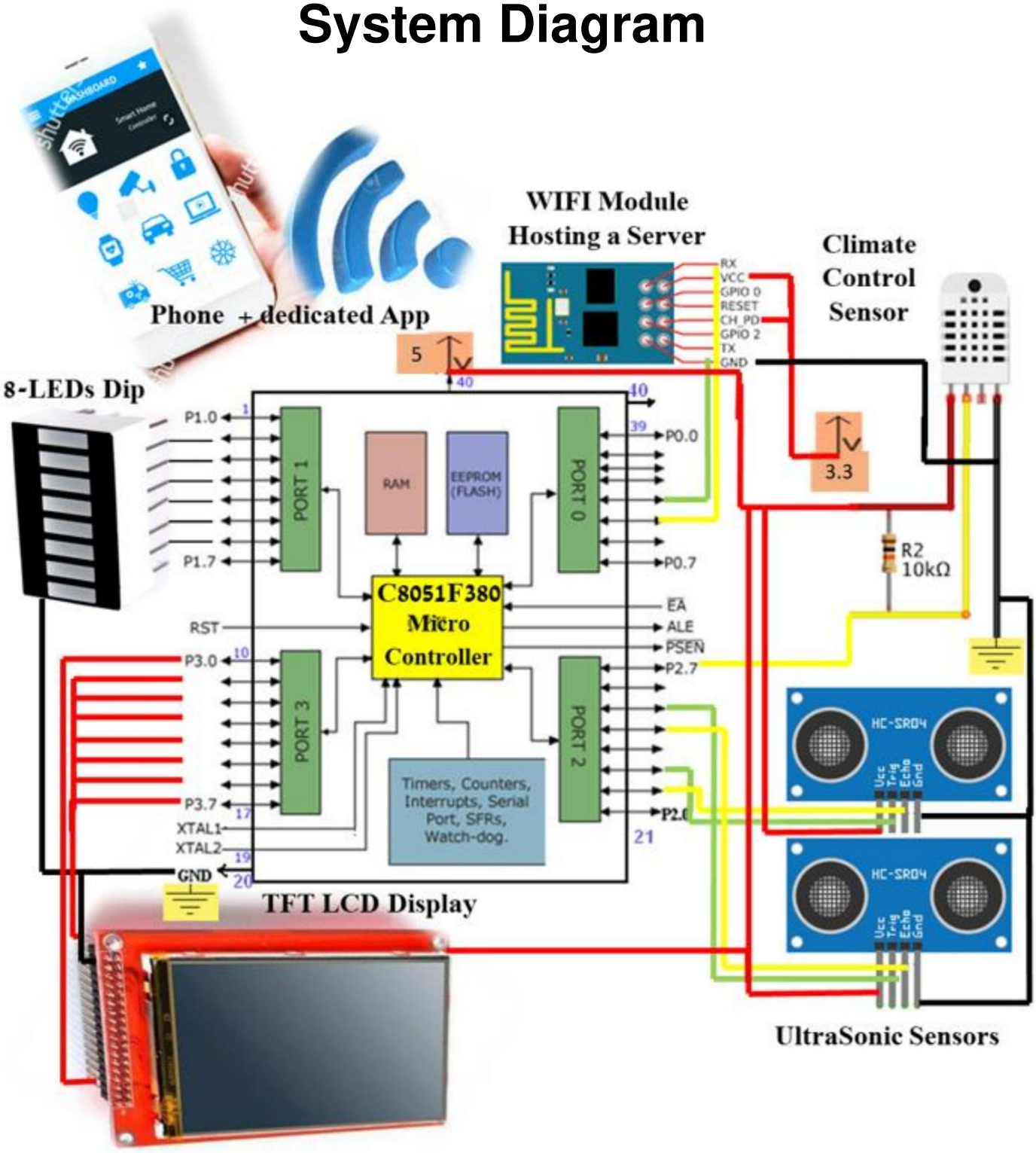
The connection ports of a microcontroller to the wiring we created on the WireUp board



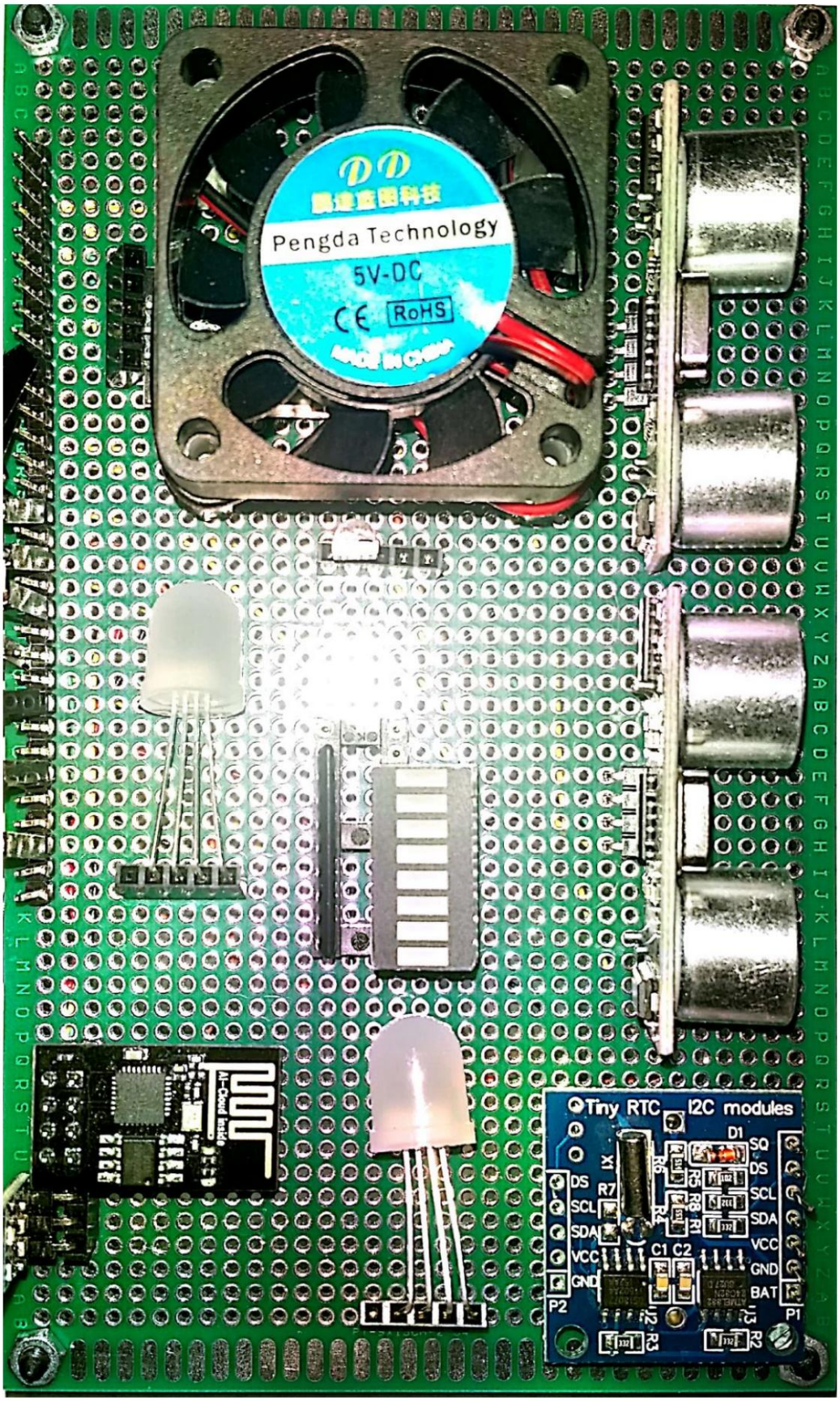
Electrical scheme (built using Altium 19 ver. software)



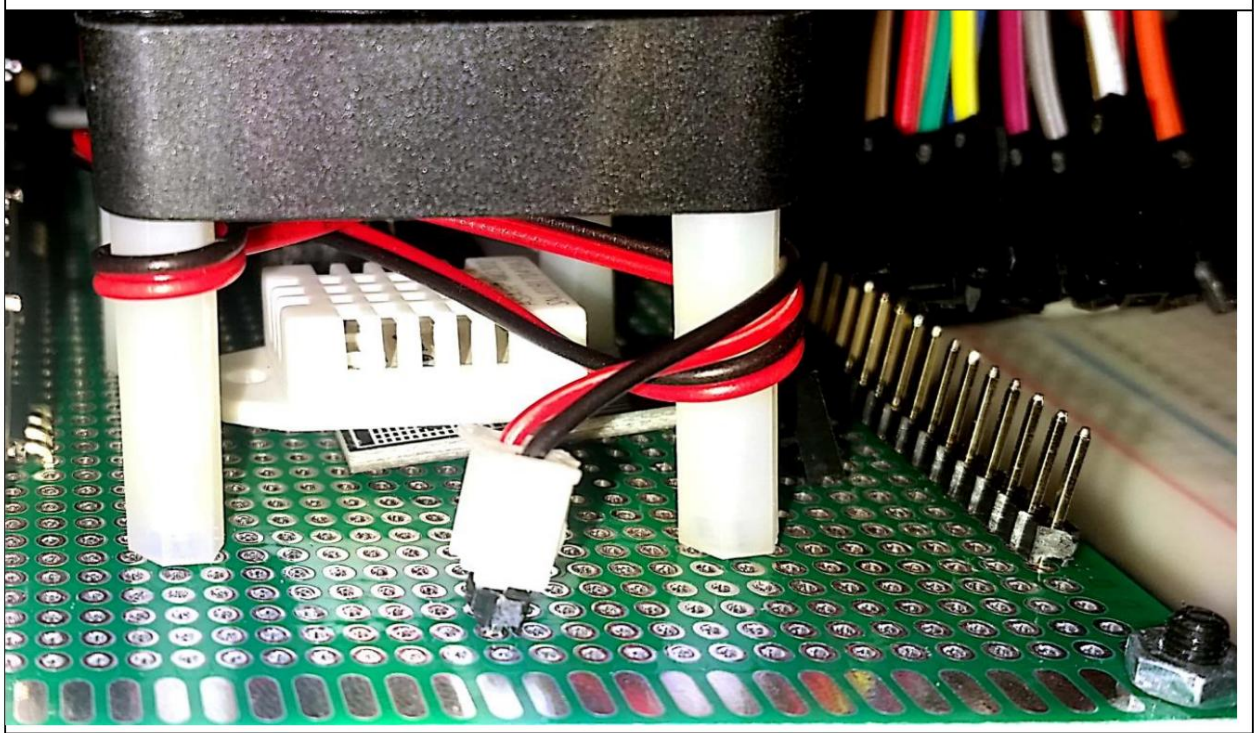
System Diagram



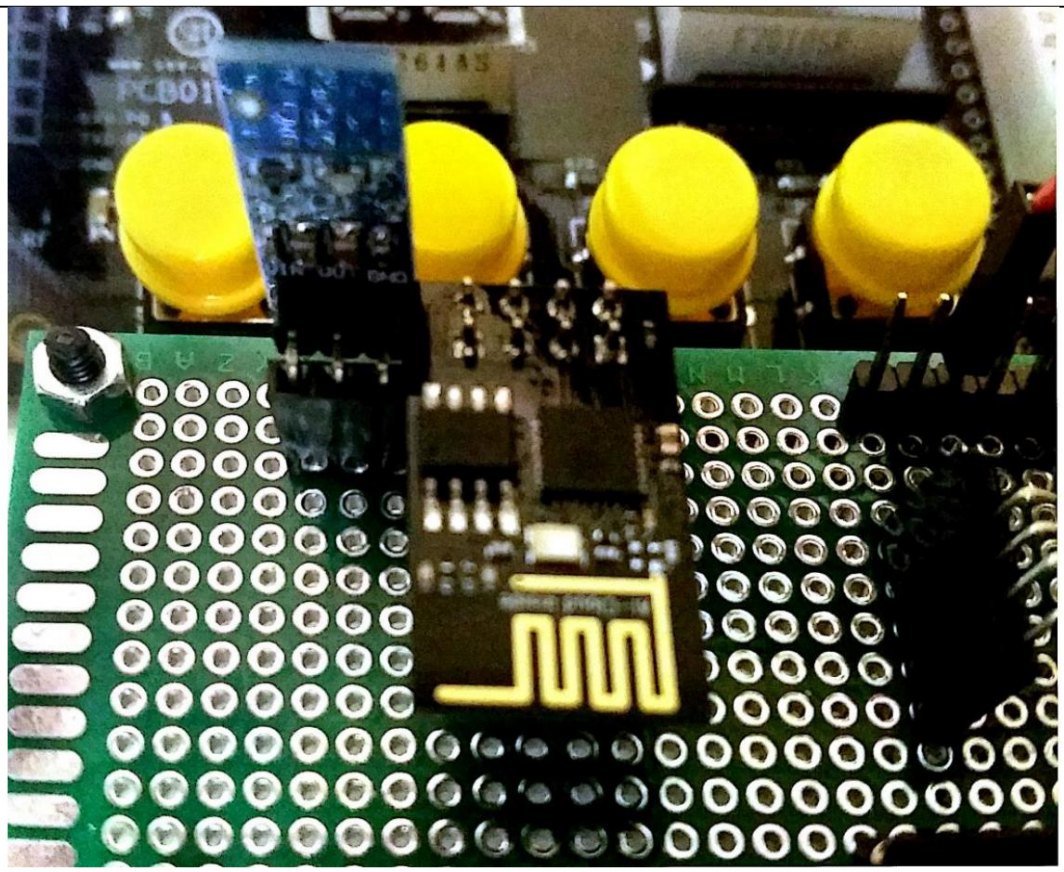
List of all components by WireUp



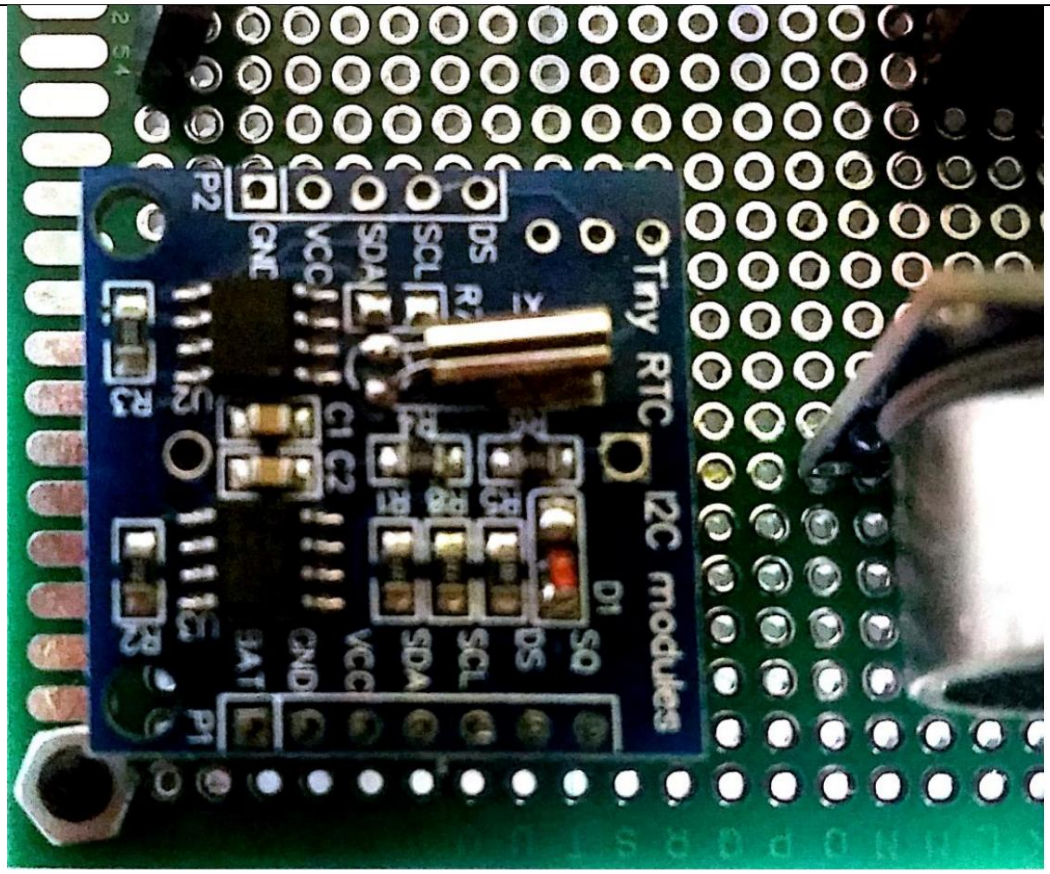
A 22-DHT humidity and temperature sensor that is fixed under a fan and monitors the change in data accordingly



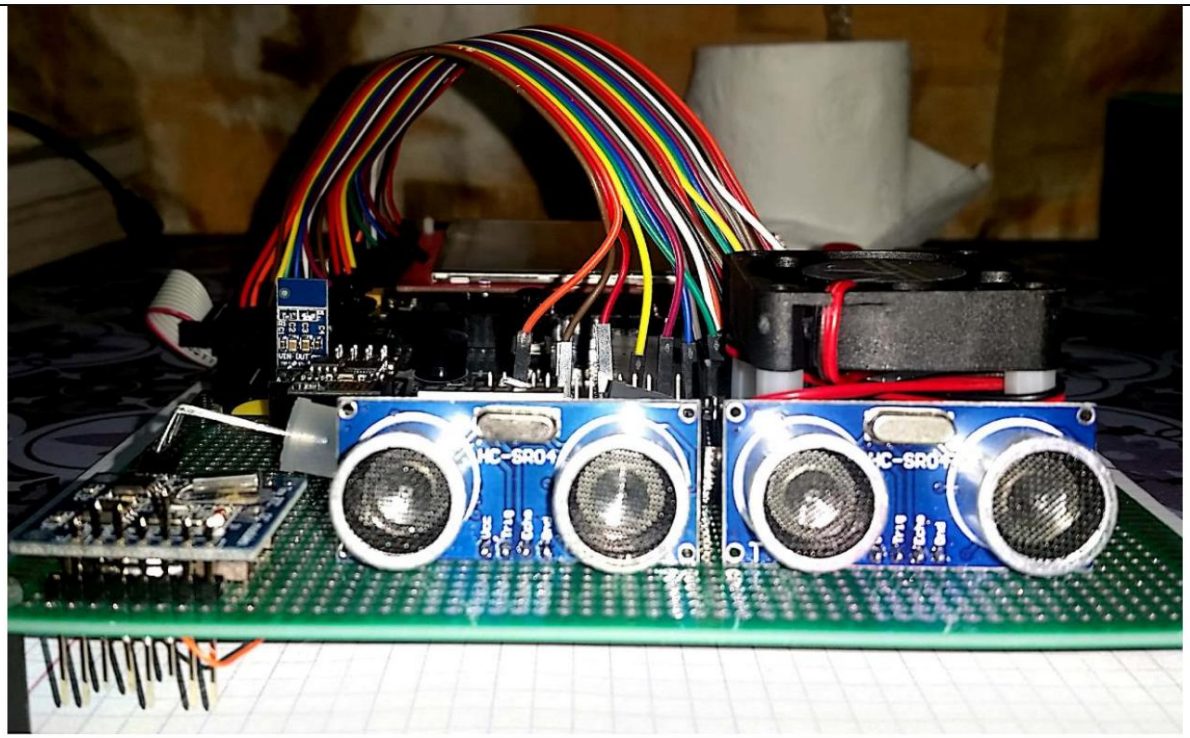
Network module .01Ver 8266ESP + voltage stabilizer



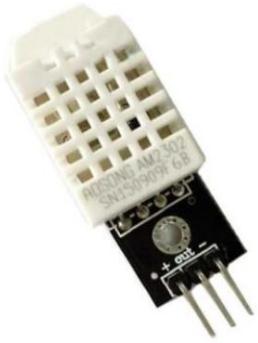
RTC DS1307 component



2 ultrasonic proximity sensors 04SR-HC



20 Integrated climate control sensor - -22DHT

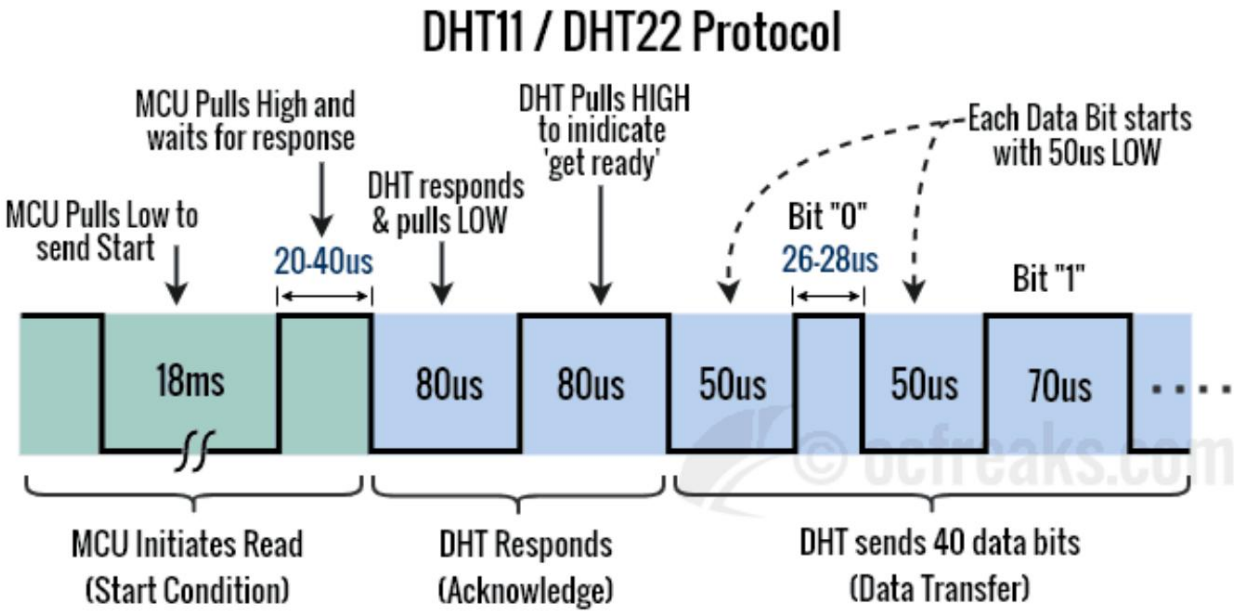


Pin Name	Pin Description
VCC	3.3 to 5.5 Volt DC, also 4.7K - 10K PullUp resistor is needed between this and DATA pin.
DATA	Digital output pin
GND	Ground

-22DHT is a sensor for monitoring temperature and humidity. The humidity value is measured in percentages (with an error range of 2-5%) and values - in degrees Celsius in a working range of C80° - C-40° (with an error range of The metric temperature is measured by the method.) ±0.5°C

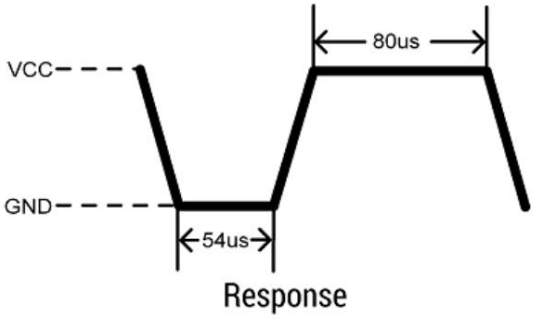
The measurement method is **electrical,** that is, through **the conductivity of a material** that is affected by the above data, and these are converted digital. The allowed reference rate for the component is 0.5 Hz, which means that **2 data can be 'pulled' from it only every second .**

One is used for communication. **The communication process is divided into three** For the sensor the 3 minutes as described above - the minute means only **stages, the first** is sending a request to the sensor, **in both** the sensor will send a pulse (pulse) a response and then in the **third** stage 40 bits for the microcontroller that runs it. Total starts sending data

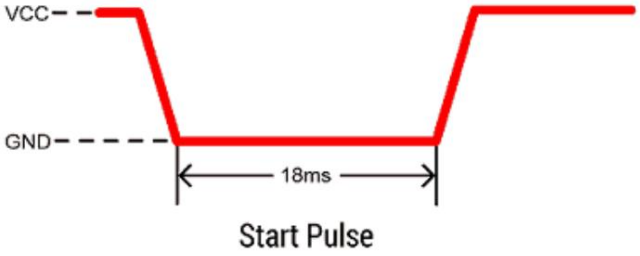


As a response, a pulse is received as below with a length of 54 us. Immediately after it is a high pulse, after which the sensor pushes the data in the information line.

To provide the **initial pulse,** a low pulse is provided 18 ms long.

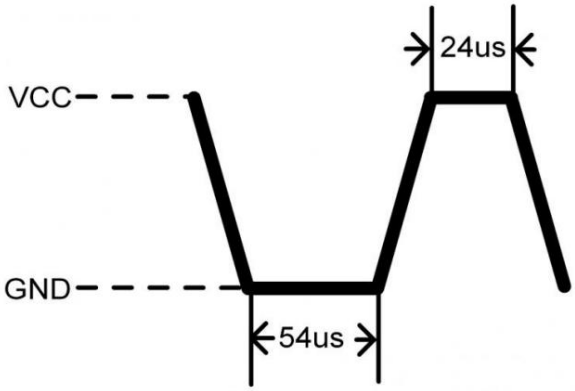


Response

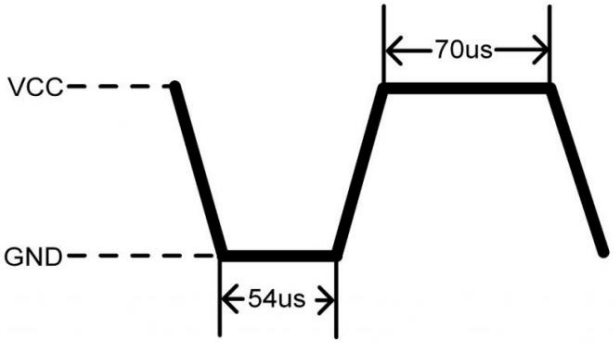


Start Pulse

The data frame has a **total length of 40 bits ,** 5 and it contains segments (bytes) and each segment is 8 Bits. In **these 5 segments,** the first two segments contain a **moisture** value in the form of a decimal number. This value gives us ·Relative humidity percentages. The first 8 bits are an integer part and the next 8 bits are a simulated part. The next two bits contain a **temperature** value in the form of a decimal integer. This value gives us a temperature in the form Celsius. The figure is sent in a similar way to the form in which the previous figure was sent.



Output 0 bit representation



Output 1 bit representation

Example 40 bits read from the sensor and their decoding: 0000 1110 1110 1111 0101 0001 0000 1100 1000 0010

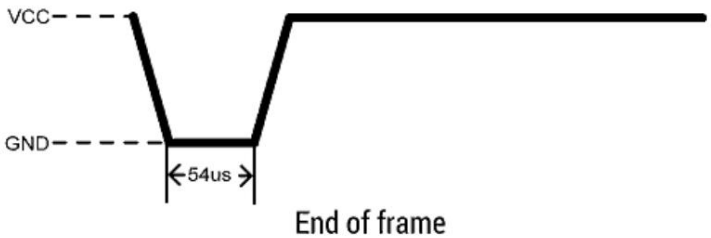
• 16 bits RH data: 0000 0010 1000 1100 ÿ 652 ÿ RH=652/10=65.2%RH

• 16 bits T data: 0000 0001 0101 1111 ÿ 351 ÿ T=351/10=35.1ÿ

What is called 1' means that the temperature is negative (below 0): (eg ' when the MSB 1000 0000 0110 0101, T= minus 10.1ÿ

8) A bit is a CheckSum which is a summation of the first four sectors, in this form (The last sector provides an option to verify the correctness of the received data. Calculation according to the examples given: 1110 1110=1111 0001+0101 1100+0000 0010+1000 0000=sum of bytes

At the end of sending, the sensor goes into low power consumption mode until it receives a start pulse, not before sending Last pulse indicating the end of data transfer:



End of frame

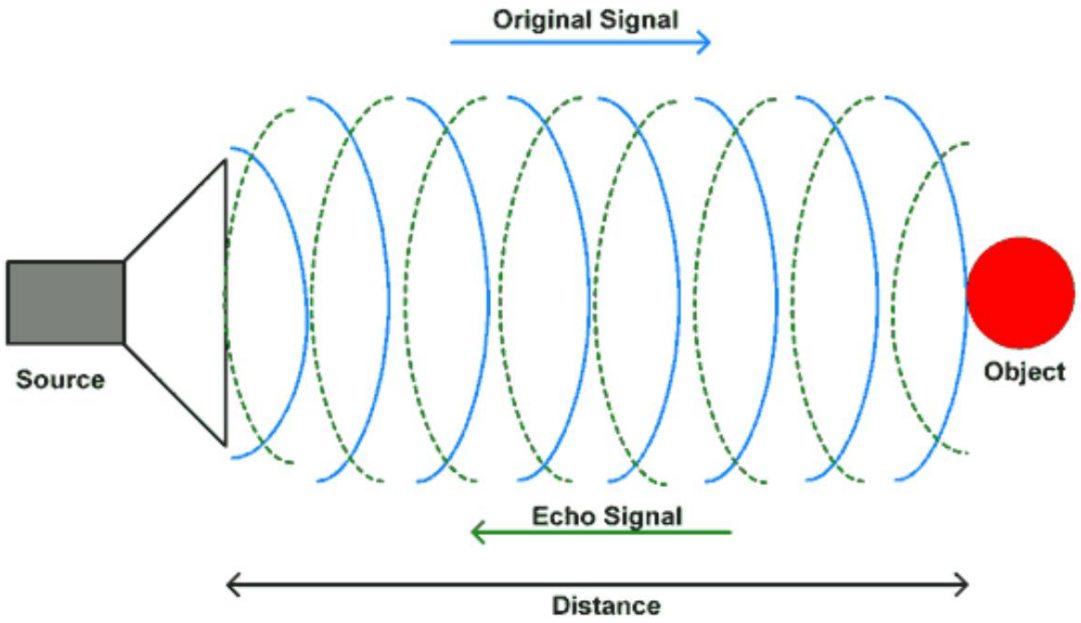
- 04SR-HC 21. Proximity sensor range monitoring

Pin Name	Pin Description
VCC	5 Volt DC
TRIG	Trigger input of sensor. Microcontroller applies a 10 us trigger pulse to the HC-SR04 ultrasonic module.
ECHO	Echo output of sensor. Microcontroller reads/monitors this pin to detect the obstacle or to find the distance.
GND	Ground

04SR-HC is a sensor for measuring distances between 2 cm and 3 meters. So that it is possible to measure large distances The sensor should be placed higher than the floor, otherwise the signal reflected from the floor could disrupt the measurements. location The sensor 8-10 cm above the floor will be enough to measure ranges of about a meter from the sensor.

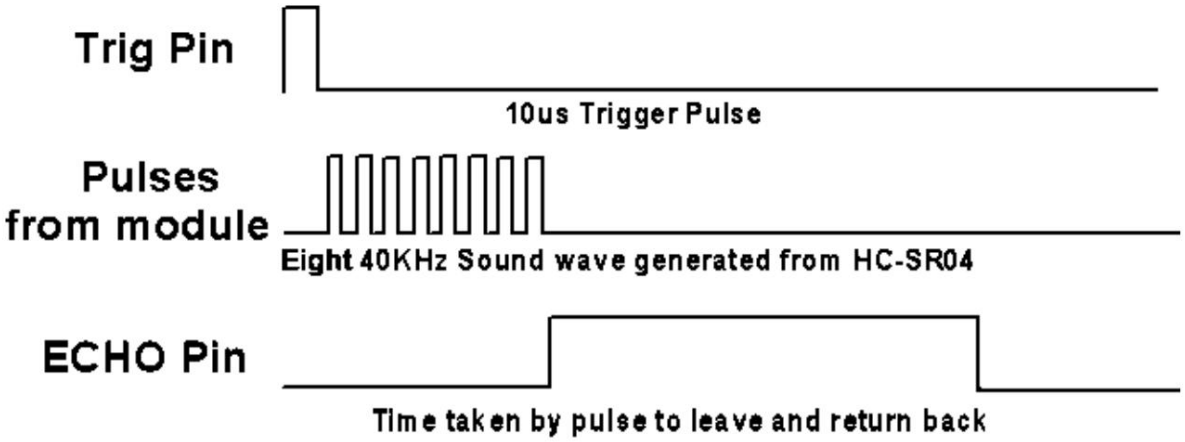
The sensor works on the principle on which **SONAR** or **RADAR** are based, which are used to determine the distance to an object) left and right to the sensor, and therefore essentially contains **a transmitter and a receiver**

, ultrasound), but not perceptible to the human ear. An ultrasonic sensor creates high-pitched sound waves (40KHz **frequency)** when they hit an object, they return as an echo that is felt by the receiver as shown in the diagram below.



Calculating the range from the object:

By measuring the time it takes for an echo to reach the receiver, we can calculate the distance. There is the measurement of time to start **immediately with the sending of the sound waves by the transmitter,** and therefore we use a timer (in the project - 0TIMER), **for 5 microseconds** and it immediately upon giving **the high component Trigger pulse for activation**



Ultrasound 8 - pulses of 40 kHz by the sensor. As soon as they are completed, **a line rises** The axis of the pulse causes me, and waits in this state until the voice is not received back. **to logical level '1 the Echo**

And we have to respond in the software to stop the counter. **,To logical level '0'** with the return of the sound waves, **the echo line** objectively **drops.** The resulting pulse width represents the time it took for the sound waves to complete the journey from the transmitter - to the shelter

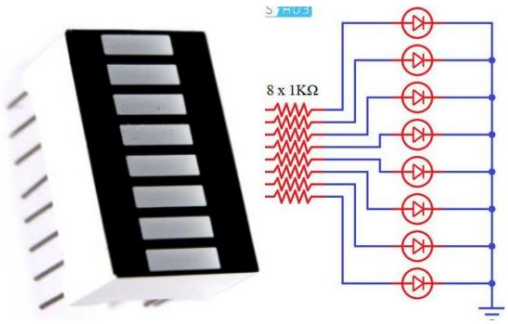
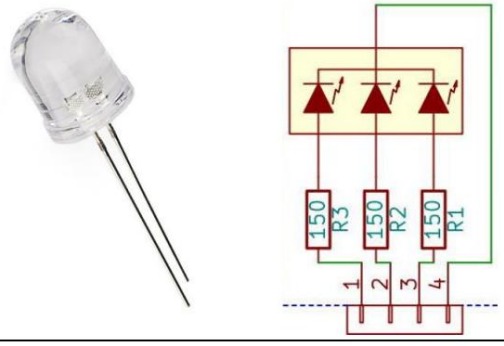
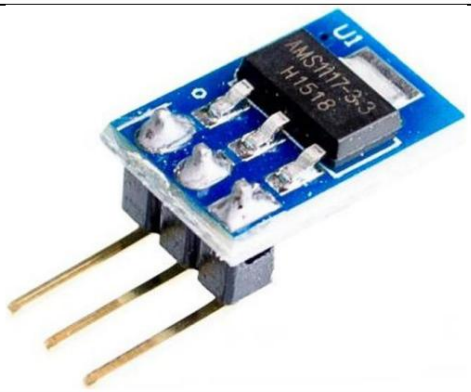
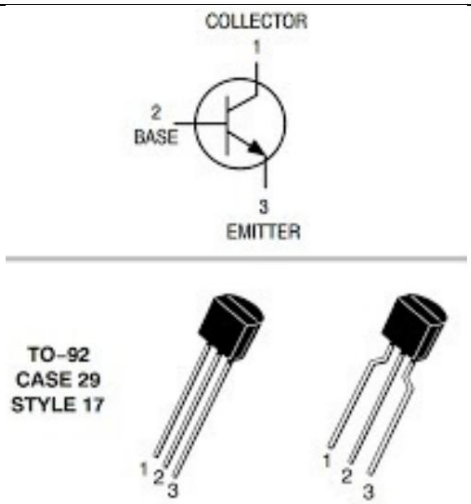
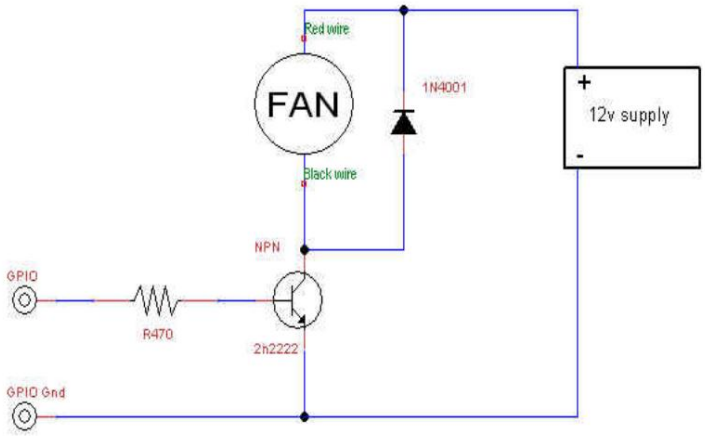
Another figure that is important to complete the equation is **the speed of sound** - which is a constant figure (in a good approximation) **and has a value of 343 m/s.** It can be calculated Since **speed multiplied by time is equal to distance**

$$\text{Total Distance} = \frac{343 \text{ x Time of High(Echo) Pulse}}{2}$$

As a general approximation, it can be said that the distance in cm to the measured object will be the length of the returned pulse in microseconds divided by 58

It is important to see that **the total distance is divided by 2 because it is important for us to consider only the distance traveled by the sound waves from the transmitter to the object without including their way back to the receiver.**

22. Other analog components in the project

Pack of 8 bulbs - for simulating home lighting	RGB LED - for automatic clock indication for parking lighting
	
1117AMS voltage stabilizer for constant voltage supply to the home server, and stabilization of the ESP component	**Ventilator V - 5 simulates an air conditioning system at home**
	
Bipolar transistor used to increase current in order to turn on the fan	**Electrical diagram for connecting the fan in the project**
	

23 Real time clock component - RTC 1307 -DS

Pin Name	Pin Description
The minutes 2,1 -X1 X2	Between the two triggers is connected a quartz crystal with a frequency of HZ32.768 which provides a square wave to activate the circuits inside the watch. 1X is the input of the internal oscillator and instead of a crystal, an external oscillator with a frequency of KHZ 32.768 can be connected to this input or Another square wave source at this frequency. **The accuracy of the crystal will determine the accuracy of the watch.**
Trigger - 3 VBAT	The positive voltage input of the backup battery. The backup battery is a 3 volt battery (you can connect a battery between 2 and 3.5). volts). The second trigger of the backup battery will be connected to ground. If the external backup battery is not used, connect the Trigger 3 to the ground. mAh48 battery can hold .10 years
Trigger - 4 GND	.The soil of the thin component
Trigger - 5 SDA DATA - SERIAL	**The two-way** data trigger of the **C2I serial communication interface.**
Trigger - 6 SCL SERIAL - CLOCK	This trigger is the clock input in the C2I interface it is used to synchronize the data movement in the serial interface. Connect to a resistance clamp External PULLUP because **it is of the 'open funnel' type (drain open).**
Trigger - 7 SQW/OUT	When the software enables the output of a square wave at a desired frequency (KHZ 1, KHZ 4, KHZ 8, KHZ) 32, the wave is output with this trigger square. Also to this port, a pull-up resistor must be connected to up .
Trigger - 8 VCC	the positive voltage trigger of the power supply.

General description:

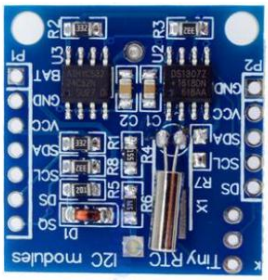
• A real-time clock component that connects via C2I serial communication with a microcontroller. The component has low power consumption with time and date and another 56 bytes of static RAM for general use according to the user's wishes.

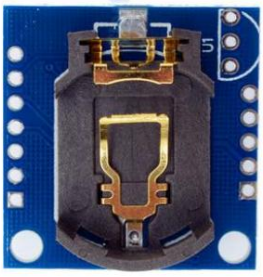
• The clock provides us with time that includes seconds, minutes and hours and the date that includes the day of the week, day of the month and the year. end The month is automatically updated in months that have less than 31 days including leap year corrections.

• The clock can work in a 24-hour format or in a 12-hour format with an indication of AM and PM.

• Inside the component there is a circuit that senses a voltage drop and automatically switches the circuits to battery voltage Backup. Creating the time Keeping the time continues even if the component is powered from the external backup battery.

• The component is activated in the C2I serial communication protocol and is used as a SLAVE component in this communication.





Characteristics:

• A real time clock that counts seconds, minutes, hours, the day of the month, the month, the day of the week, the year Includes a leap year and a leap year correction and is valid until the year 2100.

• 56 bytes of general RAM that can be backed up by an external battery with an unlimited amount of write operations disability.

I. 2 • C serial interface

• Square wave output signal with programmable frequency.

• Automatic voltage detector that switches from the mains voltage to the backup battery or vice versa.

• Small current consumption - nA500 when connecting a backup battery and there is no external supply voltage.

• Industrial temperature range from -40 degrees to .85 degrees

• Can be obtained in a package of 8 plastic DIP or SO pins.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Logic 1 Input	V_{IH}		2.2		V_{CC} + 0.3	V
Logic 0 Input	V_{IL}		-0.3		+0.8	V
V_{BAT} Battery Voltage	V_{BAT}		2.0	3	3.5	V

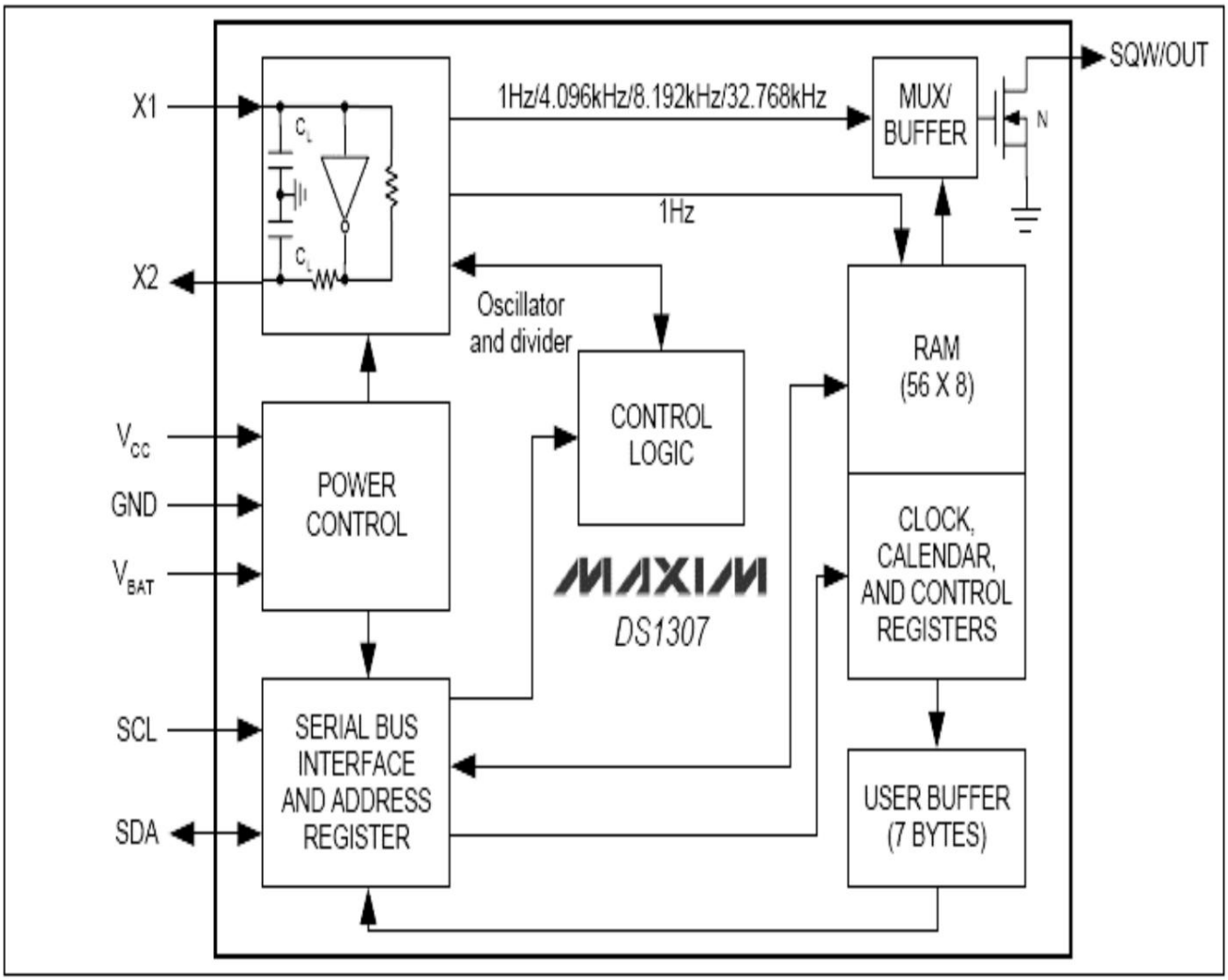
Maximum nominal values:

Recommended voltages:

• From the table you can see that the power supply voltage is between V 4.5 and V 5.5. • Input voltage of logic 1 is from V 2.2 to voltage V 0.3+ VCC.

• Logic '0 -' voltage at the input is from V 0.3- to a maximum of V 0.8 (logic 0 maximum). • The backup battery voltage is from V 2 to V 3.5.

Logical scheme:



The memory division - the time and date:

ADDRESS	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	FUNCTION	RANGE
00h	CH	10 Seconds			Seconds				Seconds	00–59
01h	0	10 Minutes			Minutes				Minutes	00–59
02h	0	12 24	10 Hour PM/ AM	10 Hour	Hours				Hours	1–12 +AM/PM 00–23
03h	0	0	0	0	0	DAY			Day	01–07
04h	0	0	10 Date		Date				Date	01–31
05h	0	0	0	10 Month	Month				Month	01–12
06h	10 Year				Year				Year	00–99
07h	OUT	0	0	SQWE	0	0	RS1	RS0	Control	—
08h–3Fh									RAM 56 x 8	00h–FFh

0 = Always reads back as 0.

All the data in the clock is in a crowded BCD code, **which means that every 4 bits are used as** one decimal digit. For example, 30 minutes in binary.) the maximum decimal number in the 4 digits 0011 0000 will be indicated in the address 1 in H30, meaning it will be 1001, which is 9. A number greater than this cannot appear.

Address 0 contains the seconds. Bit 7 called CH - Halt Clock - is a bit controlled by the programmer. **0 bit makes the clock work. If you put 1 in this bit the oscillator circuit stops working.** When turning on the electricity, he looked Can wake up on a random situation. The bit must be initialized to 0. Stopping the clock is worthwhile if you want to extend its life of the external backup battery. Stopping the clock means that the electronic circuits in the component are not activated and thus Significantly reduce the energy consumption from the battery.

Bits 0 to 3 are the units digit of the seconds. Bits 4 to 6 are of the tens of seconds.

·digit **Address 1 contains the minutes .** Here again, bits to 3 are the seconds digit and bits 4 to 6 are the tens Bit 7 is always in .0

Address 2 contains the hours. It is possible to work with a 12 or 24 hour working mode. Bits 0 to 3 determine the manner. If 12 hours 1 in this)bit (or work The unit digit of the hours. Bit 6 determines if you work in a (24 hour 0 bit) in a 12-hour manner, so bit 5 says whether AM (before noon) or PM 1 (afternoon) when in bit says PM (afternoon). If you work 24 hours then bit 5 together with bit 4 are the tens digit of the hours. For example, if you write the binary number 00100011 to address 2, it means that you work 24 hours a day. 6 (bit at 0) and the time is 11 (11 pm).

.for Saturday **Address 3 contains the day of the week .** In bits 0 to 2, the number can appear between 1 and Sunday and 7. The other bits are 0.

Address 4 contains the day of the month (a number between 1 and 31). Bits 0 to 3 the number of units in the month and bits 4 and 5 the tens digit of the month. The 2 bits 6 and 7 will be at 0

.4 to the tens digit **Address 5 contains the month** 1 (a number between 12 and 12). Bits 0 to 3 are the units digit. The remaining bits are 0.

Address 6 contains the year 0 (a number between 99 indicating the years 2000 to 2099). Bits 0 to 3 are the digit .7 the tens digit The units and 4 bits until the

, day of the week change is done at midnight. Relevant data must be entered. Sunday of the week should be noted as 1 Monday about 2 and so on. Entering illogical data will cause illogical results.

Current consumption:

To see in the first row the current consumption from the battery when the component is working and you do not output a square wave in leg 7 of The component (will be explained later). The typical current is 300 nanoamperes. If a square wave is output - second row in the table - The current increases to 480 nanoamps.

When the oscillator circuit is stopped (the electronic circuits are not activated) - the current decreases - third row in the table - .to 10 nano amps

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{BAT} Current (OSC ON); SQW/OUT OFF	I_{BAT1}			300	500	nA
V_{BAT} Current (OSC ON); SQW/OUT ON (32kHz)	I_{BAT2}			480	800	nA
V_{BAT} Data-Retention Current (Oscillator Off)	I_{BATDR}			10	100	nA

Control register:

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
OUT	0	0	SQWE	0	0	RS1	RS0

At address 7 is the control register. The programmer can determine whether to output a square wave with the component's OUT/SQW 7 leg or determine a desired fixed logic level with this leg. If the programmer wants to **output a square wave,** he has the option of choosing one of 4 possible frequencies. If the programmer does not want to output a wave square he can determine whether this output leg (leg 7) will be 0 or 1

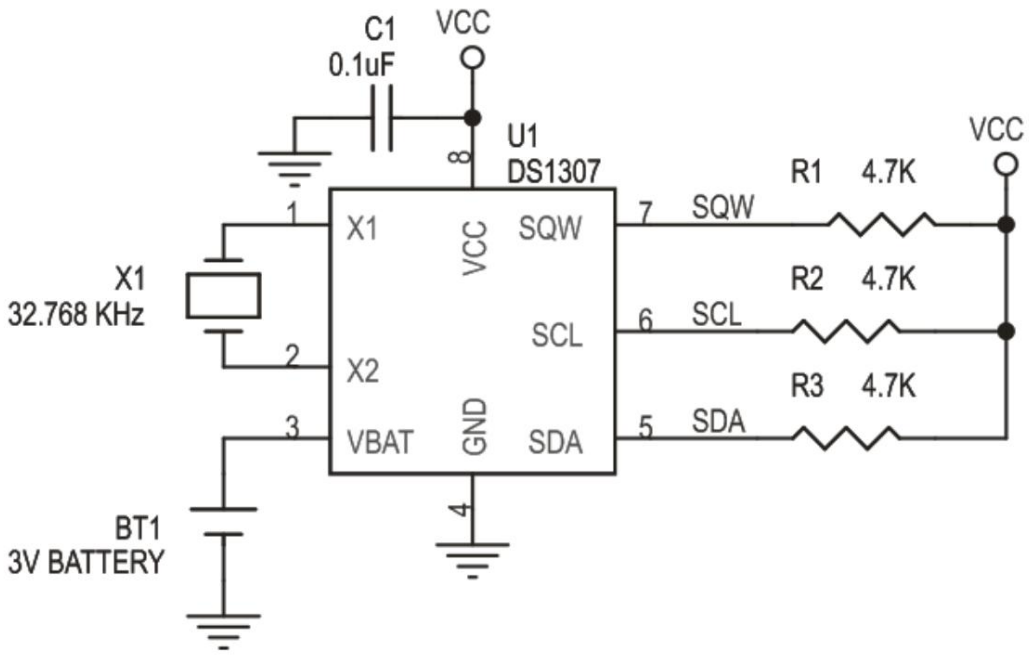
With the help of bit 4 SQWE - **Enable Wave SQuare - enable square** wave - determine whether to allow outputting a square wave (put 1 in the bit) or not (put 0 in the bit). If we put a 1 in bit 4 (enable outputting a square wave) then the bits 0 and 1 1RS 0RS) determine the output frequency on this leg. **Select Rate - RS - rate selection .**

RS1	RS0	SQW/OUT OUTPUT	SQWE	OUT
0	0	1Hz	1	X
0	1	4.096kHz	1	X
1	0	8.192kHz	1	X
1	1	32.768kHz	1	X
X	X	0	0	0
X	X	1	0	1

If we put the value 0 in bit 4 (a square wave output is not allowed) then in bit 7 of the register called OUT - it is possible to determine whether leg 7 of the component will be 0 or 1. If we put 0 in bit then leg 7 will be 0 and if bit 7 we put 1 then leg 7 will be 1

From address 8 to 3FH 55 (decimal) there are RAM addresses for general use according to the user's wishes.

Typical operating circuit:



The component connects as **a SLAVE** to a processor - CPU - which is used as **a MASTER** with the help of 2 lines of C2I communication. foot

SDA of serial data - Data Serial and the SCL leg - the serial clock Clock Serial, which synchronizes the input of the data

The serial from the processor to the component or from it to the processor.

2 "Up Pull" resistors must be connected from these two legs to the Vcc voltage. The reason for this is that inside

The component has FET transistors in an Open Drain connection (open source). The reason for this connection is that on 2 communication lines

These C2Is, you can connect at the same time an additional number of components such as EEPROM, FLASH ADC, etc. and you don't want to

the communication lines that the resistors inside the component will affect - load - you

Another external resistor is also seen at the output in leg 7 of the component - OUT/SQWE. Here too the port of the component is Open

Drain and an external resistor must be connected.

The external PullUp resistor that will be connected is a resistor in the order of 2 kilo ohms to ten kilo ohms.

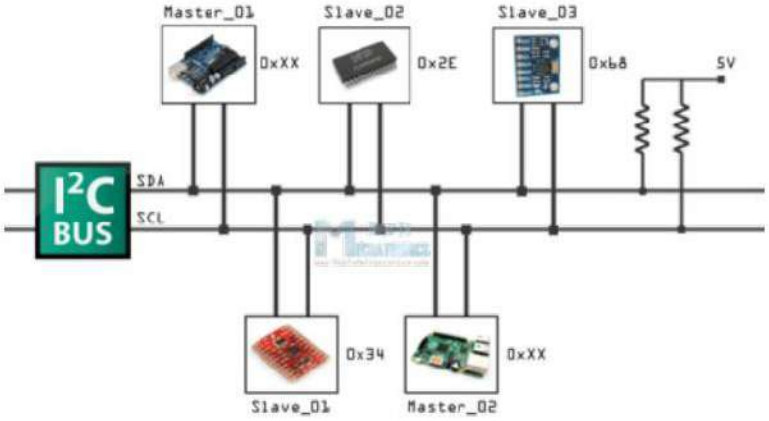
The component communicates with a processor in C2I communication. A number of different components can be connected on a C2I communication band .

24. I2C protocol

The I2C protocol is a BUS communication protocol with two lines, for data at a slow to medium rate, as a result the physical size of the components communicating through it can be reduced - the number of their triggers remains small and so does their cost.

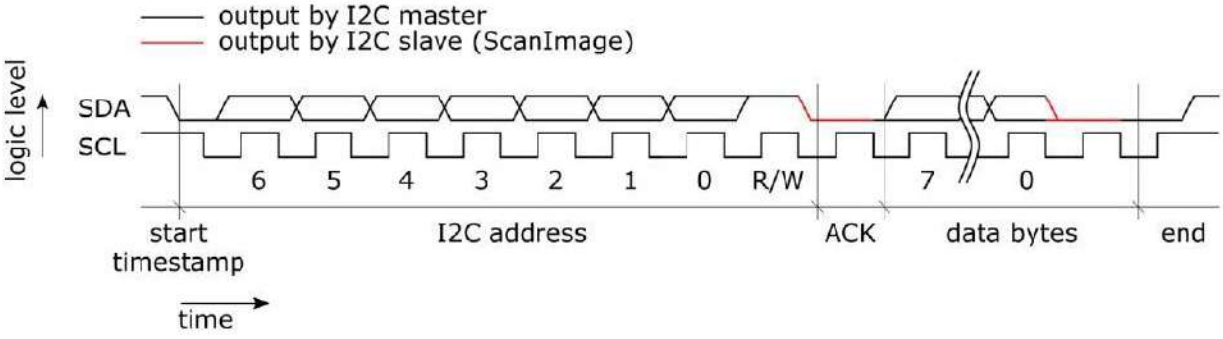
More importantly, it is also possible to chain a large number of components to the same transmitter (memories, converters, real-time clocks, etc.).

The component that manages the communication process (the processor) is called MASTER and the components that connect to it are called SLAVES. In addition, the MASTER controls access to the band and creates the START and STOP states.



The mode of operation in this communication is called Half-Duplex because it is not possible to write and read at the same time. The BUS includes two lines:

- Serial clock line - (SCL (Serial Clock) which is one-way and operated by the MASTER, its function is to synchronize the The information transferred between the two components.
- Serial data line - (SDA (Serial Data) which is bidirectional and its function is to transfer the information between two components.



It can be seen that several components can be connected to the 2 lines SDA (the data line) and SCL (the clock line). Each component has own unique address. For the DS1307 component the address is DH DH1101000 .(

In the figure you see 2 components that connect on the lines. In the lower part of the figure you see the internal structure of a component and you see that the component is connected with the help of a buffer (depicted by the triangle) that receives data from the line. Above the buffer there is a transistor connected

that can Collector Open (or Field Effect Transistor - FET - in an open collector connection) (Drain Open, write to a given line.

An external resistor between 2 kilo ohms and 10 kilo ohms must be connected to the transistor. The values are chosen so that on one hand the resistors will not be too small so that a large current does not flow through the lines and through the component (when the component outputs 0) and on the other hand that the resistor should not be too large because it determines the charging and discharging time in transitions between 0 and 1 and vice versa and a resistor that is too large will limit the rate of communication.

Rules and definitions in I2C communication:

• Transfer can only start when the line is not busy - BUSY NOT.

• While transferring data, the data line must remain stable when the clock line is high. Change in the given line when line ·as control signals The clock will be interpreted high

•

Not BusyBus - not busy bus - both the data line and the clock line are high.

• **TRANSFER DATA START** - Start data transfer

• A change in the state of the data line from high to low when the clock is high is defined as the START state

• TRANSFER DATA STOP - stop data transfer

• Change in the state of the given line from low to high when the clock in high state is defined as STOP state.

• VALID DATA- data validity

• The state of the data line represents the validity of a data when after the START state - the data line is stable for the maximum time of a signal the clock The data on the line must change only during the low state of the clock signal. There is one clock pulse for each bit of given.

Each data transfer starts with a START state and ends with a STOP state. The amount of bytes transferred between START to STOP is not limited and is determined by the MASTER component. The information is transmitted byte by byte And each receiver acknowledges receiving the house with the ninth bit of ACKNOWLEDGE.

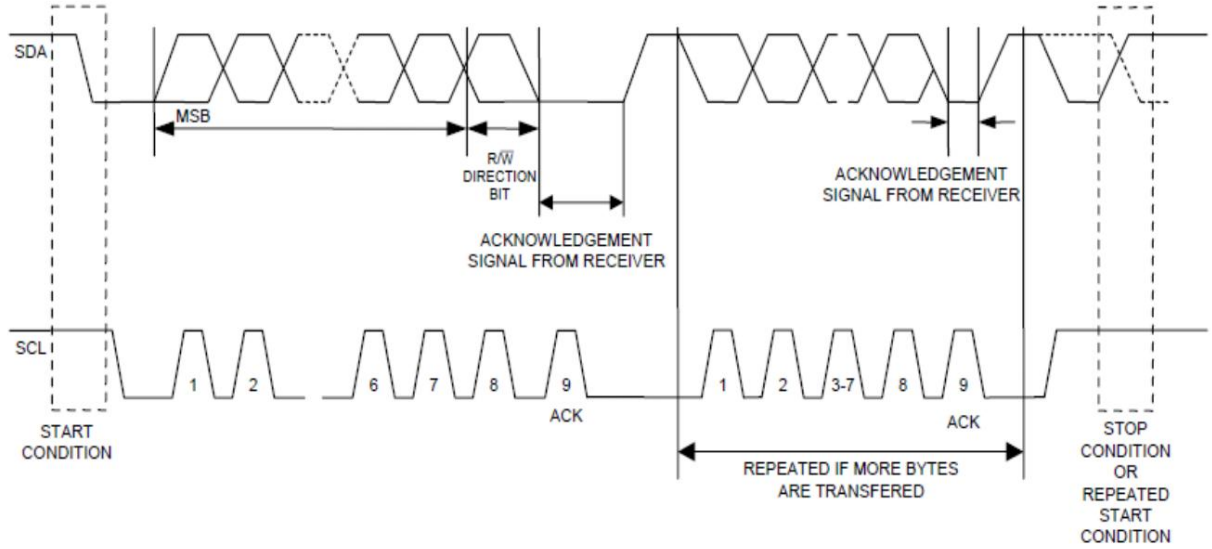
I There is a rate standard for 100KHz and there is a standard for 400KHz. The DS1307 component works at a rate ^{2}In the settings of C of . only KHz100

• ACKNOWLEDGE – approval

• Each receiving component must, at the end of receiving a byte, which was transferred to it, create an ACKNOLEDGE bit. The MASTER component Generates another clock pulse associated with this bit.

The ACKNOLEDGE creator component must lower the serial data line - SDA - to 0 during the clock pulse, i.e. The data line will be steady low while the clock line is high. The MASTER component signals to the SLAVE that it is finished the communication by **not generating** the ACKNOLEDGE bit when it received the last byte from the SLAVE. In such a case, the SLAVE must leave the given line high to allow the MASTER to create a STOP state.

Scheme for the transfer of serial data:



The SCL line (the bottom line in the drawing) is always created by the MASTER .

The START state happens when the SCL line is high and then the MASTER lowered the data line to 0. Then the MASTER creates 8 clock pulses and then it sends 8 bits on the given line - SDA. 7 bits are the address of the component and the bit (. – 2 reading ,0 writing The 8 says whether he wants to write to the component or read from it) -

After that, the MASTER creates another pulse 9 where the SLAVE has to return ACKNOWLEDGE afterwards
There is no need for an additional START and the bytes are sent one after the other when the receiving side gives an ACKNOWLEDGE

In bit number 9, the STOP (or repeated START) state is depicted on the right side of Fig. 6

to 1. The repeated START state is drawn with a dashed line and inIt is created when the clock line is at 1 and then the given line has a transition from 0

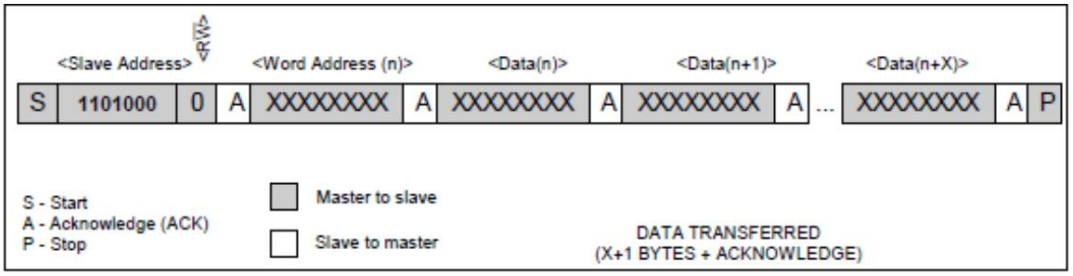
You see that while the clock line is at 1, the data line drops to 0

Data transmission in I2C communication:

Two data transfer options exist in a C2I communication line:

A. The MASTER transmits and the SLAVE receives - write mode - Write Mode

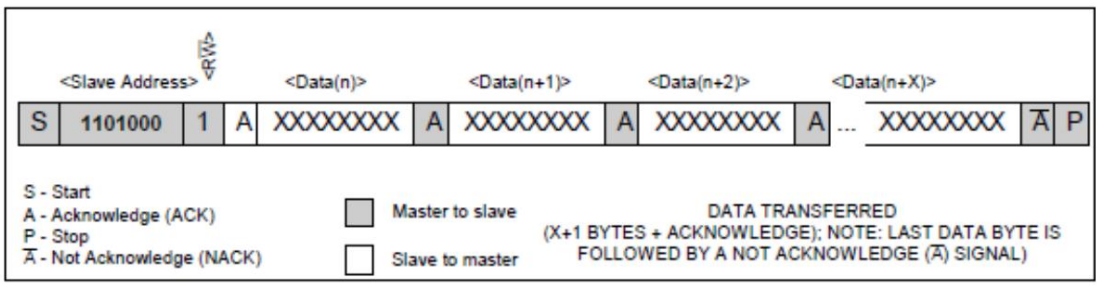
In this case the first byte transmitted by the MASTER is the address of the SLAVE (in the case of a component 1307DS The address is X1101000 - H0D in the case of writing to the component or H1D if reading from the component. After This will be followed by several bytes of data. The SLAVE returns ACKNOLEDGE at the end of each byte of data it received. The data is transmitted with the MSB bit first.



The MASTER creates a START state (marked with S). 7. Then it sends bits of the component address - H0D In the case of the 1307DS component - and the 8th bit is 0 indicating that it is the writer and the SLAVE is the receiver. on the SLAVE Answer with ACKNOWLEDGMENT (marked with A). Then the MASTER sends another byte that loads the pointer (register). Each data is written The addresses inside the component. The following data is written to this address and the address pointer automatically increases by 1 at the address in the address pointer and the address pointer advances by 1 after each byte received by the SLAVE is Sends acknowledgment received - ACKNOELEDGE. The MASTER terminates the communication using the STOP mode (appears On the right side with the letter P.

on. A byte is transmitted from the SLAVE to the MASTER - Mode Read

In this case the first address sent is by the MASTER sending the address of the SLAVE which returns the The ACKNOWLEDGE bit. From here the SLAVE sends a number of data bytes. The MASTER returns a bit ACKNOWLEDGE after each reception of a given byte except for the last byte which does not return ACKNOWLEDGE Or you can say that he returns. ACKNOWLEDGE Not



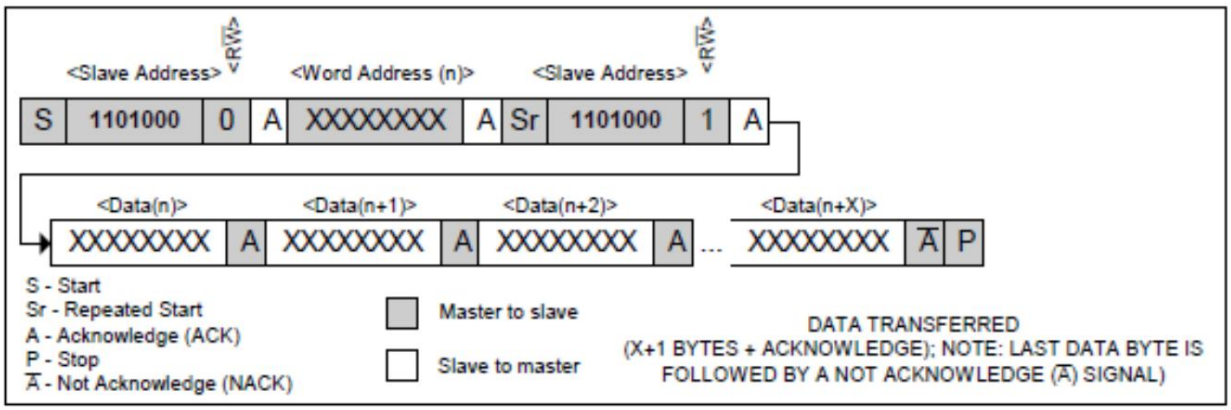
This situation also always starts in the situation where the MASTER transmits to the SLAVE but here he says he wants to to read from him. The first byte that the MASTER transmits is received by the SLAVE as described in the previous paragraph, i.e. the MASTER

Creating a START state will send the 7 bits of the address 10110001 but the eighth bit will be 1 where it says that he wants to read. From here the SLAVE transmits the data and the MASTER replies with an ACKNOWLEDG bit. It does not respond with the 9th bit and does not send when the MASTER wants the end of the communication in the last byte, ACKNOLEDGE (marked in figure b **Â)** and also sends a tenth STOP bit.

The data transmitted from the SLAVE starts from the last address where the address pointer is located. Any data that .- automatically SLAVE sends it advances the address pointer to the next address

2 stanzas to the component in the first stanza he says Usually the communication process will be as follows: the MASTER will write to the component it addresses for writing. In the second stanza he will indicate the desired address. Immediately after, STOP will be sent (or START returns (and will then perform a new communication where it will refer to the component to be read from the address it sent to it in the operation the writing.

Write and read operation from the address:



The MASTER sent 2 bytes to the SLAVE. Immediately after that created a repeated START mode (marked by Sr), send home added where there is the component address 10110001 (the eighth bit is for reading) and from this moment the SLAVE transmits and MASTER responds with ACKNOWLEDGMENT. At the end of the communication, the MASTER does not give an ACKNOWLEDGMENT (marked with **Â)** and then gives STOP mode.

.25 touch screen "3.95 TFT - LCD

Name	Parameter
Display Color	RGB 65K color
SKU	MAR3953
Screen Size	3.95 inches
Type	TFT
Driver IC	ST7796
Resolution	480*320 (Pixels)
Interface Module	8-bit parallel transmission, interface for reading from an SD card
Active Area	60.53x88.38(mm)
Module PCB Size	61.54x105.69 (mm)
back light	6 chip HighLight white LEDs
Operating Temperature	-10ÿ~60ÿ
Storage Temperature	-20ÿ~70ÿ
Operating Voltage	5V/3.3V
Power Consumption	TBD
Product Weight	About 45(g)

Details of the clamps:

Pin Name	Pin Description	Pin Name	Pin Description
1 5V	Positive power supply	2 5V	Positive power supply
3 DB8	8th bit of data bus	4 DB9	9th bit of data bus
5 DB10	10th bit of data bus	6 DB11	11th bit of data bus
7 DB12	12th bit of data bus	8 DB13	13th bit of data bus
9 DB14	14th bit of data bus	10 DB15	15th bit of data bus
11 DB7/NC 7th bit of data bus (does not need to be connected when using 8-bit mode)		12 DB6/NC 6th bit of data bus (does not need to be connected when using 8-bit mode)	
13 DB5/NC 5th bit of data bus (does not need to be connected when using 8-bit mode)		14 DB4/NC 4th bit of data bus (does not need to be connected when using 8-bit mode)	
15 DB3/NC third bit of data bus (does not need to be connected when using 8-bit mode)		16 DB2/NC 2nd bit of data bus (does not need to be connected when using 8-bit mode)	
17 DB1/NC 1st bit of data bus (does not need to be connected when using 8-bit mode)		18 DB0/NC 0 bit of data bus (does not need to be connected when using 8-bit mode)	
19 LCD_RS LCD register / data selection signal Low level: register, high level: command		20 LCD_WR LCD write control signal	
21 LCD_CS LCD screen select control signal, low level enable		22 LCD_RST LCD reset control signal, low reset	
23 NC	Undefined, reserved	24 LCD_RD LCD read control signal	
25 TP_IRQ Touch screen interrupt control signal, low level when touch is detected		26 NC	Undefined, reserved
27 NC	Undefined, reserved	28 NC	Undefined, reserved
29 SD_CS	SD card select control signal, low level enable	30 NC	Undefined, reserved
31 MISO	SPI bus input signal	32 MOSI	Touch screen chip select control signal, low level enable
33 EX_CLK SPI bus clock signal		34 TP_CS	SD card select control signal, low level enable
35 GND	Power ground	36 GND	Power ground

It is important to note that **all communication in front of the screen is within the 'closed code' library reserved for the project manager as well**

The manufacturer of the development board, and all rights are reserved to them regarding the implementation of the interface as well as a variety of graphic drawing functions on it

and define their color. ,The screen that actually builds the various polygons **in the final user interface**

Write cycle of the internal controller on the screen:

The WRX signal is driven from high to low then pulled back to high during the write cycle. The host processor provides information while the display module captures the information from the host processor on the rising edge of the WRX. Figure 1 below shows the write cycle of the DBI Type B interface.

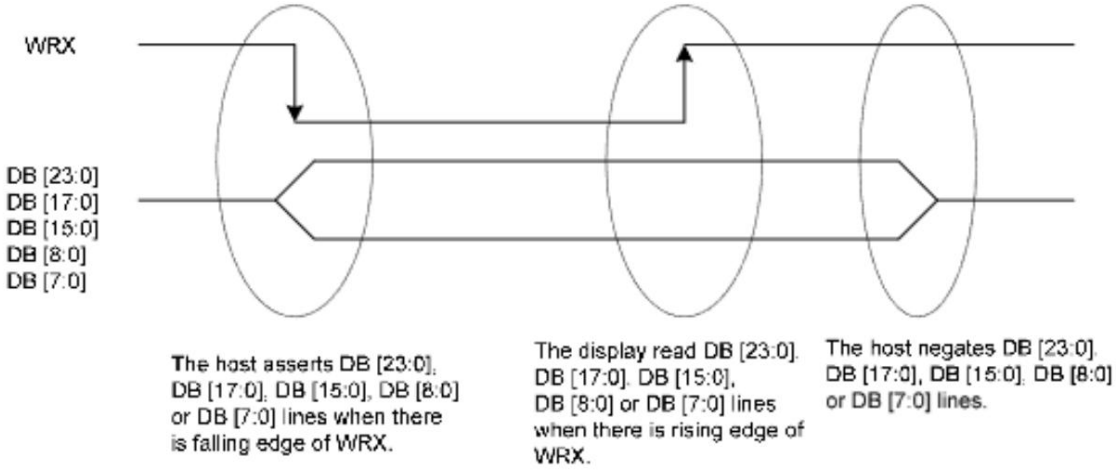


Figure 1: DBI Type B Write Cycle

Note: WRX is an unsynchronized signal that can be terminated when not being used.

When the D/CX signal is driven to low level, the input data on the interface is interpreted as command information. The D/CX signal can also be pulled to high level when the data is RAM data or command parameter.

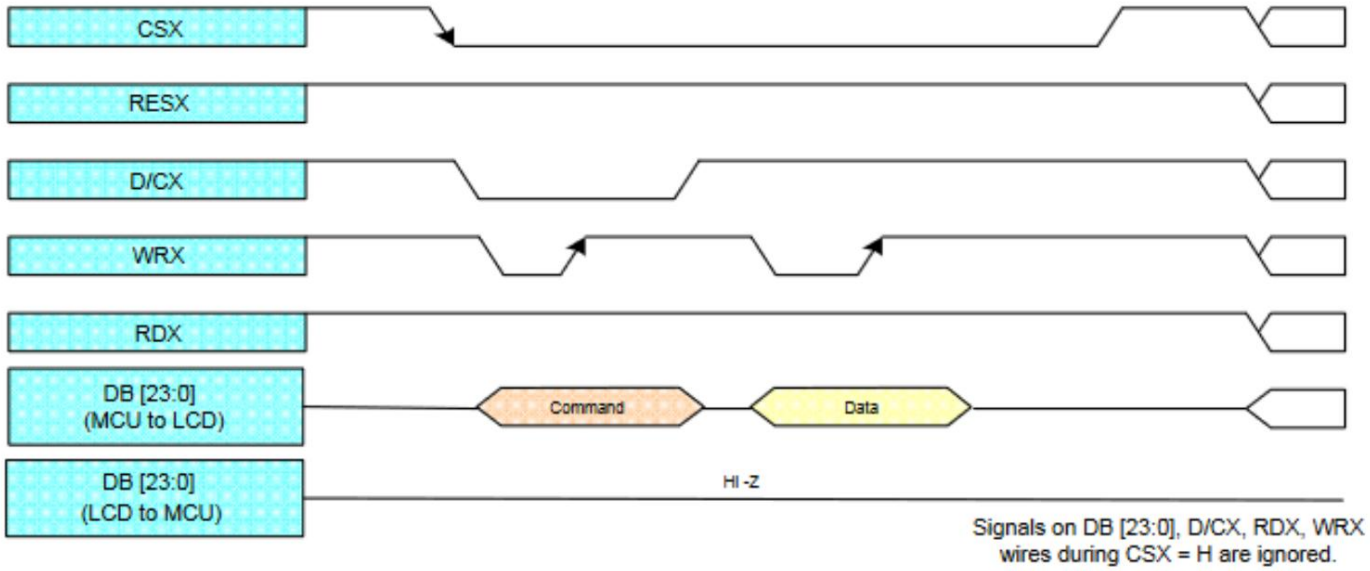


Figure 2: DBI Type B Write Cycle Sequence

The RDX signal is driven from high to low and then pulled back to high during the read cycle. The display module provides information to the host processor while the host processor reads the display module information on the rising edge of the RDX signal. Figure 3 below shows the read cycle of the DBI Type B interface.

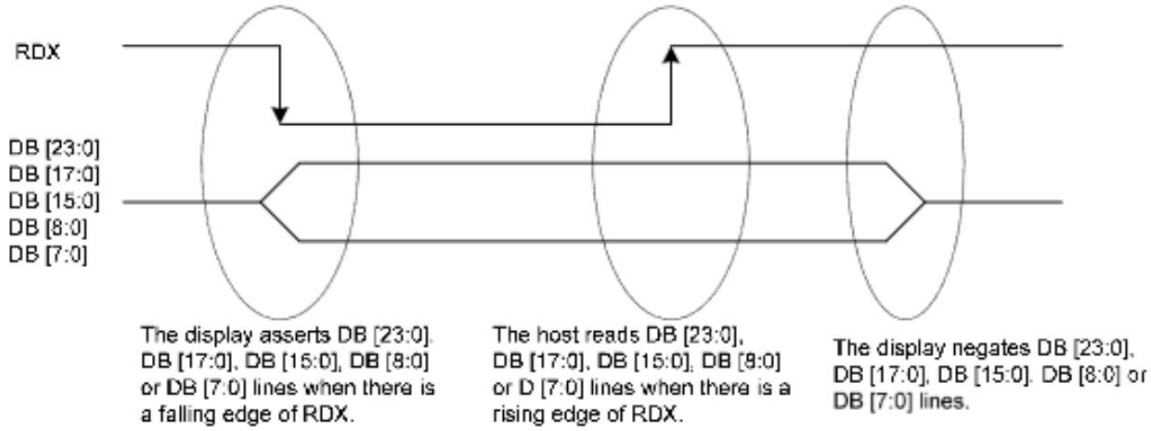


Figure 3: DBI Type B Read Cycle

Note: RDX is an unsynchronized signal that can be terminated when not being used.

When the D/CX signal is driven to the low level, the input data on the interface is interpreted as internal status or parameter data. The D/CX signal can also be pulled to a high level when the data on the interface is RAM data or a command parameter data.

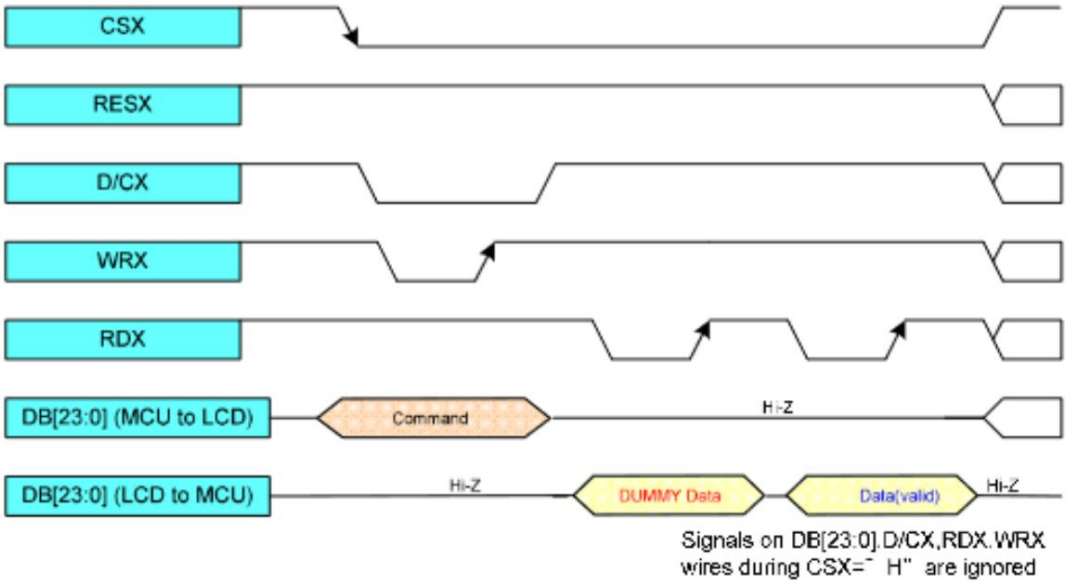


Figure 4: DBI Type B Read Cycle Sequence

Note: Read Data is only valid when the D/CX input is pulled high. If the D/CX signal is driven to low during the read cycle then the display information outputs will be High-Z.

26. The means of development - microcontroller

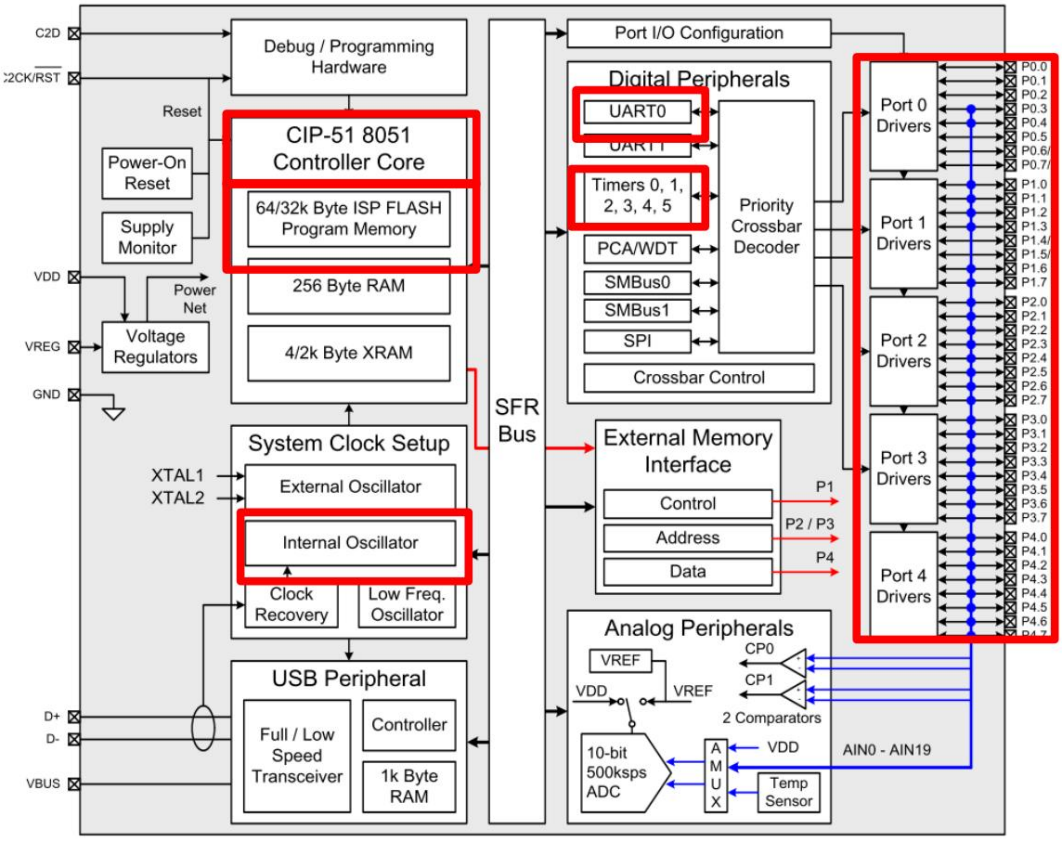
A microcontroller is **a programmable component** that contains in one case **hardware units** that allow it to be **a control system**
To control and control hardware devices, where **the flexibility** of the interface **and the speed** of communication is the 'name of the game'. this
Unlike computer systems such as the personal computer (PC), central computers of organizations/businesses or cloud servers -
and has **a fast processor** ,All intended **for data storage and processing** - which are **memory intensive**

, **memories,** oscillators (clocks), ports for connecting devices The main components of a microcontroller are **an input/**
output processor, serial and parallel communication interfaces , an array of **counters** and timers, an interrupt system and **interrupt control,** converters
DtA and AtD, therefore it is common to think of a microcontroller as **a compromise between the two worlds presented in the opening - system**
Data control and processing.

These characteristics of the controller make it a very popular platform for didactic needs for educational institutions
,A new system and students, a cheap and common option for small businesses that wish to **develop in an experimental/initial way** and
more importantly - the wide variety of hardware options available on the market allows to **'tailor' a controller to the customer's needs -** for reasons
of budget, development environment, threshold requirements, etc.

The controller we worked with throughout the school year is **a 380F8051C** realized on **a development board** that was designed according to an order
, personal of the project leader and includes several hardware elements such as LEDs, buttons, potentiometer, S 7' display
and a matrix for additional hardware wiring.

This board was used by us and we performed all the labs and exercises in preparation for the certification tests. The controller is based on **an 8051 processor**
of Intel but **very different from the similar,** and usually only the names and terminology are varieties in their name. **in the following chapters The**
mythological was chosen to delve only into the hardware most relevant to the project, the methods of operation, and how it was defined in our implementation, as
which we marked in the above logical scheme.

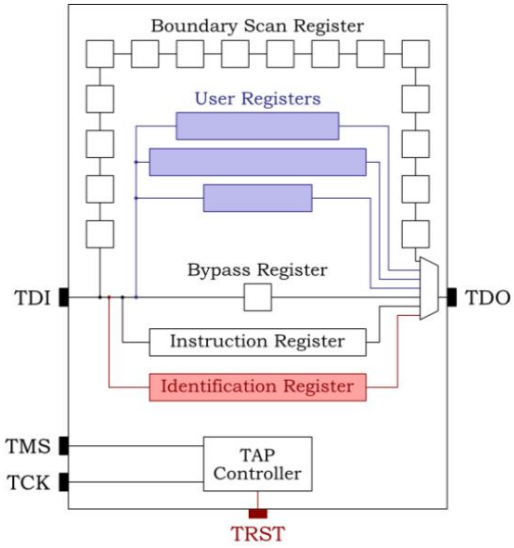


.27 JTAG and real-time development

The connection between a PC and our development board is made using a JTAG connector connected to the USB interface on the computer, and a unique 10-pin Xlink interface to the board.

Inside the JTAG converter is a relatively small silicon chip whose purpose is to allow "real-time" access to data in the controller's memory and ports. And of course, with it we burn our program on the ROM, every time a change is made to the code and the expansion of the functionality.

Only through this component, it was possible for us to DEBUG in real time, and in fact to make minor changes to the code while developing - at the end of the new software - to run a BreakPoint tool that allows monitoring the execution of the program line by line, and watching in real time the contents of registers and ports.



The use of JTAG was developed in the late 1980s as a method for testing large pieces of silicon, which were growing in size at an increasing rate and contained many, many thin BGA components. There was a need for comprehensive inspection of every detail **and access to them despite the density on the piece of silicon.**

And in fact, a standard of the International Association of Engineers (IEEE) stated that silicon manufacturers will implement JTAG-supporting hardware in their products, which means peripheral hardware for each of the triggers on the silicon, which is actually an array of sliding pads that can be written to and called the "Scan Boundary".

The ability to **individually** access the entire chip and manipulate it is the one that provides the ability to debug, test, change the content in real time - therefore in conclusion - **hardware supporting JTAG is needed and at the same time an external software and hardware interface to perform the testability.**

IDE Keil µVision work environment .28

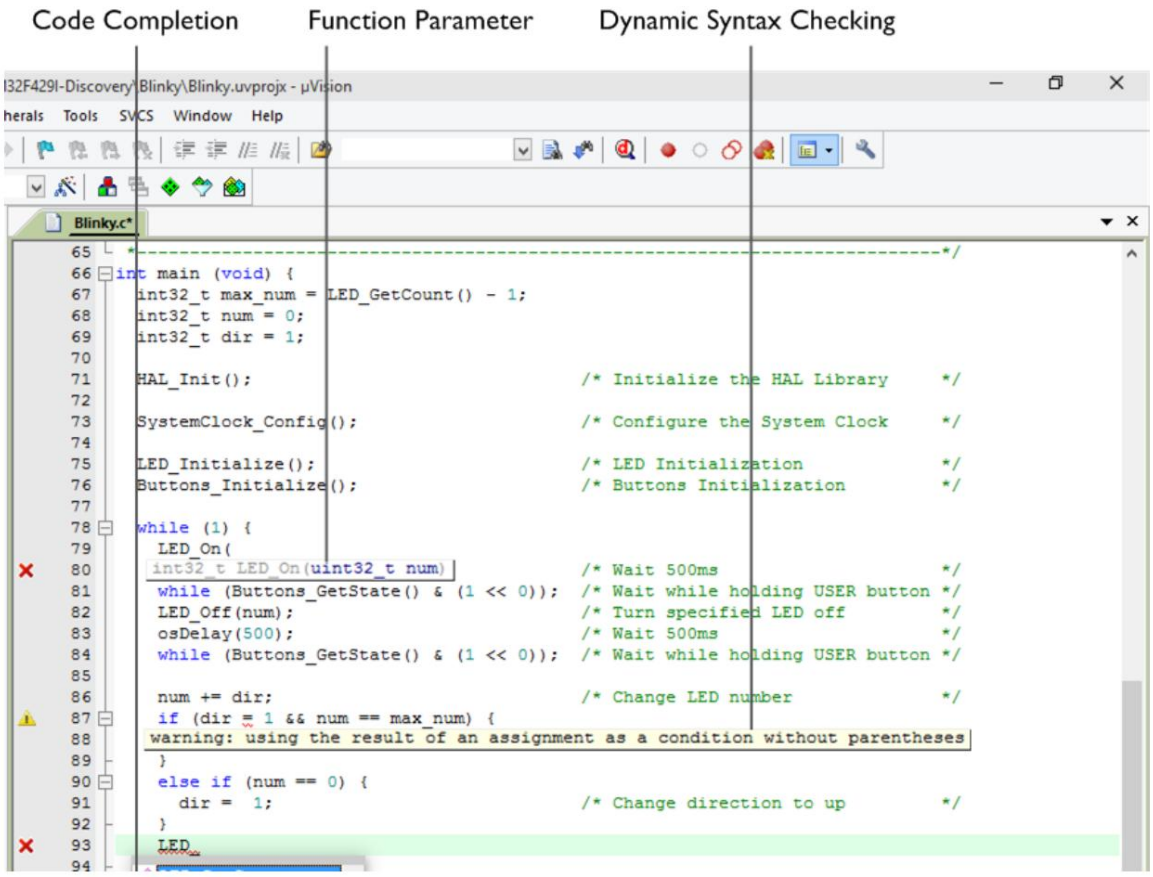
The working environment we used is a well-known and common environment in the world of programming embedded processor systems. Its name is **ÿVision from the Keil company.** The company is a veteran in the field, founded in 1982 in Germany, and as early as 1985 was converted as a software house **for development adapted to silicon manufacturers,** and even implemented **the first compiler for the C language for an 8051** microcontroller. In 2005, it was acquired by the ARM corporation, which today leads the development of the world's most advanced processors of the same series The name, which are found in every conceivable device from cell phones to tablets.

ÿVision combines **project management, real-time environment, source code editing and debugging in a single, easy-to-use interface,** as it supports multiple screens/controls that can be deployed anywhere on the screen. A very important ability lies in the file menu through which you can manage the software components - directories, source files, configuration files, and pages

and documentation.

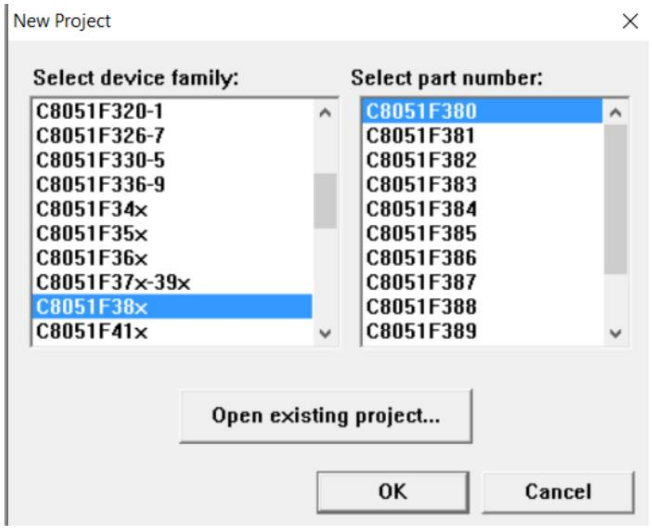
An example of the 'runtime management' window which expands the capabilities of **the debugging tool** - **Debugger** and allows you to locate bugs and filter errors, similar to other traditional features, but also to use breakpoints and real-time viewing windows of the variables and their content in memory or alternatively **the register values** of the input-output devices.

The main screen - which contains the code editor - includes all **the standard features of a modern code editor,** allows syntax color highlighting, text indentation, and **is optimized for the** C language.



29 Wizard Configuration 2 tool

The configuration tool from Labs Silicon is **a graphical interface (GUI) that allows us to conveniently and quickly configure the microcontroller** we are working with (there are a variety of versions embedded in the tool) and to save a huge amount of time in planning the registers that control timers, clock frequency, communication protocols, enabling ports, etc.



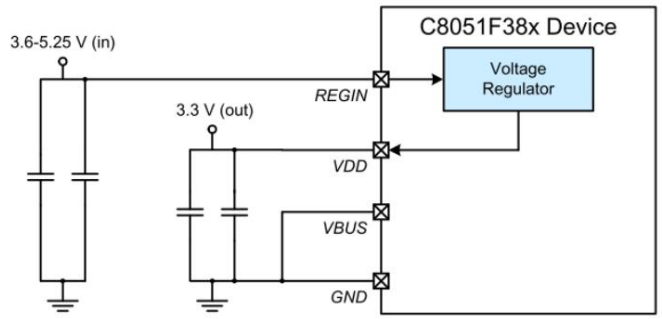
These settings are performed only once upon starting work on each project, and a C code file is obtained which is an accurate interpretation of the register values that represent the settings we performed. **This file is added to the list of configuration files in the** work environment and is an integral part of it.

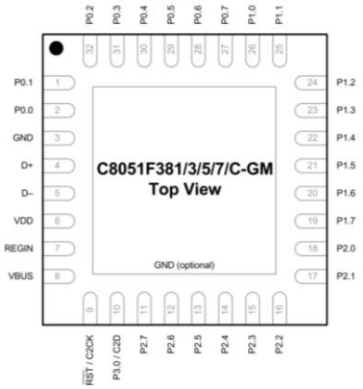
In order to deeply understand the definitions that we will present below, one must delve deeper into the first chapters of the book **that illustrate the features of the controller** with which the development was carried out, and **the special registers** that store the settings for operating the hardware

sit down

30 electrical properties of the controller

The processor in the system receives an **operating voltage of V3.3** and therefore largely dictates currents and voltages in the entire circuit.





- The development board In order to provide this voltage, a higher input voltage must be obtained, **which is divided and supplies the components.**

The conversion will be carried out using a regulator that the manufacturer marked as a 'black box' in the video. **Several possible voltage sources :**

• A JTAG converter connected to the USB interface on the computer, which provides V 5.

• Input from a transformer connected to the wall that supplies 9V, pay attention to the + line in the middle.

• USB TYPE-A input on the board used for both development and operation.

The **total current** supply (maximum) of the board is mAmp 500 in the voltage supply clamps on the board. **This limitation**

The difficulty in realizing the project because **the total current consumption by all the hardware components is over 500 mAmp**

And so we had to connect to an external voltage V 9 and also use a voltage stabilizer for the network controller.

Parameter	Conditions	Min	Typ	Max	Units
Maximum Total Current through V_{DD} or GND		—	—	500	mA
Maximum Output Current sunk by $\overline{RST}$ or any Port Pin		—	—	100	mA

The maximum current that the trigger is able to provide is **mAmp25** and the peak current that the entire trigger can "tolerate" is **mAmp100 .**

V_{DD} = 2.7 to 3.6 V, –40 to +85 °C unless otherwise specified

Parameters	Conditions	Min	Typ	Max	Units
Output High Voltage	I_{OH} = –3 mA, Port I/O push-pull	V_{DD} – 0.7			V
	I_{OH} = –10 µA, Port I/O push-pull	V_{DD} – 0.1			
	I_{OH} = –10 mA, Port I/O push-pull		V_{DD} – 0.8		
Output Low Voltage	I_{OL} = 8.5 mA			0.6	V
	I_{OL} = 10 µA			0.1	
	I_{OL} = 25 mA		1.0		
Input High Voltage		2.0			V
Input Low Voltage				0.8	V
Input Leakage Current	Weak Pull-up Off			±1	µA
	Weak Pull-up On, V_{IN} = 0 V		15	50	

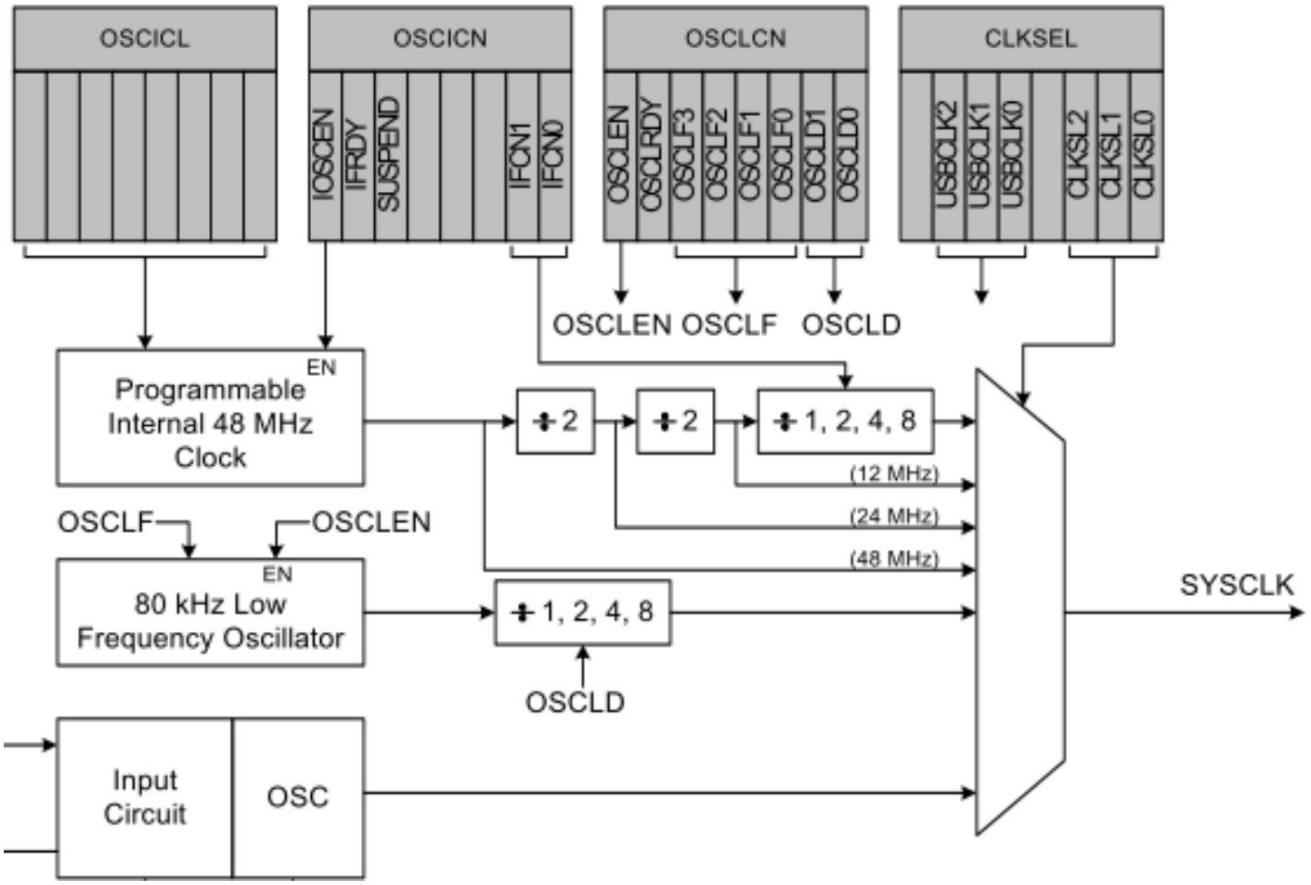
.31 clock/oscillator

In the controller we have, there are **2 programmable oscillators** - one for high frequency and the other for low frequency. Their programming is underway Using OSCICN and OSCICL registers. The maximum speed of **the internal clock is Mhz 48 and it is that**

which we also defined.

As with any design - one must always make sure that the clock speed **is not a bottleneck** for the realized communication speed, and indeed the network controller (which will be expanded upon later) communicates **at a speed of 115,200 BPS .** That is, the frequency of the signal (the same because it is a balanced square signal (it **is Hz 57,600 and therefore it is understood that the processor will have** enough time to process, Our **program** is without any difficulty. ,divided into 2 and also have **serial communication**

The architecture of the internal clock is as follows, and its definition is affected **by the registers** at the top. There is also an ability Connect an external oscillator, omitted from the drawing.



Setting the registers in the C language in the configuration file of the controller:

```
void Oscillator_Init()
{
    FLSCL     = 0x90; //set as system  main clock
    CLKSEL    = 0x03; //enable crossbar system clock output
    OSCICN    = 0xC3; //enable internal High Frequency oscilator- 48MHz
}
```

We will explain the determination of the values, according to the different modes to which the watch can be set - as defined by the manufacturer:

SFR Definition 19.1. CLKSEL: Clock Select

Bit	7	6	5	4	3	2	1	0
Name		USBCLK[2:0]			OUTCLK	CLKSL[2:0]		
Type	R	R/W			R/W	R/W		
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xA9; SFR Page = All Pages

Bit	Name	Function
7	Unused	Read = 0b; Write = don't care
6:4	USBCLK[2:0]	**USB Clock Source Select Bits.** 000: USBCLK derived from the Internal High-Frequency Oscillator. 001: USBCLK derived from the Internal High-Frequency Oscillator / 8. 010: USBCLK derived from the External Oscillator. 011: USBCLK derived from the External Oscillator/2. 100: USBCLK derived from the External Oscillator/3. 101: USBCLK derived from the External Oscillator/4. 110: USBCLK derived from the Internal Low-Frequency Oscillator. 111: Reserved.
3	OUTCLK	**Crossbar Clock Out Select.** If the SYSCLK signal is enabled on the Crossbar, this bit selects between outputting SYSCLK and SYSCLK synchronized with the Port I/O pins. 0: Enabling the Crossbar SYSCLK signal outputs SYSCLK. 1: Enabling the Crossbar SYSCLK signal outputs SYSCLK synchronized with the Port I/O.
2:0	CLKSL[2:0]	**System Clock Source Select Bits.** 000: SYSCLK derived from the Internal High-Frequency Oscillator / 4 and scaled per the IFCN bits in register OSCICN. 001: SYSCLK derived from the External Oscillator circuit. 010: SYSCLK derived from the Internal High-Frequency Oscillator / 2. 011: SYSCLK derived from the Internal High-Frequency Oscillator. 100: SYSCLK derived from the Internal Low-Frequency Oscillator and scaled per the OSCLD bits in register OSCLCN. 101-111: Reserved.

Clock Selection Register:

the desired value
0
000
0
011

SFR Definition 19.3. OSCICN: Internal H-F Oscillator Control

Bit	7	6	5	4	3	2	1	0
Name	IOSCEN	IFRDY	SUSPEND				IFCN[1:0]	
Type	R/W	R	R/W	R	R	R	R/W	
Reset	1	1	0	0	0	0	0	0

SFR Address = 0xB2; SFR Page = All Pages

Bit	Name	Function
7	IOSCEN	**Internal H-F Oscillator Enable Bit.** 0: Internal H-F Oscillator Disabled. 1: Internal H-F Oscillator Enabled.
6	IFRDY	**Internal H-F Oscillator Frequency Ready Flag.** 0: Internal H-F Oscillator is not running at programmed frequency. 1: Internal H-F Oscillator is running at programmed frequency.
5	SUSPEND	**Internal Oscillator Suspend Enable Bit.** Setting this bit to logic 1 places the internal oscillator in SUSPEND mode. The internal oscillator resumes operation when one of the SUSPEND mode awakening events occurs.
4:2	Unused	Read = 000b; Write = don't care
1:0	IFCN[1:0]	**Internal H-F Oscillator Frequency Divider Control Bits.** The Internal H-F Oscillator is divided by the IFCN bit setting after a divide-by-4 stage. 00: SYSCLK can be derived from Internal H-F Oscillator divided by 8 (1.5 MHz). 01: SYSCLK can be derived from Internal H-F Oscillator divided by 4 (3 MHz). 10: SYSCLK can be derived from Internal H-F Oscillator divided by 2 (6 MHz). 11: SYSCLK can be derived from Internal H-F Oscillator divided by 1 (12 MHz).

Frequency setting register:

the desired value
1
1
0
000
11

.32 memory

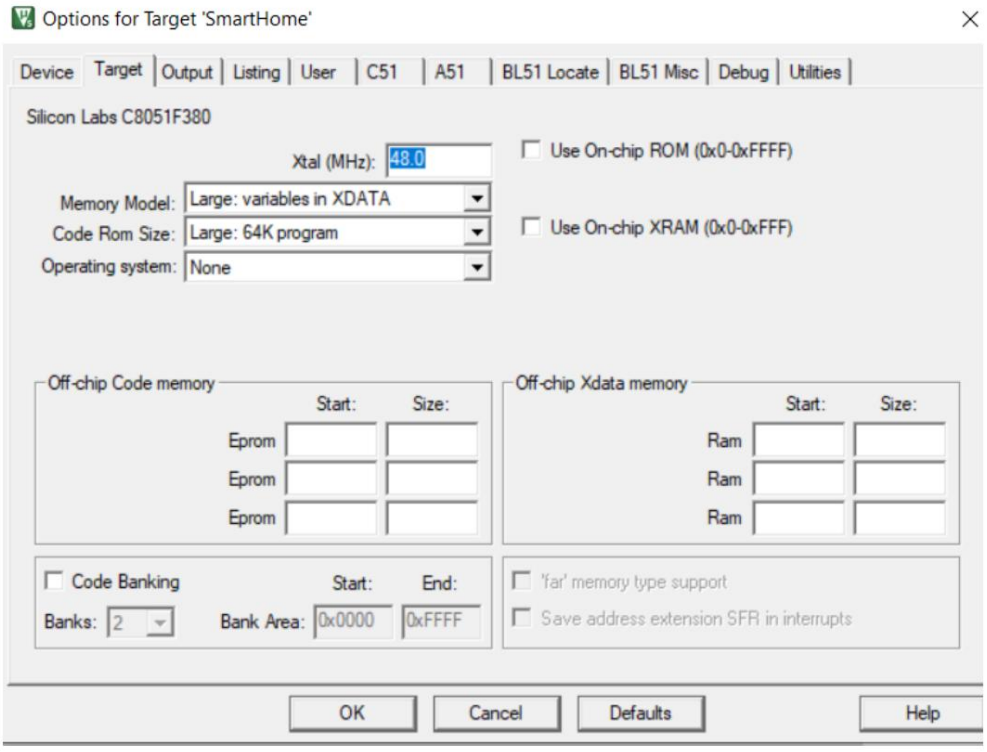
The **ROM** memory size in our controller is 64 KB and our **program** is stored on it . Also on board 4 KB of memory External **RAM** where all **data** is stored as arrays, variables. The total size of the program at the end of the development amounts to about 30 KB and the size of the data about 2 additional KB, **which means that in total we used half of the memory space allocated in the system.**

The calculation of the total size of the program **is possible at the end of the compilation** after LINK has been performed for all the files, meaning they have been converted to machine language, and stored in registers. The prompt can be obtained from the work environment:

```
Build Output
linking...
*** WARNING L13: RECURSIVE CALL TO SEGMENT
    SEGMENT: ?PR?_SERVER_ISR?WIFI
    CALLER:  ?PR?REACT?WIFI
Program Size: data=15.2 xdata=1740 code=27034
".\Objects\start" - 0 Error(s), 1 Warning(s).
Build Time Elapsed:  00:00:02
```

We note that our project **does not include extensive use of memory** mainly because of its nature - a controller that allows real-time communication with input-output devices in the house (sensors and lighting) and therefore no external memory expansion was required.

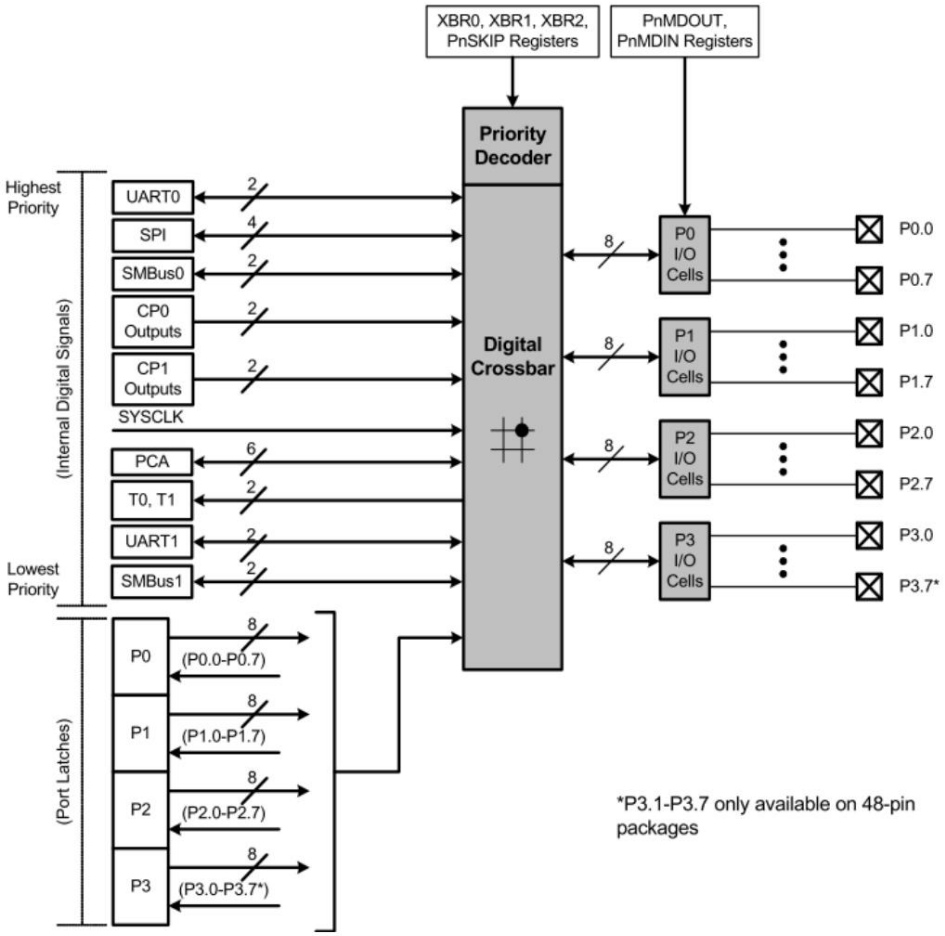
We will emphasize that we were required to define the size of the memory within the framework of the work environment in which we worked, which will be expanded on in a chapter dedicated to the subject.



33 Ports for connecting devices

To control **a wide and programmable port interface of 5 ports** in total - numbered 4 - 0.8. Each port contains the chips which Linked to a 'lock' register which enables the holding of the information intended for reading/writing from them. The 40 minutes **'endure' a logic level of V5** as 'input' and vice versa Let's recall that all five ports (which make it possible to push a current of up to 25 mAmp if they were defined as 'output').

The control of the direction of the ports is through the **CrossBar** interface that controls partitions through a read option and writing to them, similar to the operation of the S 3 'interface. These settings are made using the registers at the top of the diagram:



Setting the registers in the C language in the configuration file of the controller:

```
void Port_IO_Init()
{
    P1MDOUT    = 0xFF; //port 1 enable for LEDs
    P2MDOUT    = 0xB6; //port 2 enable for DATA wires of sensors
    //next are both for UART pins Rx & Tx enable:
    XBR0       = 0x01;
    XBR1       = 0x40;
}
```

Each **of the triggers** is wired to allow several additional modes under the control of the user:

• **Pushing low/high current** is possible by **enabling/releasing** the WEAK-PULLUP line which is wired to the switch ' to leave 0' and allow the base of the gate, and thus the trigger accustomed. A logic 0' level on the line will cause the CMOS VDD OR gate to "pull" some of the current into it and leave a low current to go to the trigger itself.

• Determining 'input-output' is possible using the PUSH-PULL switch, OUTENABLE PORT and PORT OUTPUT, which control the NOT CMOS gate.

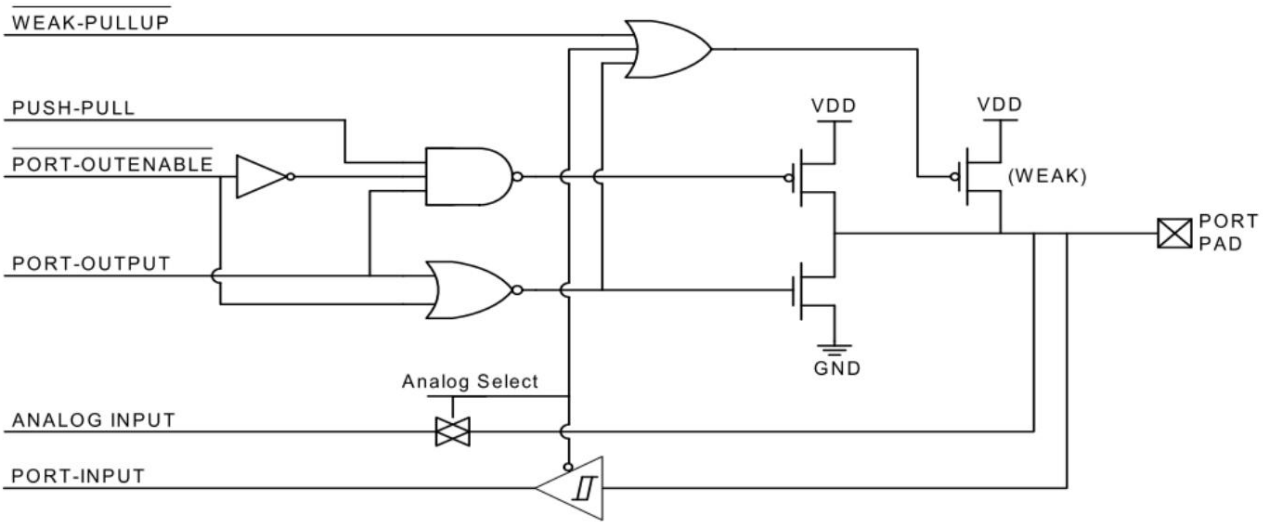
necessarily exclude a logical 1 and thus cause A 'logic 0' on the **PUSH-PULL** line will cause the NAND gate to keep o level the information received in the trigger unchanged (without influence from VDD), meaning the port is defined as 'input'.

necessarily output a logical 0 and thus cause o Logical level '1' on the PUSH-PULL line will cause the NAND gate to the voltage obtained from VDD to reach the trigger - that is, the entire port respectively will show xF0 during initialization The board, and this value will change of course, immediately after the game with the values obtained on the following lines:

necessarily exclude a logical 1 and thus A logical 0 on the **OUTPUT PORT** line will cause the NAND gate to necessarily output a level 0, so the information that will be written in the end will be The upper gate is not relevant. At the same time the NOR gate is really '0'. Similarly change the OUTPUT PORT line to '1 1.' He will indeed dictate on the way out

o The **'OUTENABLE PORT'** line simply interferes with the previous process and 'disrupts' it or 'enables' it Thus dictating when to write the information to the latch, therefore this line is used by the processor.

WP PP		POE PO	T1		T2	T3	PORT-e mode
H						off	**WEAK-PULLUP**
		L	L	off	on		**Output - L**
L	L		H	on	off	off	**Output – H PullUp**
	H	L	H	on	off		**Output - H Push**



We will explain the determination of the values, according to the different situations in which the shredders can be set -: as defined by the manufacturer

SFR Definition 20.1. XBR0: Port I/O Crossbar Register 0

Bit	7	6	5	4	3	2	1	0
Name	CP1AE	CP1E	CP0AE	CP0E	SYSCKE	SMB0E	SPI0E	URT0E
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xE1; SFR Page = All Pages

Bit	Name	Function	Register 0XBR
			the desired value
7	CP1AE	**Comparator1 Asynchronous Output Enable.** 0: Asynchronous CP1A unavailable at Port pin. 1: Asynchronous CP1A routed to Port pin.	0
6	CP1E	**Comparator1 Output Enable.** 0: CP1 unavailable at Port pin. 1: CP1 routed to Port pin.	0
5	CP0AE	**Comparator0 Asynchronous Output Enable.** 0: Asynchronous CP0A unavailable at Port pin. 1: Asynchronous CP0A routed to Port pin.	0
4	CP0E	**Comparator0 Output Enable.** 0: CP0 unavailable at Port pin. 1: CP0 routed to Port pin.	0
3	SYSCKE	**$\overline{\text{SYSCLK}}$ Output Enable.** 0: $\overline{\text{SYSCLK}}$ unavailable at Port pin. 1: $\overline{\text{SYSCLK}}$ output routed to Port pin.	0
2	SMB0E	**SMBus I/O Enable.** 0: SMBus I/O unavailable at Port pins. 1: SMBus I/O routed to Port pins.	0
1	SPI0E	**SPI I/O Enable.** 0: SPI I/O unavailable at Port pins. 1: SPI I/O routed to Port pins. Note that the SPI can be assigned either 3 or 4 GPIO pins.	0
0	URT0E	**UART I/O Output Enable.** 0: UART I/O unavailable at Port pin. 1: UART TX0, RX0 routed to Port pins P0.4 and P0.5.	1

SFR Definition 20.2. XBR1: Port I/O Crossbar Register 1

Bit	7	6	5	4	3	2	1	0
Name	WEAKPUD	XBARE	T1E	T0E	ECIE	PCA0ME[2:0]		
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xE2; SFR Page = All Pages

Bit	Name	Function	1XBR register
			the desired value
7	WEAKPUD	**Port I/O Weak Pullup Disable.** 0: Weak Pullups enabled (except for Ports whose I/O are configured for analog mode). 1: Weak Pullups disabled.	0
6	XBARE	**Crossbar Enable.** 0: Crossbar disabled. 1: Crossbar enabled.	1
5	T1E	**T1 Enable.** 0: T1 unavailable at Port pin. 1: T1 routed to Port pin.	0
4	T0E	**T0 Enable.** 0: T0 unavailable at Port pin. 1: T0 routed to Port pin.	0
3	ECIE	**PCA0 External Counter Input Enable.** 0: ECI unavailable at Port pin. 1: ECI routed to Port pin.	0
2:0	PCA0ME[2:0]	**PCA Module I/O Enable Bits.** 000: All PCA I/O unavailable at Port pins. 001: CEX0 routed to Port pin. 010: CEX0, CEX1 routed to Port pins. 011: CEX0, CEX1, CEX2 routed to Port pins. 100: CEX0, CEX1, CEX2, CEX3 routed to Port pins. 101: CEX0, CEX1, CEX2, CEX3 routed to Port pins. 11x: Reserved.	000

SFR Definition 20.10. P1MDOUT: Port 1 Output Mode

Bit	7	6	5	4	3	2	1	0
Name	P1MDOUT[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xA5; SFR Page = All Pages

Bit	Name	Function
7:0	P1MDOUT[7:0]	**Output Configuration Bits for P1.7–P1.0 (respectively).** These bits are ignored if the corresponding bit in register P1MDIN is logic 0. 0: Corresponding P1.n Output is open-drain. 1: Corresponding P1.n Output is push-pull.

Register enable port 1

The entire port is used to connect to 8 built-in LEDs on a board The development simulates 8 bulbs in the house lighting

the desired value

1111,1111

SFR Definition 20.14. P2MDOUT: Port 2 Output Mode

Bit	7	6	5	4	3	2	1	0
Name	P2MDOUT[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xA6; SFR Page = All Pages

Bit	Name	Function
7:0	P2MDOUT[7:0]	**Output Configuration Bits for P2.7–P2.0 (respectively).** These bits are ignored if the corresponding bit in register P2MDIN is logic 0. 0: Corresponding P2.n Output is open-drain. 1: Corresponding P2.n Output is push-pull.

Register Enable Port 2

Quilmuses information for climate control sensors and location control as functions of the 'smart home' and communication indication via an RGB light

the desired value

1011,0110

Summary of the allocation of triggers in the project:

```
/*****************************************************************
                        SBIT DECLERATION
 *****************************************************************/
//LEDs are connected to each wire to represent room/area light
sbit Cameras =    P1^2;
sbit Alarm =      P1^3;
sbit MainLights = P1^4;
sbit PetFeeder =  P1^5;
sbit FrontGate =  P1^6;
sbit Heater =     P1^7;
//RGB LEDs are connected to each wire to represent AirCon_ON status
sbit AirCon_OFF =    P2^0; //OFF = RED
sbit AirCon_WAIT =   P2^1; //Waiting for Clock = BLUE
sbit AirCon_ON =     P2^2; //ON = GREEN
sbit SDA=            P2^3; //I2C DATA
sbit Garage_OFF =    P2^4; //OFF = RED
sbit Garage_WAIT =   P2^5; //Waiting for Clock = BLUE
sbit Garage_ON =     P2^6; //ON = RED
sbit SCL=            P2^7; //I2C CLK
//Wires for date stream of each sensor
sbit Trigger_Car= P0^0;
sbit Echo_Car=    P0^1;
sbit Trigger_Pet= P0^2;
sbit Echo_Pet=    P0^3;
sbit TX=          P0^4;
sbit RX=          P0^5;
sbit DHT_DATA=    P0^6;
```

We note that **port 3 is used for communication with an LCD touch screen** in a closed code package frame, and its configuration is done separately.

.34 timers/counters

A timer is **a counter** that counts pulses that reach it at a constant rate, so it actually **measures time.** The distinctions in names are made according to the role for which it is required. If you connect to the input of the counter a signal derived from the CPU clock (that is, it arrives at a uniform rate), **the component functions as** a TIMER. If you connect the counter input to an external source of signals, which produces pulses not necessarily at a uniform rate, **the component will function as an event counter** (COUNTER).

In the controller there are 6 different counters for the use of the developers. 2 of them are completely identical to the counters known from the 8051 processor and 4 more are multi-use timers. In our implementation, timer #1 is used **for serial communication and timer #2 for measuring time for an ultrasonic sensor.**

Timer 0 and Timer 1 Modes:	Timer 2, 3, 4, and 5 Modes:
13-bit counter/timer	16-bit timer with auto-reload
16-bit counter/timer	
8-bit counter/timer with auto-reload	Two 8-bit timers with auto-reload
Two 8-bit counter/timers (Timer 0 only)	

In addition, as in any system - the controller contains a **WatchDog** clock which is an important tool that allows **a window of time to reset the system ,** - if there is a requirement for this. The WatchDog functions in such a way that it expects an interrupt from a counter that counts down a fixed amount of time that can be set.

If the count ends, the system is **reset and the counter is reloaded.** If you want to cancel this option, you can do **so** - and that's what we chose to do, although it is important to note that it is acceptable to use the **function to** disable WatchDog in final products because in reality even a system designed to live 'always' requires an update, maintenance and initialization routine, and it is possible to plan so that they are not Feeling for the end user.

Setting the registers in the C language in the configuration file of the controller:

```
void PCA_Init()
{
  //Watchdog disable for proper continuity of system
    PCA0MD    &= ~0x40;
    PCA0MD    = 0x00;
}
void Timer_Init()
{
  //Timers 1,2,5 enable
    TCON      = 0x40; //50
  //Timer 1 mod 8bit auto-reload for UART0 auto BAUD rate handling
    TMOD      = 0x20;
  //sysclock as configured in Oscillator_Init
    CKCON     = 0x08; //0C
  //115200 BAUD equivalent value to reload in hex (at 48MHz)
    TH1       = 0x30;
  //Timer 2 mod 16bit timer-  for ultrasonic sensors
    TMR2CN    = 0x04;
```

SFR Definition 26.1. CKCON: Clock Control

Bit	7	6	5	4	3	2	1	0
Name	T3MH	T3ML	T2MH	T2ML	T1M	T0M	SCA[1:0]	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x8E; SFR Page = All Pages

Bit	Name	Function	Register definition and choice counters the value the desired
7	T3MH	**Timer 3 High Byte Clock Select.** Selects the clock supplied to the Timer 3 high byte (split 8-bit timer mode only). 0: Timer 3 high byte uses the clock defined by the T3XCLK bit in TMR3CN. 1: Timer 3 high byte uses the system clock.	0
6	T3ML	**Timer 3 Low Byte Clock Select.** Selects the clock supplied to Timer 3. Selects the clock supplied to the lower 8-bit timer in split 8-bit timer mode. 0: Timer 3 low byte uses the clock defined by the T3XCLK bit in TMR3CN. 1: Timer 3 low byte uses the system clock.	0
5	T2MH	**Timer 2 High Byte Clock Select.** Selects the clock supplied to the Timer 2 high byte (split 8-bit timer mode only). 0: Timer 2 high byte uses the clock defined by the T2XCLK bit in TMR2CN. 1: Timer 2 high byte uses the system clock.	0
4	T2ML	**Timer 2 Low Byte Clock Select.** Selects the clock supplied to Timer 2. If Timer 2 is configured in split 8-bit timer mode, this bit selects the clock supplied to the lower 8-bit timer. 0: Timer 2 low byte uses the clock defined by the T2XCLK bit in TMR2CN. 1: Timer 2 low byte uses the system clock.	0
3	T1	**Timer 1 Clock Select.** Selects the clock source supplied to Timer 1. Ignored when C/T1 is set to 1. 0: Timer 1 uses the clock defined by the prescale bits SCA[1:0]. 1: Timer 1 uses the system clock.	1
2	T0	**Timer 0 Clock Select.** Selects the clock source supplied to Timer 0. Ignored when C/T0 is set to 1. 0: Counter/Timer 0 uses the clock defined by the prescale bits SCA[1:0]. 1: Counter/Timer 0 uses the system clock.	0
1:0	SCA[1:0]	**Timer 0/1 Prescale Bits.** These bits control the Timer 0/1 Clock Prescaler: 00: System clock divided by 12 01: System clock divided by 4 10: System clock divided by 48 11: External clock divided by 8 (synchronized with the system clock)	00

SFR Definition 26.4. TMOD: Timer Mode

Bit	7	6	5	4	3	2	1	0
Name	GATE1	C/T1	T1M[1:0]		GATE0	C/T0	T0M[1:0]	
Type	R/W	R/W	R/W		R/W	R/W	R/W	
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x89; SFR Page = All Pages

Bit	Name	Function	Register definition my situation work the value the desired
7	GATE1	**Timer 1 Gate Control.** 0: Timer 1 enabled when TR1 = 1 irrespective of $\overline{INT1}$ logic level. 1: Timer 1 enabled only when TR1 = 1 AND $\overline{INT1}$ is active as defined by bit IN1PL in register IT01CF (see SFR Definition 16.7).	0
6	C/T1	**Counter/Timer 1 Select.** 0: Timer: Timer 1 incremented by clock defined by T1M bit in register CKCON. 1: Counter: Timer 1 incremented by high-to-low transitions on external pin (T1).	0
5:4	T1M[1:0]	**Timer 1 Mode Select.** These bits select the Timer 1 operation mode. 00: Mode 0, 13-bit Counter/Timer 01: Mode 1, 16-bit Counter/Timer 10: Mode 2, 8-bit Counter/Timer with Auto-Reload 11: Mode 3, Timer 1 Inactive	10
3	GATE0	**Timer 0 Gate Control.** 0: Timer 0 enabled when TR0 = 1 irrespective of $\overline{INT0}$ logic level. 1: Timer 0 enabled only when TR0 = 1 AND $\overline{INT0}$ is active as defined by bit IN0PL in register IT01CF (see SFR Definition 16.7).	0
2	C/T0	**Counter/Timer 0 Select.** 0: Timer: Timer 0 incremented by clock defined by T0M bit in register CKCON. 1: Counter: Timer 0 incremented by high-to-low transitions on external pin (T0).	0
1:0	T0M[1:0]	**Timer 0 Mode Select.** These bits select the Timer 0 operation mode. 00: Mode 0, 13-bit Counter/Timer 01: Mode 1, 16-bit Counter/Timer 10: Mode 2, 8-bit Counter/Timer with Auto-Reload 11: Mode 3, Two 8-bit Counter/Timers	00

SFR Definition 26.3. TCON: Timer Control

Bit	7	6	5	4	3	2	1	0
Name	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x88; SFR Page = All Pages; Bit-Addressable

Bit	Name	Function	Register definition Rulings and level Logical the value the desired
7	TF1	**Timer 1 Overflow Flag.** Set to 1 by hardware when Timer 1 overflows. This flag can be cleared by software but is automatically cleared when the CPU vectors to the Timer 1 interrupt service routine.	0
6	TR1	**Timer 1 Run Control.** Timer 1 is enabled by setting this bit to 1.	1
5	TF0	**Timer 0 Overflow Flag.** Set to 1 by hardware when Timer 0 overflows. This flag can be cleared by software but is automatically cleared when the CPU vectors to the Timer 0 interrupt service routine.	0
4	TR0	**Timer 0 Run Control.** Timer 0 is enabled by setting this bit to 1.	0
3	IE1	**External Interrupt 1.** This flag is set by hardware when an edge/level of type defined by IT1 is detected. It can be cleared by software but is automatically cleared when the CPU vectors to the External Interrupt 1 service routine in edge-triggered mode.	0
2	IT1	**Interrupt 1 Type Select.** This bit selects whether the configured $\overline{\text{INT1}}$ interrupt will be edge or level sensitive. $\overline{\text{INT1}}$ is configured active low or high by the IN1PL bit in the IT01CF register (see SFR Definition 16.7). 0: $\overline{\text{INT1}}$ is level triggered. 1: $\overline{\text{INT1}}$ is edge triggered.	0
1	IE0	**External Interrupt 0.** This flag is set by hardware when an edge/level of type defined by IT1 is detected. It can be cleared by software but is automatically cleared when the CPU vectors to the External Interrupt 0 service routine in edge-triggered mode.	0
0	IT0	**Interrupt 0 Type Select.** This bit selects whether the configured $\overline{\text{INT0}}$ interrupt will be edge or level sensitive. $\overline{\text{INT0}}$ is configured active low or high by the IN0PL bit in register IT01CF (see SFR Definition 16.7). 0: $\overline{\text{INT0}}$ is level triggered. 1: $\overline{\text{INT0}}$ is edge triggered.	0

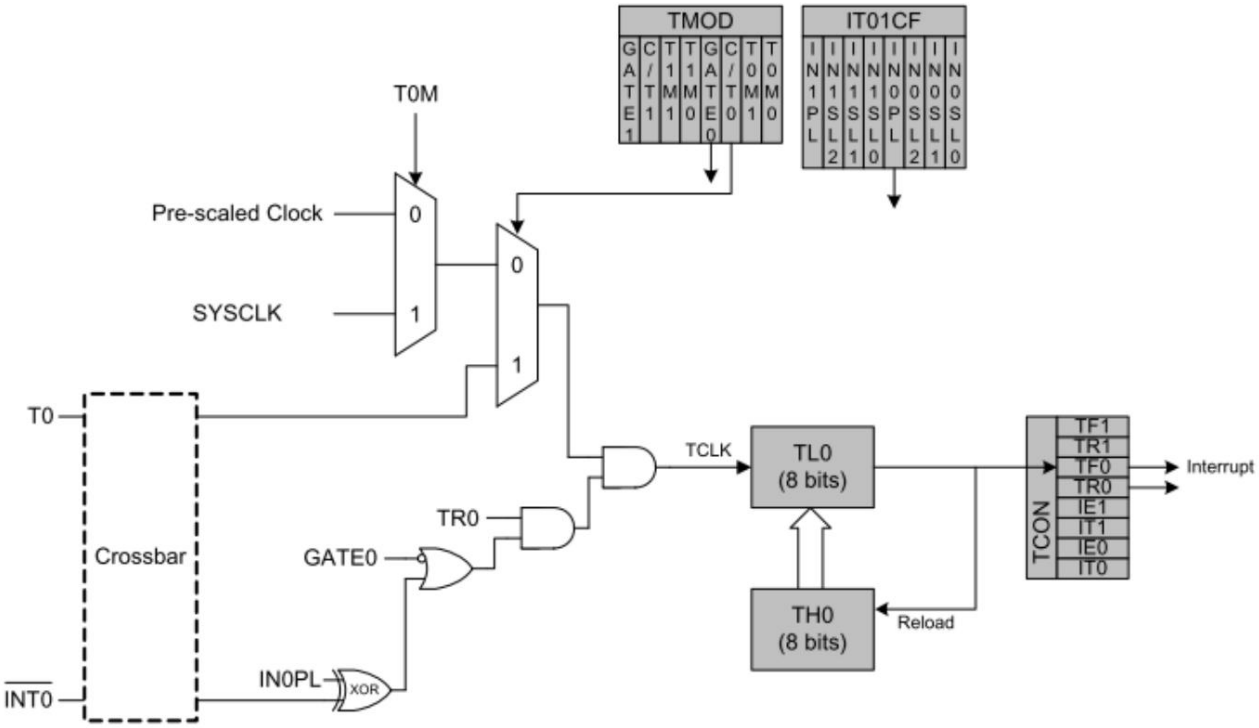
SFR Definition 26.9. TMR2CN: Timer 2 Control

Bit	7	6	5	4	3	2	1	0
Name	TF2H	TF2L	TF2LEN	TF2CEN	T2SPLIT	TR2	T2CSS	T2XCLK
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xC8; SFR Page = 0; Bit-Addressable

Bit	Name	Function	Register setting Timer 2) definition Also similar to (-5 the desired value
7	TF2H	**Timer 2 High Byte Overflow Flag.** Set by hardware when the Timer 2 high byte overflows from 0xFF to 0x00. In 16 bit mode, this will occur when Timer 2 overflows from 0xFFFF to 0x0000. When the Timer 2 interrupt is enabled, setting this bit causes the CPU to vector to the Timer 2 interrupt service routine. This bit is not automatically cleared by hardware.	**0**
6	TF2L	**Timer 2 Low Byte Overflow Flag.** Set by hardware when the Timer 2 low byte overflows from 0xFF to 0x00. TF2L will be set when the low byte overflows regardless of the Timer 2 mode. This bit is not automatically cleared by hardware.	**0**
5	TF2LEN	**Timer 2 Low Byte Interrupt Enable.** When set to 1, this bit enables Timer 2 Low Byte interrupts. If Timer 2 interrupts are also enabled, an interrupt will be generated when the low byte of Timer 2 overflows.	**0**
4	TF2CEN	**Timer 2 Low-Frequency Oscillator Capture Enable.** When set to 1, this bit enables Timer 2 Low-Frequency Oscillator Capture Mode. If TF2CEN is set and Timer 2 interrupts are enabled, an interrupt will be generated on a falling edge of the low-frequency oscillator output, and the current 16-bit timer value in TMR2H:TMR2L will be copied to TMR2RLH:TMR2RLL.	**0**
3	T2SPLIT	**Timer 2 Split Mode Enable.** When this bit is set, Timer 2 operates as two 8-bit timers with auto-reload.	**0**
2	TR2	**Timer 2 Run Control.** Timer 2 is enabled by setting this bit to 1. In 8-bit mode, this bit enables/disables TMR2H only; TMR2L is always enabled in split mode.	**1**
1	T2CSS	**Timer 2 Capture Source Select.** This bit selects the source of a capture event when bit T2CE is set to 1. 0: Capture source is USB SOF event. 1: Capture source is falling edge of Low-Frequency Oscillator.	**0**
0	T2XCLK	**Timer 2 External Clock Select.** This bit selects the external clock source for Timer 2. However, the Timer 2 Clock Select bits (T2MH and T2ML in register CKCON) may still be used to select between the external clock and the system clock for either timer. 0: Timer 2 clock is the system clock divided by 12. 1: Timer 2 clock is the external clock divided by 8 (synchronized with SYSCLK).	**0**

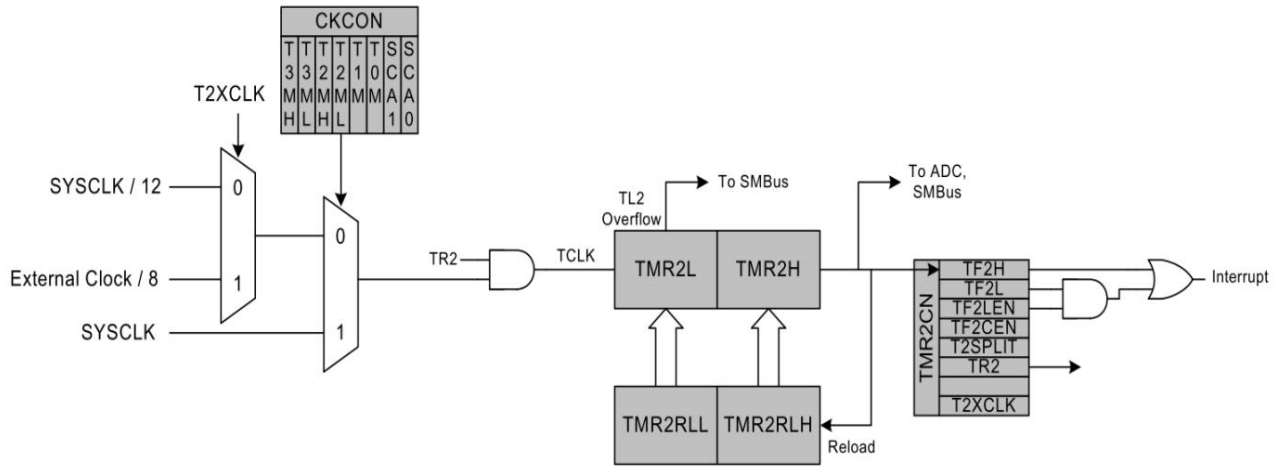
Below is a logic diagram of 1TIMER configured for BIT8 working mode and automatic loading, in order to measure time for UART serial communication.



·Below is a logic diagram of 5\2TIMER configured for BIT16 working mode

2TIMER was set to measure time for the distance sensor, 5TIMER was set to measure response delay

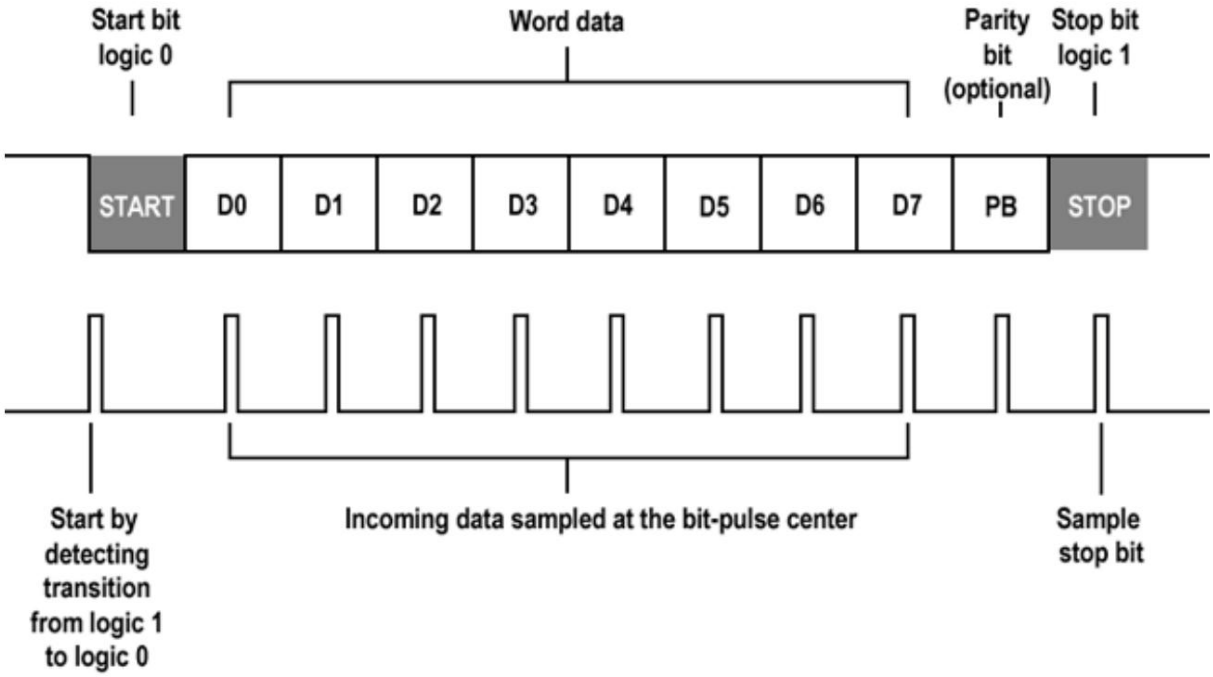
From a client in the system who requests to send a command via the cell phone to the component.



.35 UART communication

Transmitter Receiver Asynchronous Universal is **an asynchronous communication protocol** - meaning **without** existence of **a common clock signal between the two** communicating end units. In this way the microcontroller can communicate with the devices and more external such as computer, modem, bluetooth.

The information in the communication is transmitted within the framework of **rules for the composition of an information house and rules for sending/receiving at a specified rate.**



The UART is **a programmable component,** because different devices transmit at different speeds, and also in bit composition Changed (within the rules of the protocol). All information received and sent should be written to a register that will hold this data until pulse reading/writing. This register is called SBUF, and in our controller 0SBUF because there are several UART interfaces.

The SBUF register actually contains two separate registers located at the same address. When **writing information** in SBUF there . When **reading information** from the SBUF, this information (received) arrives This is to a register known as DATA **TX** transmission information, comes first in serial communication (from a register **known as** DATA **RX.**

In order to activate the UART, the provider needs a square wave (CLOCK) according to the required communication rate. At each clock pulse The UART performs a certain operation, therefore **the clock frequency must be higher than the transmission and reception frequency ,** so that the UART will be able to perform several operations between one bit to another. A clock frequency 16 times the communication frequency is accepted, indeed in the chapter on frequency The watch showed that we met this requirement.

At this frequency -2 is actually divided (gal). , The signal frequency to the UART is obtained by dividing the CPU clock frequency squared. The UART clock frequency is according to the required communication rate **BAUD** and is determined according to the following formula:

$$UARTBaudRate = \frac{1}{2} \times T1\_Overflow\_Rate$$

To create this frequency, use 1TIMER - whose output is connected to the UART as a clock generator. Kotsev programmers the Load the **timer with an initial value,** which will cause it to generate the ,Time to work in RELOAD AUTO mode UART clock frequency. We will place the given and desired values in the equation (from left to right).

= — — = — —

— —

= — — — = — —

ÿ ÿ

— —

(decimal base) = 48

= — —

= 30H (HEX base(

12 - Convert the VALUE RELOAD value The timer input receives the clock signal of the CPU in the divider. to base 16 and then to base 2 and perform 2's complement operations on the resulting binary number.

Convert the number obtained in the parables to 2 - to base 16 and then to a decimal base, and this is the number that needs to be loaded to register 1TH 1 (using a timer) in order to receive the required communication rate (Baud Rate) (register 1TL receives the The value 0.

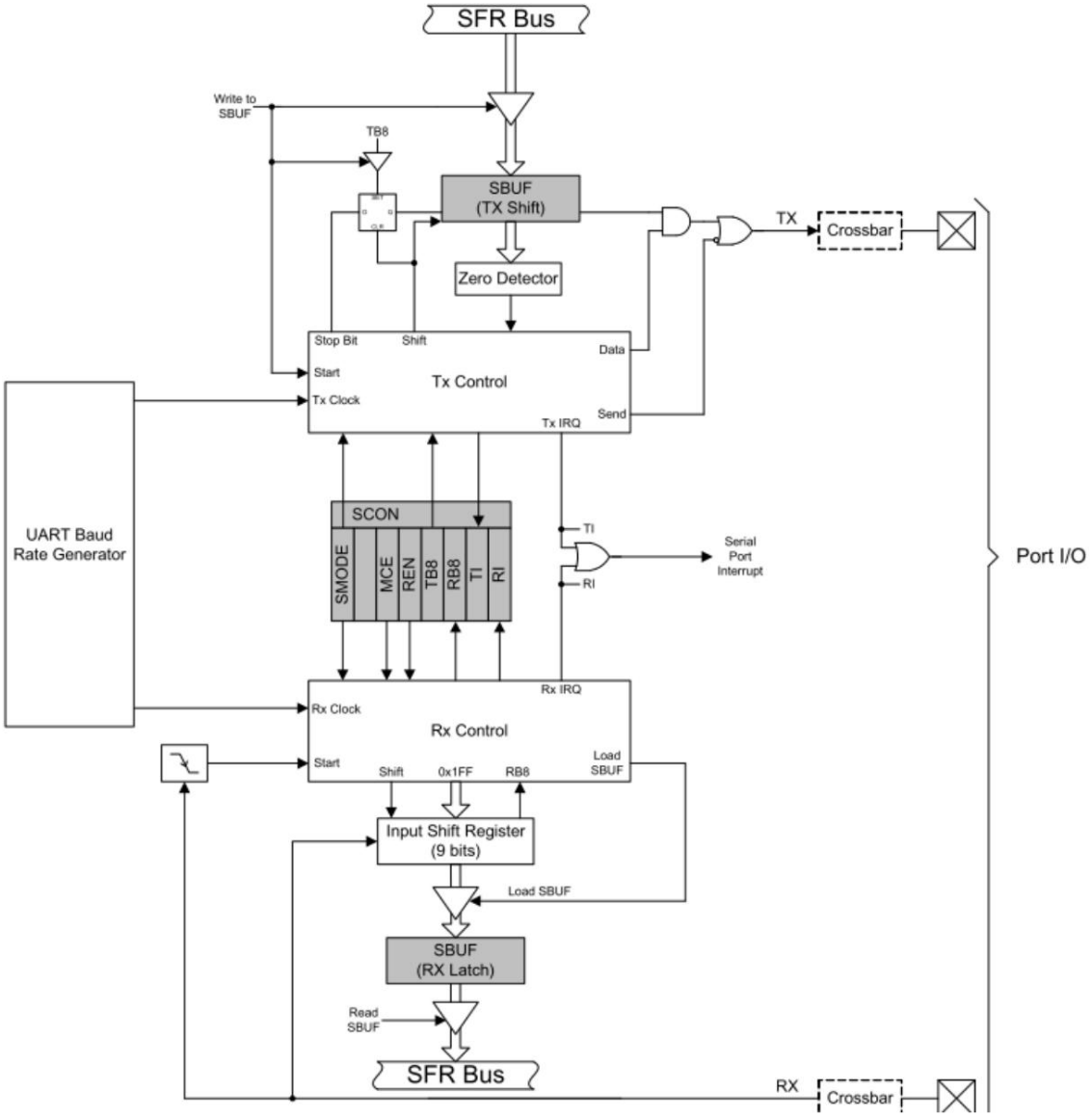
After initializing the timer and the UART, the UART starts transmitting and receiving. During transmission, the UART transmits the The information bits, each for 16 clock pulses. During reception, as soon as the UART detects that the line drops to 0"-", it is Waits 8 clock cycles and performs another sample for verification. Then count 16 more clock cycles and add the the bit of information.

Below is the definition of the register value that defines the UART, as well as the main function that initializes the rest rule The components - WatchDog, counters, ports and clock - have been explained so far.

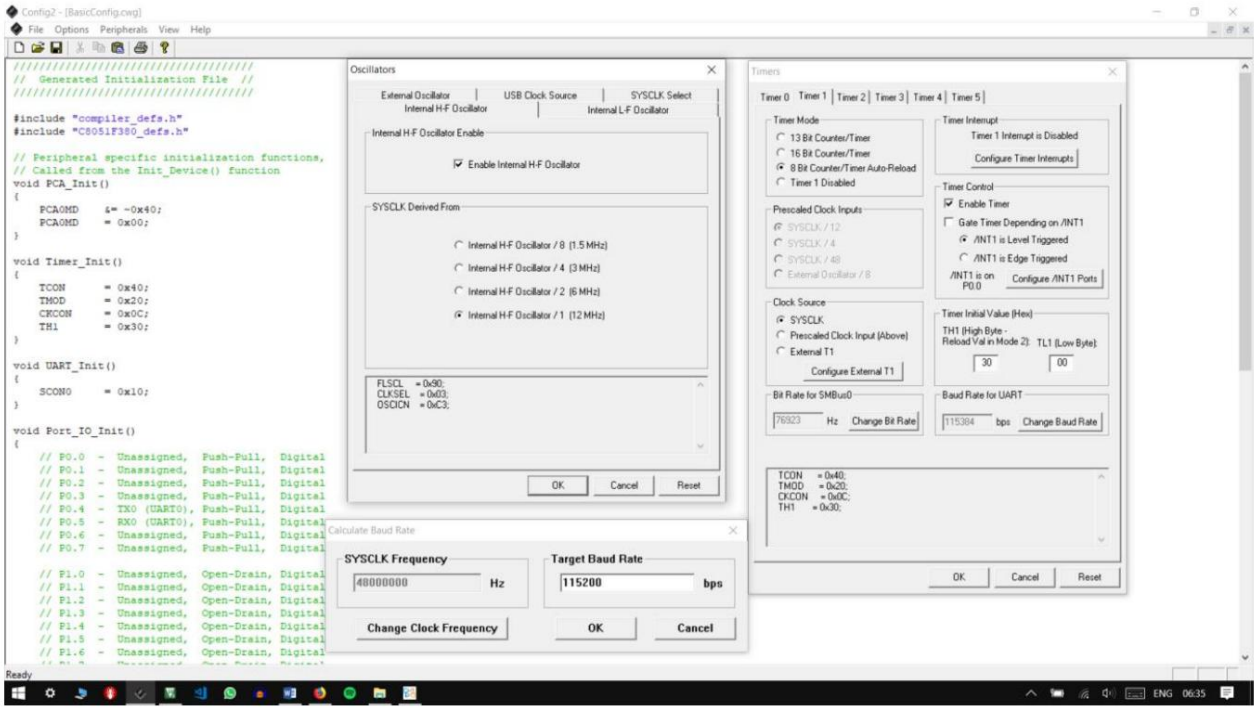
```
void UART_Init()
{
    SCON0      = 0x30;
}
void Init_Device(void)
{
  //Here all above functions are called
    PCA_Init();
    Timer_Init();
    UART_Init();
    Port_IO_Init();
    Oscillator_Init();
}
```

Below is a logic diagram of the UART 0 launcher/receiver in the controller:

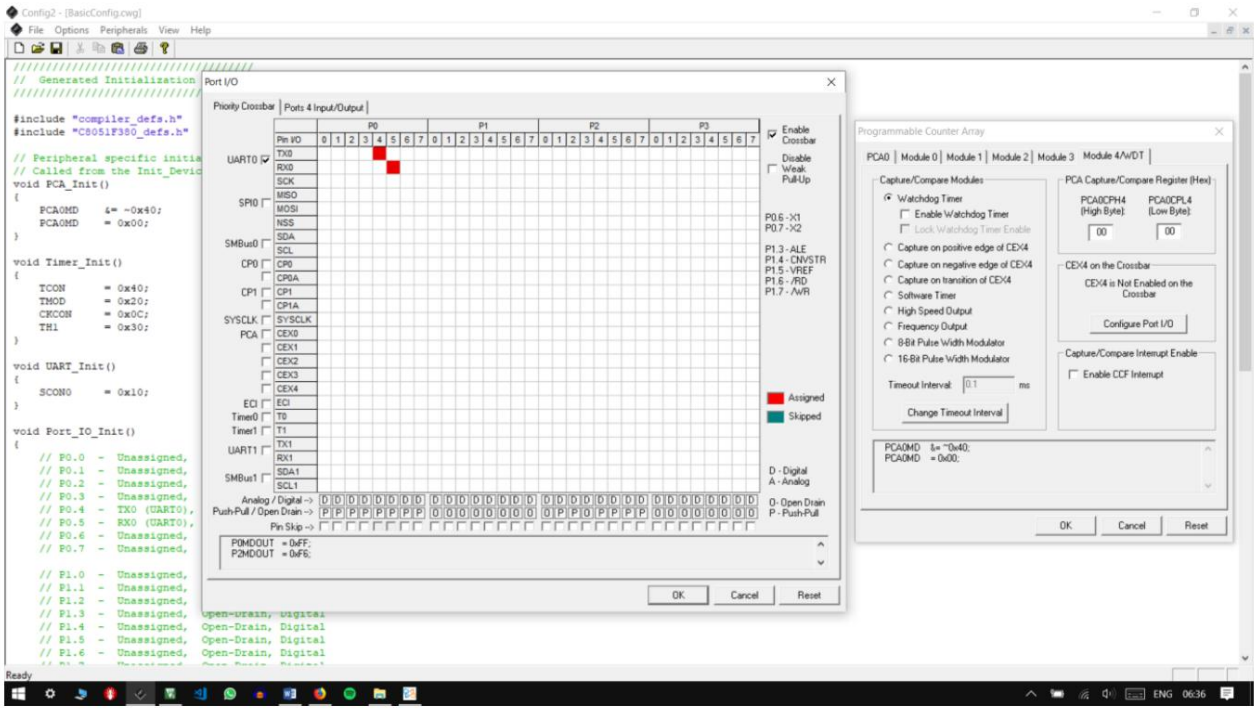
	Target Baud Rate (bps)	Actual Baud Rate (bps)	Baud Rate Error	Oscillator Divide Factor	Timer Clock Source	SCA1-SCA0 (pre-scale select*)	T1M	Timer 1 Reload Value (hex)
SYSCLK = 48 MHz	230400	230769	0.16%	208	SYSCLK	XX	1	0x98
	115200	115385	0.16%	416	SYSCLK	XX	1	0x30
	57600	57692	0.16%	832	SYSCLK / 4	01	0	0x98
	28800	28846	0.16%	1664	SYSCLK / 4	01	0	0x30
	14400	14388	0.08%	3336	SYSCLK / 12	00	0	0x75
	9600	9615	0.16%	4992	SYSCLK / 12	00	0	0x30
	2400	2404	0.16%	19968	SYSCLK / 48	10	0	0x30



Below is a screen shot that illustrates the settings we actually made in our project **in connection with the desired internal clock frequency ,** the activation of 1Timer for the purpose of allocating time for transmission within **the UART protocol** - which is derived from the bit transmission rate we chose - 115,200.; BAUD



Below is a screenshot that illustrates **settings we made in the visual port matrix** - which defines which of the ports will be accessible for use for **connecting input-output devices. Rx and Tx lines** are marked in red , which are the data lines to which **the network controller is connected.**



.36 String functions - deepening

As you can understand, throughout the development a very important aspect of the functionality that we wanted to offer developed The 'smart home' controller - the ability to **request information** from the sensors in the home, and display it within the application on the cell phone **(DataOnDemand) .** Even without this ability, the information received from the sensors has to be **processed so that it is valid** And not necessarily quantitative. ,**A short, matter-of-fact meaning**

Therefore - the code we developed makes a lot of use **of strings and functions** that **manipulate** them, in order copy, connect, cut, convert and reset - all the modifiers that store these strings, so that they can be displayed Or alternatively **in the SmartPhone application** as part of the WiFi communication ,on **the graphic screen**

As a result, we were required to work with a popular **code library for handling strings,** which usually comes with an environment rule development, and in this case one suitable for **the C language:> h.string <.** The library makes extensive use **of 'pointers'** - a programming tool designed to refer to and control the location of variables in memory, in order to allow functions to access them, thus saving unnecessary **operations** such as copying variables and returning them as parameters **that take up additional space in memory .**

: miscellaneous Below is a small part of the functions we used, **the full library contains 22 and functions**

Function and description	function
void * memset (void * str, int c, size_t n) Copies the character c to the first n characters of the string str .	5
char * strcat (char * dest, const char * src) Concatenates (concatenates) the string src with the end of the string dest.	6
char * strncat (char * dest, const char * src, size_t n) concatenates (concatenates) the string src with the place n in the string dest.	7
char * strchr (const char * str, int c) searches for the first instance of the character in place c in the string str and returns it (its character value)	8
int strcmp (const char * str1, const char * str2) Compares the string 1str with 2str and returns yes/no if there is an equality of the form 1/0.	9
int strncmp (const char * str1, const char * str2, size_t n) Compares first n bytes in strings 1str and 2str and returns yes/no if equality exists in the form 1/0.	10
char * strcpy (char * dest, const char * src) Copies the string src into the string dest. char * strncpy (char	12
* dest, const char * src, size_t n) Copies up to n characters from the string src into the string dest.	13
Size_t strlen (str char * str) Calculates and returns the length of the string str up to the null character and not including the terminating character.	16
char * strstr (const char * haystack, char * needle) searches for and returns the first occurrence of the needle string within the haystack string. if not found, returns null .	20

.38 Bibliography

address	site/organization	essence of chapters	
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