Information Technology Institute

Ministry of Communication and Information Technology

Bootloader-Smart Home Graduation Project

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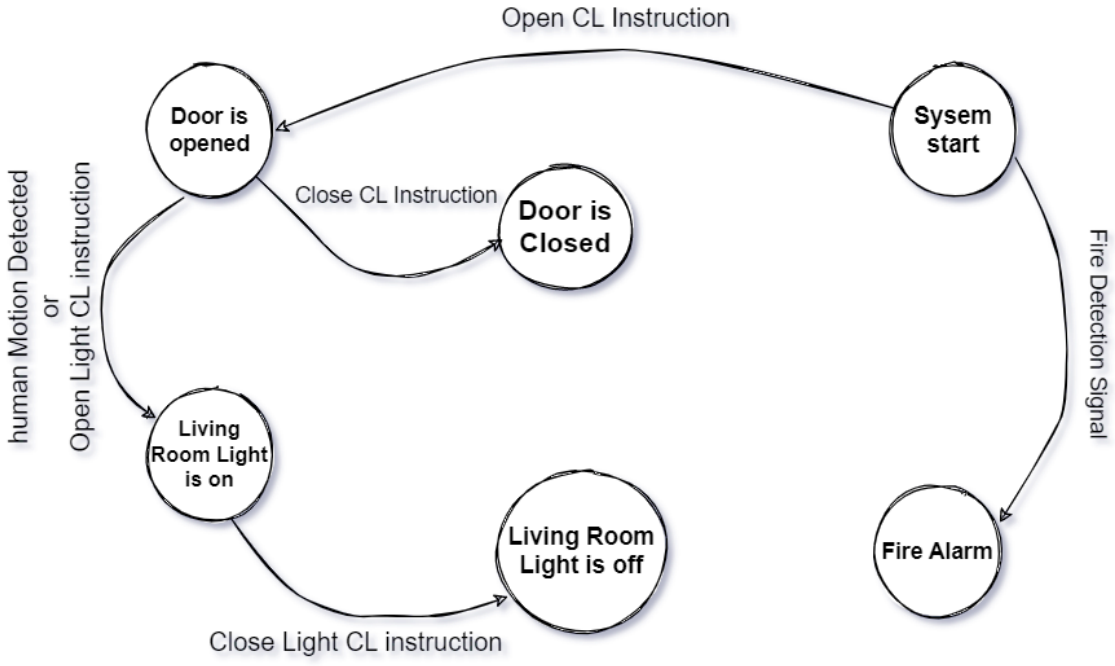
Chapter 1:Introduction

1.1 Overview of Project Idea:

For the implementation of smart homes, the control is placed within the infrastructure of the building, and therefore it is difficult to do maintenance or improvements in the programs without huge disruption to flashing the code by off circuit programming. Therefore, the bootloader is the most appropriate solution in smart homes.

Reprogramming Embedded Systems Remotely This is the bootloader that becomes necessary to maintain projects quickly, efficiently and securely, it allows to decouple parts of the program that are mission critical, or that have security implications, from application code and apply the changes that needed.

1.2 State Machine Diagram:



Chapter 2:Features of ARM Cortex-M3 STM32F10x

2.1 Introduction

The architecture of the ARM processor is created by Advanced RISC Machines, hence the name ARM. This needs very few instruction sets and transistors. It has a very small size. This is the reason that it is a perfect fit for small size devices. It has less power consumption along with reduced complexity in its circuits.
They can be applied to various designs such as 32-bit devices and embedded systems. They can even be upgraded according to user needs.

2.2 Processor Features

The main features of ARM Processor are mentioned below :

1. Multiprocessing Systems
   ARM processors are designed so that they can be used in cases of multiprocessing systems where more than one processor is used to process information.
2. Tightly Coupled Memory
   Memory of ARM processors is tightly coupled. This has a very fast response time. It has low latency (quick response) that can also be used in cases of cache memory being unpredictable.
3. Memory Management
   ARM processors have a management section. This includes the Memory Management Unit and Memory Protection Unit. These management systems become very important in managing memory efficiently.
4. More user Configuration
   Using STM32 gives the users more control on input/output signals,For example: The target can act as a square wave generator by configuring pins as output and adjusting the frequency generated.

Chapter 3:Bootloader

3.1 Introduction:

Bootloader or In App Programming (IAP) allows the user to re-program the flash memory while the application is running.
Nevertheless, part of the application has to be been programmed in the flash memory using In circuit programmer (ICP)
Steps:

- receive the file.
- Flash it (page by page).

There is two Applications APP1 and File.elf, We need a flash driver then the APP1 must be flashed ICP firstly, now we can use Boot-loader (IAP).

Why do we need a Bootloader?

- To fix Bugs.
- Updating system with new features

3.2 Bootloader Requirements:

1. Needs Flash Driver (FPEC) which is responsible for program/erase flash.
2. Selects Communication Protocol (USART) to download programming data into memory.
3. Record parsing requirement (hex format).
4. Flash system requirements (erase, write, read, location).
5. EEPROM requirements (partition, erase, read, write).
6. Application checksum (verifying the app is not corrupt).
7. Code Security (Protecting the bootloader and the application)

3.3 Implementation:

3.3.1 Implementation in simple steps:

1. The processor initializes a communication port in the microcontroller to make it ready to receive data.
2. A computer starts sending the application code through this communication port to our microcontroller as shown in the following flow chart, Figure (3.1).
3. the processor reads the data, then sends it to the in-circuit flash driver which in turn writes this data in the flash, eventually the target controller is updated with the code (Flash the file page by page).

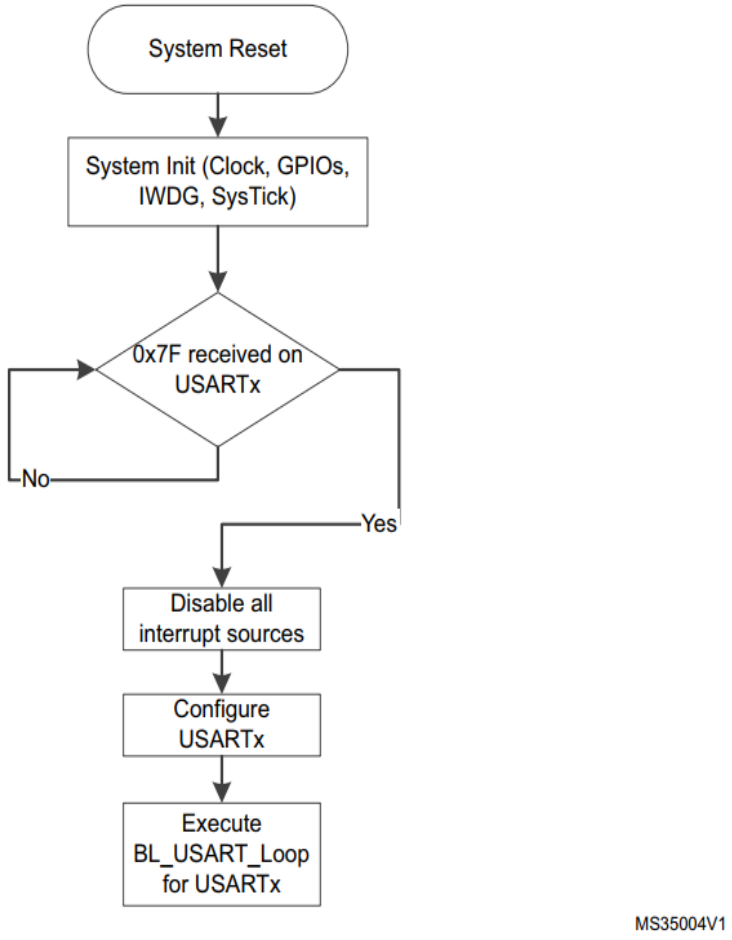


Figure (3.1) : Sending the Application through Communication Port.

3.3.2 UART Sender Tool DiskTop Application:

This tool is capable of sending hex file format record by record via UART communication Protocol over STM32F103XXX flash regarding verified and updated code using USB-TTL .

Tool configuration parameters:

1. Communication Port.
2. USART Baud Rate .
3. Intel Hex file format .

3.3.3 Hex Parser

The HEX file is read by a programmer to write the machine code into a PROM or is transferred to the target system for loading and execution. a compiler or assembler converts a program's source code (such as in C or assembly language) to machine code and outputs it into a HEX file. Common file extensions used for the resulting files are (.HEX).

HEX file format:

HEX file consists of lines of ASCII text that are separated by line feed or carriage return characters or both. Each text line contains hexadecimal characters that encode multiple binary numbers. The binary numbers may represent data, memory addresses, or other values, depending on their position in the line and the type and length of the line. Each text line is called a record. Each text line is called a record.

• A record (line of text) consists of six fields (parts) that appear in order from left to right:

1. Start code: one character, an ASCII colon ‘:’
2. Byte count: two hex digits (one hex digit pair), indicating the number of bytes (hex digit pairs) in the data field. The maximum byte count is 255 (0xFF). 16 (0x10) and 32 (0x20) are commonly used byte counts.
3. Address: four hex digits, representing the 16-bit beginning memory address offset of the data. The physical address of the data is computed by adding this offset to a previously established base address, thus allowing memory addressing beyond the 64 kilobyte limit of 16-bit addresses. The base address, which defaults to zero, can be changed by various types of records. Base addresses and address offsets are always expressed as big endian values.
4. Record type: two hex digits, 00 to 05, defining the meaning of the data field.
5. Data: a sequence of n bytes of data, represented by 2n hex digits. Some records omit this field (n equals zero). The meaning and interpretation of data bytes depends on the application.
6. Checksum: two hex digits, a computed value that can be used to verify the record has no errors.

Record types

HEX files have six standard record types:

1. Data record
   Hex code: 00
   Example: : OB0010 00 6164647265737320676170A7

Description: Contains data and a 16-bit starting address for the data. The byte count specifies the number of data bytes in the record. The example shown next has 0B (eleven) data bytes (61, 64, 64, 72, 65, 73, 73, 20, 67, 61, 70) located at consecutive addresses beginning at address 0010.

2. End Of File record
   Hex code: 01
   Example: 000000 01 FF

Description: Must occur exactly once per file in the last line of the file. The data field is empty (thus byte count is 00) and the address field is typically 0000.

3. Extend Segment Address record
   Hex code: 02
   Example: 020000 02 1200EA

Description: The data field contains a 16-bit segment base address (thus byte count is always 02) compatible with 80x86 real mode addressing. The address field (typically 0000) is ignored. The segment address from the most recent 02 record is multiplied by 16 and added to each subsequent data record address to form the physical starting address for the data. This allows addressing up to one megabyte of address space.

4. Start Segment Address record
   Hex code: 03
   Example: 040000 03 00003800C1

5. Extended Linear Address record
   Hex code: 04
   Example: 020000 04 FFFFFC

6. Start Linear Address record
   Hex code: 05
   Example: 040000 05 000000CD2A

3.4 FPEC: Flash Program and Erase controller

Basic Hardware Initialization:

- Mask all interrupts.
- Set CPU speed and clock rate (RCC).
- Initialize RAM Initialize GPIO.
- Disable CPU internal Instruction/Data Cache.

Minimum Bootloader Commands:

- Erase the flash – Removal of the application image from memory
- Write flash – Addition of a new application image to memory
- Exit / Restart – reboot with the intention of entering the application code.

Chapter 4:Smart Home Application

4.1 Introduction:

This smart home Project is fully automatically controlled using the microcontroller ARM Cortex M3 and has features using various sensors that give some facilities in life inside this home. First feature is controlling the door remotely, where the mobile application plays an important role to communicate with the home controller and send instructions to open/close the door. Monitoring motion inside home using PIR (Passive InfraRed) motion sensor is the second feature,this sensor is used also to control the lighting system after making sure of detecting humans so, they need a source of light.

4.2 Fire detection system

This system contains two Components, Flame Sensor Module and Buzzer to simulate the alarm system. First component is used in several dangerous situations which include Hydrogen stations , Industrial heating, Fire alarm, Firefighting robot, Drying systems, Industrial gas turbines, Domestic heating systems and Gas-powered cooking devices.

4.2.1 Flame Sensor Module:

The pin configuration of this sensor is shown below in figure(5). It includes four pins which include the following.

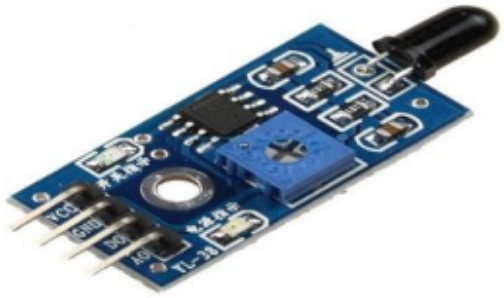


Figure (4.1): Flame Sensor Module.

When this module works with a microcontroller unit then the pins are:

- Pin1 (VCC pin): Voltage supply rages from 3.3V to 5.3V
- Pin2 (GND): This is a ground pin
- Pin3 (AOUT): This is an analog output pin (MCU.IO)
- Pin4 (DOUT): This is a digital output pin (MCU.IO).

4.2.2 Flame-sensors are classified into four types

- IR single frequency
- IR multi-spectrum
- UV flame detectors
- UV/ IR flame detectors.

4.2.3 Working Principle

It detects the presence of fire or flames. In extremely hazardous environments, it works to minimize the risks associated with fire. There are several different types of flame sensor - some will raise an alarm while others may activate a fire suppression system or deactivate a combustible fuel line. Among the many different types of flame sensor, ultraviolet flame sensors, near IR array flame sensors, infrared flame sensors and IR3 flame detection sensors are the most prominent. In a hazardous environment, such as a petrochemical processing plant, failing to detect gas leaks,fires or explosions could prove disastrous. However, more needs to be done to help distinguish dangerous gas leaks or flames from annoying false alarms. In this article, Artificial NeuralNetwork Technology Improves Gas & Flame Detection in Hazardous Areas, we take a closer look at the different ways we can reduce false alarms.

4.2.4 Features & Specifications

The features of this sensor include the following.

- Photosensitivity is high
- Response time is fast
- Simple to use
- Sensitivity is adjustable
- Detection angle is 600,
- It is responsive to the flame range.
- Accuracy can be adjustable
- Operating voltage of this sensor is 3.3V to 5V
- Analog voltage o/PS and digital switch o/PS
- The PCB size is 3cm X 1.6cm
- Power indicator & digital switch o/p indicator
- If the flame intensity is lighter within 0.8m then the flame test can be activated, if the flame intensity is high, then the detection of distance will be improved.

4.3 Remote Door Control System

In this system smart home application enables users to easily connect with various home appliances, including Door Locker, Lightings and know about home status whether all is secured and safe or not.

So, the Door Control System includes a bluetooth module as a communication medium between microcontroller and mobile application.

4.3.3 Servo motor

The servo is a motor that can rotate at a specific angle by preprogramming it via any Microcontroller. There is an electronic circuit located inside the servo drive unit.
The motor has a position-controlled shaft and is usually fitted with auxiliary parts to increase torque. The motor is controlled by an electrical signal that determines the amount of shaft movement.

How do servo motors work?

Usually, servos have three inputs and two of them supply power to the motor located inside the plastic body. The third input controls how much the servo turns.
Usually, the input signal is pulse-width modulated (PWM) and its frequency doesn’t change over time. Instead, the servo motor rotates to a certain angle when the duty cycle of the PWM input signal changes. The servo used in this example can turn 180 degrees in

total (90 degrees in each direction). When the duty cycle is 5% (a one-millisecond long high pulse), the servo rotates to its minimum position. If the duty cycle changes to 10% (which is a two-millisecond long high pulse), the servo rotates all the way to the right. Duty cycles in between correlate to different angles between -90° and +90°. However, These numbers might vary for different servos and between manufacturers. Therefore, it's always necessary to consult the datasheet of the servo.

4.4 Human Detection System

This system includes one and very important component :

4.4.1 Passive Infra-Red (PIR) Motion Sensor

Figure (4.2) : PIR Sensor Module.

4.4.1.1 Working Principle

Humans emit radiation all the time. This is nothing to be concerned about, though, as the type of radiation we emit is infrared radiation (IR), which is harmless at the levels at which it is emitted by humans. In fact, all objects at temperatures above absolute zero (-273.15C) emit infrared radiation. A PIR sensor detects changes in the amount of infrared radiation it receives. When there is a significant change in the amount of infrared radiation it detects, then a pulse is triggered. This means that a PIR sensor can detect when a human (moves in front of it.

4.4.1.2 PIR Sensor Specifications

The next table contains module specifications:

Input Voltage	DC 4.5V ~ 20V
Static Current	<50 uA
Output Signal	0V / 3V (Output high when motion detected)
Sensing Range	7 meters (120-degree cone)
Delay time	8s ~ 200s (adjustable)
Dimensions	8s ~ 200s (adjustable)24mm x 32mm x 25mm (Height with lens)

4.4.1.3 PIR Sensor features:

1. Automatic induction: The PIR Sensor Switch detects PIR body heat and automatically switches the light ON and turning it OFF again after a time adjustable from 6 seconds to12 minutes.PIR sensor switch Combined intelligent control and energy saving, it wildly used in aisles, basements, restrooms, etc. Help to save 20%~80% of your energy.

2. Photosensitive control: PIR motion sensor switch can adjust the on/off of the wall lamp to detect human movement and adopt photosensitive control. In daylight or under strong light conditions, the motion sensor switch will not turn on the lights. You can also choose to turn on the light in any light environment.
3. Wide operating voltage ranges: the input voltage of PIR is DC 4.5V ~ 20V.
4. Low micro power consumption: power consumption is 40μA if something moves in the coverage of this passive infrared motion detector, action is triggered. The PIR motion detector reacts to the heat radiation of moving bodies.
5. High output signal: output high when motion detected (0V / 3V).

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