pH Monitoring SYSTEM

A Report Submitted
as Requirements for the Mini Project 2A Course of
Semester V, AY 2023-2024

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October 2023

Don Bosco Institute of Technology
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Certificate

This is to certify that the Mini project entitled **pH Monitoring System** is a work of

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submitted as fulfilment of the requirement for the Mini Project2A of **"Semester V"** in **"Third Year of Engineering AY 2023-2024"**.

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Project Guide	Project Guide	HOD, EXTC

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Mini Project 2A Report Approval

This Mini project report entitled **'pH Monitoring System'** by **Mayuri Kadam, Himanshu Jogi, Sumith Kumar, Rohit Mali** is approved for the completion of Mini Project 2A course **of Sem V of AY 2023-2024 in Dept. of Electronics & Telecommunication Engineering.**

Examiners

1. _____

2. _____

Date : 31 / 10 / 23

Place : **Kurla, Mumbai**

Declaration

I declare that this written submission represents my ideas in my own words and where other's ideas or works have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

GROUP MEMBERS:

1. Mayuri Kadam _____
2. Himanshu Jogi _____
3. Sumith Kumar _____
4. Rohit Mali _____

Date : 31/ 10 / 2023

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Abstract

Ensuring the right pH level is crucial for the well-being of aquatic life. Aquariums are a great way to bring a piece of nature into your home. However, maintaining the water quality in an aquarium can be a challenging task. One of the key parameters to monitor in an aquarium is the pH level. A pH level that is too high or too low can be harmful to the fish and other aquatic life in the aquarium. In addition to pH, other parameters such as temperature and total dissolved solids (TDS) also need to be monitored to ensure a healthy environment for the aquatic life.

Chapter 1

Introduction

1.1 Introduction:

Ensuring the right pH level is crucial for the well-being of aquatic life. Aquariums are a great way to bring a piece of nature into your home. However, maintaining the water quality in an aquarium can be a challenging task. One of the key parameters to monitor in an aquarium is the pH level. A pH level that is too high or too low can be harmful to the fish and other aquatic life in the aquarium. In addition to pH, other parameters such as temperature and total dissolved solids (TDS) also need to be monitored to ensure a healthy environment for the aquatic life.

Deciding on a TDS Sensor of the many reasons TDS is an abbreviation for Total Dissolved Solids in a liquid, including organic and inorganic substances in a molecular,

ionic, or micro-granular suspended form. TDS is generally expressed in parts per million (ppm) or as milligrams per liter (mg/L). TDS is directly related to the quality of water i.e., the lower a TDS figure, the purer the water. As an example, reverse osmosis purified water will have a TDS between 0 and 10, whereas tap water will vary between 20 and 300, depending on where you live in the world. Precisely measures water quality, detecting any potential issues. Measure the water quality accurately to prevent imbalances that can harm your fish and plants.

Therefore, to save the aquatic life and marine life, we have designed a 'pH Monitoring System' which will help us know the TDS and the temperature of the water. Thus, contributing to a "Greener Earth" and safe environment.

1.1.1 Applications

- Aquatic Life : To keep the aquatic life healthy.
- Smart water quality monitoring system: IoT-based smart water quality monitoring systems can use pH sensors to monitor the pH levels of water, along with other parameters such as turbidity, conductivity, and temperature.
- Chemical production: pH probes and transmitters

are used in laboratories and control systems throughout the chemical production industry to monitor and control pH levels.

- Water and wastewater treatment: pH sensors can be used to monitor the pH levels of water and wastewater in treatment plants.
- Power plants: pH probes and transmitters are used in power plants to monitor and control pH levels in cooling water systems.
- Pharmaceuticals: pH monitoring systems can be used in the pharmaceutical industry to monitor and control pH levels during the production of drugs.
- Smart hydroponics monitoring system: pH monitoring systems can be used in hydroponics systems to collect parameters such as pH levels.
- Food and beverage: pH probes and transmitters are used in the food and beverage industry to monitor and control pH levels during production processes.
- Tissue engineering application: pH monitoring systems can be used in bioreactors for tissue engineering applications to monitor the pH levels of cell cultures.

Design: This circuit is made with a hardware using components like TDS sensor , DS18B20 Temperature Sensor, STM32, some wires and breadboard.

Chapter 2

Basic Idea and Working

2.1 Project Objective and Outcomes:

The main objective of this project is to design a low cost and user friendly pH Monitoring System, which will detect the pH level and the temperature of water. A pH monitoring system can be used in aquariums to monitor and control the pH levels of the water, which is essential for the survival and health of aquatic species. The objectives and outcomes of using a pH monitoring system in an aquarium are:

Maintaining optimal pH levels: Different aquatic species require specific pH levels to survive and thrive. For example, freshwater fish typically require a pH range of 6.5 to 7.5, while saltwater and coral reef aquariums require a pH range of 8.0 to 8.3. A pH monitoring system can help aquarium owners maintain the optimal pH levels for

their aquatic species by providing accurate and real-time pH readings.

Preventing pH fluctuations: pH levels in aquariums can fluctuate due to various factors such as the addition of acids or bases, changes in water sources, and the presence of waste products. Fluctuations in pH levels can be harmful to aquatic species and can even lead to their death. A pH monitoring system can help prevent pH fluctuations by alerting aquarium owners when the pH levels are outside the optimal range, allowing them to take corrective action before any harm is done. Overall, using a pH monitoring system in an aquarium can help aquarium owners maintain the optimal pH levels for their aquatic species and prevent pH fluctuations, ensuring the health and survival of their aquatic pets.

2.2 Working of circuit

Connect the TDS sensor to the STM32 microcontroller. The TDS sensor outputs an analog signal that can be measured using an ADC pin on the STM32. You can use the code provided in to interface the TDS sensor with the STM32.

The block diagram of the project is as shown in Fig-

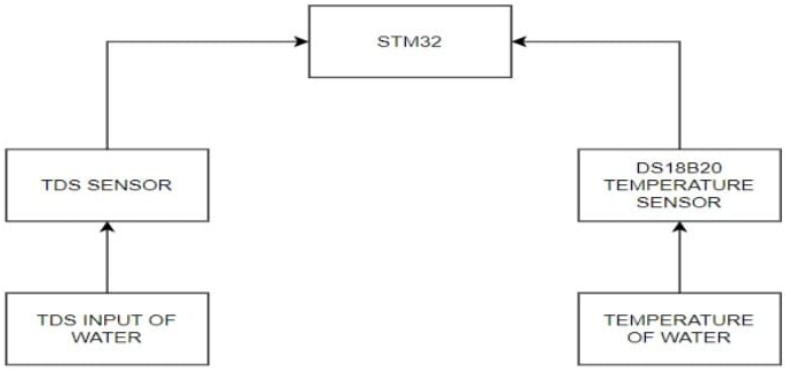

Figure 2.1: Block Diagram of pH Monitoring System

ure 2.1. Connect the DS18B20 temperature sensor to the STM32 microcontroller. The DS18B20 is a digital temperature sensor that communicates over a 1-wire bus. Use the code provided in to interface the DS18B20 with the STM32.

Use the measured temperature from the DS18B20 to compensate for the TDS reading. The TDS value depends on the temperature, so it is the need to compensate for the reading to get high calibration and high accuracy. Use the code provided in to compensate for the TDS reading.

If you want to add a pH sensor to the system, you can use a pH sensor module like the one in. The pH sensor module outputs an analog signal that can be measured

using an ADC pin on the STM32. Use the code provided in to interface the pH sensor with the STM32.

Once you have all the sensors connected and interfaced with the STM32, you can use the measured values to monitor the water quality. Display the values on an LCD display or send them to a computer for further analysis.

Note that the TDS sensor can be used for measuring the TDS of drinking water supplies, fish tanks and aquariums, hydroponics, and more. Similarly, the pH sensor can be used for measuring the pH value of hydroponic setups, aquariums, and more

Required Components for this 4017 Project:

1) TDS Sensor
2) DS18B20 Temperature Sensor
3) STM32 microcontroller
4) 4.7K resistor
5) Wires
6) Breadboard

Chapter 3

Project Implementation

3.1 Circuit Implementation

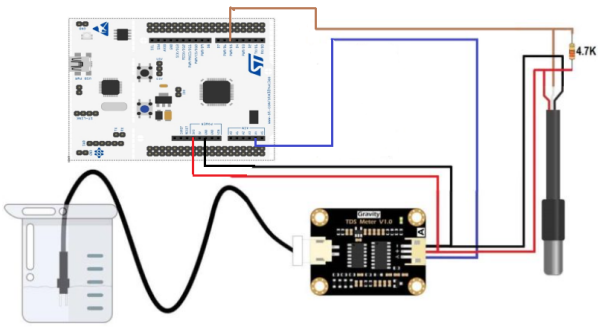

Figure 3.1: Circuit Implementation

3.2 Implementation

Connect the TDS sensor to the STM32 microcontroller. The TDS sensor will output an analog signal that can be read by the microcontroller. Connect the TDS sensor's

VCC and GND pins to the microcontroller's 3.3V and GND pins, respectively. Connect the output analog pin of the TDS sensor to an ADC input pin on the microcontroller.

Connect the DS18B20 temperature sensor to the STM32 microcontroller. The DS18B20 is a digital temperature sensor that communicates using the 1-Wire protocol. Connect the DS18B20's VCC and GND pins to the microcontroller's 3.3V and GND pins, respectively. Connect the data pin of the DS18B20 to a digital input/output pin on the microcontroller.

Write code to read the TDS sensor and DS18B20 temperature sensor data. Use the STM32's ADC to read the analog signal from the TDS sensor and convert it to a TDS value. You can use the OneWire library to communicate with the DS18B20 temperature sensor and read the temperature value.

Display the sensor data. You can use an LCD display or a serial monitor to display the TDS and temperature values.

3.3 List of Components

Table 3.1: List of Components

Name of module	Specifications	Price in Rs.
TDS Sensor	Input Voltage: 3.3 5.5V Output Voltage: 0 2.3V	1
DS18B20	Temperature Range: -55°C to +125°C Accuracy: ±0.5°C	1
Resistor	4.7K	1
Micro controller	STM32	1
Breadboard		1
Connecting Wires	Standard M/F	20

Chapter 4

Detail Description of Components:

4.1 TDS Sensor

The Gravity Analog TDS Sensor is a device that measures the Total Dissolved Solids (TDS) in water. value of water to reflect its cleanliness. It can be applied to domestic water, hydroponic, and other fields of water quality testing. The sensor gives an analog output that is compatible with most micro controllers, such as Arduino, ESP32, and Raspberry Pi.
The sensor consists of a signal transmitter board, a waterproof TDS probe, and a Gravity-3Pin Analog Sensor Cable. The TDS probe has two needles and a total length of 83cm. The module size is 42 x 32mm, and the module interface is PH2.0-3P. The electrode interface is XH2.54-2P TDS probe

The sensor can be used to measure the TDS value of water, which indicates how many milligrams of soluble solids dissolved in one liter of water. The higher the TDS value, the more soluble solids dissolved in water, and the less clean the water is. Therefore, the TDS value can be used as one of the references for reflecting the cleanliness of water.

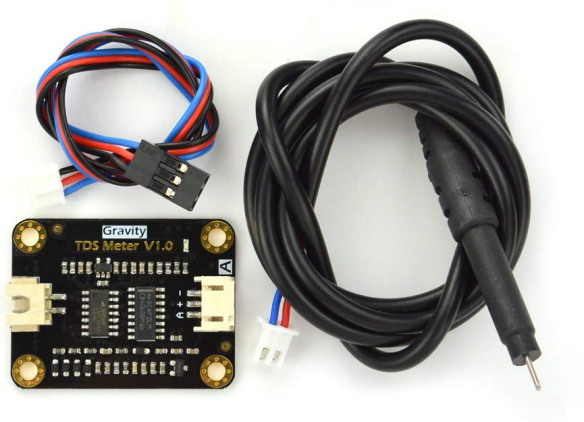

Figure 4.1: TDS Sensor

The sensor comes with a signal transmitter board that requires an input voltage of 3.3 5.5V and outputs a voltage between 0 2.3V. The TDS measurement range

is between 0 1000ppm with an accuracy of ± 10The working current of the sensor is between 3 6mA

4.1.1 Specifications

Input Voltage: 3.3 5.5V
Output Voltage: 0 2.3V
Working Current: 3 6mA
TDS Measurement Range: 0 1000ppm
TDS Measurement Accuracy: ± 10
It is available in different packages like 16-pin.
TL or Lead Temperature is 260°C.
RTC In-built 32kHz with calibration

4.2 DS18B20 Temperature Sensor

The DS18B20 is a digital thermometer that can measure temperature in hard environments like chemical solutions, mines, or soil. It is a 1-wire programmable temperature sensor that communicates over a one-wire interface, so only one wire (and ground) needs to be connected from a central microprocessor to a DS18B20. The sensor provides 9 to 12-bit (configurable) temperature readings, which indicate the temperature of the device. The resolution of the DS18B20 is configurable (9, 10, 11, or 12 bits), with 12-bit readings the factory default state. This equates to a temperature resolution of 0.5 °C, 0.25°C, 0.125°C, or 0.0625 °C. The DS18B20 has four main data components: 1) 64-bit lasered ROM, 2) temperature sensor, 3) nonvolatile temperature alarm triggers TH and TL, and 4) a 1-wire communication interface.

The DS18B20 temperature sensor can be easily connected to an Arduino digital input. Each sensor has a unique serial number assigned by the manufacturer, and your sketch must be programmed with these serial numbers so it can identify and interrogate each sensor. The sensor can be used in various applications, such as temperature monitoring in hydroponics, aquariums, and greenhouses.

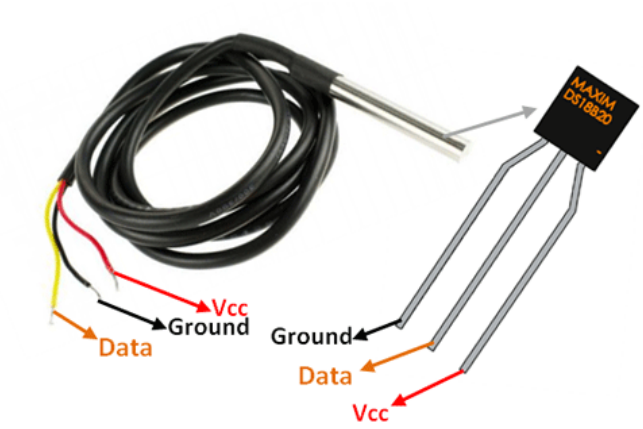

Figure 4.2: DS18B20 Temperature Sensor

The waterproof version of the DS18B20 sensor is also available, which is pre-wired and waterproofed with heat shrink. The sensor in this housing can be used up to the sensor's 125°C limit. The cable is jacketed in PVC, so it is suggested to keep it under 100°C. These 1-wire digital temperature sensors are fairly precise (±0.5°C over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter. They work great with any microcontroller using a single digital pin, and you can even connect multiple ones to the same pin, each one has a unique 64-bit ID burned in at the factory to differentiate them.

4.2.1 Specifications

Pin Configuration: Ground, Vcc, Data
Operating voltage: 3V to 5V
Temperature Range: -55°C to +125°C
Accuracy: ±0.5°C
Output Resolution: 9-bit to 12-bit (programmable)

4.3 Micro controller - STM32 Nucleo 64

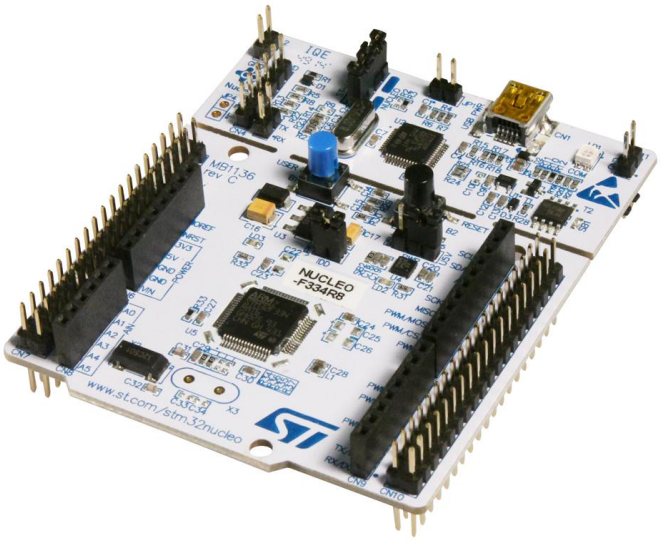

Figure 4.3: STM 32 Nucleo-64 Microcontroller

The STM32 Nucleo-64 is a development board that features a 32-bit microcontroller with LQFP64 package, which is ideal for quick prototyping and learning about the features of the entire STM32 MCU family. The board has a standardized connectivity that allows the designer to build and reuse add-on hardware across the whole portfolio of Nucleo boards. The board connectors are compatible with Arduino, and a new standardized ST connector (Morpho) gives access to all IOs available on the MCU. The board comes with ready-to-use software examples and is supported by IAR and Keil development tools, as well as GCC-based IDEs. Each of these boards contains

an ST-LINK/V2-1 in-circuit debugger and programmer, which can be used either with the onboard MCU or - in standalone mode - with any other applications containing an STM32 MCU.

The STM32 Nucleo-64 development board is available in different versions, such as the STM32F401 Nucleo-64, STM32F103 Nucleo-64, and STM32F303 Nucleo-64. The name STM32 represents that the board has a 32-bit microcontroller, and the name Nucleo-64 represents that the microcontroller has 64 pins. The board can be used for various applications, such as motor control, robotics, and IoT.

4.3.1 Specifications

Microcontroller: STM32F401RET6 (32-bit)
Architecture: ARM Cortex M4 CPU with FPU
Power consumption: 2.4uA at standby without RTC
CPU Frequency: 84 MHz
Crystal Oscillator Range: 4 to 26 MHz
MCU Operating Voltage (VDD): 1.7V to 3.6V
Board Operating Voltage (VIN): 7V to 15V
Flash Memory: 512KB
SRAM: 96 KB
GPIO Pins: 50

ADC: 12-bit 16Channel
RTC: In-built 32kHz with calibration
Timers: 16-bit (6), 32-bit (2)
Watchdog Timers: 2
USART/UART Communication: 3
I2C Communication: 4
SPI Communication: 3
USB2.0 Support: Yes
Internal Crystal Oscillator: Yes, 16MHz

Chapter 5

Advantages and Disadvantages

Advantages:
pH monitoring systems using TDS sensors, DS18B20 temperature sensors, and STM32 Nucleo 64 can provide accurate and reliable measurements of pH, temperature, and total dissolved solids (TDS) in water. These sensors can be used for a wide variety of applications such as water quality monitoring, hydroponics, and scientific research. pH meters provide numerical values of pH directly and are very accurate, providing exact pH values with the help of pH sensors. The DS18B20 temperature sensor is a digital sensor that provides high accuracy and resolution.

Disadvantages:
TDS sensors can affect pH sensors when they are in the same water sample, causing the pH sensor to give incorrect readings. pH meters are expensive and require

calibration. The pH sensor probe is a rod-like structure made of glass, which can be fragile and break easily. The pH sensor and TDS sensor require separate calibration. The TDS sensor module is an analog signal and may require additional circuitry to interface with the STM32 Nucleo 64. The pH/EC/TDS multiparameter probe is expensive and may not be suitable for all applications.

Overall, pH monitoring systems using TDS sensors, DS18B20 temperature sensors, and STM32 Nucleo 64 can provide accurate and reliable measurements of pH, temperature, and TDS in water. However, they require separate calibration, can be expensive, and may require additional circuitry to interface with the STM32 Nucleo 64. Additionally, TDS sensors can affect pH sensors when they are in the same water sample, causing the pH sensor to give incorrect readings.

Chapter 6

Conclusion

By understanding the importance and implications of pH levels in aquarium and can create a harmonious ecosystem that promotes the well- being of the aquatic inhabitants. Continual monitoring, suitable adjustment and diligent care will ensure a thriving and beautiful aquarium.
pH monitoring systems are used to measure the acidity or alkalinity of water or other solutions. The pH value is an important indicator of water quality and can be used to ensure the safety and quality of a product and the processes that occur within a wastewater or manufacturing plant. There are different types of pH sensors built for different applications, and understanding the differences between them is important when choosing the appropriate pH diagnostic tool.

Continuous pH monitoring systems are used to mea-

sure the pH of drinking, surface, and saline waters, domestic and industrial waste waters. The pH of a sample is determined electrometrically using a glass electrode with a reference electrode or a single combination electrode. The continuous pH monitoring system should be initially calibrated against two buffers before being placed into service, and recalibration at two points is recommended every 30 days to ensure the measuring electrode is in working order.

Wireless pH monitoring systems have been introduced into clinical applications, such as the Medtronic Bravo pH monitoring system. This system includes a radiotelemetry pH capsule attached to the mucosal wall of the esophagus, which simultaneously measures pH and transmits data to a wireless data receiver. This system can decrease discomfort and social inconvenience, and patients can better tolerate and keep normal daily activities easily.

In conclusion, pH monitoring systems are essential tools for ensuring water quality and safety. Continuous pH monitoring systems are used to measure the pH of drinking, surface, and saline waters, domestic and industrial waste waters. Wireless pH monitoring systems have been introduced into clinical applications, such as the Medtronic Bravo pH monitoring system. Understanding the differ-

ences between the various types of pH sensors can play an important role in choosing the appropriate pH diagnostic tool.

Bibliography

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[4] https://how2electronics.com/tds-sensor-arduino-interfacing-water-quality-monitoring/

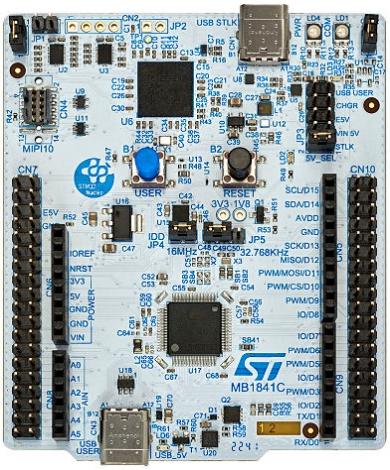
Appendix A

Datasheets

NUCLEO-XXXXCX NUCLEO-XXXXRX NUCLEO-XXXXRX-P NUCLEO-XXXXRX-Q

Data brief

STM32 Nucleo-64 boards



NUCLEO-U545RE-Q example. Boards with different references show different layouts. Picture is not contractual.

Product status link
NUCLEO-XXXXCX
NUCLEO-C031C6
NUCLEO-XXXXRX
NUCLEO-F030R8, NUCLEO-F070RB, NUCLEO-F072RB, NUCLEO-F091RC, NUCLEO-F103RB, NUCLEO-F302R8, NUCLEO-F303RE, NUCLEO-F334R8, NUCLEO-F401RE, NUCLEO-F410RB, NUCLEO-F411RE, NUCLEO-F446RE, NUCLEO-G070RB, NUCLEO-G071RB, NUCLEO-G0B1RE, NUCLEO-G431RB, NUCLEO-G474RE, NUCLEO-G491RE, NUCLEO-H503RB, NUCLEO-L010RB, NUCLEO-L053R8, NUCLEO-L073RZ, NUCLEO-L152RE, NUCLEO-L452RE, NUCLEO-L476RG
NUCLEO-XXXXRX-P
NUCLEO-L412RB-P, NUCLEO-L433RC-P, NUCLEO-L452RE-P
NUCLEO-XXXXRX-Q
NUCLEO-U545RE-Q

Features

Common features

- STM32 microcontroller in an LQFP64 or LQFP48 package
- 1 user LED shared with ARDUINO®
- 1 user and 1 reset push-buttons
- 32.768 kHz crystal oscillator
- Board connectors:
  - ARDUINO® Uno V3 expansion connector
  - ST morpho extension pin headers for full access to all STM32 I/Os
- Flexible power-supply options: ST-LINK USB V_{BUS} or external sources
- On-board ST-LINK debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
- Comprehensive free software libraries and examples available with the STM32Cube MCU Package
- Support of a wide choice of Integrated Development Environments (IDEs) including IAR Embedded Workbench®, MDK-ARM, and STM32CubeIDE

Board-specific features

- External SMPS to generate V_{core} logic supply
- 24 MHz or 48 MHz HSE
- User USB Device full speed, or USB SNK/UFP full speed
- Cryptography
- Board connectors:
  - External SMPS experimentation dedicated connector
  - USB Type-C®, Micro-B, or Mini-B connector for the ST-LINK
  - USB Type-C® user connector
  - MIPI® debug connector

Description

The STM32 Nucleo-64 board provides an affordable and flexible way for users to try out new concepts and build prototypes by choosing from the various combinations of performance and power consumption features, provided by the STM32 microcontroller. For the compatible boards, the external SMPS significantly reduces power consumption in Run mode.

The ARDUINO® Uno V3 connectivity support and the ST morpho headers allow the easy expansion of the functionality of the STM32 Nucleo open development platform with a wide choice of specialized shields.

The STM32 Nucleo-64 board does not require any separate probe as it integrates the ST-LINK debugger/programmer.

The STM32 Nucleo-64 board comes with the STM32 comprehensive free software libraries and examples available with the STM32Cube MCU Package.

1 Ordering information

To order an STM32 Nucleo-64 board, refer to Table 1. For a detailed description of each board, refer to its user manual on the product web page. Additional information is available from the datasheet and reference manual of the target STM32.

Table 1. List of available products

Order code	Board reference	User manual	Target STM32	Differentiating features
NUCLEO-C031C6	MB1717	UM2953	STM32C031C6T6	• ST-LINK/V2-1 on USB Micro-B connector • 48 MHz HSE • LQFP48
NUCLEO-F030R8	MB1136	UM1724	STM32F030R8T6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F070RB			STM32F070RBT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F072RB			STM32F072RBT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F091RC			STM32F091RCT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F103RB			STM32F103RBT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F302R8			STM32F302R8T6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F303RE			STM32F303RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F334R8			STM32F334R8T6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F401RE			STM32F401RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F410RB			STM32F410RBT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F411RE			STM32F411RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-F446RE			STM32F446RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-G070RB	MB1360	UM2324	STM32G070RBT6	• ST-LINK/V2-1 on USB Micro-B connector • LQFP64

Order code	Board reference	User manual	Target STM32	Differentiating features
NUCLEO-G071RB	MB1360	UM2324	STM32G071RBT6	• ST-LINK/V2-1 on USB Micro-B connector • LQFP64
NUCLEO-G0B1RE			STM32G0B1RET6	• ST-LINK/V2-1 on USB Micro-B connector • LQFP64
NUCLEO-G431RB	MB1367	UM2505	STM32G431RBT6	• STLINK-V3E on USB Micro-B connector • 24 MHz HSE • MIPI® debug connector • LQFP64
NUCLEO-G474RE			STM32G474RET6	• STLINK-V3E on USB Micro-B connector • 24 MHz HSE • MIPI® debug connector • LQFP64
NUCLEO-G491RE			STM32G491RET6	• STLINK-V3E on USB Micro-B connector • 24 MHz HSE • MIPI® debug connector • LQFP64
NUCLEO-H503RB	MB1814	UM3121	STM32H503RBT6	• USB FS (device only) on USB Type-C® connector • STLINK-V3EC on USB Type-C® connector • LQFP64
NUCLEO-L010RB	MB1136	UM1724	STM32L010RBT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-L053R8			STM32L053R8T6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-L073RZ			STM32L073RZT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-L152RE			STM32L152RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-L412RB-P	MB1319	UM2206	STM32L412RBT6P	• ST-LINK/V2-1 on USB Micro-B connector • External SMPS • LQFP64
NUCLEO-L433RC-P			STM32L433RCT6P	• ST-LINK/V2-1 on USB Micro-B connector • External SMPS • LQFP64
NUCLEO-L452RE	MB1136	UM1724	STM32L452RET6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-L452RE-P	MB1319	UM2206	STM32L452RET6P	• ST-LINK/V2-1 on USB Micro-B connector • External SMPS • LQFP64

Order code	Board reference	User manual	Target STM32	Differentiating features
NUCLEO-L476RG	MB1136	UM1724	STM32L476RGT6	• ST-LINK/V2-1 on USB Mini-B connector • LQFP64
NUCLEO-U545RE-Q	MB1841	UM3062	STM32U545RET6Q	• USB SNK/UFP (FS mode) on USB Type-C® connector • STLINK-V3EC on USB Type-C® connector • Internal SMPS • LQFP64 • Cryptography

1.1 Product marking

The stickers located on the top or bottom side of all PCBs provide product information:

- First sticker: product order code and product identification, generally placed on the main board featuring the target device.
  Example:

  Product order code
  Product identification

- Second sticker: board reference with revision and serial number, available on each PCB.
  Example:

  MBxxxx-Variant-yzz
  syywwxxxxx

On the first sticker, the first line provides the product order code, and the second line the product identification.

On the second sticker, the first line has the following format: *"MBxxxx-Variant-yzz"*, where *"MBxxxx"* is the board reference, *"Variant"* (optional) identifies the mounting variant when several exist, *"y"* is the PCB revision, and *"zz"* is the assembly revision, for example B01. The second line shows the board serial number used for traceability.

Parts marked as *"ES"* or *"E"* are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

"ES" or *"E"* marking examples of location:

- On the targeted STM32 that is soldered on the board (for an illustration of STM32 marking, refer to the STM32 datasheet *Package information* paragraph at the *www.st.com* website).
- Next to the evaluation tool ordering part number that is stuck, or silk-screen printed on the board.

Some boards feature a specific STM32 device version, which allows the operation of any bundled commercial stack/library available. This STM32 device shows a *"U"* marking option at the end of the standard part number and is not available for sales.

To use the same commercial stack in their applications, the developers might need to purchase a part number specific to this stack/library. The price of those part numbers includes the stack/library royalties.

1.2 Codification

The meaning of the codification is explained in Table 2.

Table 2. Codification explanation

NUCLEO-XXYYZT NUCLEO-XXYYZT-P NUCLEO-XXYYZT-Q	Description	Example: NUCLEO-L452RE
XX	MCU series in STM32 32-bit Arm Cortex MCUs	STM32L4 Series
YY	MCU product line in the series	STM32L452
Z	STM32 package pin count • C for 48 pins • R for 64 pins	64 pins
T	STM32 flash memory size: • 6 for 32 Kbytes • 8 for 64 Kbytes • B for 128 Kbytes • C for 256 Kbytes • E for 512 Kbytes • G for 1 Mbyte • Z for 192 Kbytes	512 Kbytes
-P	STM32 has external SMPS function	No SMPS
-Q	STM32 has internal SMPS function	

2 Development environment

STM32 32-bit microcontrollers are based on the Arm® Cortex®-M processor.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

2.1 System requirements

- Multi-OS support: Windows® 10, Linux® 64-bit, or macOS®
- USB Type-A or USB Type-C® to Micro-B cable, or USB Type-A or USB Type-C® to Mini-B cable, or USB Type-A or USB Type-C® to USB Type-C® cable (depending on the board reference)

Note: macOS® is a trademark of Apple Inc., registered in the U.S. and other countries and regions.

Linux® is a registered trademark of Linus Torvalds.

Windows is a trademark of the Microsoft group of companies.

2.2 Development toolchains

- IAR Systems® - IAR Embedded Workbench®(1)
- Keil® - MDK-ARM(1)
- STMicroelectronics - STM32CubeIDE

1. *On Windows® only.*

2.3 Demonstration software

The demonstration software, included in the STM32Cube MCU Package corresponding to the on-board microcontroller, is preloaded in the STM32 flash memory for easy demonstration of the device peripherals in standalone mode. The latest versions of the demonstration source code and associated documentation can be downloaded from *www.st.com*.

Revision history

Table 3. Document revision history

Date	Revision	Changes
10-Feb-2014	1	Initial release.
13-Feb-2014	2	Added *Table 1: Device summary* and updated *Table 2: Ordering information*.
11-Apr-2014	3	Extended the applicability to NUCLEO-F302R8. Updated *Table 1: Device summary* and *Table 2: Ordering information*.
26-May-2014	4	Extended the applicability to NUCLEO-L053R8, NUCLEO-F072RB, NUCLEO-F334R8 and NUCLEO-F411RE. Updated *Table 1* and *Table 2*.
9-Sep-2014	5	Extended the applicability to NUCLEO-F091RC and NUCLEO-F303RE. Updated *Features*. Updated *Table 1: Device summary* and *Table 2: Ordering information*.
16-Dec-2014	6	Extended the applicability to NUCLEO-F070RB, NUCLEO-L073RZ and NUCLEO-L476RG. Updated *Table 1: Device summary* and *Table 2: Ordering information*.
8-Jul-2015	7	Extended the applicability to NUCLEO-F410RB, NUCLEO-F446RE. Updated *Table 1: Device summary* and *Table 2: Ordering information*.
29-Nov-2016	8	Extended the applicability to NUCLEO-L452RE. Updated *Table 1: Device summary* and *Table 2: Ordering information*. Added *Table 3: Codification explanation*.
16-Nov-2017	9	Extended document scope to the NUCLEO-L452RE-P and NUCLEO-L433RC-P boards: • Updated *Features* • Updated *Table 1: Device summary*, *Table 2: Ordering information* and *Table 3: Codification explanation* • Updated *System requirement*, *Development toolchains* and *Demonstration software*
15-Dec-2017	10	Updated *Features*, *Description* and *System requirement*. Extended document scope to the NUCLEO-L010RB board: updated *Table 1: Device summary* and *Table 2: Ordering information*.
24-Aug-2018	11	Extended document scope to the NUCLEO-L412RB-P board: updated *Table 1: Device summary* and *Table 2: Ordering information*.
22-Oct-2018	12	Extended document scope to the NUCLEO-G070RB and NUCLEO-G071RB boards: • Updated *Table 1: Device summary* and *Table 2: Ordering information* • Added NUCLEO-GXXXRX top view on the cover page
8-Apr-2019	13	Revised the entire document to accommodate to multiple feature combinations: • Reorganized *Features* • Updated *Description* • Added *Ordering information* and *Development environment* • Updated *Table 1. List of available products* and *Table 2. Codification explanation* Extended document scope to the NUCLEO-G431RB and NUCLEO-G474RE boards.
25-Oct-2020	14	Extended document scope to the NUCLEO-G0B1RE and NUCLEO-G491RE: updated *List of available products*.

Date	Revision	Changes
17-Dec-2021	15	Extended document scope to the NUCLEO-C031C6. Updated ST-LINK USB connectors in *List of available products*. Removed the references to Arm® Mbed™.
6-Feb-2023	16	Extended document scope to the NUCLEO-H503RB. Added board-specific user USB in *Features*. Updated ST-LINK USB connector range in *Features* and *System requirements*. Updated *Product marking*.
20-Feb-2023	17	Extended document scope to the NUCLEO-U545RE-Q.