RL78/G23

GNSS data logger Sample Sketch (Arduino™ sketch)

Introduction

This application note explains how to use the RL78/G23-64p Fast Prototyping Board (FPB) library for Arduino to obtain location information from a Global Navigation Satellite System (GNSS) module and record it on a SD card, as well as how to display recorded location information on a map with an open-source Geographic Information System (GIS).

Target Device

Evaluation Board	: RL78/G23-64p Fast Prototyping Board
GNSS Module	: Grove-GPS module (Air530) / 109020022
micro-SD Card Module	: KKHMF micro-SD TF Card memory shield module
micro-SD Card	: KIOXIA KMUB-A016G
Mobile Battery	: CHE-061-WH-IOT2

Trademark

Arduino is a trademark of Arduino SA.

QGIS is a trademark of QGIS.ORG.

Contents

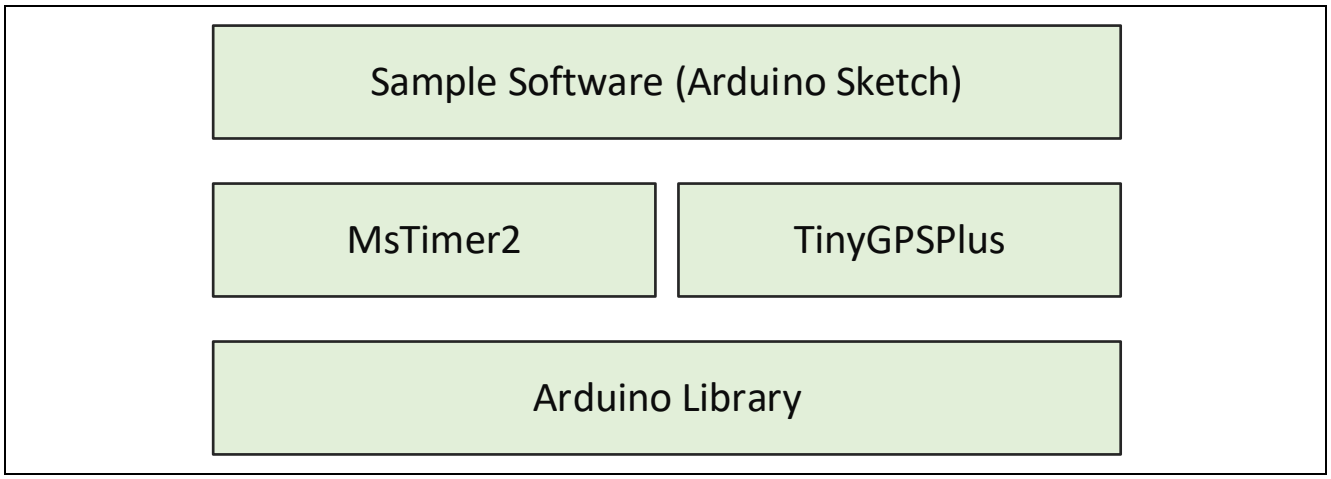
1. System overview

This system is composed of the RL78/G23-64p Fast Prototyping Board (FPB), GNSS module and micro-SD card module. Arduino™ IDE is used for creating a program and writing a program to RL78/G23.

After powering up the FPB, the system starts obtaining location and time information from the GNSS module, processing data into form that can be displayed by a geographic information system and writing it to the micro-SD card. After starting operation, LED1 blinks while the FPB is receiving data from the GNSS module, and when the user switch is pressed, LED2 turns on after obtaining location and time information and writing it to the micro-SD card.

The block configuration of the sample code used in this system is shown below.

Figure 1-1 Block configuration of software



1.1 Modules used

Figure 1-2 shows the system configuration diagram at the time of development of this system, and Figure 1-3 shows the system configuration diagram when recording data logs and displaying location information.

Figure 1-2 System configuration when developing

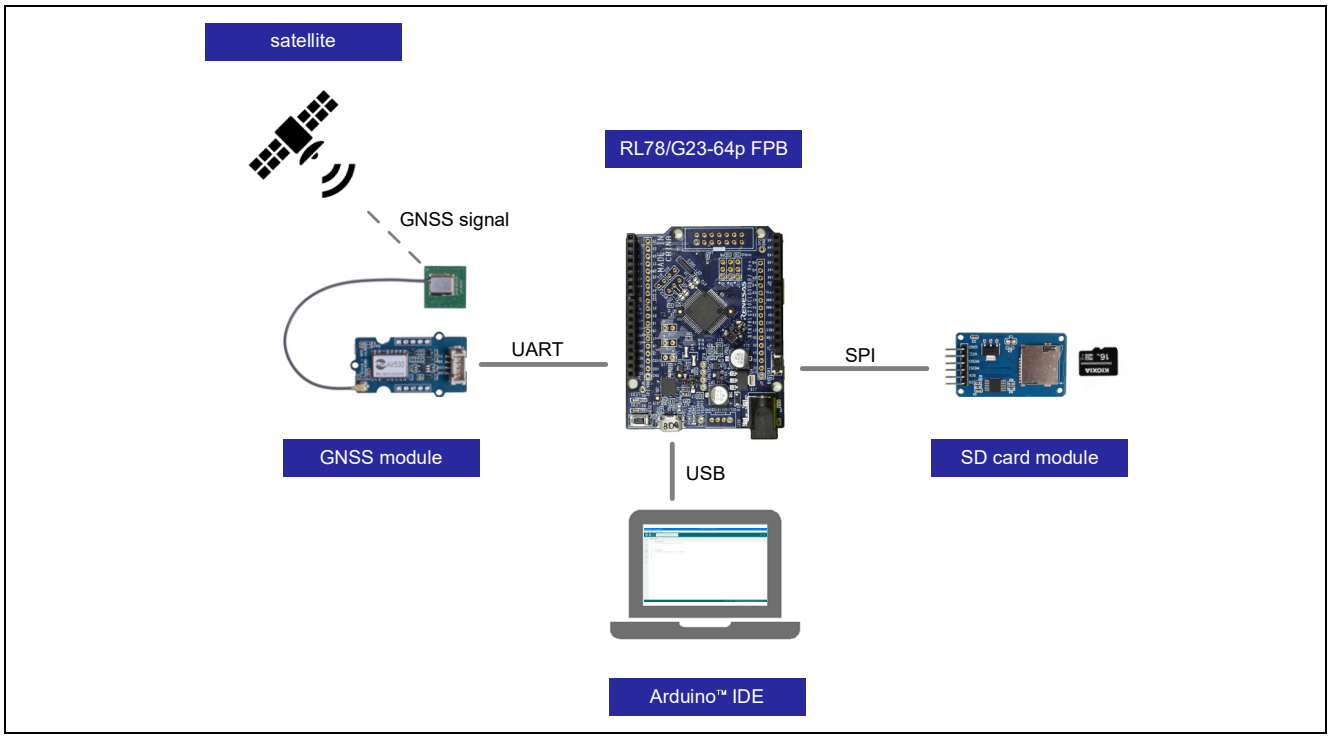
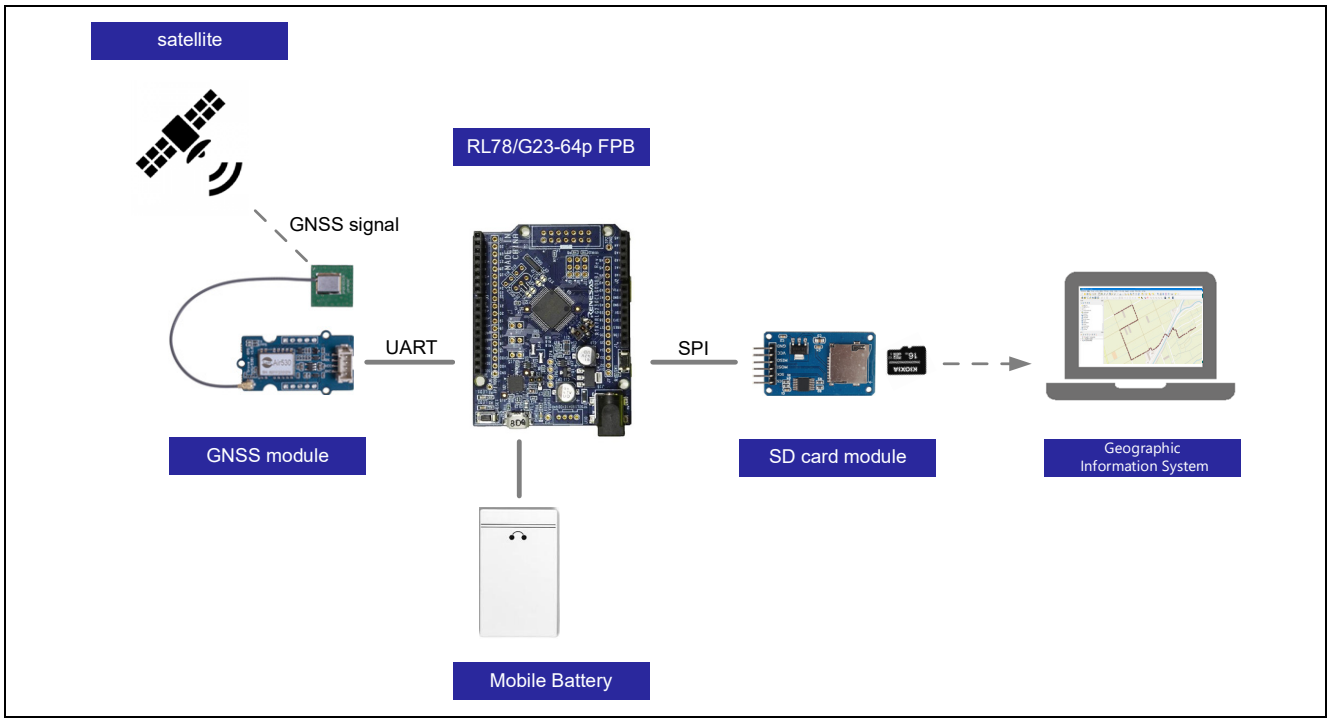


Figure 1-3 System configuration when recording data logs and displaying location information

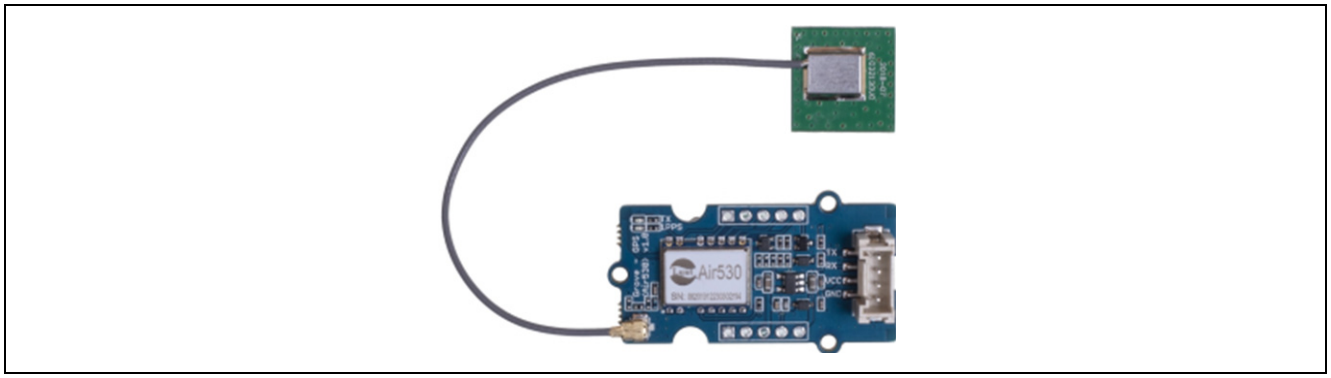


1.1.1 GNSS module

This GNSS module is equipped with the Air530 GPS module that supports many satellite positioning systems such as US GPS, China's Beidou, and Europe's Galileo, and is compatible with the Grove connector. The communication interface is UART, and location information can be obtained as text data in the NMEA format (described later).

The following is the GNSS module used in this system.

Figure 1-4 GNSS module

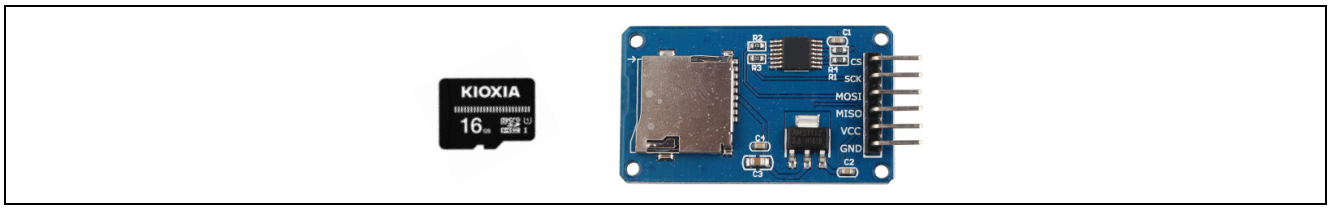


1.1.2 micro-SD card module

This is a module for micro-SD cards that can be read and written using SPI communication. This system uses it to write data received from GNSS to the micro-SD card. It is also equipped with a 3.3V conversion circuit so that it can be used at 5V as well.

The following is the micro-SD card module used in this system.

Figure 1-5 micro-SD card module



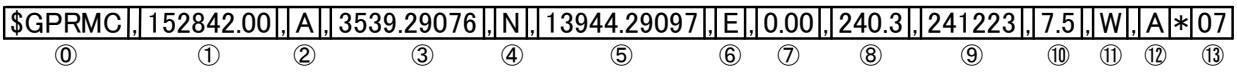
1.1.3 NMEA format

NMEA is an abbreviation for National Marine Electronics Association.
The NMEA format is one of the data formats for positioning results output from GNSS receivers and is also used for information transmission in ocean-related measurement systems.

The NMEA format used in GNSS consists of a collection of sentences containing various information such as location information and time information. An RMC message (Recommended Minimum Data) is shown below as an example of text data in NMEA format.

Figure 1-6 Example of NMEA format

【e.g.】 $GPRMC,152842.00,A,3539.29076,N,13944.29097,E,0.00,240.3,241223,7.5,W,A*07



No.	example	Description	Result
0	GPRMC	Data type First 2 characters: GNSS System type(Talker ID). refer to Figure 1-7. Last 3 characters: Sentence type	GPSRMC
1	152842.00	UTC time	15:28:42:00
2	A	Positioning status A: Valid, V: Invalid	Valid
3	3539.29076	Latitude	35°39.29076'
4	N	North (N) / South (S)	North
5	13944.29097	Longitude	139°44.29097'
6	E	East longitude (E) / West longitude (W)	East longitude
7	0.00	Speed over ground (knots)	0.00 knots
8	240.3	Course over ground (degrees)	240.3 degrees
9	241223	Date (UTC)	Dec 24, 2023
10	7.5	Magnetic variation (degrees)	7.5 degrees
11	W	Magnetic variation (E/W)	East
12	A	Positioning mode status N: No fix E: Estimated/Dead Reckoning F: RTK Float (version 4.10 or later) R: RTK Fixed (version 4.10 or later) A/D: GNSS Fix	
13	07	Checksum	0x07

Figure 1-7 Talker ID

Talker ID	GNSS system	Note
GP	GPS	ver2.3 or later
GL	GLONASS	ver2.3 or later
GA	Galileo	ver4.10 or later
GB	BeiDou	ver4.11 or later
GQ	QZSS	ver4.11 or later (GP is used in ver4.10 or less)
GN	combination of above	

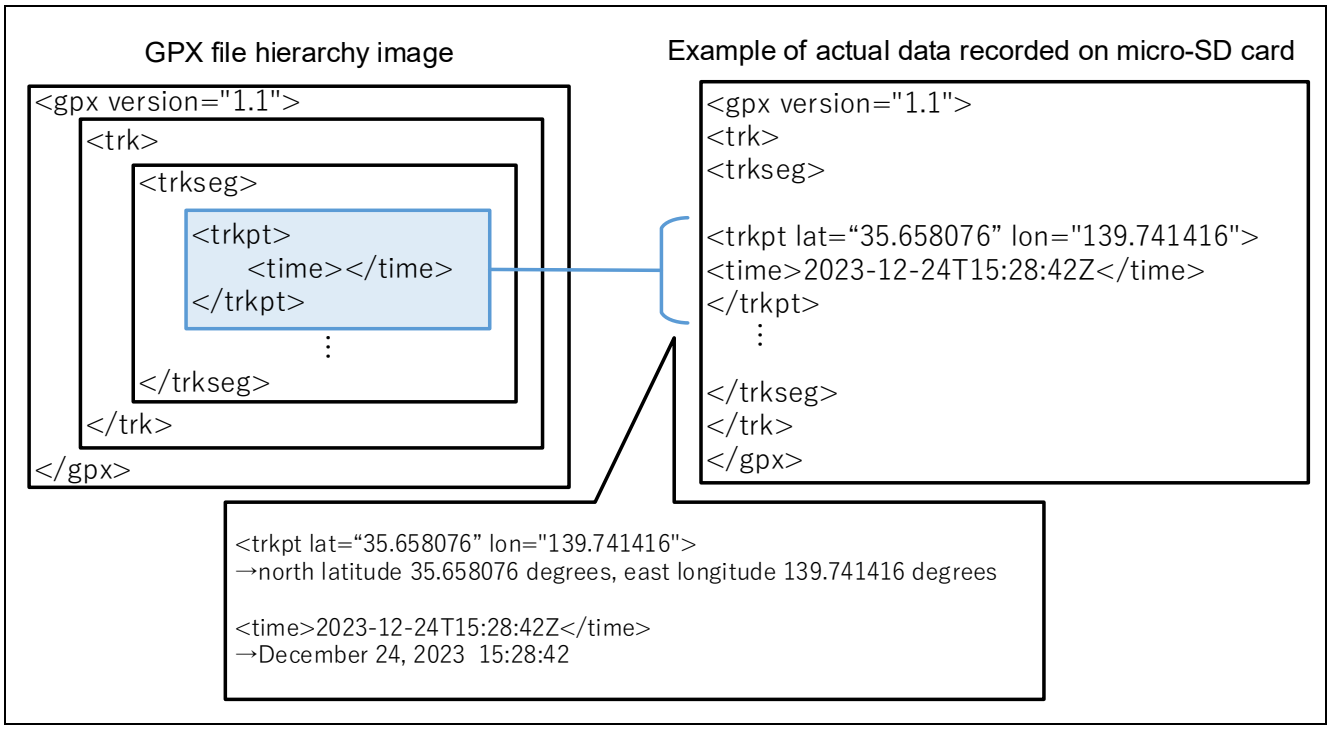
1.1.4 GPX file

GPX (GPs eXchange Format) is an XML (Extensible Markup Language)-based file format for storing GPS/GNSS data. GPX files can contain track, waypoint, and route information.

In this sample sketch, latitude, longitude, and timestamp information are extracted from NEMA format, converted to track information in GPX format, and recorded on a micro-SD card.

Below is an image of the hierarchical structure of a GPX file and an example of the actual data. This sample sketch extracts latitude, longitude, and timestamp information from NEMA format, converts it to GPX format trajectory information (<trk> element), and records it on a micro-SD card. Due to the specifications of the GNSS module, location information is obtained every second, and latitude and longitude information (<trkpt> element) and timestamp information (<time> element) are recorded on the micro-SD card.

Figure 1-8 GPX file hierarchy image and example of actual data



1.2 Operation explanation

Figure 1-9 shows an overview of the operation.

(1) After powering on, initialize LED1 and LED2. In the initial state, LED1 and LED2 are off. Check if the micro-SD card is inserted.

(2) If a micro-SD card is not inserted, LED2 blinks. Rebooting the system or pressing the reset button returns the system to (1).

(3) If a micro-SD card is inserted, LED1 turns on and check the capacity of the micro-SD card.

(4) If the capacity of the micro-SD card is less than 10MB, LED1 turns off and LED2 blinks. Rebooting the system or pressing the reset button returns the system to (1).

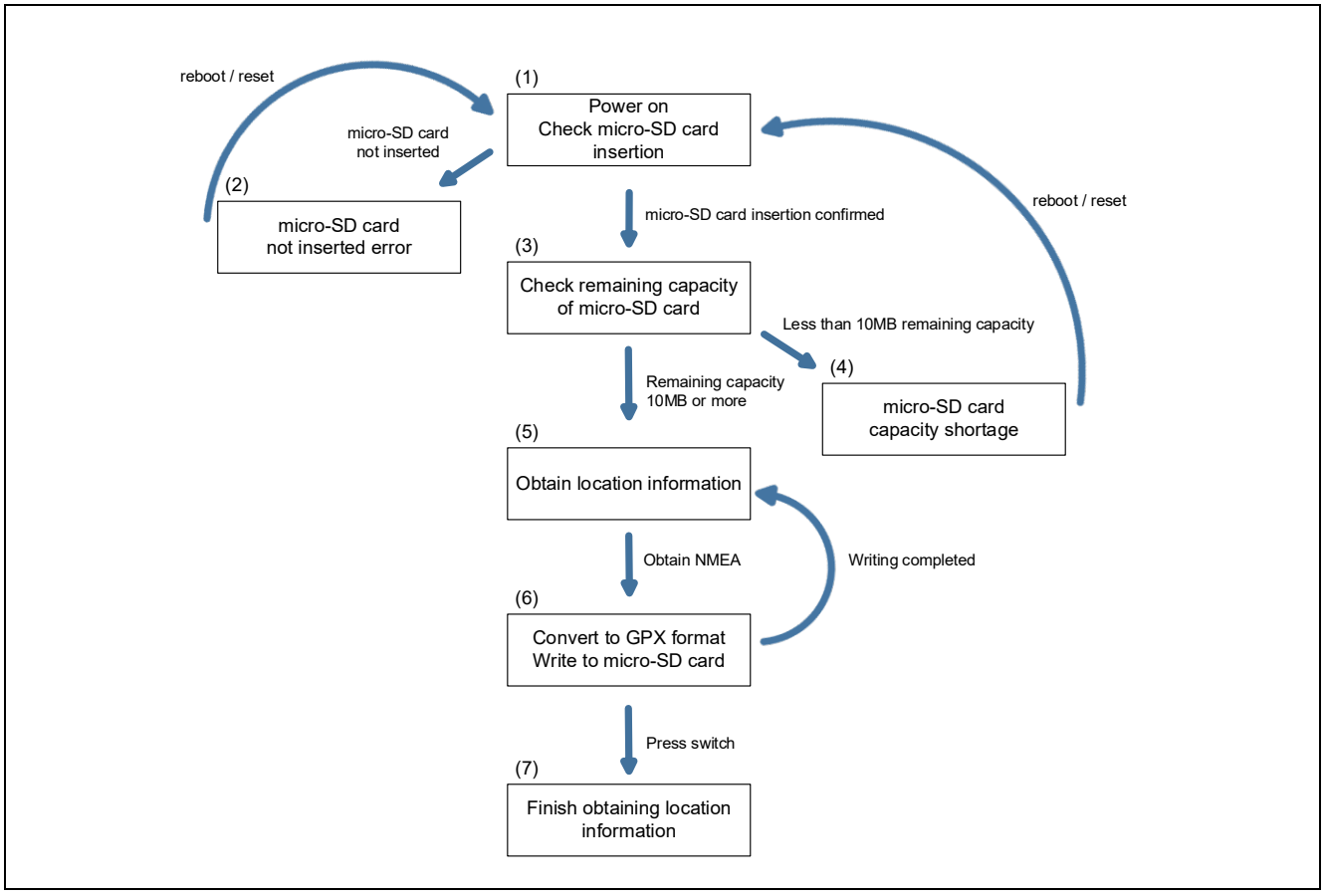
(5) If the capacity of the micro-SD card is 10MB or more, LED1 turns off and location and time information is obtained. (Depending on the environment, it will take about 30 seconds to several minutes.) After the information is obtained, writing to the micro-SD card starts and LED1 turns on.

(6) Once the location and time information has been written to the micro-SD card, the system returns to (5) and LED1 turns off.
By repeating steps (5) and (6), LED1 repeatedly turns on and off. As the amount of received data increases, the speed at which LED1 turns on and off increases, so to the naked eye it appears as if LED1 is on.

(7) When pressing the user switch, the information written to the micro-SD card is saved and recording ends. Then LED1 turns off and LED2 turns on.

Remark. For information on what to do when rebooting/resetting, please refer to “6.4 LED2 is blinking (micro-SD card error)”.

Figure 1-9 System operation overview



2. Operation confirmation environment

The operation of the sample code provided by this application note has been tested under the following conditions.

Table 2-1 Operation confirmation environments (Hardware)

Item	Description
Evaluation board	RL78/G23-64p Fast Prototyping Board – RTK7RLG230CLG000BJ
GNSS module	Grove-GPS module (Air530) / 109020022
micro-SD card module	KKHMF micro-SD TF card memory shield module
micro-SD card	KIOXIA KMUB-A016G
Operating voltage	5V
Mobile battery	CHE-061-WH-IOT2 Note 1

Note 1. Mobile batteries with an auto power off function will stop supplying power after a certain period of use in systems with low power consumption. Therefore, please use a mobile battery that does not have the auto power off function.

Table 2-2 Operation confirmation environments (Software)

Item	Description	Module
OS	Windows 10 Pro	-
Integrated development environment (IDE)	Arduino™ IDE	2.3.2
Arduino Library	SdFat	2.2.3
Library	RL78/G23-64p FPB library	2.3.2

3. Development environment setup

How to connect boards and how to set up the Arduino™ IDE are explained.

The Arduino™ IDE 2.3.2 is used in this system. If it is not installed, please install the Arduino™ IDE 2.3.2 or later.

https://www.arduino.cc/en/software

3.1 Board connection

Connect the evaluation board, micro-SD card module, and GNSS module with jumper wires as shown in Figure **3-1**.

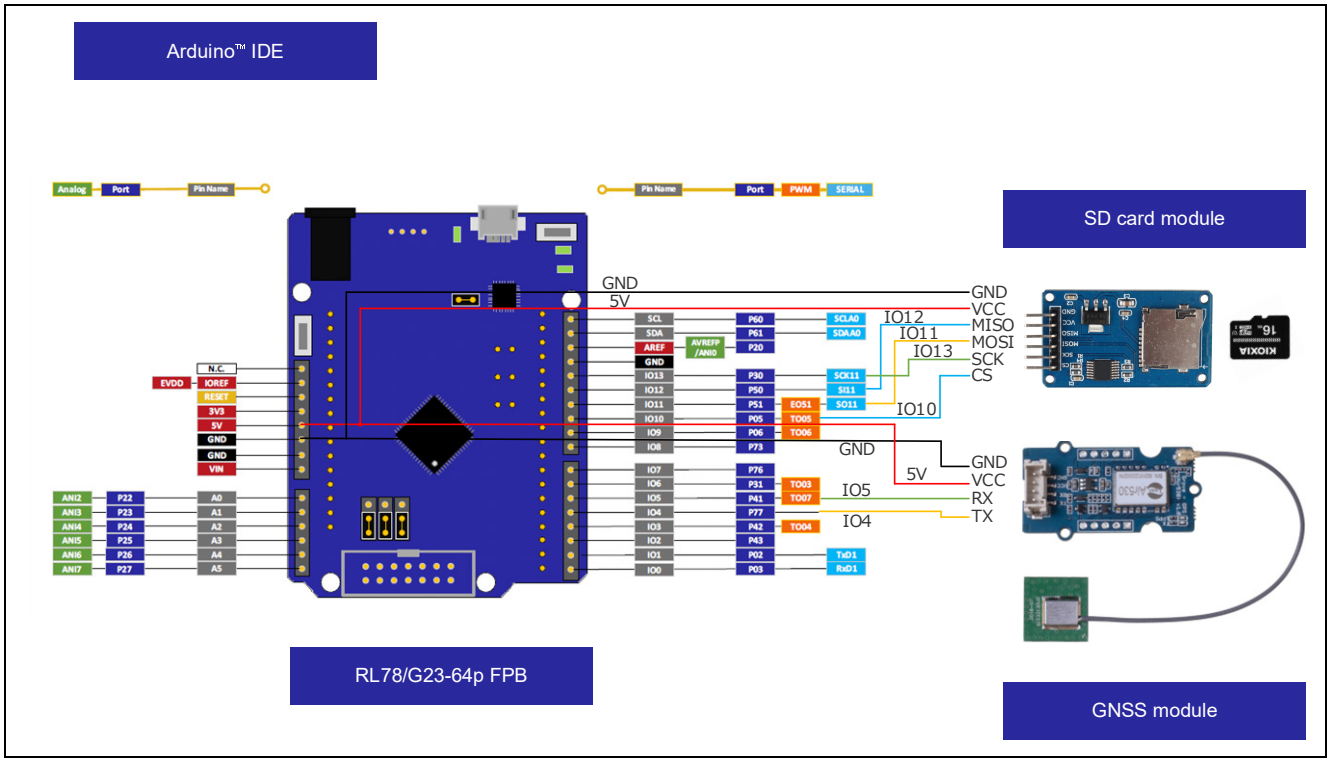
USB is used for power supply to the RL78/G23-64p FPB in this system. For the power supply, check the circuit of the RL78/G23-64p FPB by referring to the manual, and set jumpers if required.

In this system, jumpers of the RL78/G23-64p FPB are set as shown in Table **3-1**.

Table 3-1 Jumper pins setting of RL78/G23-64p FPB

Jumper pin	Setting	Function
J8	1-2 short-circuit	COM port debugging
J9		
J11		
J13	Open circuit	
J17	1-2 short-circuit	5V power supply to MCU

Figure 3-1 Connection of evaluation board, GNSS module, micro-SD card module



3.2 List of pins used

The pins used in this system are shown below.

Table 3-2 Pins used

Item	Arduino™ signal name	Pin number of MCU	Pin
UARTA	IO4	4	P77
	IO5	5	P41
SPI	IO10	10	P05
	IO11	11	P51
	IO12	12	P50
	IO13	13	P30
SW1	IO26	9	P137/INTP0
V_{DD}	5V	-	-
GND	GND	-	-

For detailed pin descriptions of the evaluation board, refer to the following manual.

- RL78/G23-64p Fast Prototyping Board User's Manual (R20UT4814)

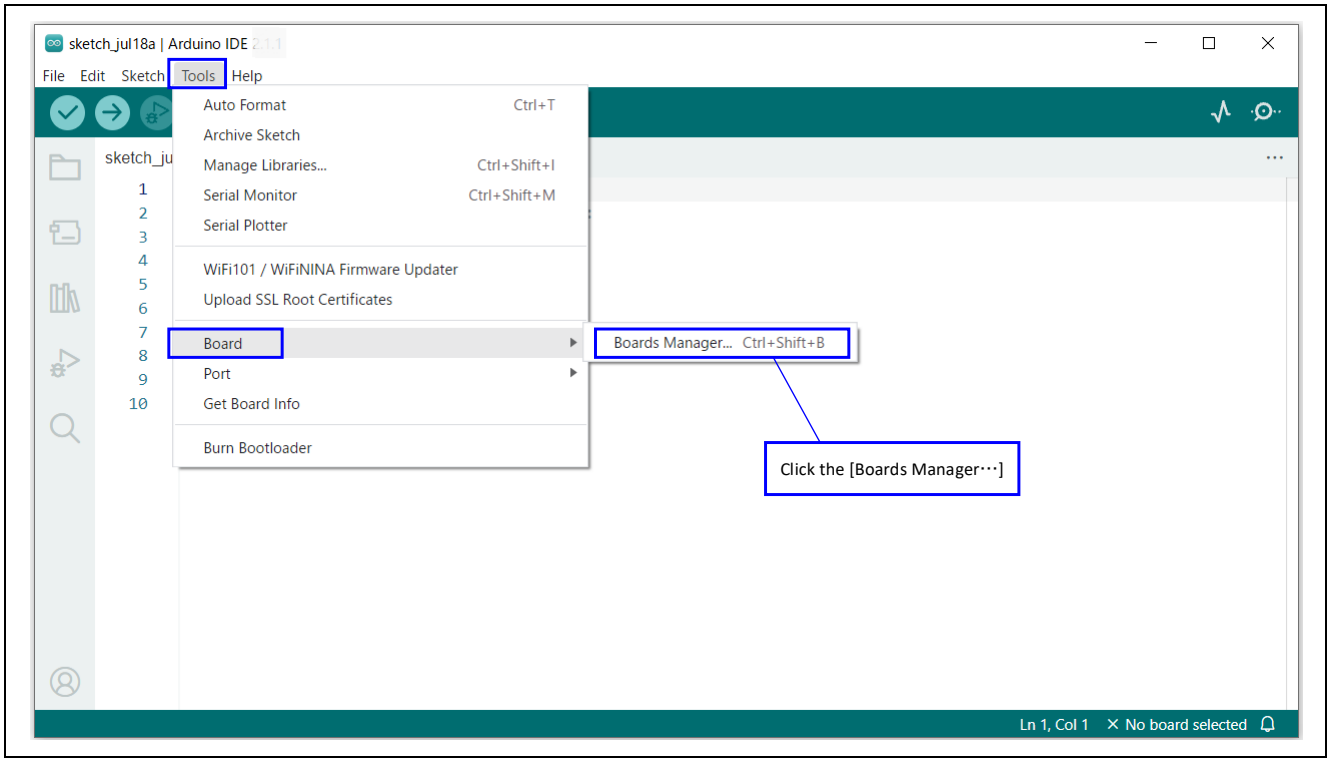
3.3 Setup of Arduino™ IDE

The setup procedure of Arduino™ IDE is explained.

Remark. The setup procedure is almost the same as the procedure explained on the Quick Start Guide : renesas/Arduino Wiki · GitHub. The sample sketch to flash LED is described on the above site. Refer to it if required.

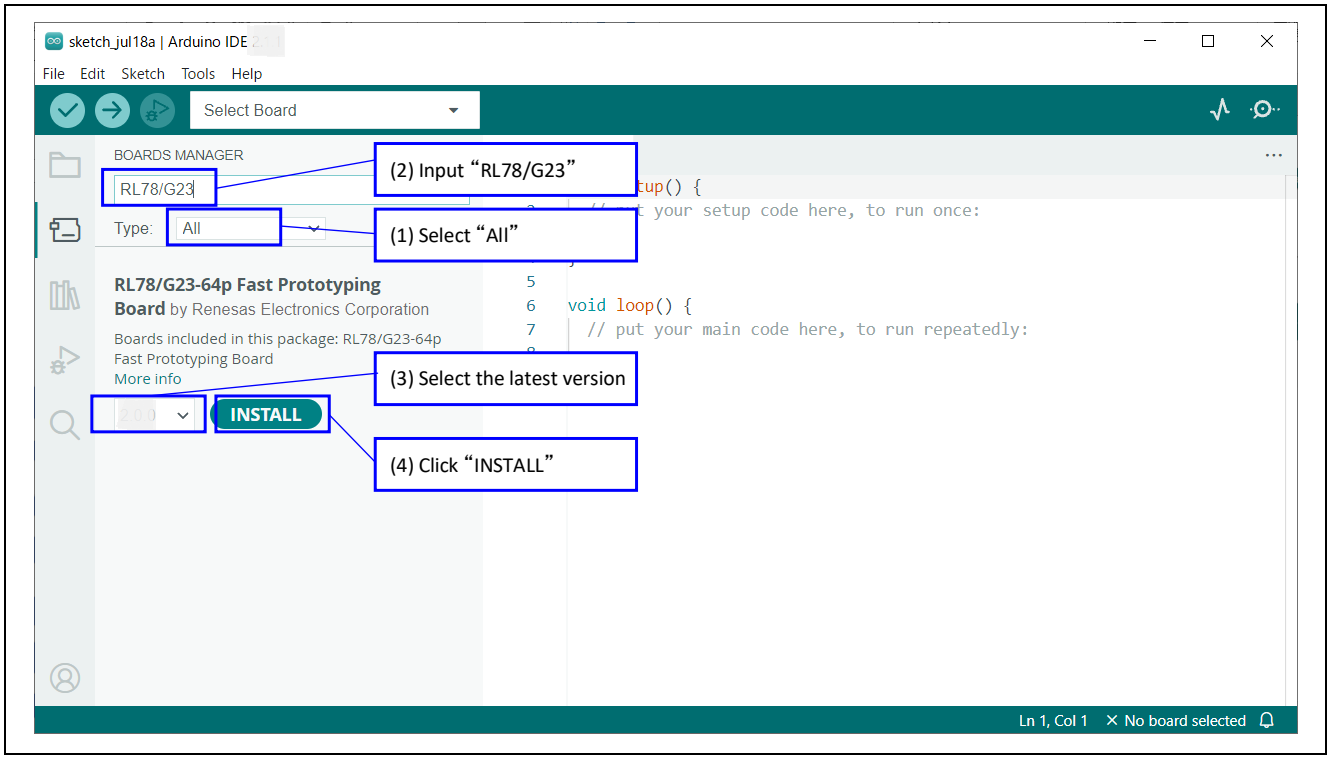
1. Start the Arduino™ IDE.
2. Click the [Tools] - [Board] - [Boards Manager…] menu.

Figure 3-2 Selection of [Boards Manager…]



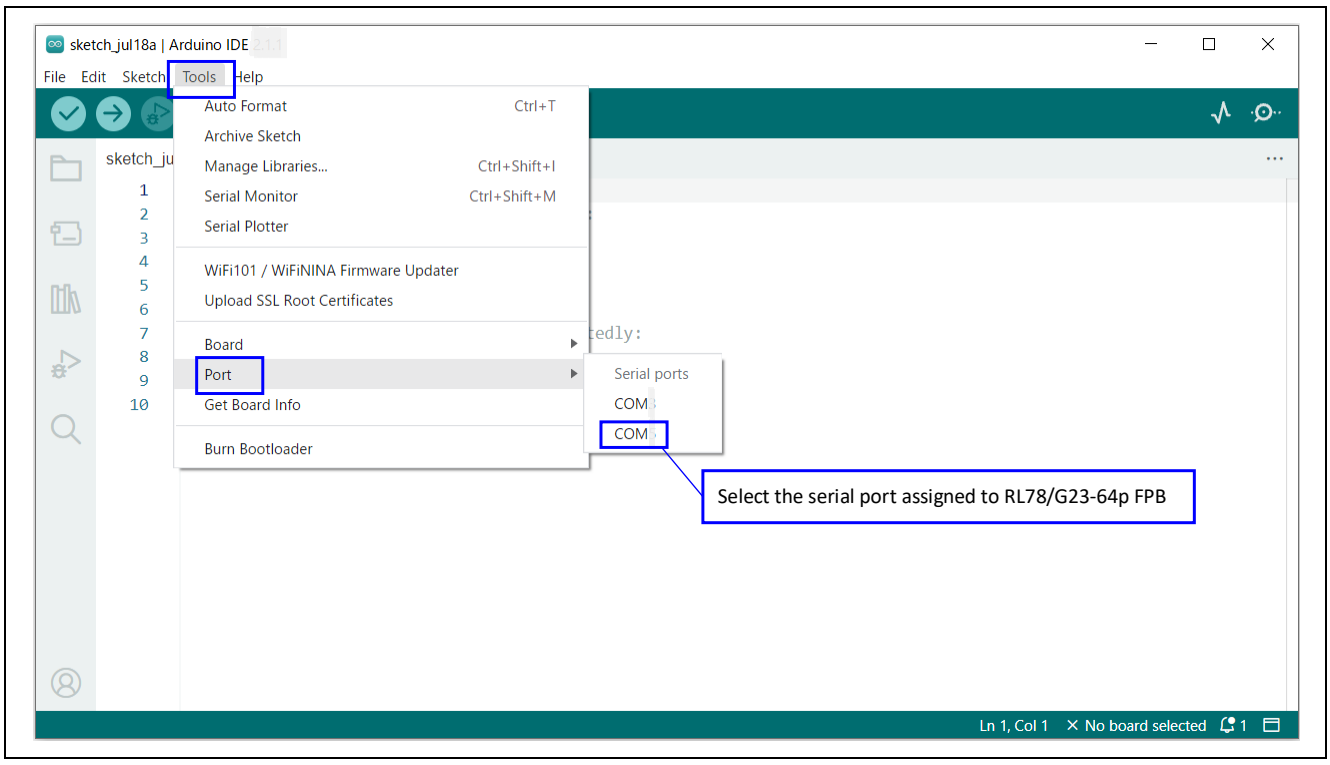
3. Select “All” at the [Type] and input “RL78/G23” in the textbox. Then, “RL78/G23-64p Fast Prototyping Board” is displayed. Next, click the [INSTALL].

Figure 3-3 Installation of Board Manager



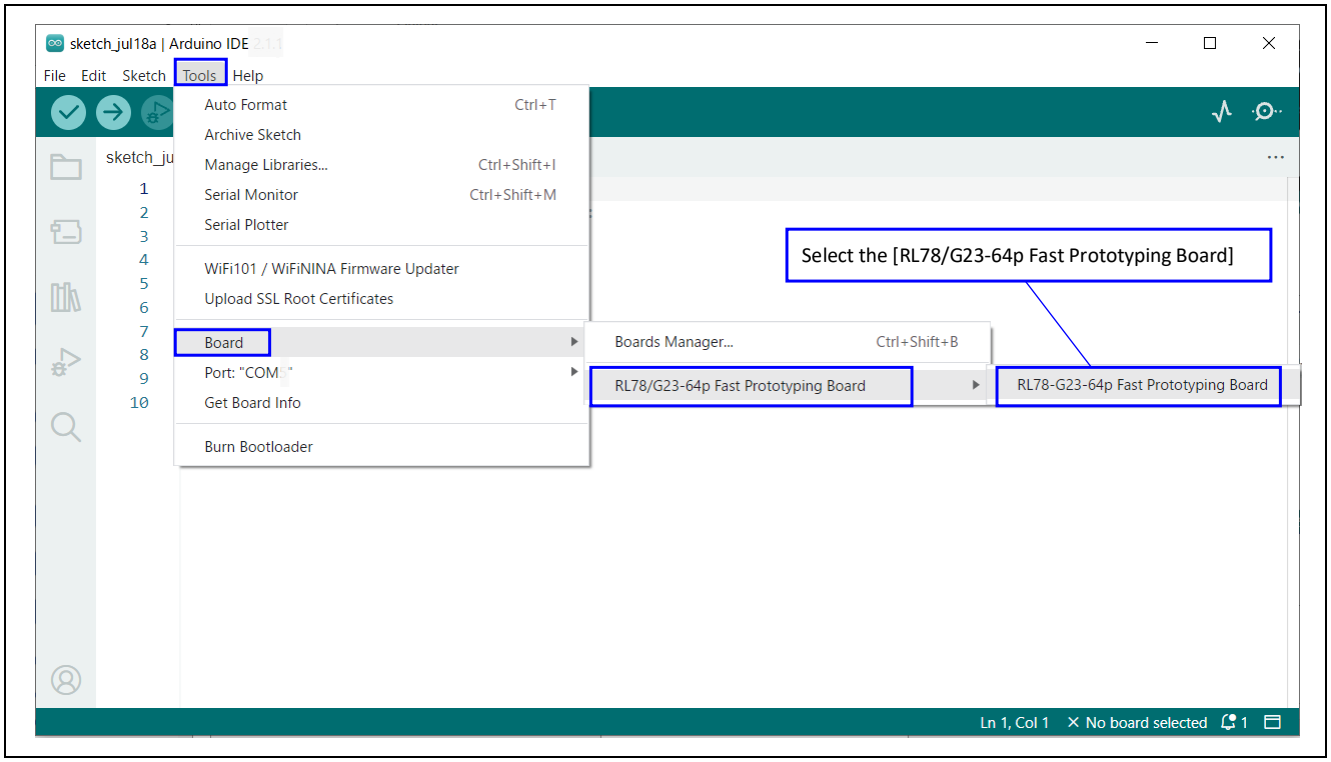
4. Select the serial port assigned to the RL78/G23-64p FPB from the [Tools] - [Port] menu. COM port number can be checked at the Device Manager of Windows.

Figure 3-4 Selection of serial port



5. Select the [Tools] - [Board] - [RL78/G23-64p Fast Prototyping Board] - [RL78/G23-64p Fast Prototyping Board] menu.

Figure 3-5 Selection of board



4. Software

4.1 Overview of sample code

This sample code is a sample sketch that executes on the Arduino™ IDE and consists of the libraries shown in Table 4-1.

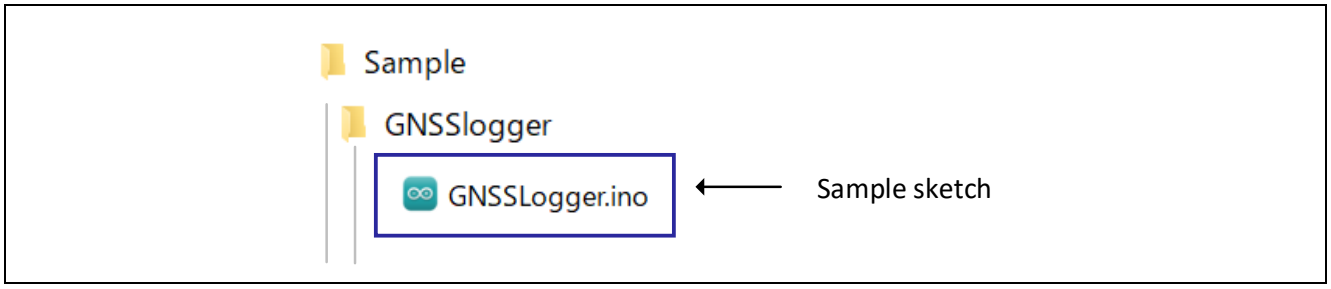
Table 4-1 Sample code overview of the library used

Library used	description
Sdfat	Process of checking the capacity of the micro-SD card and writing data
MSTimer2	LED blinking frequency
SoftwareSerial	UART communication with GNSS module
TinyGPSPlus	Extract necessary information from obtained location information

The file structure is shown below.

Please refer to "4.3 API functions" for the API functions used, and "4.4 Procedure for checking operation of sample sketch" for details on the sample sketch.

Figure 4-1 File structure of sample code



4.2 Sketch example used in sample code

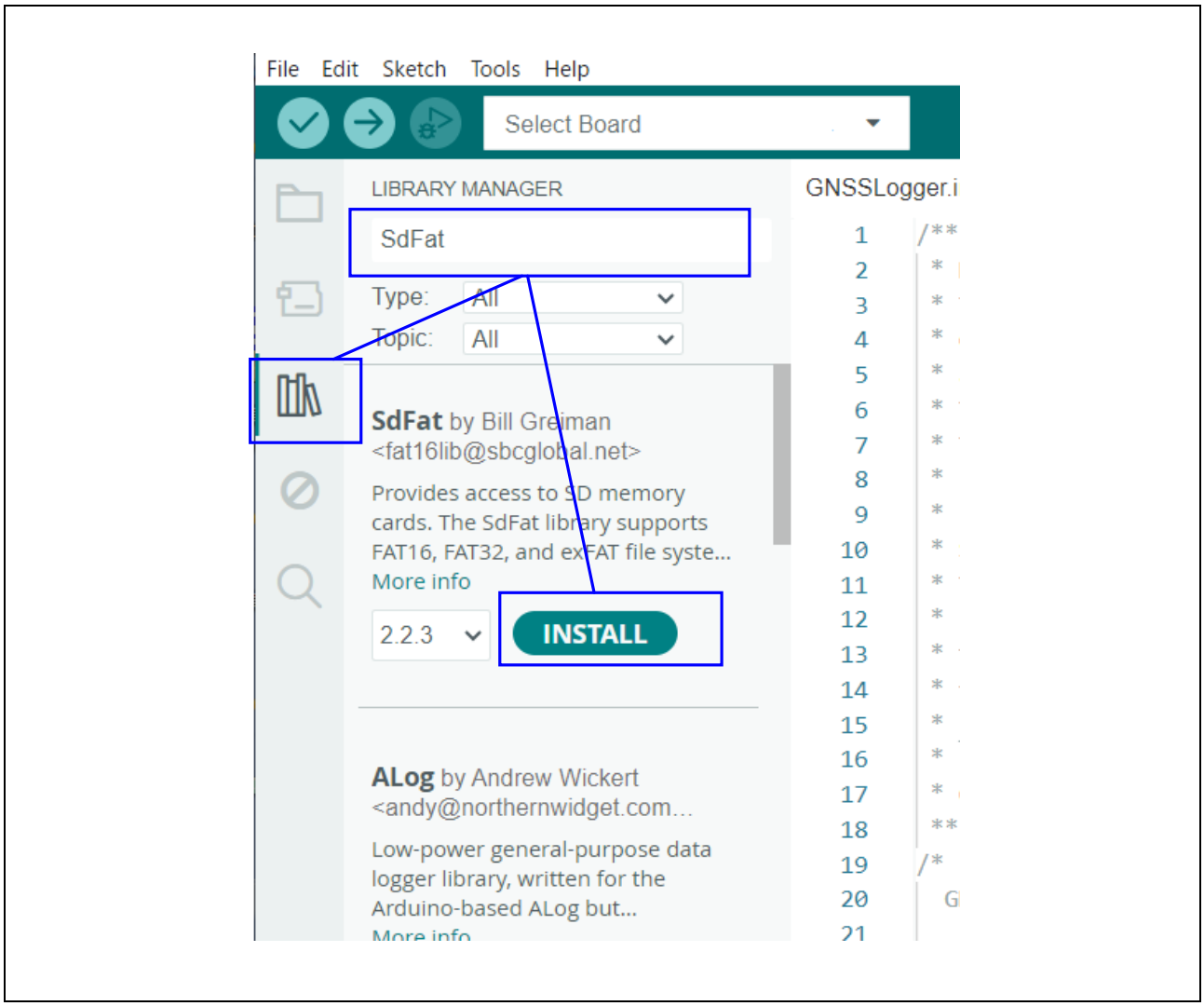
This sample code uses sketch examples provided by Arduino™ IDE. The following shows how to refer to sketch examples.

4.2.1 SdFat / BackwardCompatibility, SdFat / SdInfo

These are sketch examples of SdFat. In this sample code, this examples are used for checking the capacity of a micro-SD card and writing data. Please refer it in the following steps.

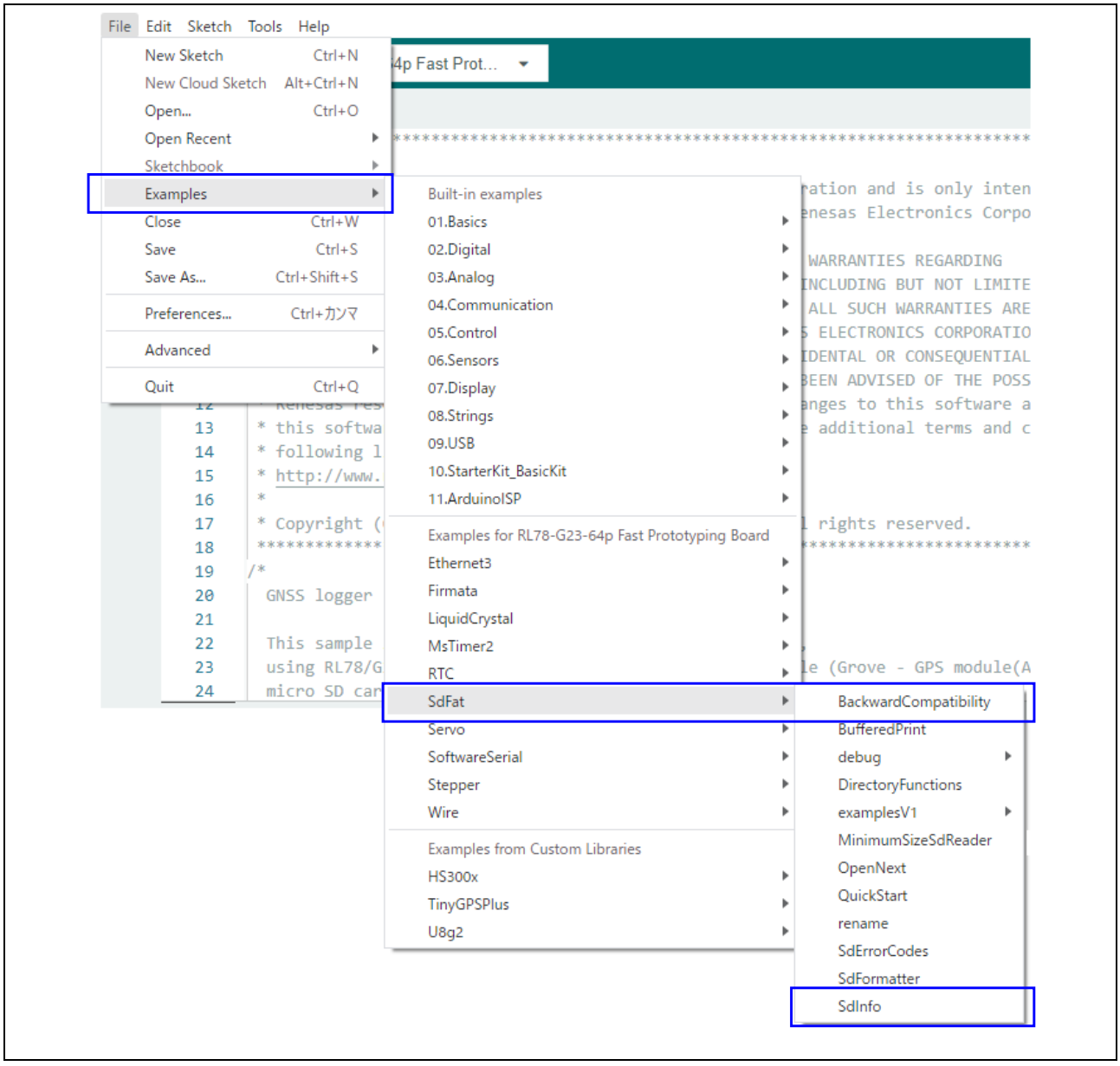
1. Start the Arduino™ IDE.
2. Open the library manager on the left side of the screen, search for [SdFat] in the search field, and install [SdFat].

Figure 4-2 Install SdFat



3. Click the [Files] - [Examples] - [SdFat] – [BackwardCompatibility].
4. Click the [Files] - [Examples] - [SdFat] – [SdInfo].

Figure 4-3 Selection of [SdFat] – [BackwardCompatibility], [SdInfo]

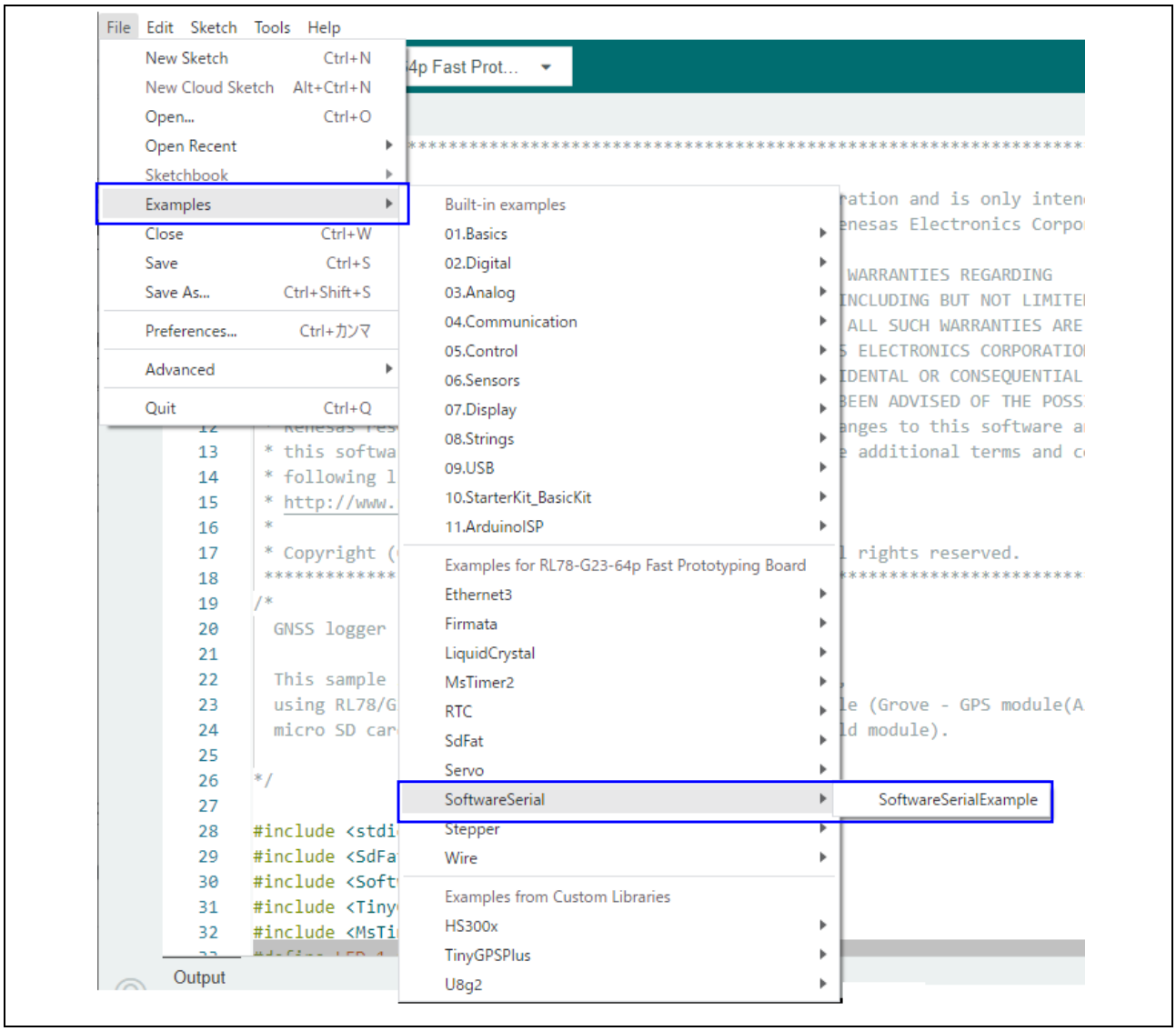


4.2.2 SoftwareSerial / SoftwareSerialExample

This is a sketch example of SoftwareSerial. In this sample code, this example is used for UART communication with the GNSS module. Refer to it in the following steps.

1. Start the Arduino™ IDE.
2. Click the [File] – [Examples] - [SoftwareSerial] - [SoftwareSerialExample].

Figure 4-4 Selection of [SoftwareSerial] – [SoftwareSerialExample]

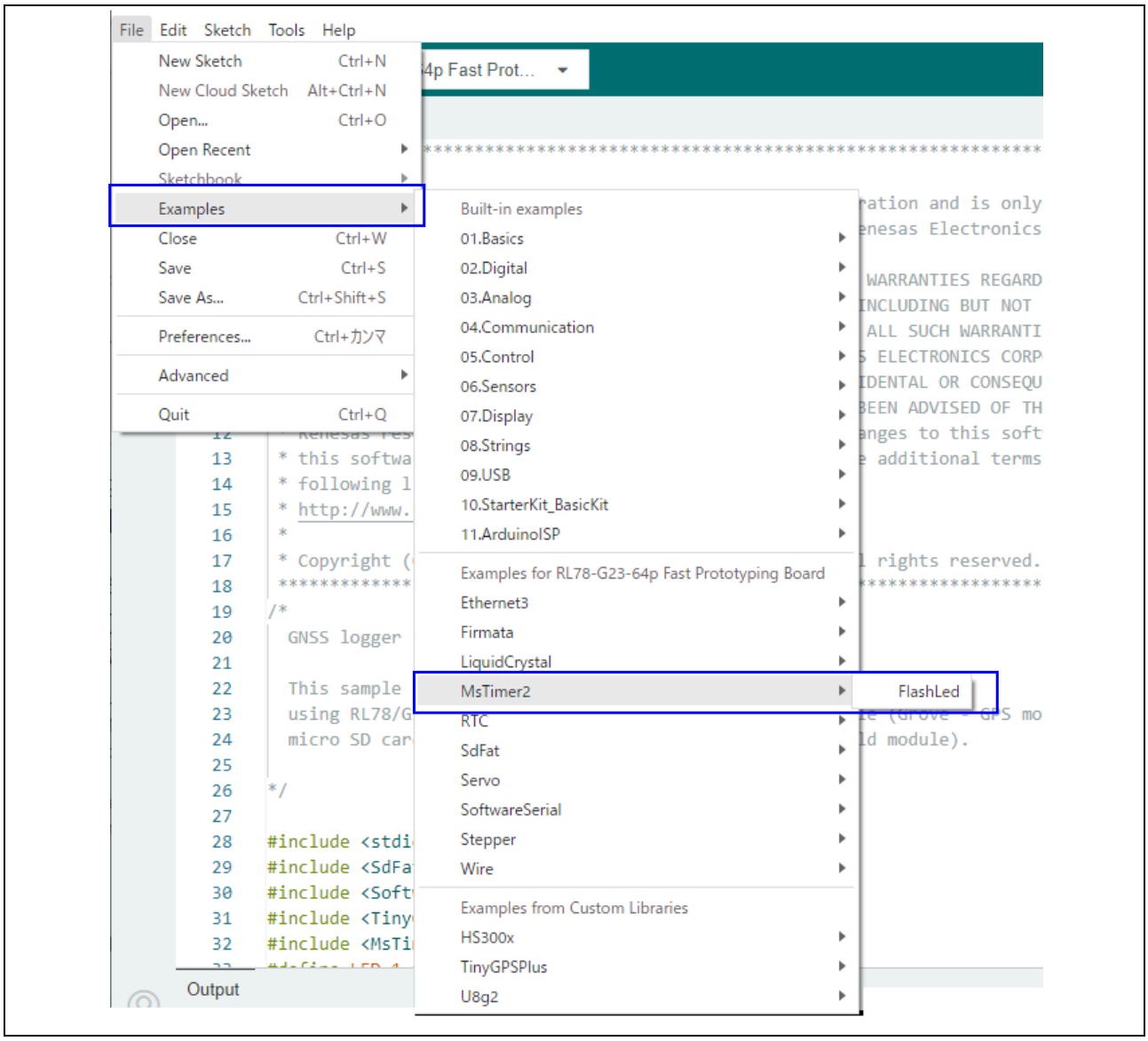


4.2.3 MSTimer2 / FlashLed

This is a sketch example of MSTimer2. In this sample code, this example is used to blink the LED on the RL78/G23-64p Fast Prototyping Board at 0.5 second intervals. Refer to it in the following steps.

1. Start the Arduino™ IDE.
2. Click the [File] – [Examples] - [MSTimer2] - [FlashLed].

Figure 4-5 Selection of [MSTimer2] - [FlashLed]

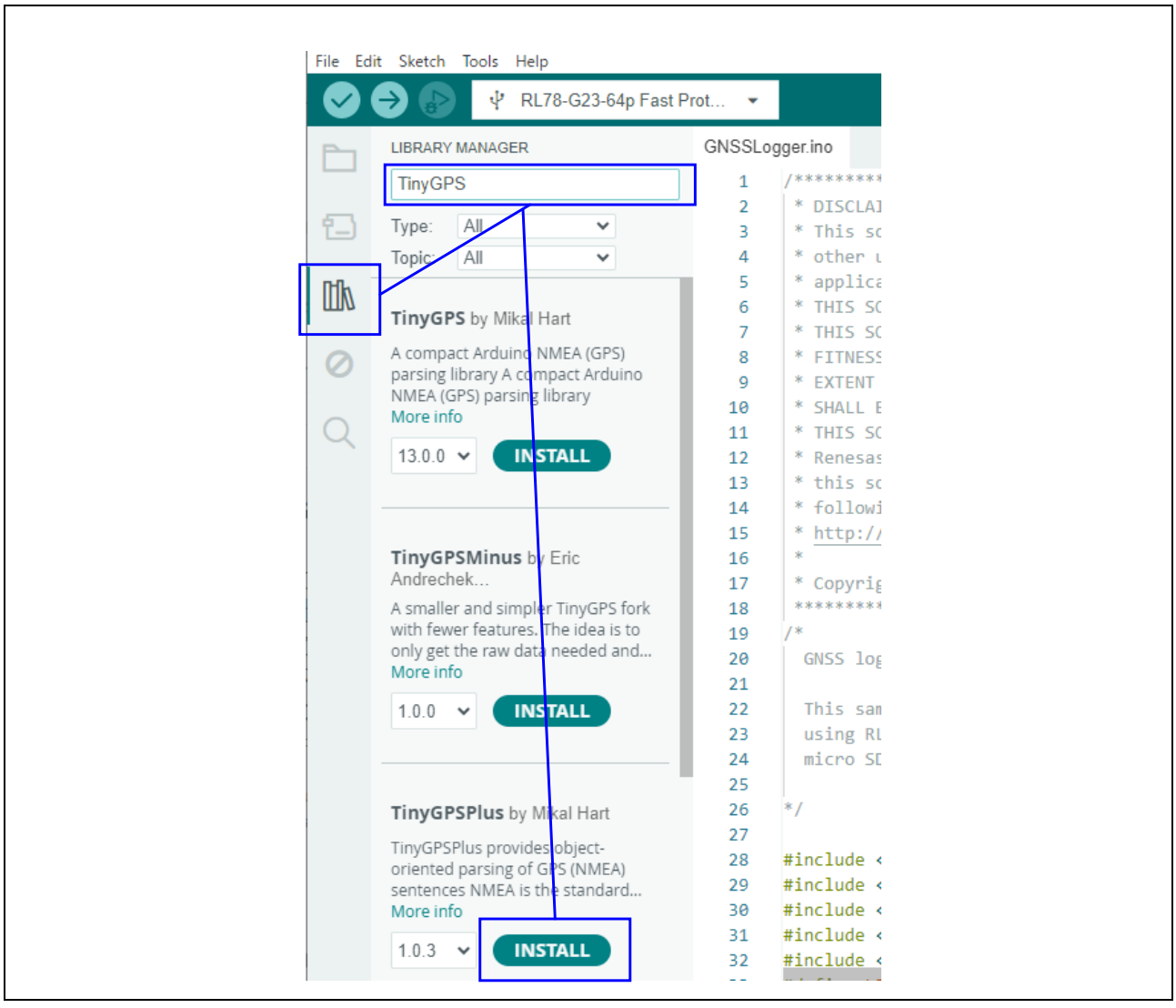


4.2.4 TinyGPSPlus / DeviceExample

This is a sketch example of TinyGPSPlus. In this sample code, this example is used to extract the necessary information from the obtained location information. Refer to it in the following steps.

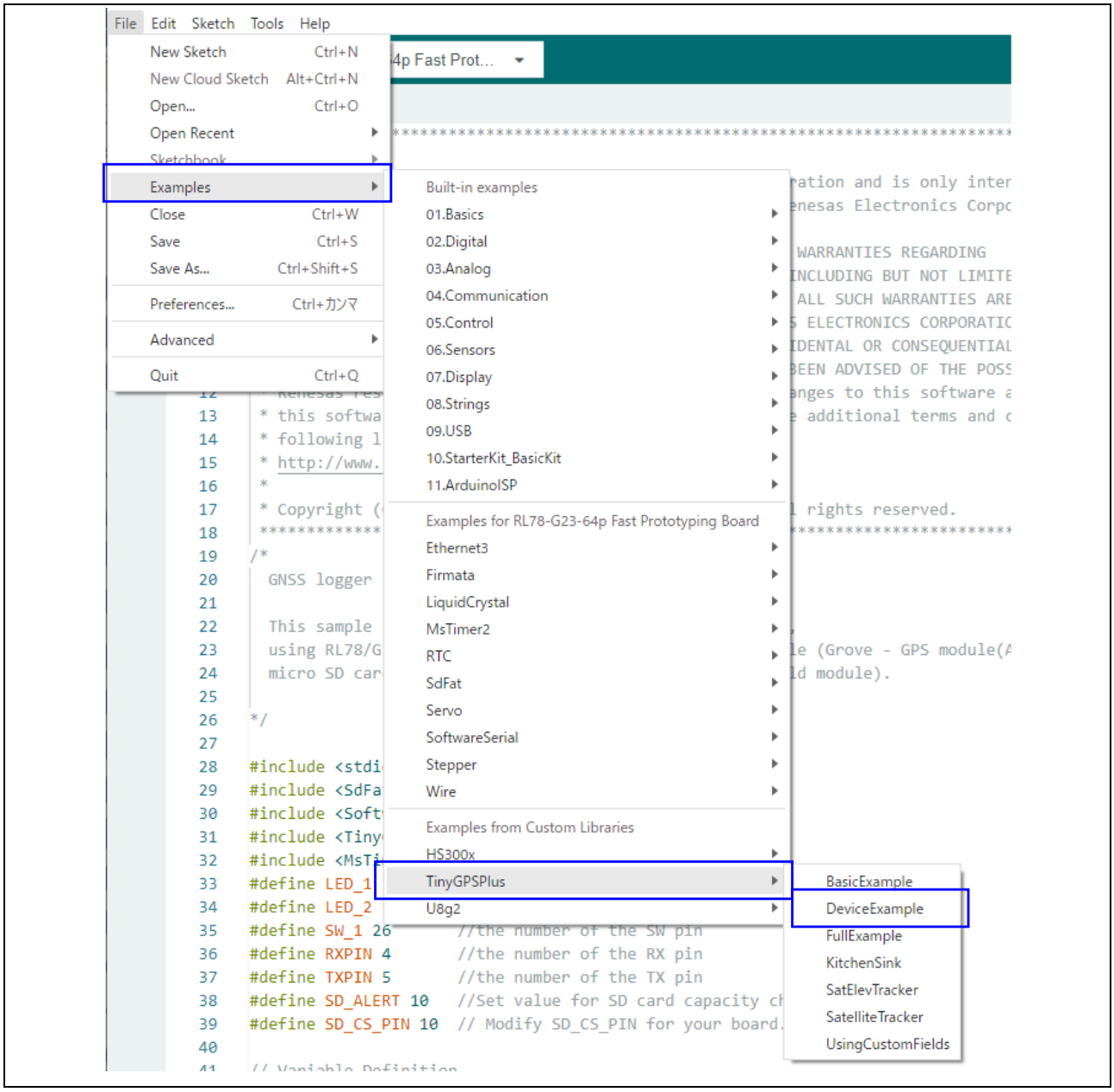
1. Start the Arduino™ IDE.
2. Open the library manager on the left side of the screen, search for [TinyGPS] in the search field, and install [TinyGPSPlus].

Figure 4-6 Install TinyGPSPlus



3. Click the [File] - [Examples] - [TinyGPSPlus] - [DeviceExample].

Figure 4-7 Selection of [TinyGPSPlus] – [DeviceExample]



4.3 API functions

The API functions of each library used in this sample code are shown below.

Table 4-2 List of APIs

API	Function
digitalWrite(pin,value)	Output HIGH/LOW from the digital pin.
attachInterrupt(digitalPinToInterrupt(pin), ISR, mode)	Set the function to be executed when an external interrupt occurs.
.SD.begin(cspin)	Initialize the library and micro-SD card.
SD.freeClusterCount()	Get the number of writable clusters in a micro-SD card.
SD.sectorsPerCluster()	Get the number of sectors per cluster.
SD.exists(fileName)	Check the existence of the specified file (fileName).
SD.open(filename, mode)	Open the specified file (fileName) on the micro-SD card in the specified mode (mode). Create a new file if the specified file does not exist.
myFile.close()	Close file and save data.
myFile.print()	Write data to a file opened in write mode.
myFile.println()	Add a newline code to the end of the data and write the data to the file.
d.toCharArray(buf, len)	Copy a string to a byte type array (buf). len is the size of buf (int).
MsTimer2::set(ms, function)	Specify a periodic operation (function) executed in the specified interval (ms).
MsTimer2::start()	Start the periodic operation specified by set function.
gps.location.isValid()	Check if the received location information is valid.
gpsSerial.begin(speed)	Set the baud rate (speed) of UART to communicate with the GNSS module.
gpsSerial.available()	Get the number of bytes of data in the software serial port buffer.
gps.encode()	Extract arbitrary information from received NMEA format text data.

For API function specifications of each library, refer to the website of Arduino™ and the other.

API List · renesas/Arduino Wiki · GitHub

digitalWrite() - Arduino Reference

SdFat - Arduino Reference

attachInterrupt() - Arduino Reference

SoftwareSerial Library | Arduino Documentation

MsTimer2 - Arduino Reference

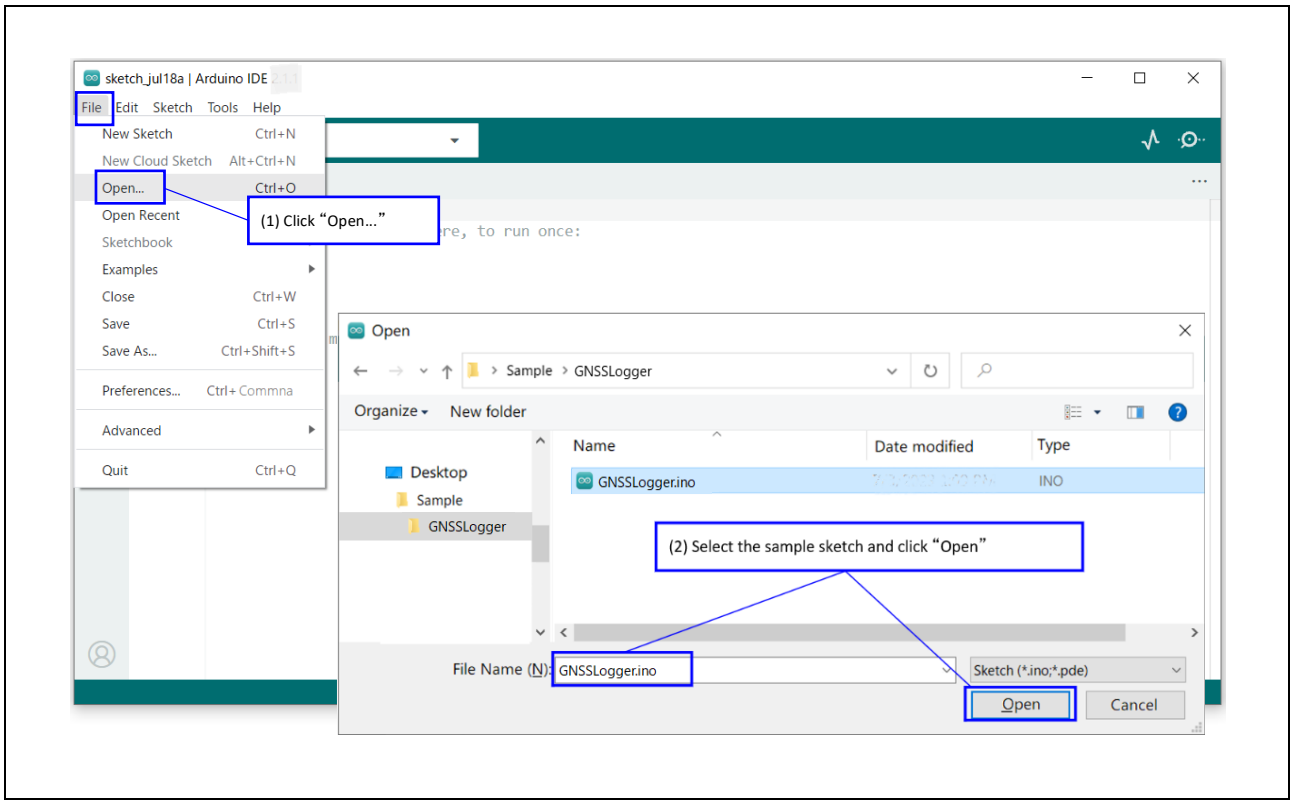
TinyGPSPlus - Arduino Reference

4.4 Procedure for checking operation of sample sketch

The steps to check the operation of this sample sketch are shown below. Please setup the Arduino™ IDE in the “3.3 Setup of Arduino™ IDE” in advance.

1. Select the [File] - [Open…] menu to open the sample sketch “GNSSLogger.ino”.

Figure 4-8 Open sample sketch

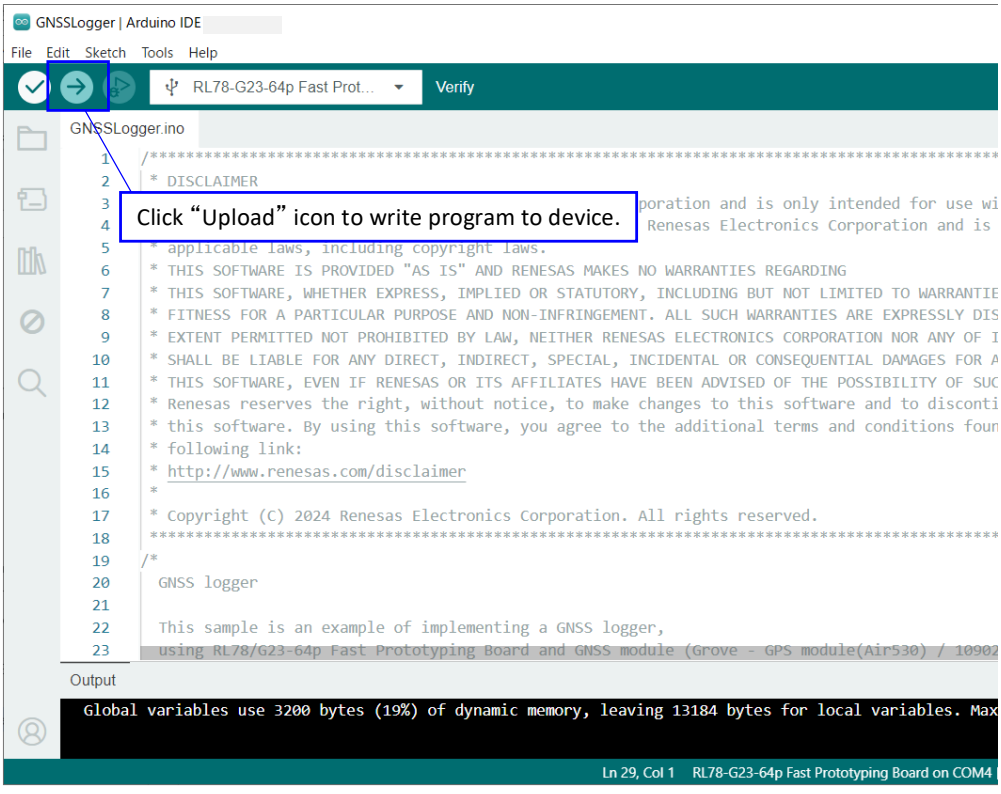


2. Click the [Verify] icon to start compiling the sketch.

Figure 4-9 Compile sketch

3. After compiling is finished, click the [Upload] icon to write the program to the board (miclocontroller).

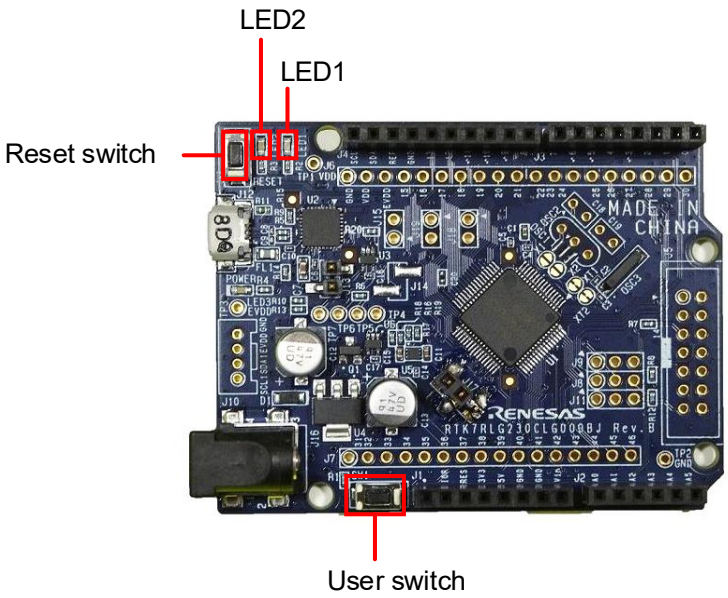
Figure 4-10 Write sketch to board



4. After writing is completed, LED1 turns on when the microcontroller starts operating.
5. After checking the capacity of the micro-SD card, LED1 turns off.
6. LED1 blinks while the location information is being repeatedly received and written to the micro-SD card.
7. After pressing the user switch, the data is saved on the micro-SD card, LED1 turns off and LED2 turns on. Recording is complete when LED2 turns on. If you want to record again, please reboot or press the reset switch.

Figure 4-1 shows the location of the user switch, reset switch, LED1 and LED2.

Figure 4-11 Location of switch and LED



4.5 Flowchart

4.5.1 main processing

The flow of the sample sketch is shown below.

Figure 4-12 Flowchart of main processing (1/2)

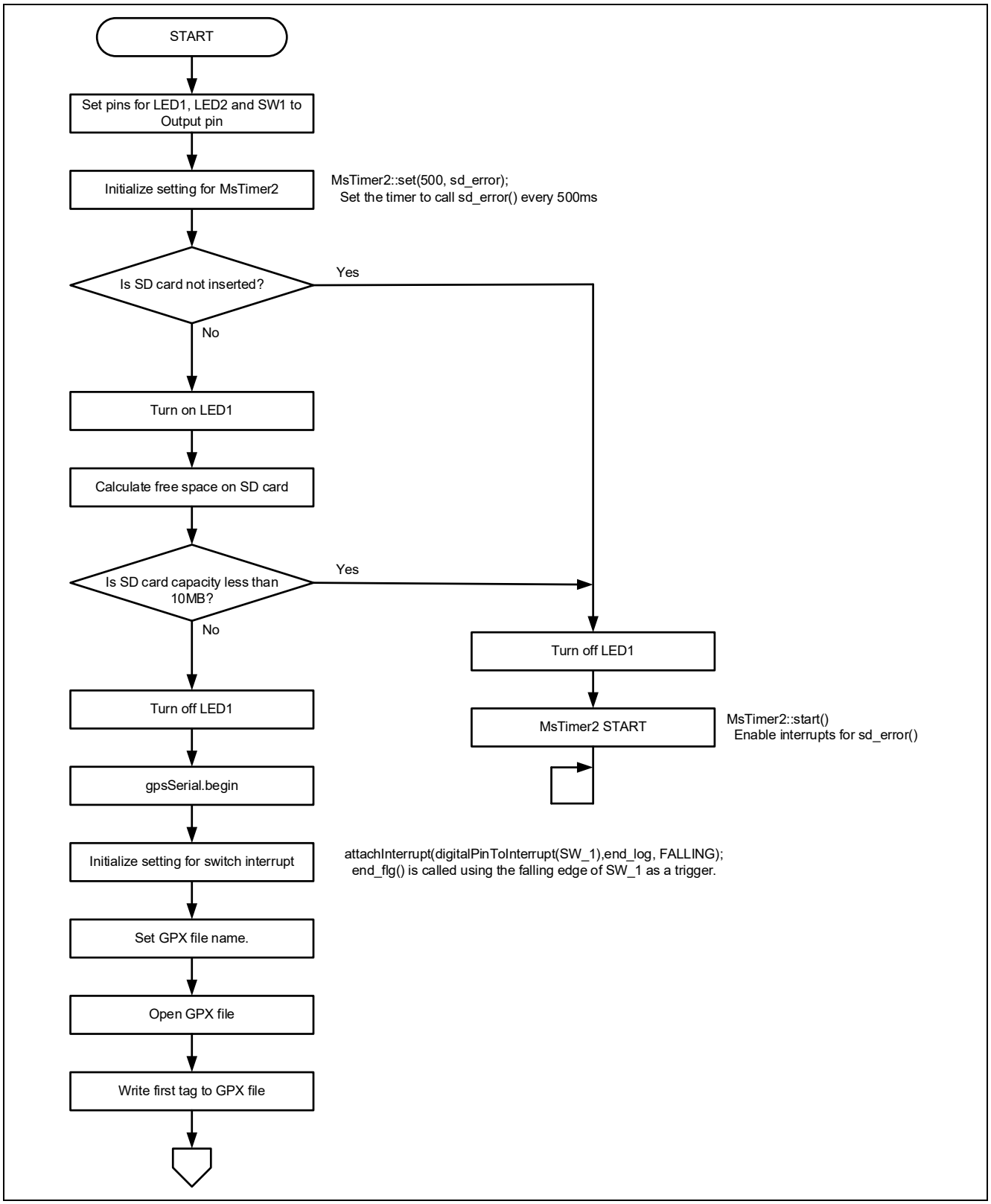
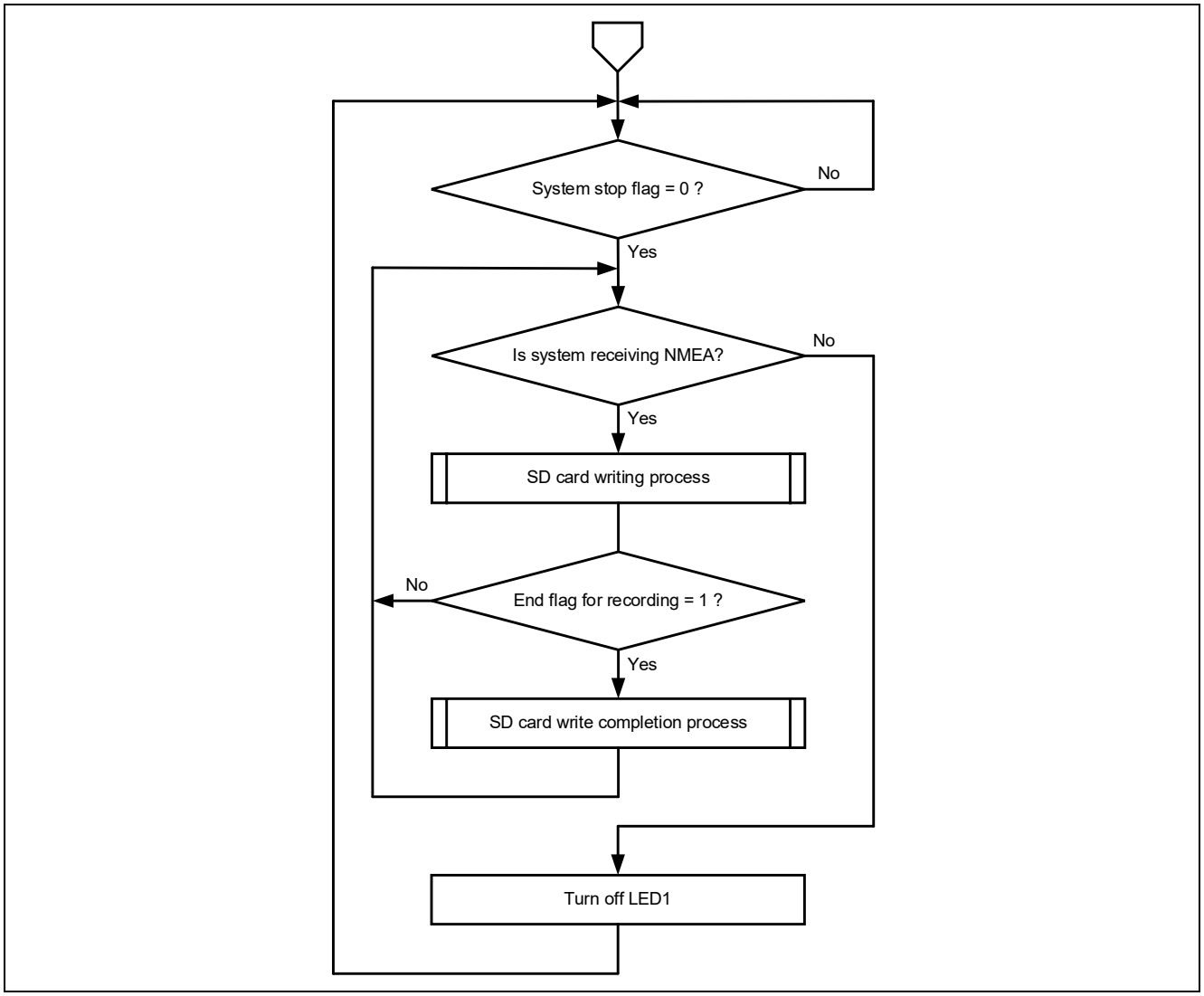


Figure 4-13 Flowchart of main processing (2/2)

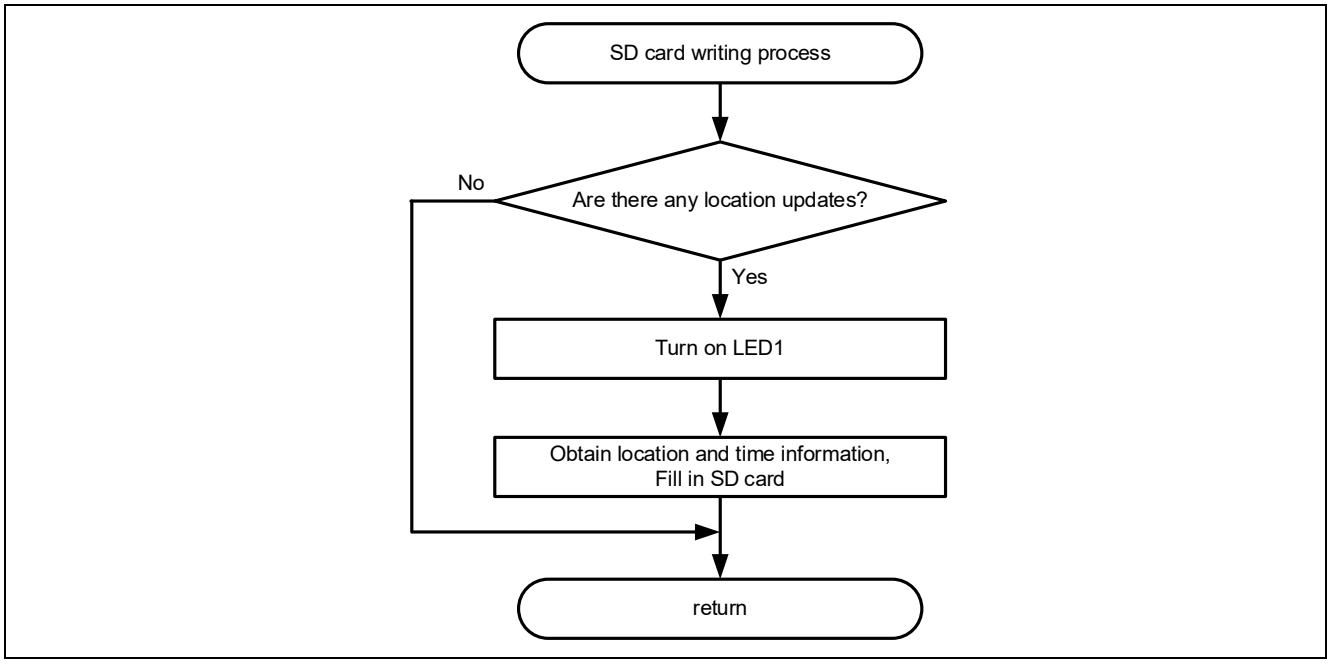


4.5.2 Sub routine

The flows of functions called from the loop function are shown below.

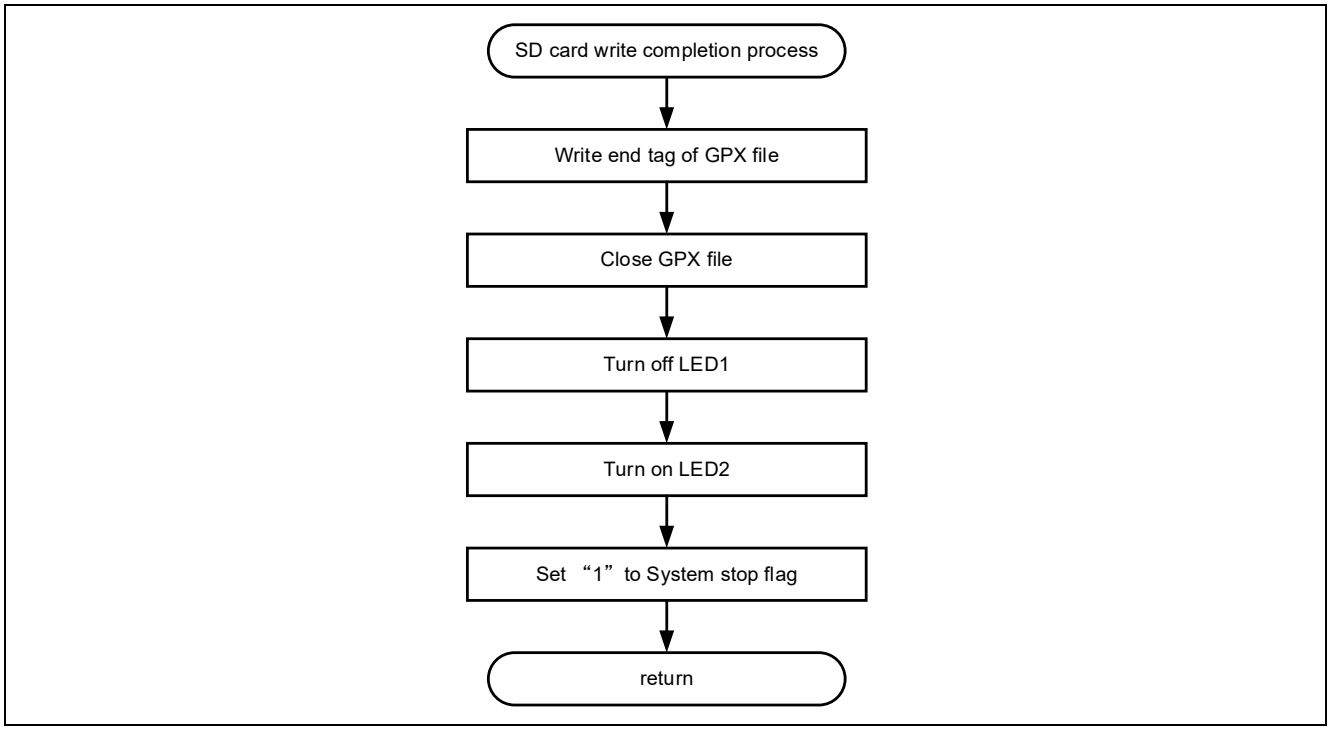
(1) SD card writing process: write_file function:

Figure 4-14 Flowchart of write_file



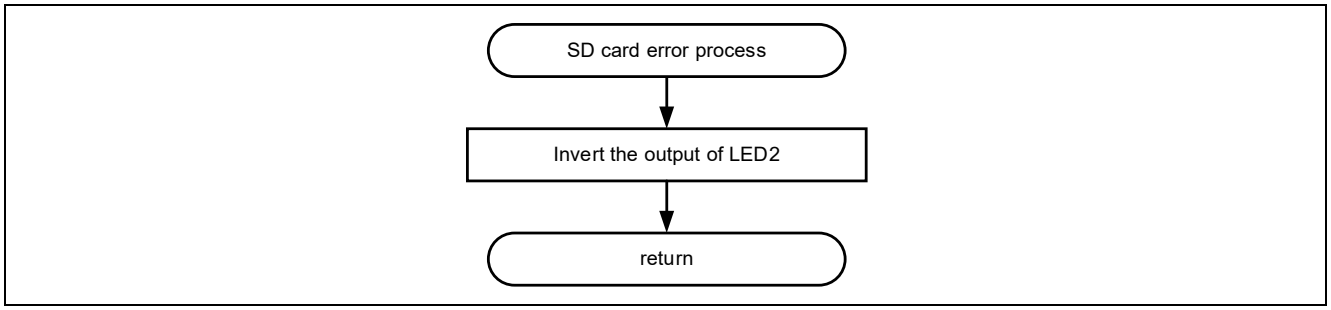
(2) SD card write completion process: sd_close function

Figure 4-15 Flowchart of sd_close



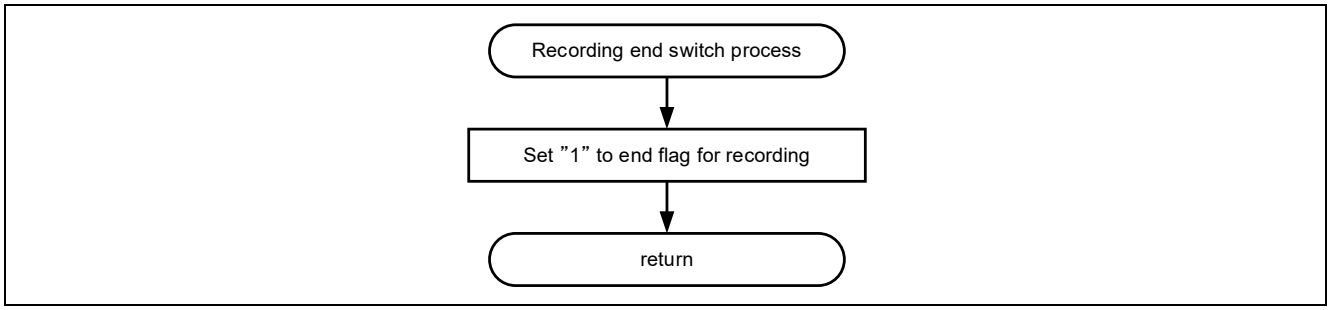
(3) SD card error process: sd_error function:

Figure 4-16 Flowchart of sd_error



(4) Recording end switch process: end_log function:

Figure 4-17 Flowchart of end_log



4.5.3 Specification of sub routine

The details of the sub routine are as follows.

void write_file (void)	
Outline	SD card writing process. Write the obtained location information to the micro-SD card in GPX format.
Argument	None
Return value	None

void sd_close (void)	
Outline	SD card write completion process. Write the GPX file tag and closes the file. Terminate the UART and set the system stop flag.
Argument	None
Return value	None

void sd_error (void)	
Outline	SD card error process. Blink LED2. This is a function called by MsTimer2 every 0.5 seconds.
Argument	None
Return value	None

void end_log (void)	
Outline	Recording end switch process. Set the end flag for recording. This is a function called by attachInterrupt when pressing the user switch.
Argument	None
Return value	None

5. How to view log data on Geographic information system (QGIS)

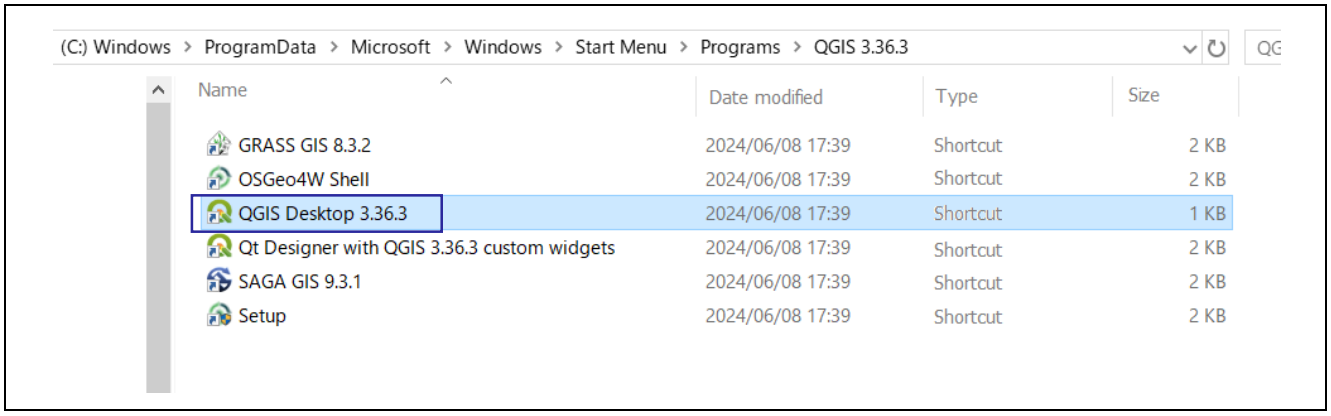
The steps to display log data on the QGIS are shown below.

Please install " QGIS x.xx" in advance from the URL below.

QGIS downnlad

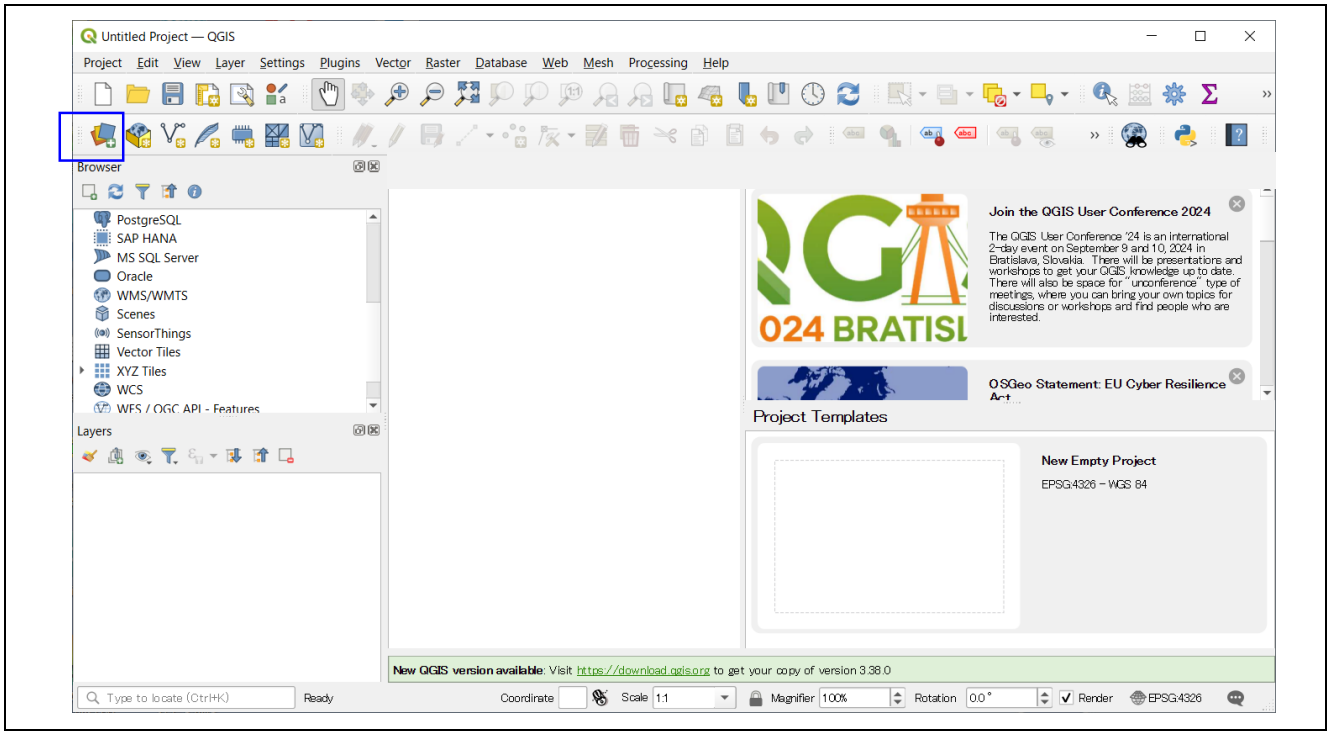
1. Double click the [QGIS Desktop x.xx.x] on the Windows explorer to start the QGIS.

Figure 5-1 Start QGIS



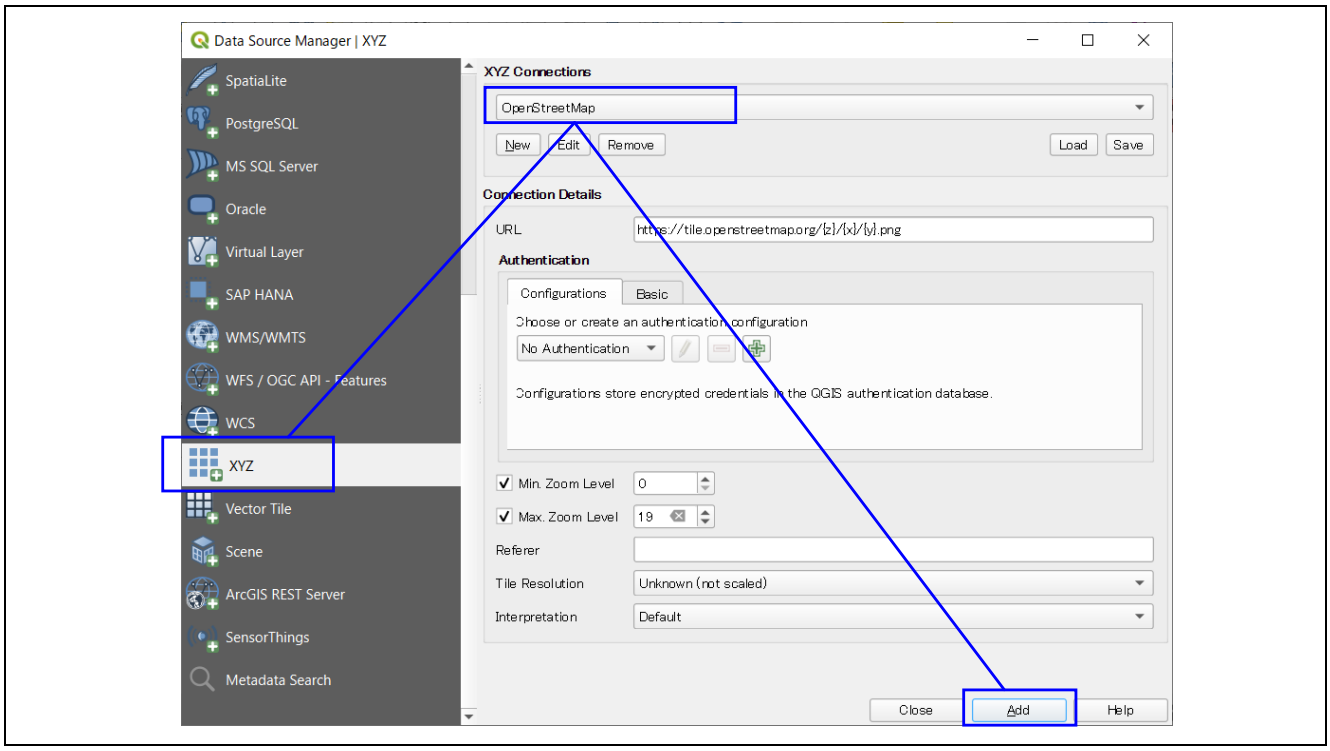
2. Open the Database Manager by clicking the overlapping red, yellow, and blue squares in the top left of the screen.

Figure 5-2 Open Database Manager



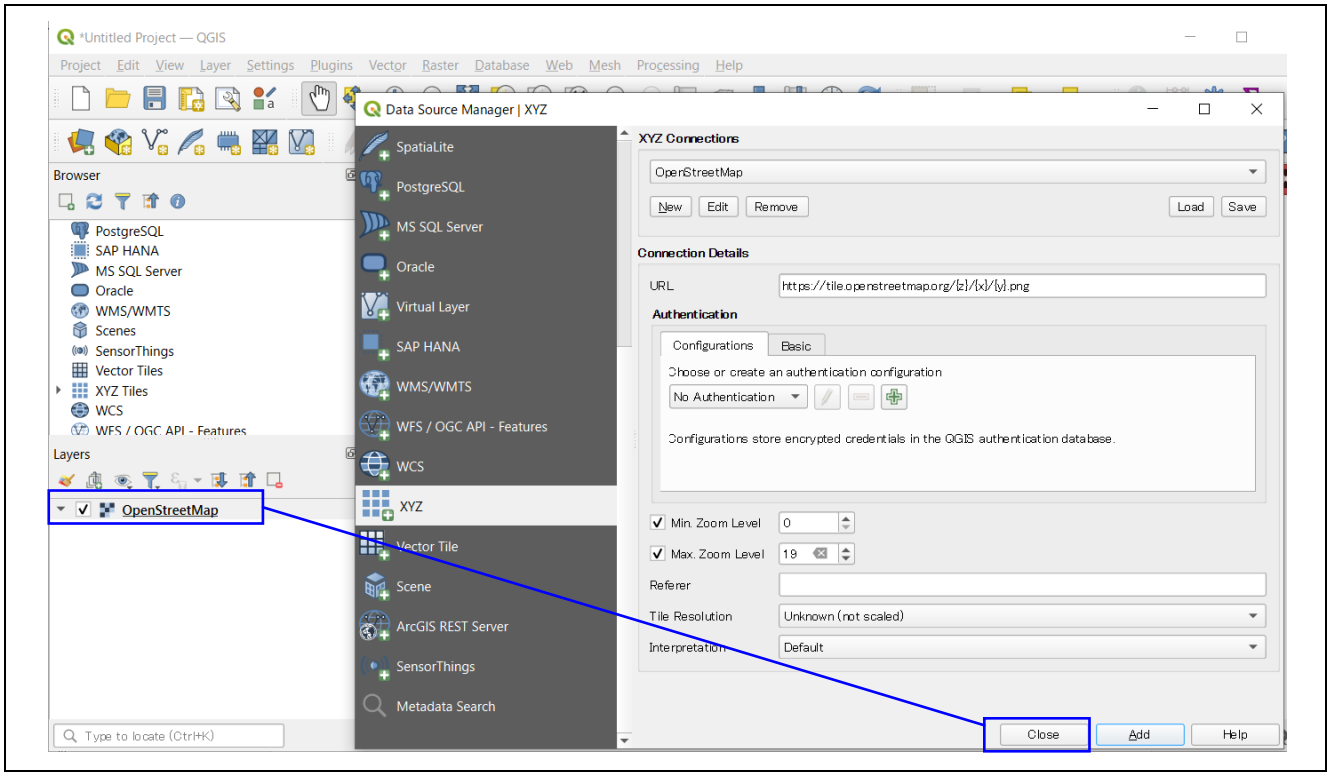
3. Select the [XYZ] - [OpenStreetMap] and click the [Add].

Figure 5-3 Add OpenStreetMap



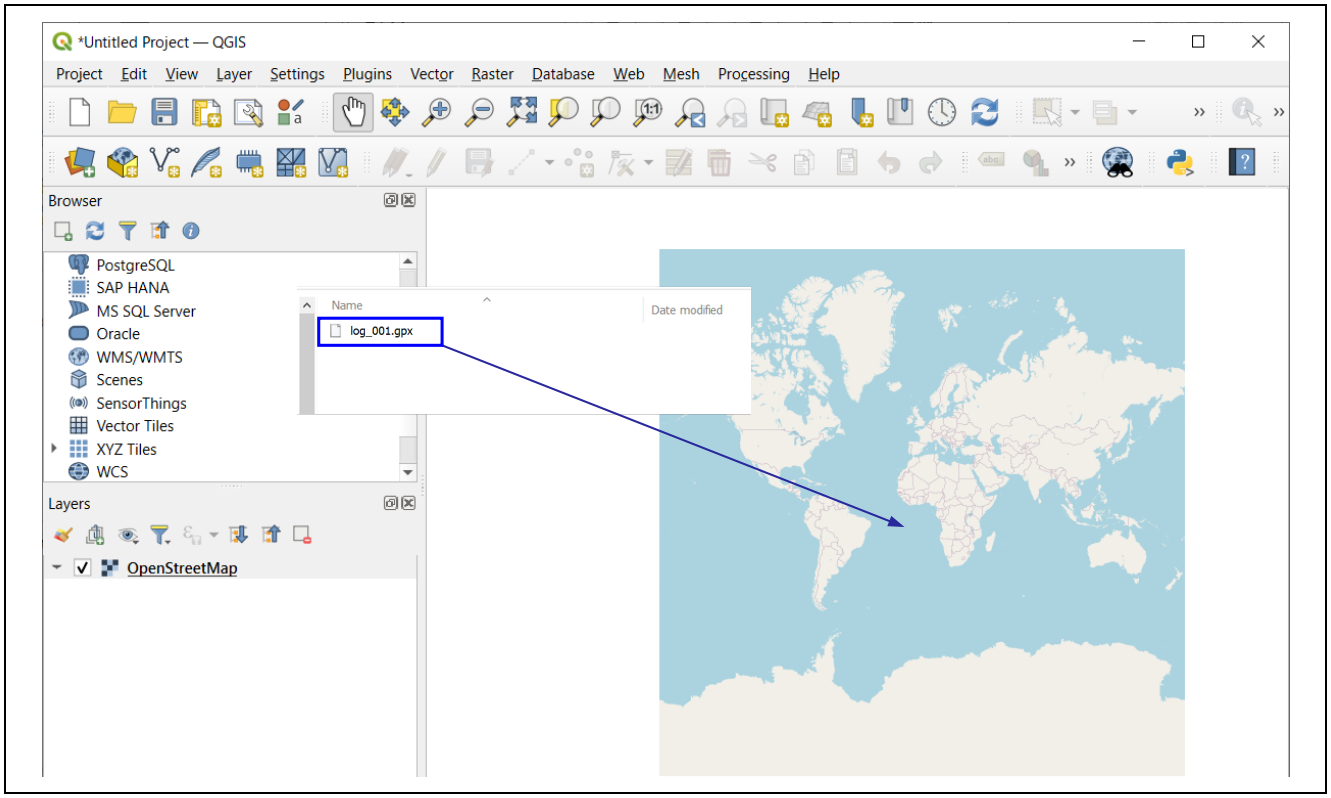
4. After confirming that [OpenStreetMap] has been added at the bottom left, click the [Close].

Figure 5-4 Confirm addition of OpenStreetMap



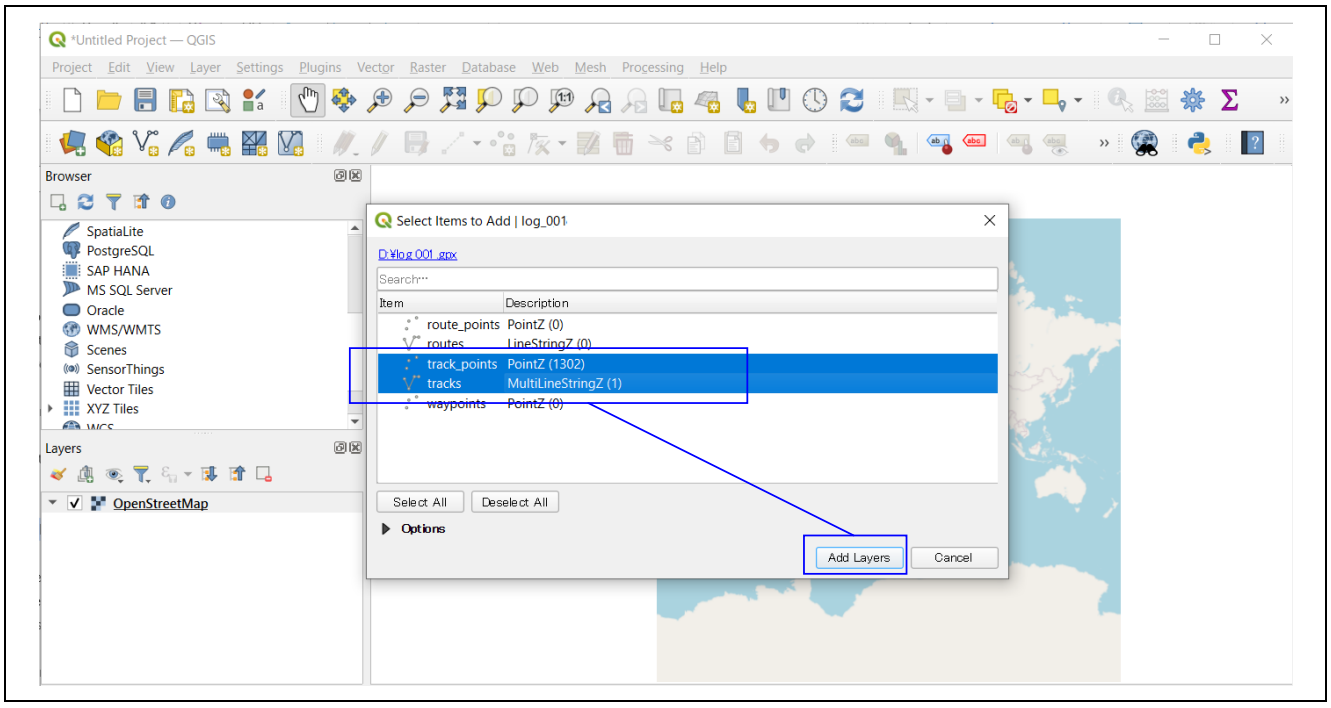
5. Drag and drop the location information file saved on the micro-SD card onto the map.
   We recommend that you copy the files saved on the microSD card to your computer in advance.

Figure 5-5 Add recorded location information



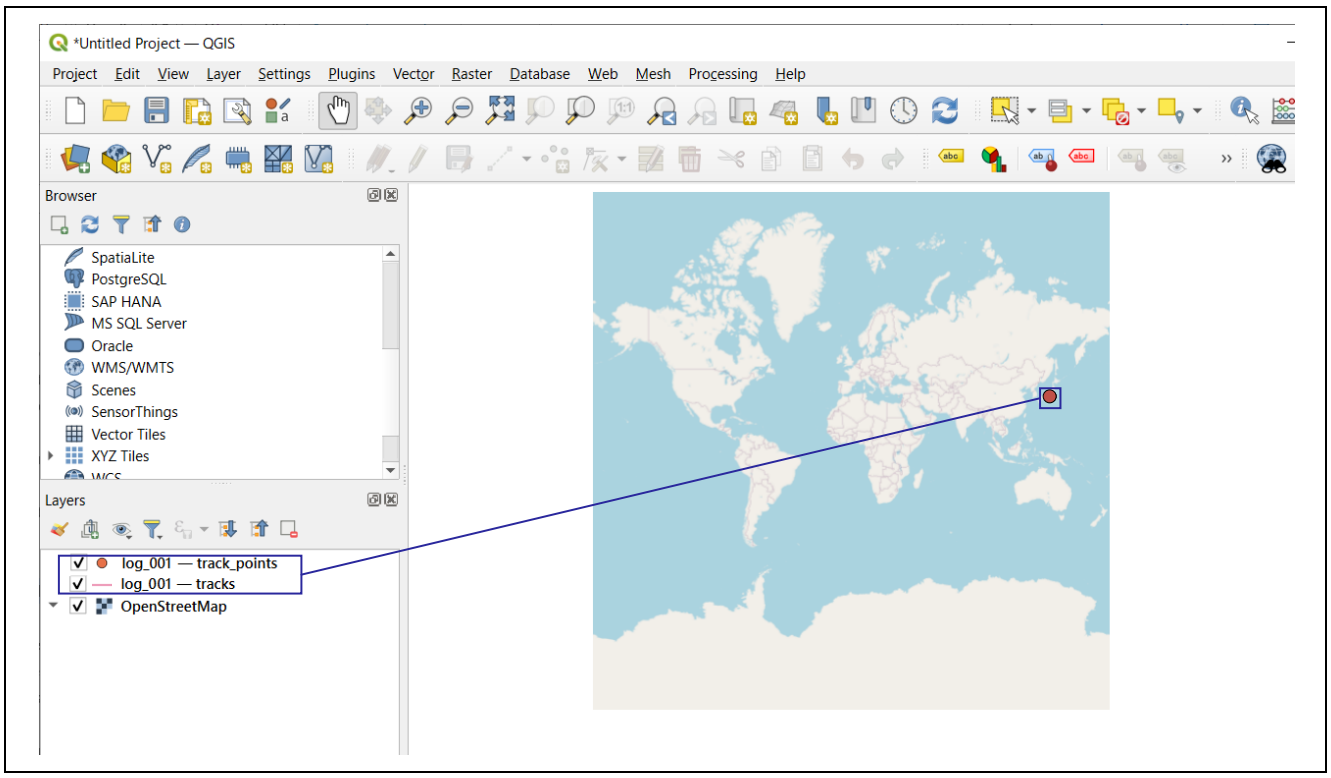
6. Select [track_points] and [tracks] in the window that appears and click the [Add Layers].

Figure 5-6 Add layers



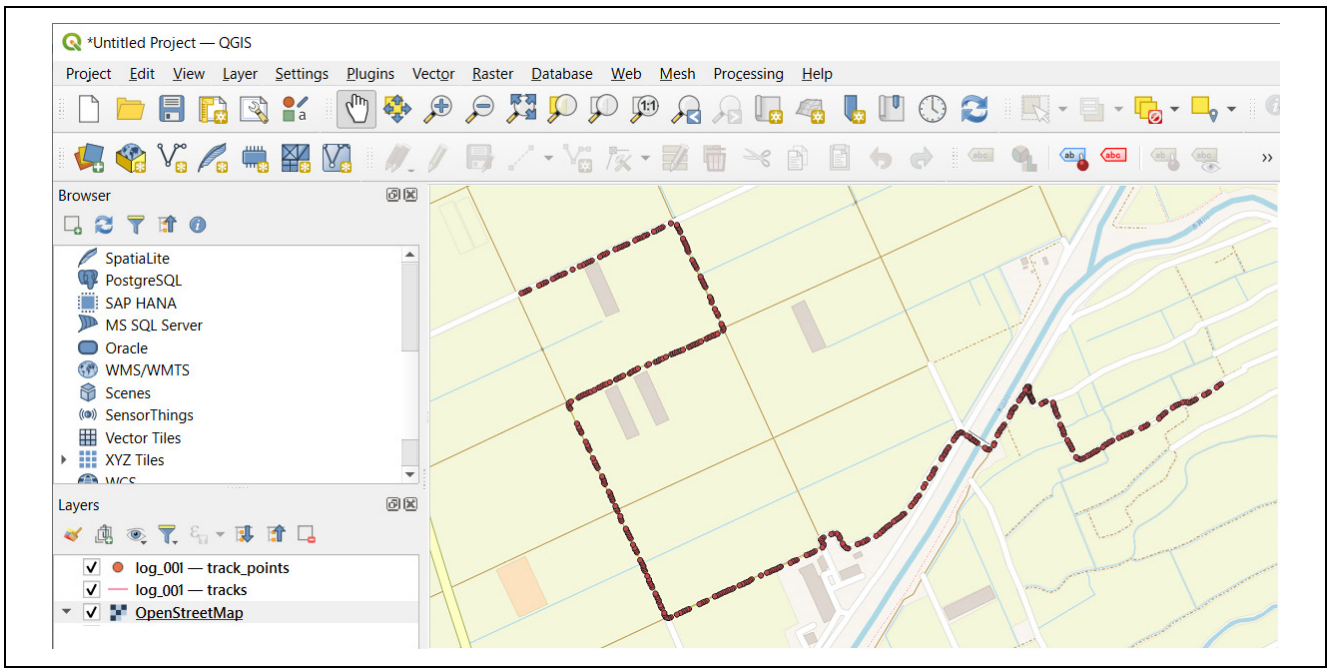
7. Confirm that [track_points] and [tracks] are added at the bottom left and the location information is added on the map.

Figure 5-7 Confirm addition of Layer



8. Zoom in on the map to see the recorded location information.

Figure 5-8 Map display



6. Troubleshooting

6.1 COM port is not displayed on the Windows Device Manager

When connecting the PC and the evaluation board (RL78/G23-64p FPB) for the first time, the PC may not recognize the port and the COM port may not be displayed in Windows Device Manager.

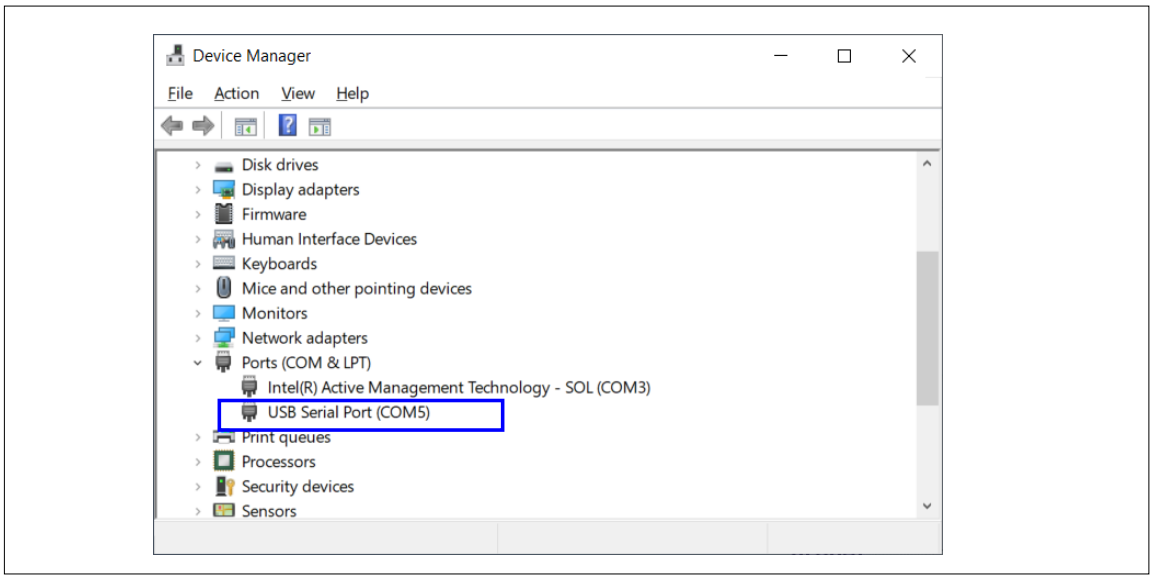
If the COM port is not displayed, install the driver of the USB-to-serial convertor (FT232RQ) from FTDI on the RL78/G23-64p FPB by the following procedure.

1. Download the latest driver installer for the target OS from FTDI's website and install it.

   https://ftdichip.com/drivers/vcp-drivers/

2. After installation, “USB Serial Port (COMx)” is displayed under the “Ports (COM & LPT)” on the Device Manager. In the following figure, COM5 is the target COM port.

Figure 6-1 Windows Device Manager after installation of device driver



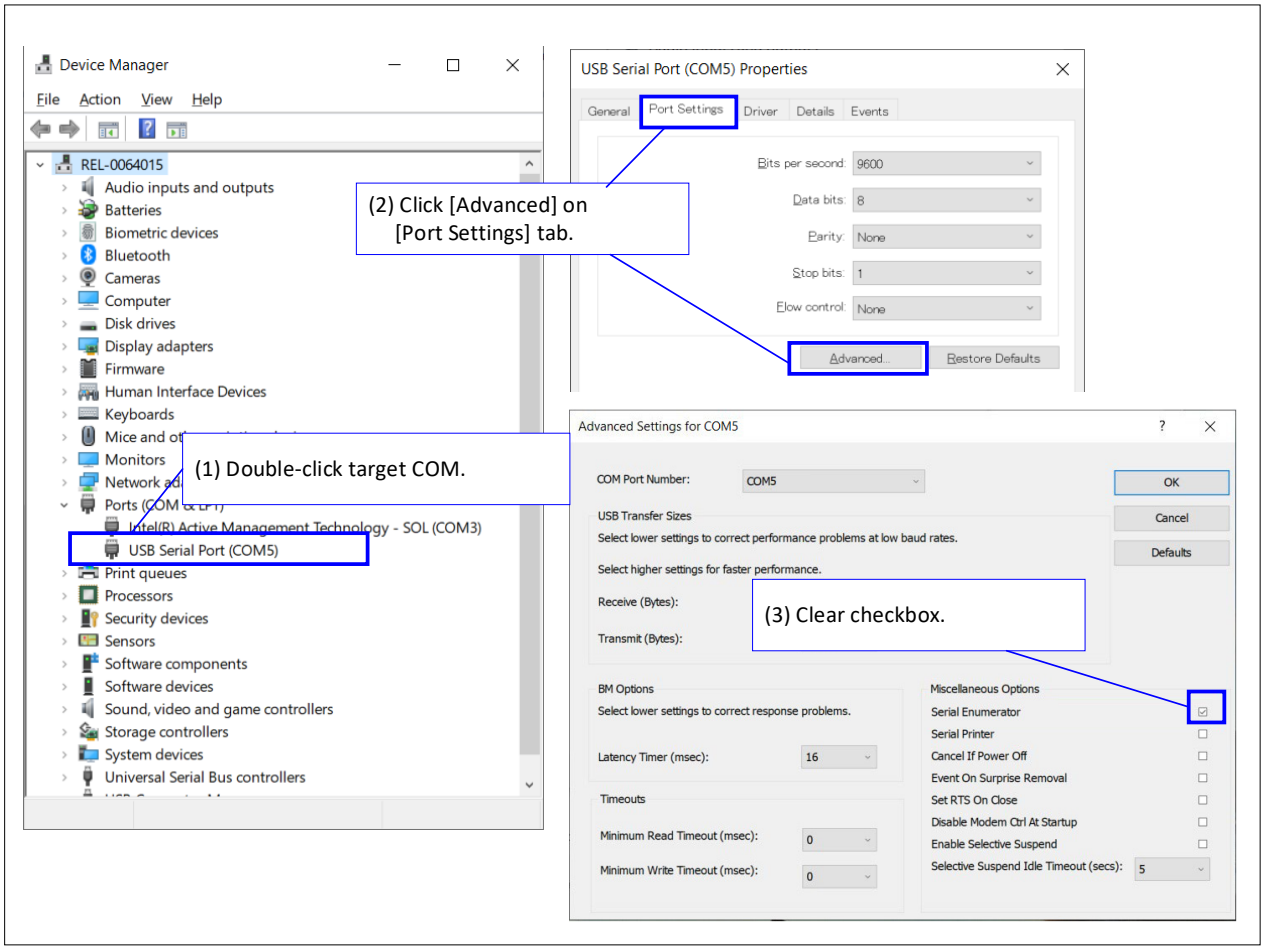
For details of USB-to-serial convector and COM port, refer to “5.11 USB-to-Serial Converter” and “5.12 USB-to-Serial Converter Reset Header” in RL78/G23-64p Fast Prototyping Board User’s manual.

6.2 Program is not written correctly to RL78/G23-64p Fast Prototyping Board

It may not be connected correctly the PC and the RL78/G23-64p FPB even if “USB Serial Port (COMx)” is displayed. Because the RL78/G23-64p FPB is not recognized correctly.

If the program is not written correctly, double-click the target COM port on Windows Device Manager and clear the checkbox of [Serial Emulator].

Figure 6-2 Setting example of target COM



6.3 Power supply from the mobile battery stops immediately after starting

You may be using a mobile battery with an auto power off function.

If you use a general mobile battery to power a board that operates on a weak current such as the FPB, the protection function (auto power off function) will be activated and the power supply will be cut off, so please use a mobile battery that does not automatically turn off the power.

6.4 LED2 is blinking (micro-SD card error)

- If LED2 continues to blink after power is supplied
  micro-SD card is not inserted. Turn off the power of the mobile battery and then insert the micro-SD card.
- If LED1 turns on and LED2 continues to blink after power is supplied
  The capacity of the micro-SD card is less than 10MB. Turn off the power of the mobile battery, remove the inserted micro-SD card, and insert a micro-SD card with sufficient capacity.

7. Sample Code

There is the sample code for this application note.

Sample code can be downloaded from the Renesas Electronics website.

8. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)

RL78/G23-64p Fast Prototyping Board User's Manual (R20UT4814)

The latest versions can be downloaded from the Renesas Electronics website.

Technical update

The latest versions can be downloaded from the Renesas Electronics website.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jul. 18, 2024	-	First edition

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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