

OB1203SD-RL-EVK

Evaluation kit for Heart Rate, SpO2, and Respiration Rate

This OB1203SD-RL-EVK evaluation kit for Heart Rate, SpO2, and Respiration Rate uses Renesas' highly integrated biosensor OB1203 for reflective photoplethysmography.

With the provided algorithm, the kit can determine Heart Rate, Oxygen Saturation (SpO2), and Respiration Rate. The sensor transmits its data via an I2C interface to an MCU for data analysis and result display.

The design incorporates an RL78/G13-16 bit microcontroller as MCU, an ISL9111 voltage boost converter for battery operation, and an OLED display.

Functions

- Collects data from Renesas OB1203 sensor module through I2C communication
- Calculates the oxygen saturation, pulse, and respiration rate using the provided algorithm
- Displays oxygen saturation, pulse, and respiration rate and battery level on an OLED display
- Boosts battery voltage to system's voltage needs

Specifications

The OB1203SD-RL-EVK monitors heart rate, blood oxygen saturation, and respiration rate. Battery-operated and portable the evaluation kit is suitable for monitoring at home, during exercise, or travel.

- Operating voltage: 3.0V (AAA battery * 2)
- Detector module: OB1203 sensor module
- Display module: OLED (Built-in control chip)
- Measurement range: Oxygen saturation: 70% to 100%
- Pulse rate: 25bpm to 200 bpm
- Operating temperature: -40 to 85°C
- Operating humidity: 5 to 99% RH (No condensate water)

Target Devices

- MCU: RL78/G13 (R5F100BGA)
- Sensor: OB1203 module
- Boost: ISL9111 (ISL9111EH33Z)

When applying the provided algorithm to another microcontroller, modify the program to the specifications for the target microcontroller and conduct an extensive evaluation of the modified program. Changes in analog or power supply components need to be fully evaluated as well.

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1. Functional Description

1.1 RL78/G13 Microcontroller

The RL78/G13 is 32MHz, 16-bit CPU. Figure 1 shows the block diagram of the RL78/G13.

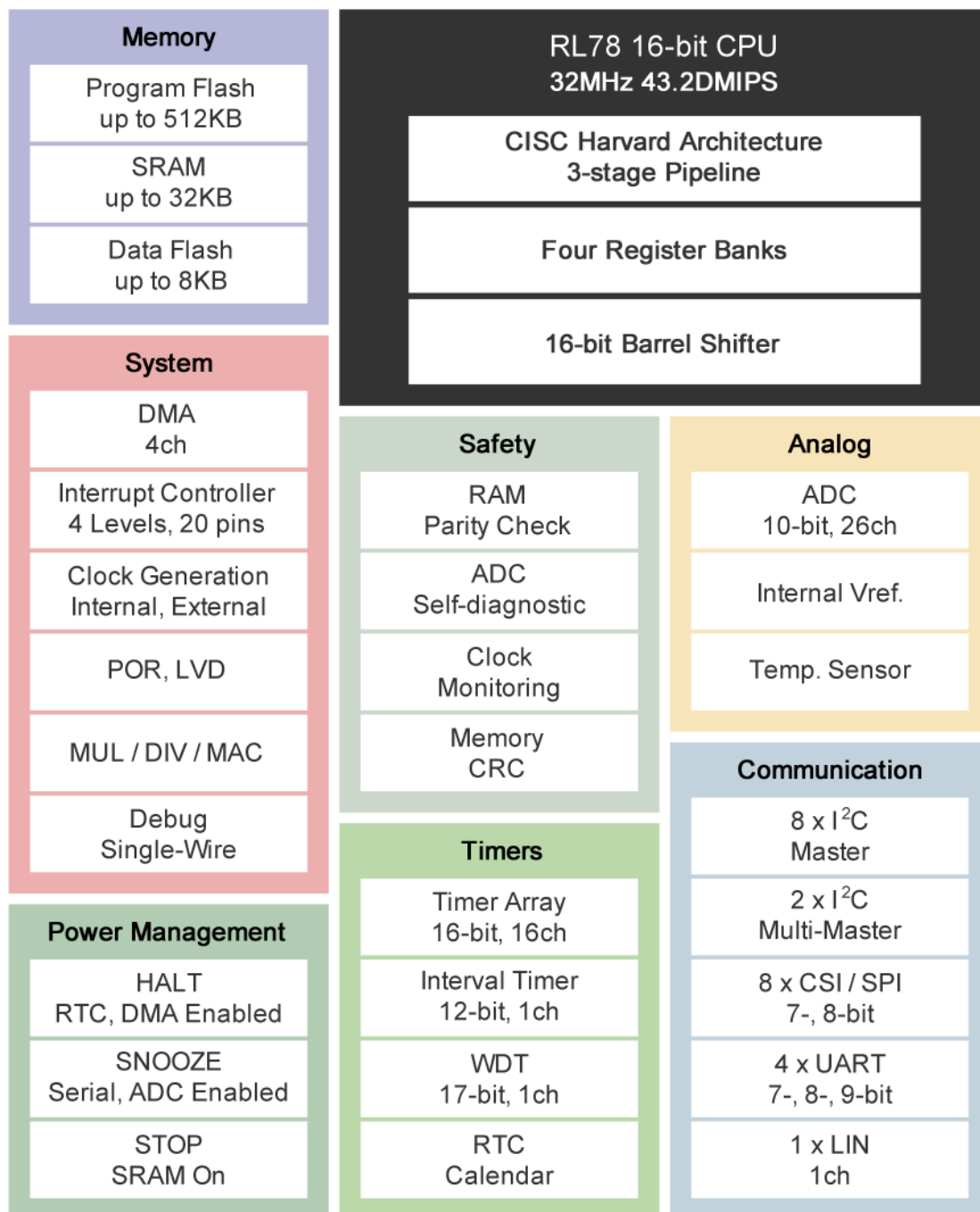


Figure 1. RL78/G13 Block Diagram

Figure 2 shows the pin configuration of the RL78/G13 (32-pin products).

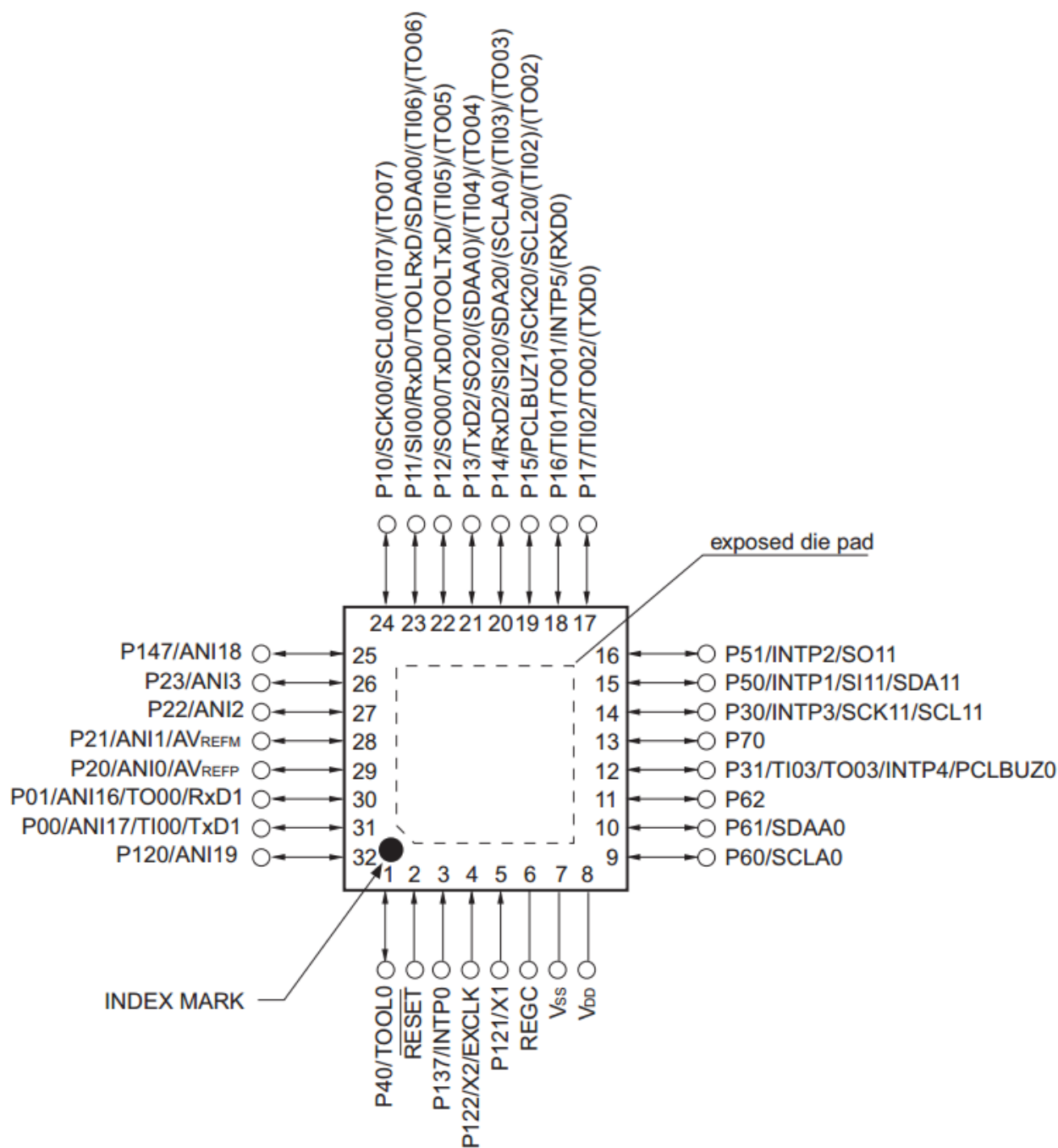


Figure 2. RL78/G13 (32-pin Products) Pin Configuration

1.1.1. RL78/G13 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.03125μs: at 32MHz operation with high-speed on-chip oscillator) to ultra-low speed (30.5μs at 32.768kHz operation with subsystem clock)
- General-purpose registers: (8-bit register × 8) × 4 banks
- ROM: 16KB to 512KB, RAM: 2KB to 32KB, Data Flash: 4KB to 8KB
- Selectable high-speed on-chip oscillator clock: 32/24/16/12/8/6/4/3/2/1 MHz (Typical)
- On-chip single power supply flash memory
- Power management and reset function
- On-chip power-on-reset (POR) circuit
- On-chip voltage detector (LVD) (Select interrupt and reset from 14 levels)
- On-chip debug function
- On-chip key interrupt function
- On-chip clock output/buzzer output controller
- I/O port: 16 to 120 (N-ch open drain I/O [withstand voltage of 6 V]: 0 to 4, N-ch open drain I/O [V_{DD} withstand voltage EV_{DD} withstand voltage]: 5 to 25)
- Timers
 - 16-bit timer: 8 to 16 channels
 - 12-bit interval timer: 1 channel
 - Real-time clock: 1 channel (calendar for 99 years, alarm function, and clock correction function)
 - Watchdog timer: 1 channel (operable with the dedicated low-speed on-chip oscillator)
- Serial interface
- CSI: 2 to 8 channels
- UART/UART (LIN-bus supported): 2 to 4 channels
- I2C/Simplified I2C communication: 2 to 8 channels
- 8/10-bit resolution A/D converter: 6 to 26 channels
- Internal reference voltage (1.45 V) and temperature sensor
- DMA (Direct Memory Access) controller: 2/4 channels
- Multiplier and divider/multiply-accumulator
- 16 bits × 16 bits = 32 bits (Unsigned or signed)
- 32 bits ÷ 32 bits = 32 bits (Unsigned)
- 16 bits × 16 bits + 32 bits = 32 bits (Unsigned or signed)
- Standby function: HALT mode, STOP mode, SNOOZE mode
- Power supply voltage: V_{DD} = 1.6 to 5.5V
- Operating ambient temperature: T_A = -40 to +85°C

1.2 OB1203 Photoplethysmography Sensor

The OB1203 Sensor Module has a fully integrated sensor for reflective photoplethysmography (PPG), a proximity sensor (PS), and a multi-channel light sensor (LS/CS, not used in this application). The OB1203 integrates light sources, drivers, sensors, ADC, and I2C interface in a single optically optimized package.

With the provided algorithm, human heart rate (HR), oxygen saturation (SpO₂), and respiration rate are determined.

The following figure shows the typical application circuit of OB1203.

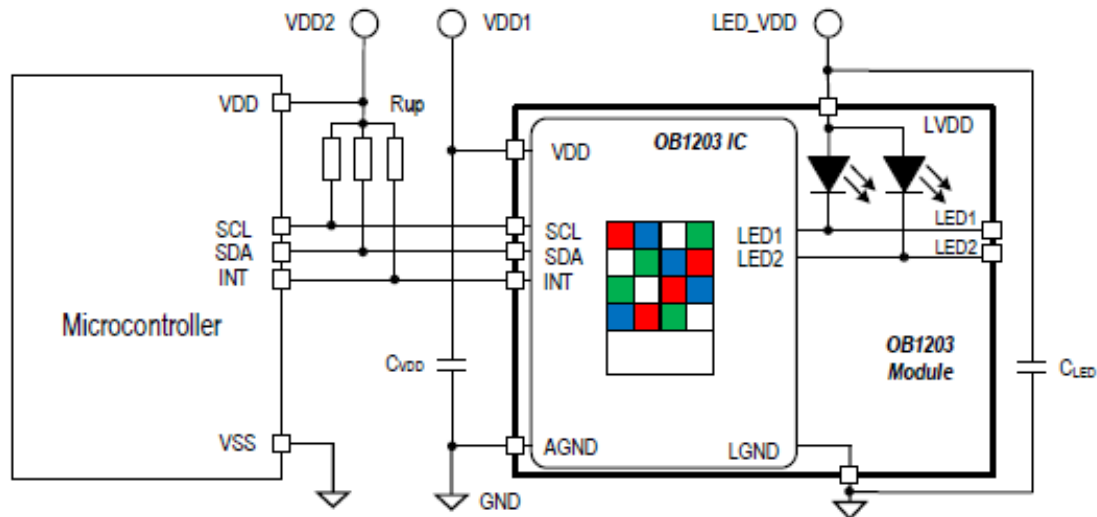


Figure 3. Typical Application Circuit

1.2.1. OB1203 Key Features

1.2.1.1. Biosensor Features

- SpO₂ measurement behind visibly dark, IR transmissive ink
- Industry's smallest optical biosensor module
- Fully integrated and trimmed module, including two LEDs, 250mA maximum drive current, and photodetectors
- Output resolution PPG: 16 to 18 bits
- Data stored in 18-bit wide, 32-sample FIFO memory
- Integrated averaging function for higher signal-to-noise ratio (SNR) and data rate reduction
- Programmable measurement rate: up to 3200 samples per second
- High SNR

1.2.1.2. Biosensor Applications

- Sensor for Heart rate, blood oxygen saturation, and respiration rate
- Secondary sensor for blood pressure
- Fitness and wellness, wearable devices

1.2.1.3. Physical Characteristics

- Highly reliable and industry-proven OSIP package with integrated cover glass for hypoallergenic products
- Wide operation temperature: - 40 to +85°C
- Wide supply voltage: 1.7V to 3.6V
- Low standby current: 2μA typical

- I2C interface capable of Standard Mode or Fast Mode communication; 1.8V to 3.3V logic compatible
- Programmable level-based interrupt functions with upper and lower thresholds for extending battery life
- Industry's smallest package: $4.2 \times 2 \times 1.2$ mm³ 14-OSIP module

1.3 ISL9111 Boost

The ISL9111 is a low input voltage and high-efficiency synchronous boost converter with a 1A switch. The device provides a power supply solution for single-cell, dual-cell, or three-cell alkaline, NiCd or NiMH battery-powered applications. The ISL9111 has a typical 0.8V start-up voltage and can supply up to 5.25V output voltage. It guarantees to supply 100mA from a single-cell input and 240mA from a dual-cell input when the output is 3.3V. High 1.2MHz switching frequency allows the use of tiny, low-profile inductors and ceramic capacitors to minimize the size of the solution.

The following figure shows the typical application circuit of ISL9111.

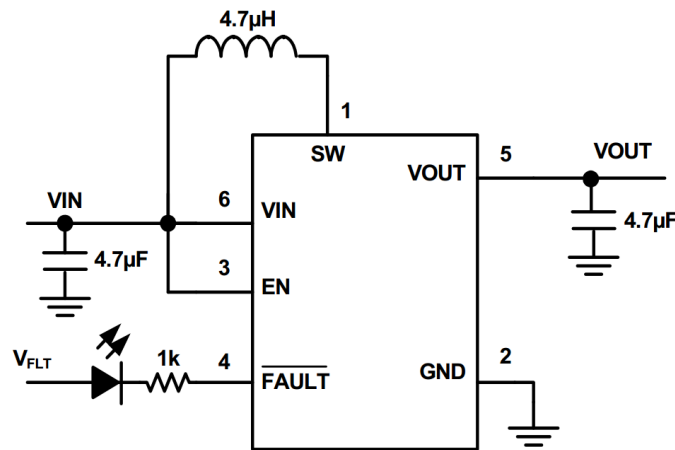


Figure 4. Typical Application Circuit

1.3.1. ISL9111 Key Features

- Up to 97% Efficiency at Typical Operating Conditions
- Minimum Start-up Voltage
 - 0.8V (ISL9111)
 - 0.6V (ISL9111A)
- Minimum Operating Voltage
 - 0.7V (ISL9111)
 - 0.5V (ISL9111A)
- Low Quiescent Current: 20µA (Typical)
- At VOUT = 3.3V
 - 100mA Output Current at VIN = 0.9V
 - 240mA Output Current at VIN = 1.8V
- Logic Control Shutdown ($I_q < 1\mu A$)
- Output Voltage up to 5.25V
- Output Disconnect during Shutdown
- Skip Mode under Light Load Condition
- Undervoltage Lockout (ISL9111 Only)
- Fault Protection: OVP (ADJ Version Only), OTP, Short Circuit
- 6 Ld SOT-23 Package

1.4 Setup and Configuration

The evaluation kit runs on battery power. After switching the battery switch ON, press the power key S1 to start the SpO₂ and HR measurements.

Without target (for example, a finger) or without available SpO₂ or HR data, the OLED displays lines as shown in Figure 5.



Figure 5. No Measurement

Place your finger on the sensor as shown in Figure 3.3. Keep the pressure on the sensor low to avoid blood flow restriction. With the finger on the sensor, the IR LED and red LED light up and the measurement starts. After a few seconds, the SpO₂ and heart rate are displayed (see Figure 6).

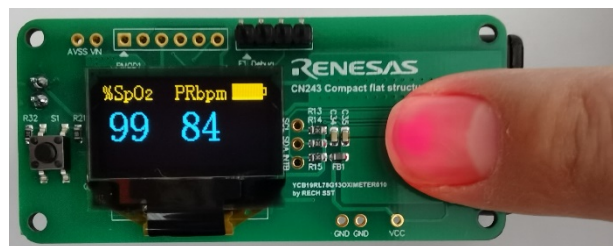


Figure 6. Measurement

2. Board Design

The OB1203 sensor interrupt triggers the MCU to read the sensor data.

The MCU determines blood oxygen saturation, heart and respiration rate, and sends the data via I2C to the OLED display. The OLED displays the data along with the battery status.

The ISL9111 adjusts the voltage of two AAA batteries to the systems supply needs of 3.3V.

The S1 button powers on the system.

The following figures show the board's pictures.

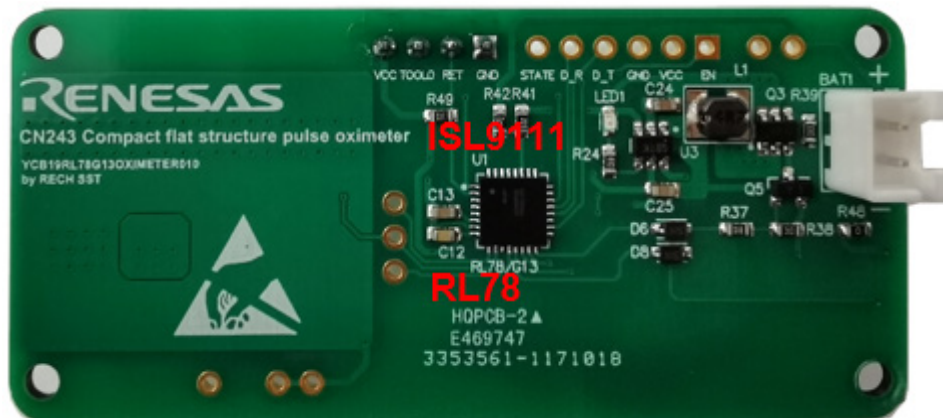


Figure 7. OB1203SD-RL-EVK (Bottom)



Figure 8. OB1203SD-RL-EVK (Top)

2.1 System Outline

The OB1203 (bio-sensor module) integrates a red and IR LED, LED drivers, photodetectors, ADC and I2C module. In PPG mode, it measures the amount of reflected light of the red and infrared LEDs from a target object like a finger. The photodiodes output signals are converted to digital values by the integrated ADC and stored in a FIFO buffer readable via I2C bus.

The MCU calculates oxygen saturation, pulse and respiration rate with the provided algorithm. Oxygen saturation, pulse and respiration rate are displayed on an OLED panel.

The ISL9111 is a low input voltage and high efficiency synchronous boost converter with 1A switch.

The following figure shows the system block diagram.

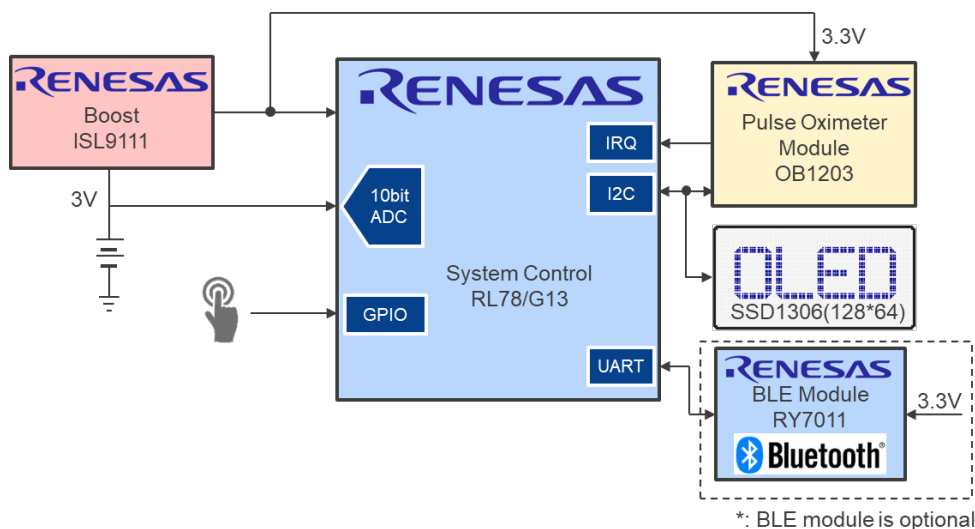


Figure 9. System Block Diagram

2.1.1. Main Components

The following table lists the main components of the evaluation kit.

Table 1. Main Components of the Evaluation Kit

Component	Type	Remark
Photoplethysmography sensor module	OB1203	Renesas part: Heart Rate, Blood Oxygen Concentration, Pulse Oximetry, Proximity, Light and Color Sensor
OLED	SSD1306	Available from local suppliers
Battery	AAA battery	Available from local suppliers
Boost IC (3.3V)	ISL9111	Renesas part
MCU	RL78/G13	Renesas part (R5F100BGA)

2.1.2. MCU Pins Used

The following table lists the used pins and their functions.

Table 2. Pins used

No.	Pin Name	Connection	Function Description	Function Module
1	P31	INTB	Interrupt from HR, SpO ₂ and RR sensor (OB1203)	I2C communication with HR, SpO ₂ and RR sensor (OB1203)
2	P61	SDAA0	IIC data for OB1203	
3	P60	SCLA0	IIC clock for OB1203	
4	P30	SCL11	IIC clock for OLED module	OLED (SSD1306) control
5	P50	SDA11	IIC data for OLED module	
6	P22	ANI2	A/D input	Battery level detection
7	P51	IRQ2	Interrupt input	System power up
8	P70	POWER_ON	I/O for power enable	

2.2 Power Supply

The system's power supply includes the following parts:

- 3.3V boost Circuit
- Power ON Control
- 2 AAA batteries

2.2.1. 3.3V Boost Circuit

The following figure shows the schematic of the boost circuit.

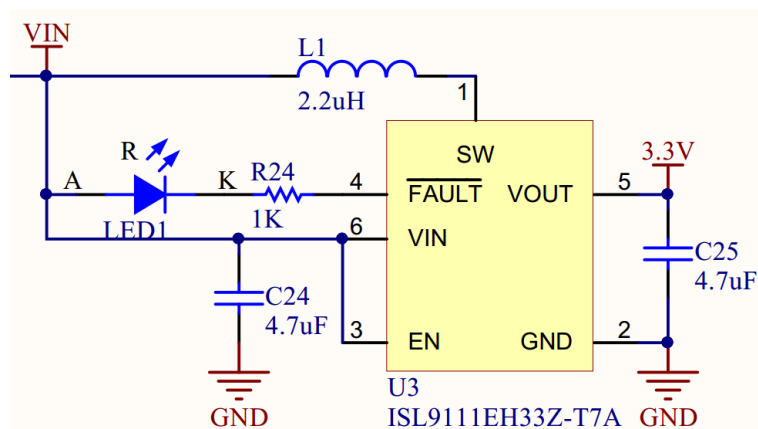


Figure 10. Boost Circuit

The power supply (2 AAA battery) acts as the input (VIN) for the ISL9111 to generate 3.3V system power. The ISL9111 provides a power supply solution for single-cell, dual- or three-cell alkaline, NiCd or NiMH battery-powered applications, capable of sourcing up to 1A output current. This boost converter operates from input voltage of 0.7V to 6.5V. The output voltage of the ISL9111 can be programmed from 2.5V to 5.25V.

2.2.2. Power ON Control

The following figure shows the schematic of power ON control circuit.

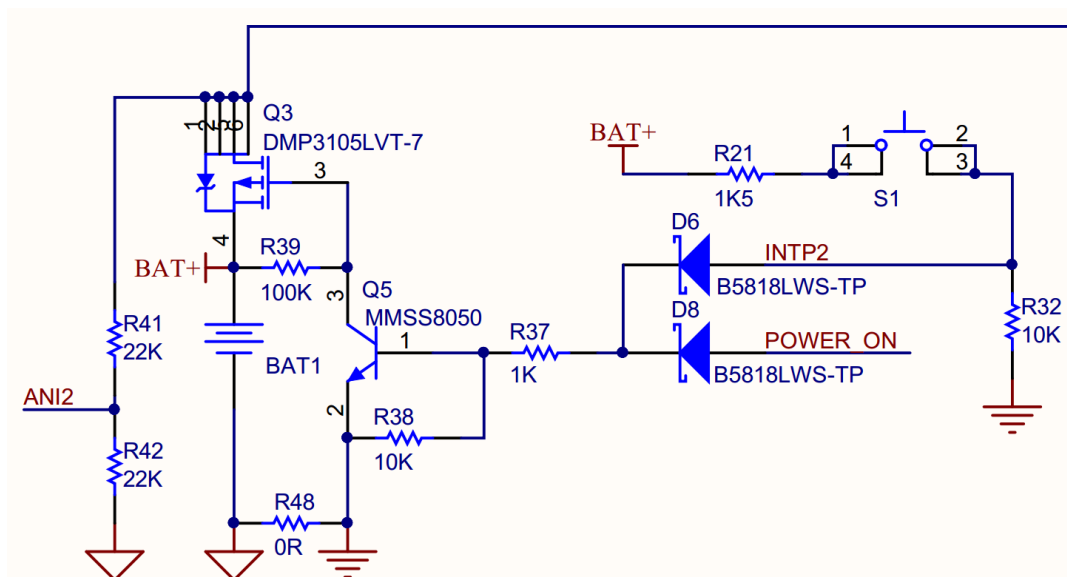


Figure 11. Power ON Control Circuit

When pressing the S1 button, the system is connected to BAT+ through D6, Q5, and the MOSFET Q3. After the MCU's Power-on Reset, the MCU checks on the battery voltage:

- Battery voltage is nominal – The MCU sets the Power_On line high keeping the system powered when S1 is released.
- Battery voltage is low – Power_On is not set high. The MCU is powered off when S1 is released.

2.3 OLED Circuit

The following figure shows the schematic of OLED circuit.

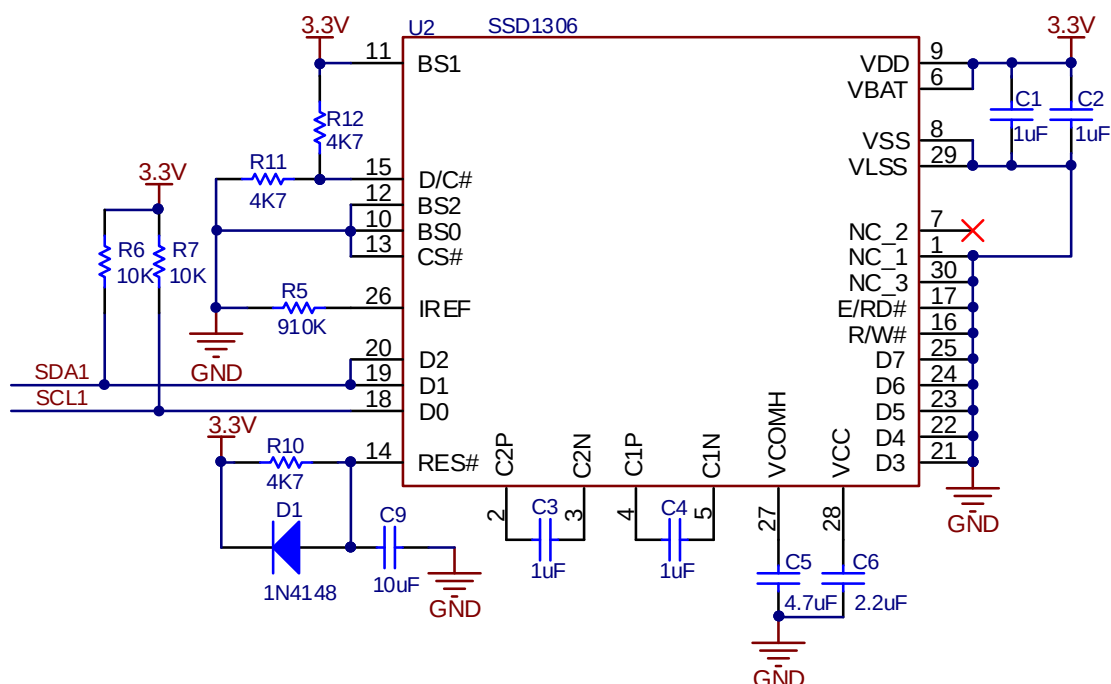


Figure 12. OLED Circuit

OLED display uses SSD1306 as the main control IC. The RL78/G13 communicates with the SSD1306 through I2C in order to control the OLED display.

2.4 OB1203 Circuit

The following figure shows the schematic for the OB1203 circuit.

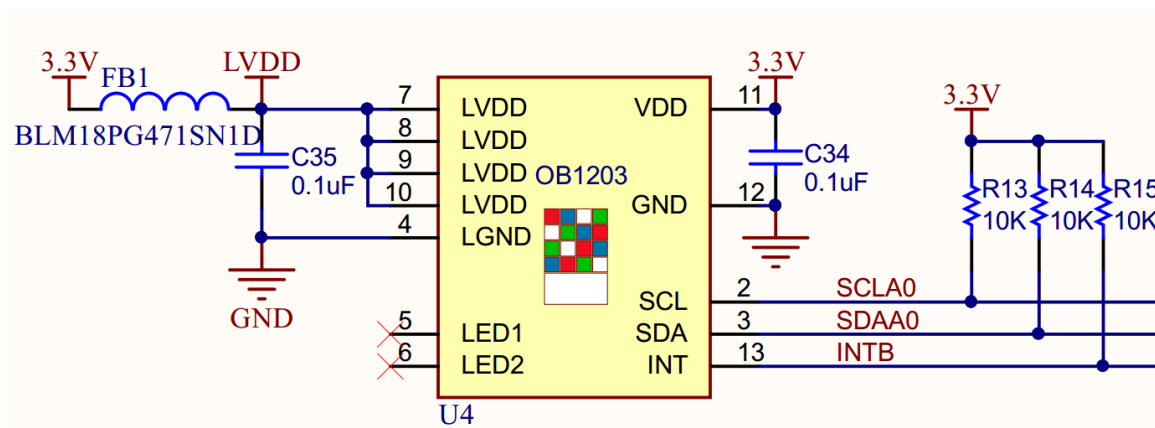


Figure 13. OB1203 Circuit

3. Software

3.1 Integrated Development Environment

The provided code has been developed to run under the conditions listed in the table below.

Table 5.1 Operation Conditions

Item	Description
Microcontroller used	RL78/G13 (R5F100BG,128KB ROM,12KB RAM)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 32MHz CPU/peripheral hardware clock: 32MHz
Operating voltage	3.3V (RL78/G13 at 24MHz: 1.6V - 5.5V; OB1203: 1.7V - 3.6V, IR LED and red LED: 3.3V - 4.5V)
Integrated development environment (e ² studio)	e ² studio V7.6.0 from Renesas Electronics Corp

3.2 Main Process

Figure 14 and Figure 15 show the flowchart for the 'main()' routine and the user initialization routine 'R_MAIN_UserInit()'.

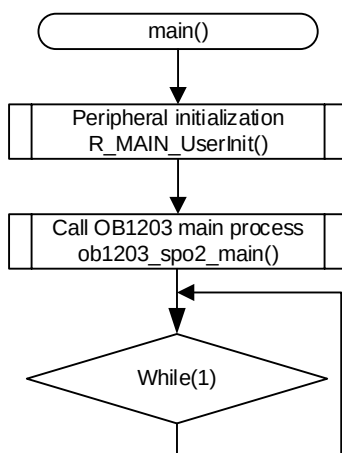


Figure 14. Main Processing Routine

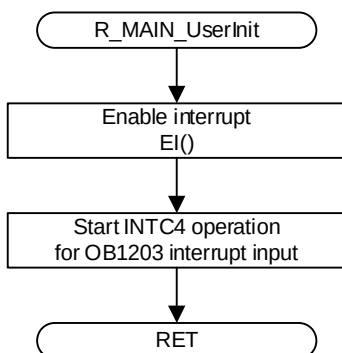


Figure 15. User Initialization Routine

3.3 OB1203 Module Routines

The following figure shows the flowchart of oximeter measure routine.

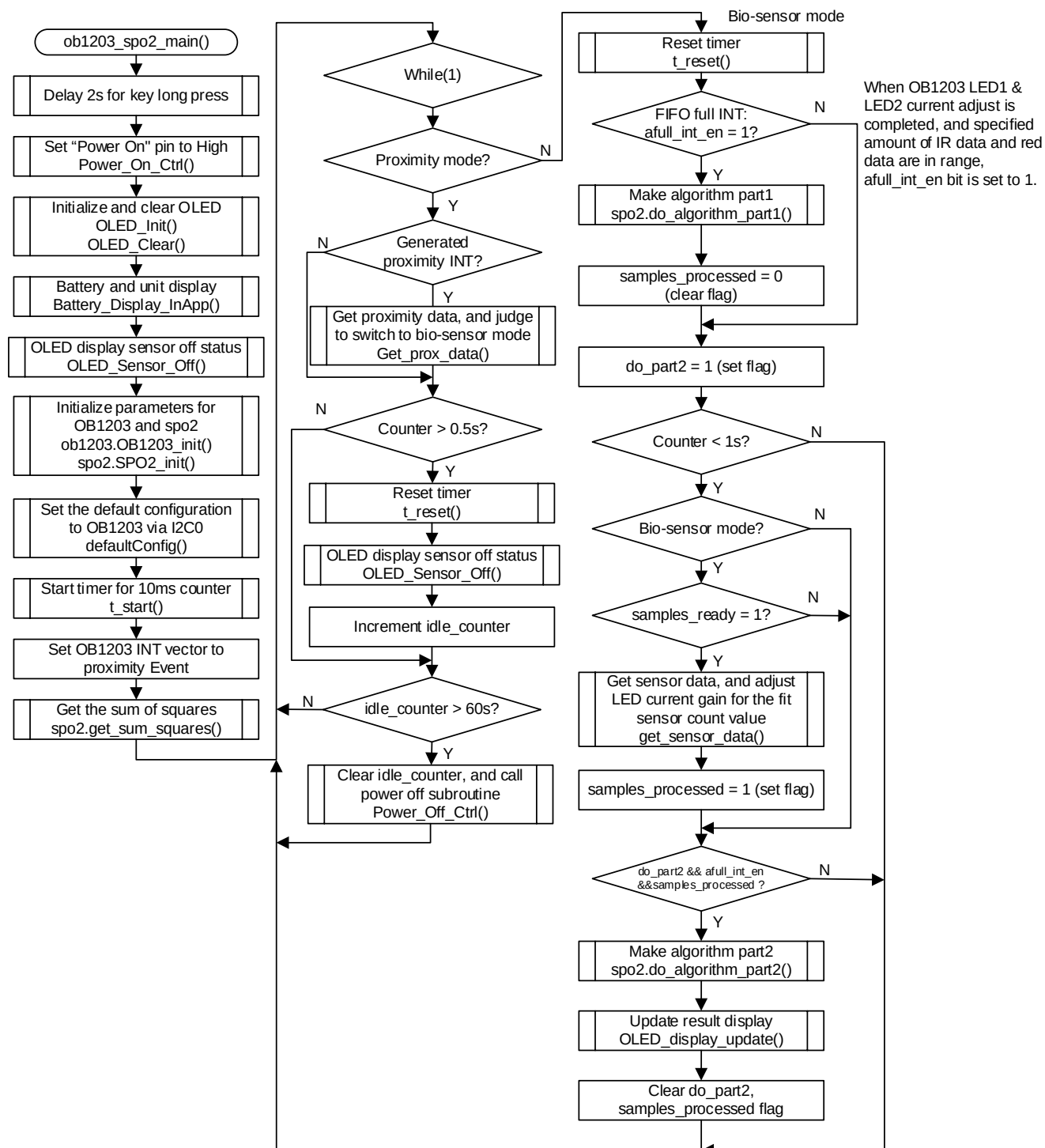


Figure 16. PPG Measurement Routine

4. Related Information

- *RL78/G13 Microcontroller User's Manual: Hardware*
- *OB1203 Datasheet*
- *ISL9111 Datasheet*

5. Ordering Information

Part Number	Description
OB1203SD-RL-EVK	OB1203SD-RL-EVK Evaluation Kit

6. Revision History

Revision	Date	Description
1.0	Feb 24, 2021	Initial release.

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