GR533x Power Consumption Measurement User Guide

Version: 1.5

Release Date: 2025-04-22

Shenzhen Goodix Technology Co., Ltd.

Trademarks and Permissions

GOODiX and other Goodix trademarks are trademarks of Shenzhen Goodix Technology Co., Ltd. All other trademarks and trade names mentioned in this document are the property of their respective holders.

Disclaimer

Information contained in this document is intended for your convenience only and is subject to change without prior notice. It is your responsibility to ensure its application complies with technical specifications.

Shenzhen Goodix Technology Co., Ltd. (hereafter referred to as “Goodix”) makes no representation or guarantee for this information, express or implied, oral or written, statutory or otherwise, including but not limited to representation or guarantee for its application, quality, performance, merchantability or fitness for a particular purpose. Goodix shall assume no responsibility for this information and relevant consequences arising out of the use of such information.

Without written consent of Goodix, it is prohibited to use Goodix products as critical components in any life support system. Under the protection of Goodix intellectual property rights, no license may be transferred implicitly or by any other means.

Shenzhen Goodix Technology Co., Ltd.

Headquarters: 26F, Goodix Headquarters, No.1 Meikang Road, Futian District, Shenzhen, China

TEL: +86-755-33338828 Zip Code: 518000

Website: www.goodix.com

Preface

Purpose

This document introduces features of each GR533x power mode, how to measure power consumptions in different scenarios, as well as reference measurement results, to quickly brief users on the power consumption features of GR533x System-on-Chips (SoCs), based on which to evaluate the power consumption performance of the SoCs.

Audience

This document is intended for:

- Device user
- Developer
- Test engineer
- Technical support engineer

Release Notes

This document is the sixth release of *GR533x Power Consumption Measurement User Guide*, corresponding to GR533x SoC series.

Revision History

Version	Date	Description
1.0	2023-10-18	Initial release
1.1	2023-11-08	Updated the RF PA matching network configuration for SK Board.
1.2	2024-01-16	• Updated the C66 capacitance in GR5331 SPA seven-component matching circuit. • Revised the GND pin indication in the hardware connection diagram.
1.3	2024-07-04	• Updated the section "Overview". • Updated RF PA matching network configurations. • Added a note to describe the system power mode configuration when adopting SPA or HPA.
1.4	2024-09-18	Updated the section "Configuring RF PA Matching Network for SK Board".
1.5	2025-04-22	• Revised the description of active mode in "Power Consumption Modes". • Updated the macro definitions of "CHIP_TYPE" and "SYSTEM_POWER_MODE" in "Firmware Configuration".

Contents

1 Overview

The Goodix GR533x series is a Bluetooth Low Energy (LE) 5.3 System-on-Chip (SoC) based on Arm® Cortex® -M4F CPU core, integrated with Bluetooth LE 5.3 Protocol Stack, a 2.4 GHz RF transceiver, on-chip programmable Flash memory, system SRAM, a rich set of peripherals, and two main power supply schemes (DC-DC and SYS_LDO), making it an ideal choice for low power and cost efficient applications.

1.1 Power Consumption Modes

Typically, GR533x SoCs operate in three modes, as described below.

- Active: The CPU operates at its full speed.
  - The MCU subsystem (including ARM processor, SRAM, and peripherals) remains in active status.
  - The Bluetooth subsystem (including RF Transceiver and Communication Core) remains in active status.
  - The PMU subsystem (including DC-DC, LDO, and real-time counter) remains in active status.
- Idle: The CPU is in idle status with no program running.
- Sleep: HFXO_32M stops running; the MCU subsystem (except Retention SRAM) and the Bluetooth subsystem are powered off. Only the always-on (AON) domain is powered on, to prevent data in the Retention SRAM from being lost, and to power the modules/IOs that can wake up the system from sleep (including Bluetooth LE timer, sleep timer, real time counter, and AON GPIOs).

The system switches between the power modes as shown in the figure below.

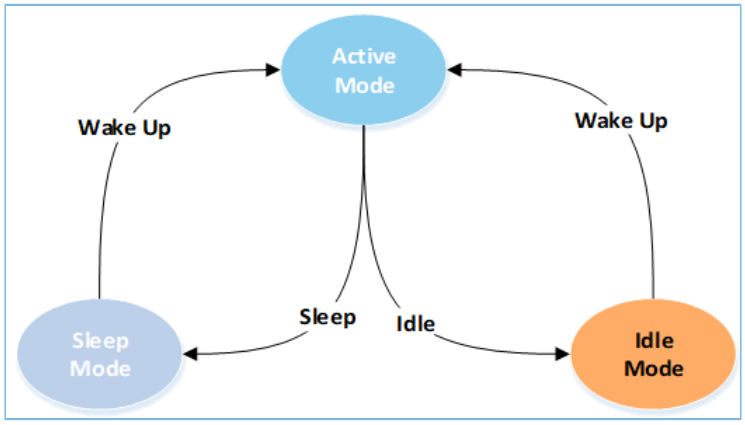

Figure 1-1 Power mode switching mechanism

1.2 Wake-up Sources

GR533x can be woken up from low power modes (idle/sleep) and enter active mode by one of the following sources:

Table 1-1 Wake-up sources

Low Power Mode	Wake-up Sources
Idle	• A reset • An NVIC event

Low Power Mode	Wake-up Sources
	• A debug event
Sleep	• Bluetooth LE controller • LPCOMP module • Real timer counter • Sleep timer • AON GPIO • A reset

1.3 Power Mode Switching Process

Typically (for example, when Bluetooth LE and peripherals are used at the same time), GR533x switches between the power modes by following the process below.

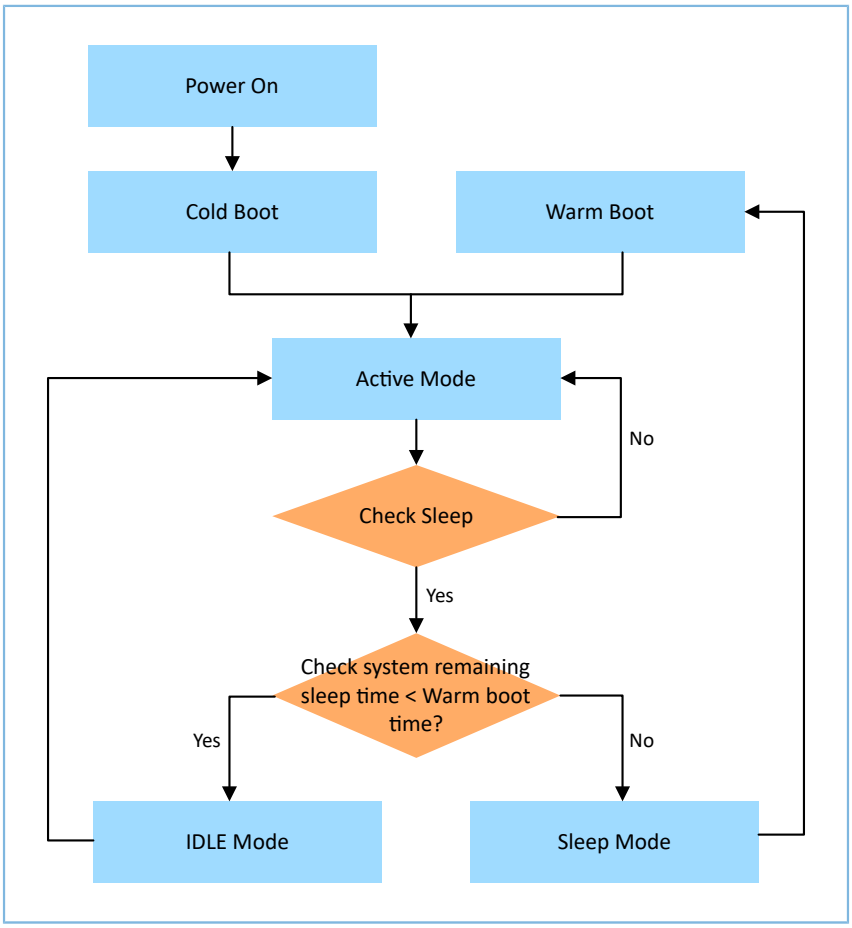

Figure 1-2 Power mode switching process diagram

1. Power on the system and launch a cold boot.
2. The system enters active mode.

3. If there is no logic task to be processed, the system goes into the Check Sleep step, to check whether the system is in idle status.
   - If the check result is “Yes”, compare the system idle time (the sleep time left for Bluetooth LE timer, sleep time, or real time counter) with the warm boot duration.
     - If the left system idle time is shorter than the warm boot duration, the system will enter idle mode.
     - If longer, the system will enter sleep mode, and wait to be woken up.
   - If the check result is “No”, the system remains in active mode.

Note:

Boot time and high boot current are required for the system to enter the warm boot process from sleep mode. When sleep time is relatively short (for example, shorter than 2s), the power consumption reduced is hardly noticeable. Therefore, to ensure better power consumption performance, it is recommended for the system to enter sleep mode only when the sleep time is longer than the time required for system warm boot.

1.4 Test Schemes

In a power consumption test on GR533x SoCs, use a GR5331 Starter Kit Board (SK Board) as the device under test (DUT), GRToolbox to configure test scenarios, and Keysight test platform to measure the current, as shown in the diagram below.

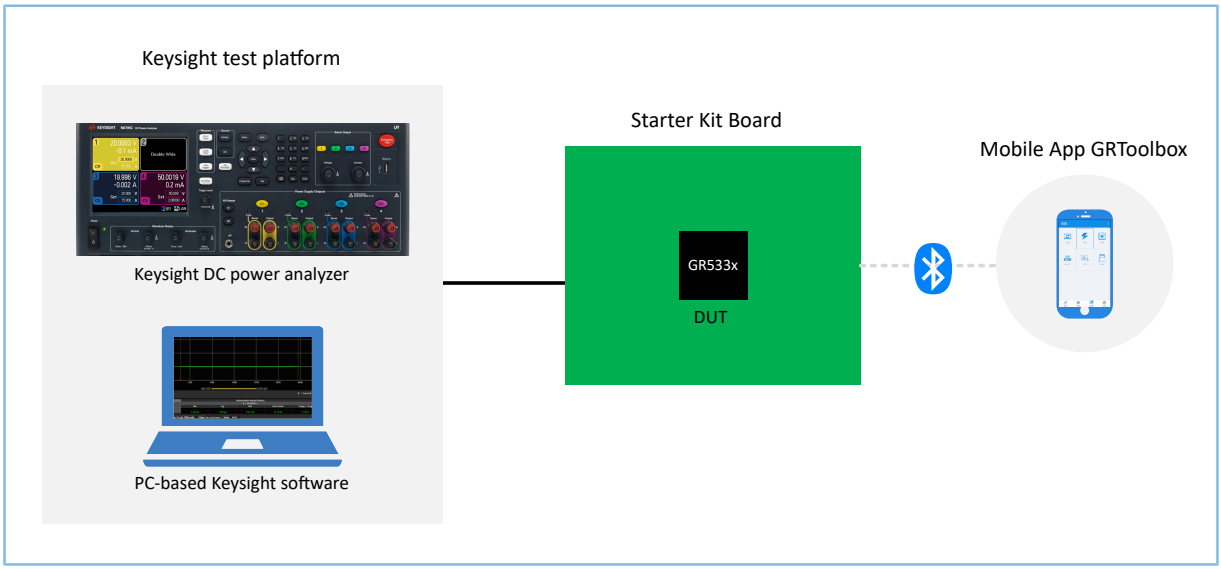

Figure 1-3 Diagram for measuring GR533x power consumption

- SK Board: DUT, where the GR533x SoC is based on. Download the firmware for power consumption measurement before the measurement starts.

Note:

By default, the SK Board is equipped with a GR5331CENI SoC, which can be replaced with other GR533x SoCs to perform corresponding tests.

- Keysight test platform: composed of Keysight N6705C DC Power Analyzer (hardware) and Keysight 14585A Control and Analysis (software). Keysight N6705C measures the average and the peak voltages and currents of a period, and displays the measurement results in curves. The sampling period and cycle can be set on Keysight 14585A.
- GRToolbox: Goodix proprietary mobile App for Bluetooth debugging which enables connection to DUTs and sets the Bluetooth PHY mode and power consumption parameters of the DUTs

2 Environment Setup

This chapter describes how to set up the environment for measuring the power consumption of GR533x SoCs, covering hardware and software preparation, software installation, firmware configuration, and hardware connection.

2.1 Preparation

- Hardware preparation

Table 2-1 Hardware preparation

Name	Description
Keysight N6705C	DC power analyzer launched by Keysight
SK Board	*GR5331-SK-BASIC-RevC*, which works as the DUT
J-Link debug probe	JTAG emulator launched by SEGGER. For more information, visit http://www.segger.com/products/debug-probes/j-link/.
USB Type-C cable	Used to connect the SK Board to the PC
USB-A to USB-B cable	Used to connect Keysight N6705C to the PC
PC	Used for Keysight 14585A for power consumption analysis
Mobile phone	Where GRToolbox runs

- Software preparation

Table 2-2 Software preparation

Name	Description
J-Link driver	A J-Link driver. Available at http://www.segger.com/downloads/jlink/.
Keil MDK5	An integrated development environment (IDE). Available at http://www.keil.com/download/product/.
GR533x SDK	GR533x software development kit (SDK), containing a rich set of example projects (such as ble_app_pcs, the project for power consumption measurement). Available at http://www.goodix.com/en/software_tool/gr533x_sdk
GRToolbox (Android)	Goodix proprietary mobile App for Bluetooth debugging, used to set the scenarios for power consumption measurement. Available at http://www.goodix.com/en/software_tool/grtoolbox
GProgrammer	A programming tool, used to download the firmware for power consumption measurement. Available at http://www.goodix.com/en/software_tool/gprogrammer_ble
Keysight 14585A	Power control and analysis software launched by Keysight

2.2 Software Installation

- Install GR533x SDK.

  GR533x SDK is installation-free, available in a .zip file, which can be used directly after extraction.

- Install the IDE.

  A proper IDE (such as Keil MDK5) is to compile the example project, so as to generate application firmware. To install the IDE, download the installation file, and follow the steps of the installation wizard.

- Install GProgrammer.

  The PC-based software is used to download application firmware to the SK Board, applicable for Windows/Linux. You can choose a proper version for installation based on project needs.

- Install Keysight 14585A.

  1. Download the installation file, and follow the steps of the installation wizard.
  2. After installation, double-click  on the desktop to launch Keysight 14585A.

- Install J-Link drivers.

  J-Link drivers are required for normal operation of the J-Link debug probe.

  1. Download the installation file, and follow the steps of the installation wizard.
  2. After installation completes, users can find the SEGGER folder. Alternatively, users can check whether the installation is successful by connecting a J-Link Commander test board and observing whether it can be correctly identified by J-Link.

- Install GRToolbox.

  GRToolbox is provided in an .apk installation file. Users can import the installation package to a mobile phone before installation, or directly download the App from an Android application store.

2.3 Configuring RF PA Matching Network for SK Board

To measure the RF power consumption of GR533x at an optimal RF efficiency, choose an appropriate RF PA matching network based on the SoC part number in use, as well as the type of the RF power amplifier (PA).

Table 2-3 RF PA matching network selection

PA Type	TX Power (dBm)	SoC Series	
		GR5332	GR5331/GR5330
HPA	-10 to 15	Six-component matching network	/
SPA	GR5332: -20 to 5 GR5331/GR5330: -20 to 6	Six-component matching network	Seven-component matching network
UPA	-15 to 2	/	Five-component matching network

2.3.1 RF PA Matching Network Parameters

The RF PA matching network (in the orange square in the figure below) on the SK Board is composed of C12, C13, C66, C101, L2, L3, L6, and C9. It can be configured as a seven-/six-/five-component matching network by adjusting the values of the matching components.

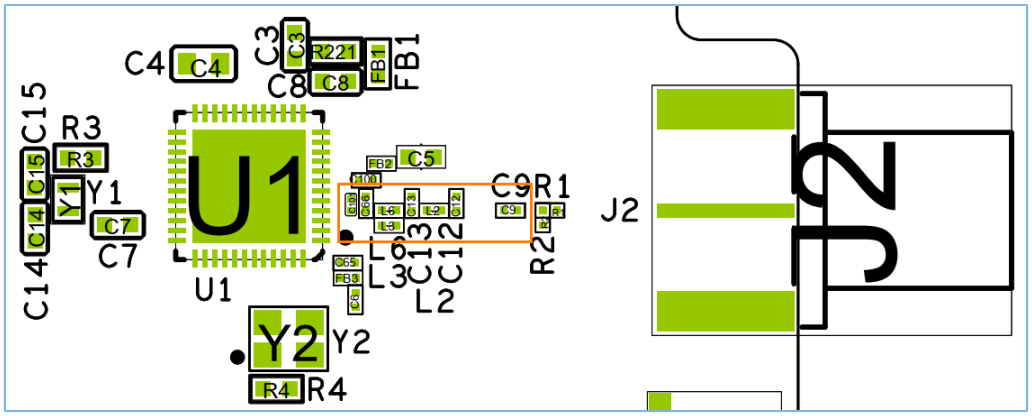

Figure 2-1 RF PA matching component layout

Recommended components of the RF PA matching network are provided in the table below.

Table 2-4 Recommended RF PA matching components

Component Type	Reference	Value		
		Six-component matching network	Seven-component matching network	Five-component matching network
Capacitor	C9	18 pF	18 pF	18 pF
Capacitor	C12	0.8 pF	0.8 pF	1.0 pF
Capacitor	C13	2.0 pF	2.0 pF	1.8 pF
Capacitor	C66	2.5 pF	2.0 pF	NC
Capacitor	C101	NC	0.3 pF	0.3 pF
Inductor	L2	2.2 nH	2.0 nH	2.4 nH
Inductor	L3	1.6 nH	1.6 nH	2.4 nH
Inductor	L6	2.4 nH	2.4 nH	0 R

Note:

1. The blocking capacitor C9 (18 pF) cannot be omitted.
2. “NC” indicates that no components are connected.
3. “0 Ω” indicates that a 0 Ω resistor is used.

2.3.2 RF Matching Circuit

2.3.2.1 Six-component Matching Network (HPA/SPA)

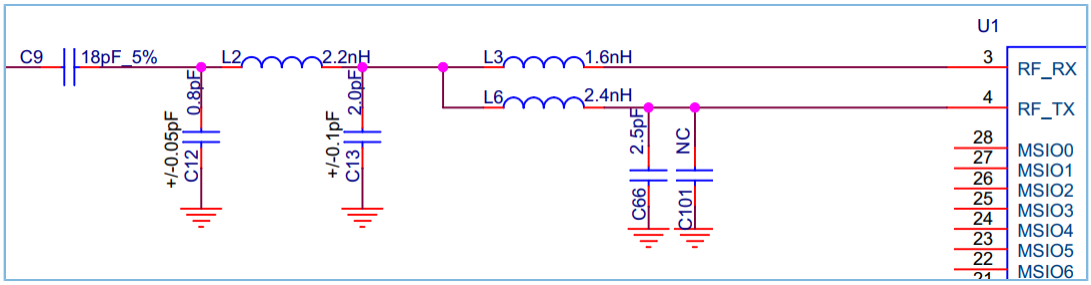

Figure 2-2 Six-component matching network for GR5332 (PA = HPA/SPA)

2.3.2.2 Seven-component Matching Network (SPA)

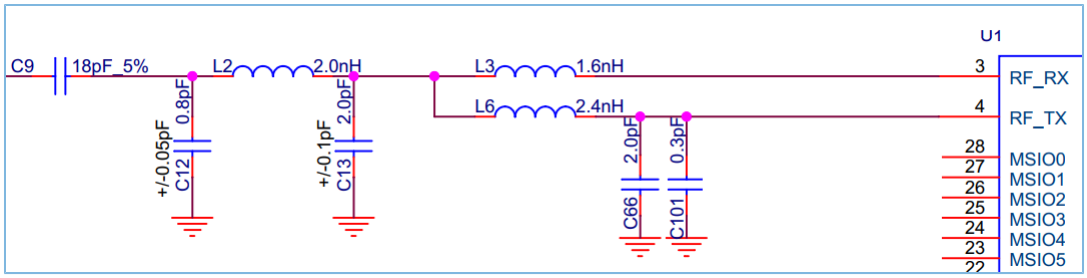

Figure 2-3 Seven-component matching network for GR5331/GR5330 (PA = SPA)

2.3.2.3 Five-component Matching Network (UPA)

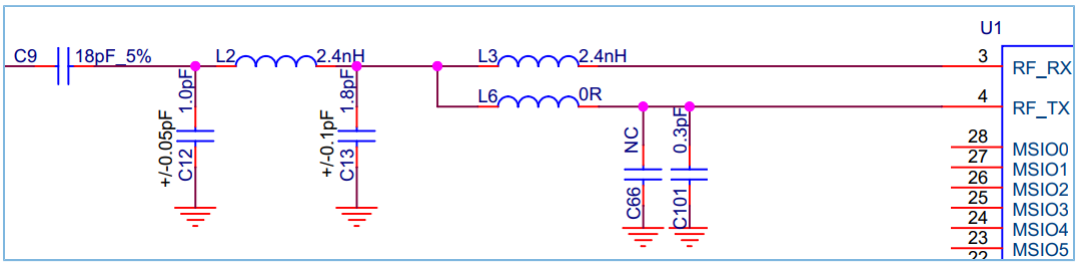

Figure 2-4 Five-component matching network for GR5331/GR5330 (PA = UPA)

2.4 Hardware Connection

Connect the devices used for GR533x power consumption measurement as shown in the figure below.

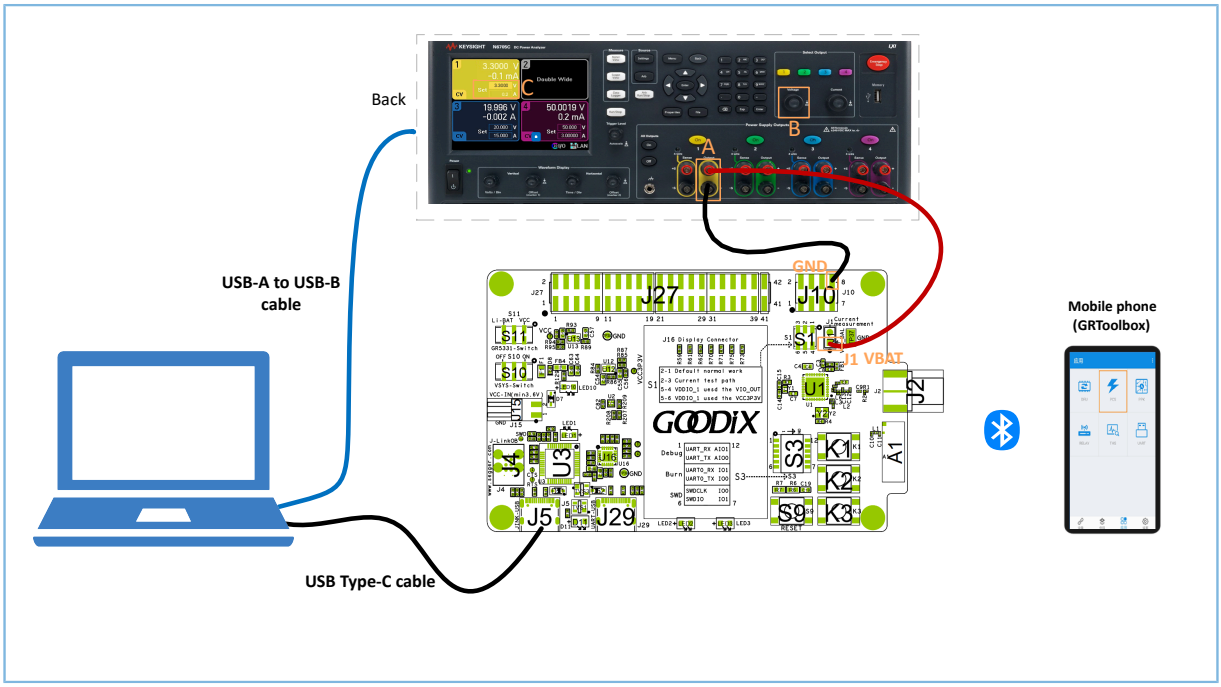

Figure 2-5 Hardware connection for GR533x power consumption measurement

Settings and connection details are elaborated in the sections below.

2.4.1 SK Board

Follow the steps below to configure and connect to the SK Board.

1. Configure the SK Board.

   (1) Toggle S10 to the right (the side printed with **ON**) to enable system power supply, so as to power on the SK Board.

   (2) Toggle S11 to the right (the side printed with **VCC**), to supply the GR533x SoC with the on-board 3.3 V power (VCC).

   (3) Toggle all the six switches of S3 to the left (the side printed with **1** and **6**), to avoid voltage leakage path formed with SoC pins and SK Board peripheral circuits, which undermines the accuracy of power consumption measurement.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC.

---

   (4) Toggle the upper switches of S1 to the left (to short connect Pin 2 and Pin 3), and the lower switches to the right (to short connect Pin 4 and Pin 5).

2. Connect the PC and the SK Board (through J5/JLINK_USB port) with a USB Type-C cable, to supply the peripheral circuits of the SK Board.

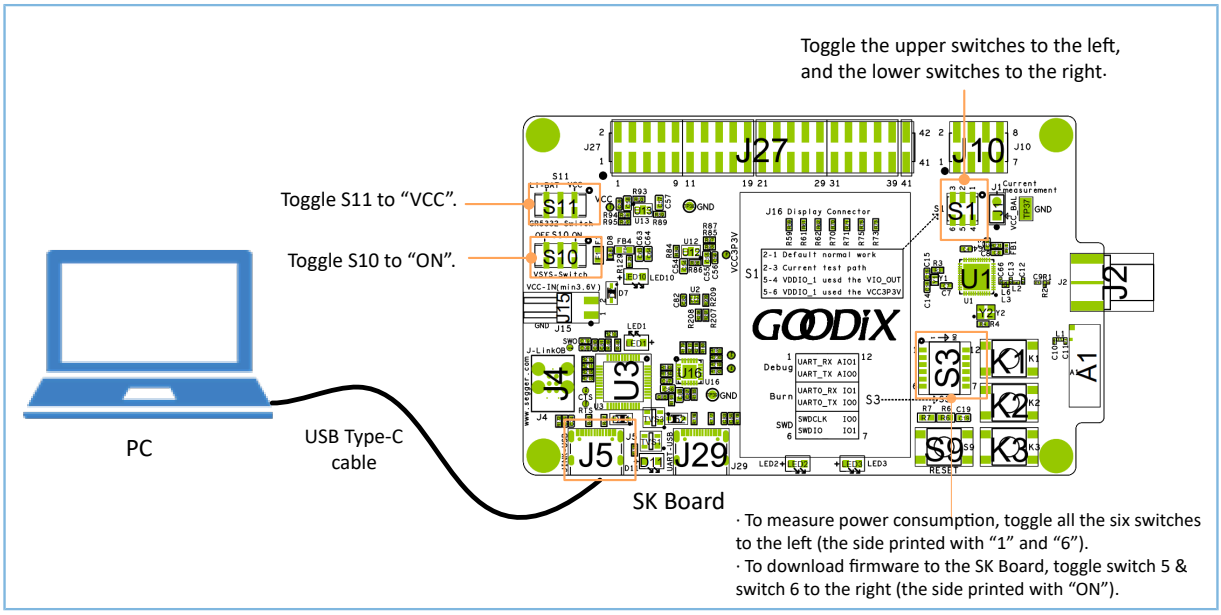

Figure 2-6 SK Board settings and connection to PC

2.4.2 Power Analyzer

Configure the DC power analyzer (Keysight N6705C), and connect the power analyzer to SK Board and PC by following the steps below.

1. Set the Keysight N6705C DC power analyzer.

   Power on Keysight N6705C, and turn the knob (at Location B in the figure below), to set the output channel voltage, until the display (at Location C in the figure below) shows voltage at 3.3 V, and current up to 0.2 A.

2. Connect Keysight N6705C with the SK Board.

   Connect the VCC port “+” of Keysight N6705C (the red channel at Location A in the figure below) to VCC_BAL on the SK Board (pin 1 of J1); connect the GND port “-” of Keysight N6705C (the black channel at Location A in the figure below) to GND on the SK Board (such as pin 8 of J10) to supply the SK Board, as shown in the figure below.

3. Connect Keysight N6705C to the PC.

   Connect Keysight N6705C (from the USB port on the back of the analyzer) to the PC with a USB-A to USB-B cable.

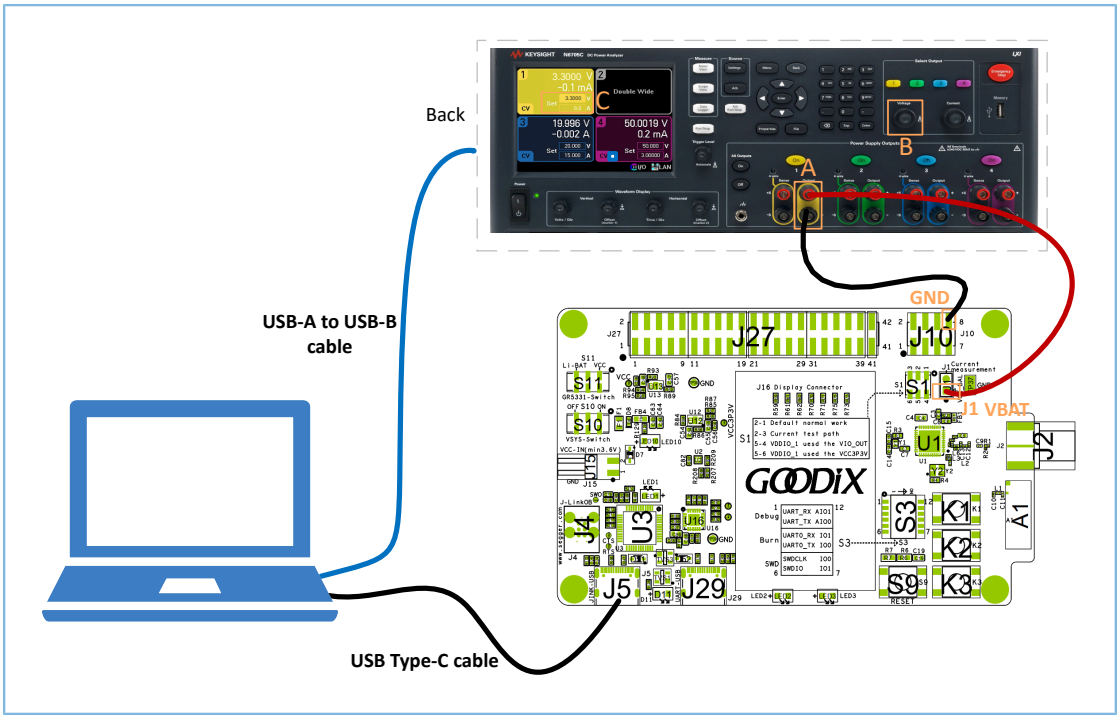

Figure 2-7 Connection to Keysight N6705C

2.5 Firmware Configuration

GR533x SDK provides an example project ble_app_pcs (available in `SDK_Folder\projects\ble\ble_peripheral\ble_app_pcs`, and SDK_Folder is the root directory of GR533x SDK) that allows users to generate the firmware for power consumption measurement after configurations and compilation based on the actual scenario.

1. Open *custom_config.h* (in `ble_app_pcs\Src\config`) of the ble_app_pcs project and make configurations.

Tip:

Alternatively, users can open **Configuration Wizard** in Keil to configure macros in *custom_config.h*.

- Set the CHIP_TYPE value based on the SoC part number in use.

  For example, if the SoC in use is GR5332CENE, set the CHIP_TYPE value to **4**.

```
// <o> Chip version
#ifndef SOC_GR533X
#define SOC_GR533X
#endif

// <o> Select chip type
// <0=> GR5330AENI
// <1=> GR5331AENI
// <2=> GR5331CENI
// <3=> GR5332AENE
// <4=> GR5332CENE
// <5=> GR5331DEBI
#ifndef CHIP_TYPE
#define CHIP_TYPE                       4
```

```
#endif
```

- Turn off boot delay by setting the BOOT_LONG_TIME value to **0**.

```
// <o> Delay time for Boot startup
// <0=> Not Delay
// <1=> Delay 1s
#ifndef BOOT_LONG_TIME
#define BOOT_LONG_TIME                  0
#endif
```

- Enable PMU calibration by setting the PMU_CALIBRATION_ENABLE value to **1**.

```
// <o> Enable PMU Calibration
// <0=> DISABLE
// <1=> ENABLE
#ifndef PMU_CALIBRATION_ENABLE
#define PMU_CALIBRATION_ENABLE          1
#endif
```

- Set the accuracy of the low-frequency clock used for sleep to 500 ppm by setting the CFG_LF_ACCURACY_PPM value to **500**.

```
// <o> External clock accuracy used in the LL to compute timing  <1-500>
// <i> Range: 1-500
#ifndef CFG_LF_ACCURACY_PPM
#define CFG_LF_ACCURACY_PPM             500
#endif
```

- Choose the suitable low-speed clock as per the requirements for power consumption measurement.

  To use the on-chip low-speed clock LFRC_32K, set the CFG_LPCLK_INTERNAL_EN value to **1**; to use the external low-speed clock LFXO_32K, set the CFG_LPCLK_INTERNAL_EN value to **0**.

```
// <o> Enable internal osc as low power clock
// <0=> Default: Disable internal osc as low power clock
// <1=> Enable internal osc as low power clock and force CFG_LF_ACCURACY_PPM to 500ppm
#ifndef CFG_LPCLK_INTERNAL_EN
#define CFG_LPCLK_INTERNAL_EN           1
#endif
```

- Set the program loading address and running address.

  Set the program loading address to **0x00202000** (Flash) in APP_CODE_LOAD_ADDR, and set the program running address to **0x00202000** (Flash XIP) in APP_CODE_RUN_ADDR.

```
// <o> Code load address
// <0x00202000=> Flash address
// <i> Default:  0x00202000(Flash)
#ifndef APP_CODE_LOAD_ADDR
#define APP_CODE_LOAD_ADDR              0x00202000
#endif

// <o> Code run address
// <0x20002000=> SRAM address
// <0x00202000=> Flash address
```

```
// <i> Default:  0x00202000(Flash XIP)
#ifndef APP_CODE_RUN_ADDR
#define APP_CODE_RUN_ADDR               0x00202000
#endif
```

- Set the system power mode in SYSTEM_POWER_MODE (0: supplied by DC-DC; 1: supplied by SYS_LDO), as required by power consumption measurement.

```
// <o> System power mode
// <0=> DCDC MODE
// <1=> SYSLDO MODE(if BLE_RF_TX_MODE_HPA_MODE used, SYSLDO must be used)
#ifndef SYSTEM_POWER_MODE
#if (RF_TX_PA_SELECT == 3)
#define SYSTEM_POWER_MODE                1
#else
#define SYSTEM_POWER_MODE                0
#endif
#endif
```

- Set the system clock frequency (0: 64 MHz; 3: 16 MHz) in SYSTEM_CLOCK, as required by power consumption measurement.

```
// <ol.0..5> System clock
// <0=> 64MHZ
// <1=> 32MHZ
// <2=> 16MHZ-XO
// <3=> 16MHZ
// <4=> 8MHZ
// <5=> 2MHZ
#ifndef SYSTEM_CLOCK
#define SYSTEM_CLOCK                    0
#endif
```

2. Modify the main() function.

   Comment out the following code in the main() function of the ble_app_pcs project (in `ble_app_pcs\Src\user\main.c`).

```
    if (is_enter_ultra_deep_sleep())
    {
        pwr_mgmt_ultra_sleep(0);
    }
```

3. Set the power mode that the system will enter when it is idle.

   Open *user_periph_setup.c* (in `ble_app_pcs\Src\platform\`) of the ble_app_pcs project, and modify the pwr_mgmt_mode_set() function called by the void app_periph_init(void) function, to set the power mode that the system will enter when it is idle.

```
void app_periph_init(void)
{
    SYS_SET_BD_ADDR(s_bd_addr);
    wkup_key_init();
    pwr_mgmt_mode_set(PMR_MGMT_SLEEP_MODE);
```

```
}
```

Three power modes can be set: PMR_MGMT_ACTIVE_MODE, PMR_MGMT_IDLE_MODE, and PMR_MGMT_SLEEP_MODE. It is recommended to keep the default setting (PMR_MGMT_SLEEP_MODE, to have the system enter sleep mode when it is idle) unless otherwise required by a power consumption measurement scenario.

2.6 Bluetooth Parameter Settings

Set the Bluetooth advertising parameters/connection parameters prior to power consumption measurement in advertising/connection scenarios.

2.6.1 Bluetooth Advertising Parameters

Open *user_app.c* (in `ble_app_pcs\Src\user`) of the ble_app_pcs project, and set the Bluetooth advertising parameters as required by a power consumption measurement scenario.

1. Set the device name, advertising interval, and advertising duration.

```
/*
 * DEFINES
 *****************************************************************************************
 */
#define DEVICE_NAME           "Goodix_Power"   /**< Device Name which will be set in GAP. */
#define APP_ADV_INTERVAL     1600   /**< The advertising interval (in units of 0.625 ms). */
#define APP_ADV_TIMEOUT      3000   /**< Advertising timeout (in units of 10ms). */
```

- Set the advertising name of the Bluetooth device by configuring DEVICE_NAME. The default name is “Goodix_Power”.
- Set the advertising interval by configuring APP_ADV_INTERVAL, in the unit of 0.625 ms. For example, when APP_ADV_INTERVAL is set to **1600**, the advertising interval is 1600 x 0.625 ms = 1000 ms.
- Set the advertising duration by configuring APP_ADV_TIMEOUT, in the unit of 10 ms. For example, when APP_ADV_TIMEOUT is set to **3000**, the advertising duration is 3000 x 10 ms = 30s.

2. Set the advertising TX power.

   Set the TX power by adding the ble_gap_tx_power_set() function in the ble_evt_handler() function in *user_app.c*.

   The last parameter in the ble_evt_handler() function is used to set the TX power. For example, to set the TX power to 5 dBm, add the function as follows: ble_gap_tx_power_set(BLE_GAP_ACTIVITY_ROLE_ADV,p_evt->evt.gapm_evt.index, 5).

```
void ble_evt_handler(const ble_evt_t *p_evt)
{
    switch(p_evt->evt_id)
    {
        case BLE_COMMON_EVT_STACK_INIT:
            ble_app_init();
            break;

        case BLE_GAPM_EVT_ADV_START:
            ble_gap_tx_power_set(BLE_GAP_ACTIVITY_ROLE_ADV,p_evt->evt.gapm_evt.index, 5)
```

```
            break;

        case BLE_GAPC_EVT_PHY_UPDATED:
            app_gap_phy_update_handler(p_evt->evt.gapc_evt.index, p_evt->evt_status);
            break;

        case BLE_GAPC_EVT_CONN_PARAM_UPDATE_REQ:
            ble_gap_conn_param_update_reply(p_evt->evt.gapc_evt.index, true);
            break;

        case BLE_GAPC_EVT_CONN_PARAM_UPDATED:
            app_gap_connection_update_handler(p_evt->evt.gapc_evt.index, p_evt->evt_status,
 &(p_evt->evt.gapc_evt.params.conn_param_updated));
            break;
    }
}
```

2.6.2 Bluetooth Connection Parameters

Set the Bluetooth connection parameters based on the measurement scenario in the mobile App GRToolbox, by following the steps below.

1. Run GRToolbox, and tap **Application** > **PCS**.

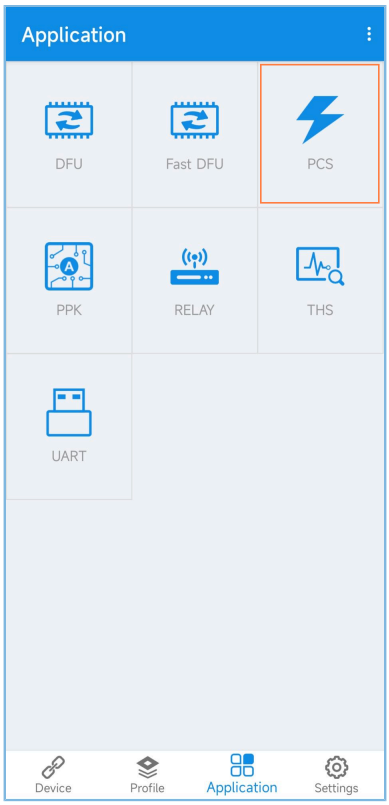

Figure 2-8 Choosing **PCS**

2. Tap **CONNECT** at the bottom of the **PCS** page, to start scanning until the target Bluetooth device (such as “Goodix_Power”, which can be modified in *user_app.c*) is found.

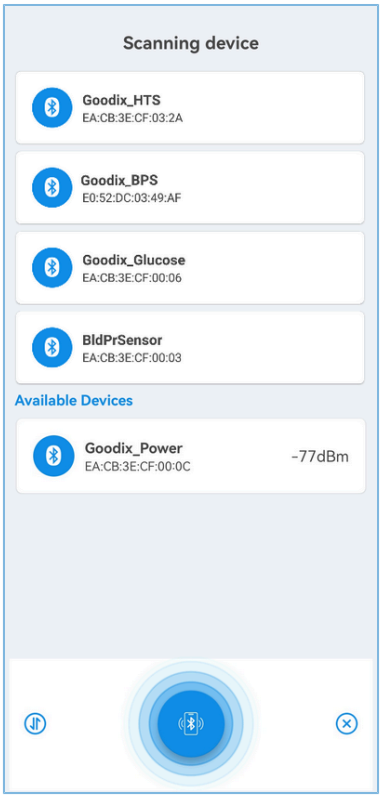

Figure 2-9 Searching for the target device

3. Tap and connect to the target device, to enter the **PCS** page (as shown in the figure below). Set the Bluetooth connection parameters as required by the specific measurement scenario.

   - **Adv Interval** and **Adv Data** can only be set through firmware configurations (as described in "Section 2.5 Firmware Configuration"), and cannot be configured in GRToolbox.
   - Settings on **Tx Power**, **Connection Param**, and **PHY Mode** are only valid for the current connection.
   - As for **Connection Param**, the value entered:the actual valid value is in a ratio of 1:1.25. For example, if the connection parameter is set to 20, the actual connection parameter is 20 x 1.25 ms = 25 ms.

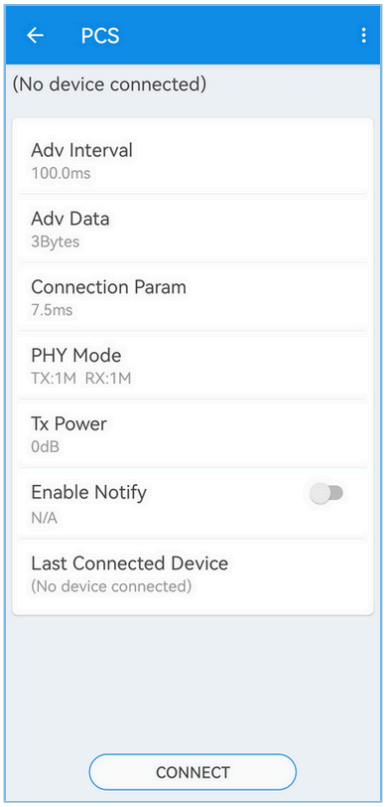

Figure 2-10 **PCS** page for scenario settings

3 Measurement Method and Reference Values

This chapter elaborates on how to measure power consumption of GR533x SoCs in various scenarios, and provides reference data on power consumption, to provide users with better knowledge about the power consumption of GR533x SoCs.

3.1 Required Settings

Unless otherwise specified, power consumption of GR533x SoCs is measured under the following conditions.

Table 3-1 Basic conditions for GR533x power consumption measurement

Item	Requirement	Remarks
Power supply	VBAT = 3.3 V	
Temperature	25°C	
CPU	WFI/WFE	
Peripheral	All peripherals are in idle status.	
Clock	System clock = 64 MHz @ HFRC Low clock = 32.768 kHz @ LFXO_32K	
Flash clock	64 MHz	
Core RAM	Full 96 KB retention	In active mode, full 96 KB RAM is powered; in sleep mode, full 96 KB RAM is retained.
Cache	Enabled, four-way associated	Only applied when the CPU is running from Flash memory
Bluetooth LE Protocol Stack	Enabled	
Bluetooth LE PHY	1 M PHY	
32 MHz XO	32 MHz	Only applied when the high-frequency XO (HFXO_32M) is running, and HFXO_32M is used when the radio is running.
32 kHz XO	32.768 kHz	Only applied when the low-frequency XO (LFXO_32K) is running.
Clock precision in sleep mode	500 ppm	
BOD/IO_LDO	BOD enabled, I/O LDO on	
DC-DC/CORE_LDO	DC-DC = 1.05 V/CORE_LDO = 0.90 V	
AON_LDO/RET_LDO	AON_LDO = 0.85 V/RET_LDO = 0.75 V	
VDDIO	3.3 V	
Regulator	DC-DC	
Flash power mode	Standby mode	In active mode, Flash is powered on; in sleep mode, Flash is powered off.

Item	Requirement	Remarks
Compiler version	MDK-Arm Plus 5.26.2.0	
SDK version	GR533x_SDK_V1.0.2	
Power analyzer	Set Keysight N6705C to measure single-channel current, with precision at 0.02048 ms.	To measure power consumption, set the precision of the power analyzer to the highest.

3.2 Power Consumption in Sleep Mode

This section describes how to measure the power consumption of GR533x SoC when it is in sleep mode.

- Steps:
  1. Connect the SK Board, Keysight N6705C, and the PC as described in “Section 2.4 Hardware Connection.
  2. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
  3. Configure the firmware for power consumption based on the scenario, by referring to “Section 2.5 Firmware Configuration”. Please note that the SoC should be set to enter sleep mode when it is idle.
  4. Set the advertising interval to 1s, and advertising duration to 30s, as described in “Section 2.6.1 Bluetooth Advertising Parameters”.
  5. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

  6. Set the sampling duration to 10s.
  7. Reset the SK Board and power on the SoC.
  8. Enter the **Data Logger** function page by clicking 

. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
  9. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  The power consumption waveform of the SoC when it enters sleep mode can be (the SoC is in sleep mode between two advertisements):

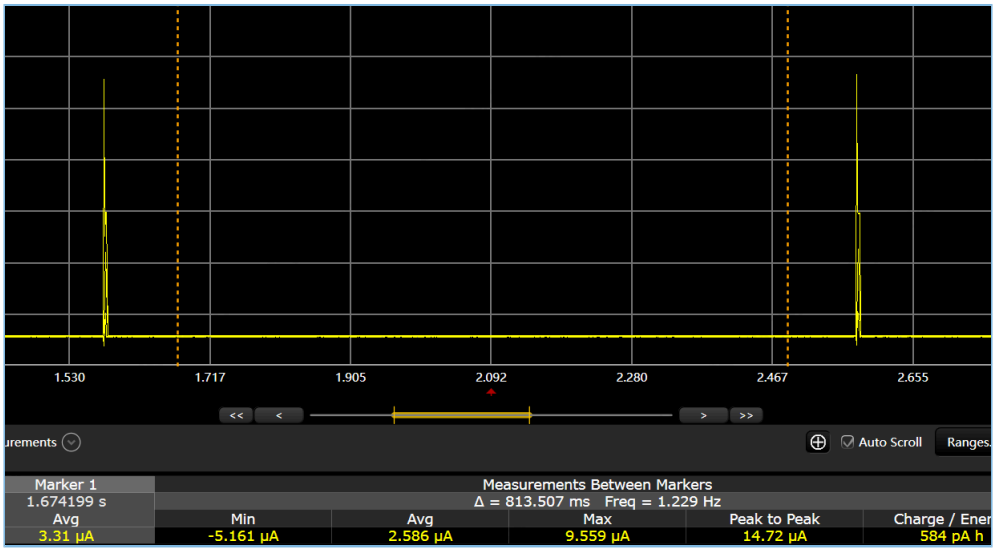

Figure 3-1 Power consumption waveform for SoC in sleep mode

Reference power consumption data is shown as follows.

Table 3-2 Reference power consumption data for SoC in sleep mode

Scenario	**Average Current (µA)**	
	LFXO_32K	**LFRC_32K**
Sleep mode	2.6	2.5

3.3 Power Consumption in Idle Mode

This section describes how to measure the total power consumption of GR533x SoC (including the COMM subsystem) when it is in idle mode.

- Steps:
  1. Connect the SK Board, Keysight N6705C, and the PC as described in “Section 2.4 Hardware Connection”.
  2. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
  3. Configure the firmware for power consumption based on the scenario, by referring to “Section 2.5 Firmware Configuration”. Please note that the SoC should be set to enter idle mode when it is idle.
  4. Set the advertising interval to 1s, and advertising duration to 30s, as described in “Section 2.6.1 Bluetooth Advertising Parameters”.
  5. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

6. Set the sampling duration to 10s.
7. Reset the SK Board and power on the SoC.
8. Enter the **Data Logger** function page by clicking Data Logger. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
9. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  The power consumption waveform of the SoC when it enters idle mode can be (the SoC is in idle mode between two advertisements):

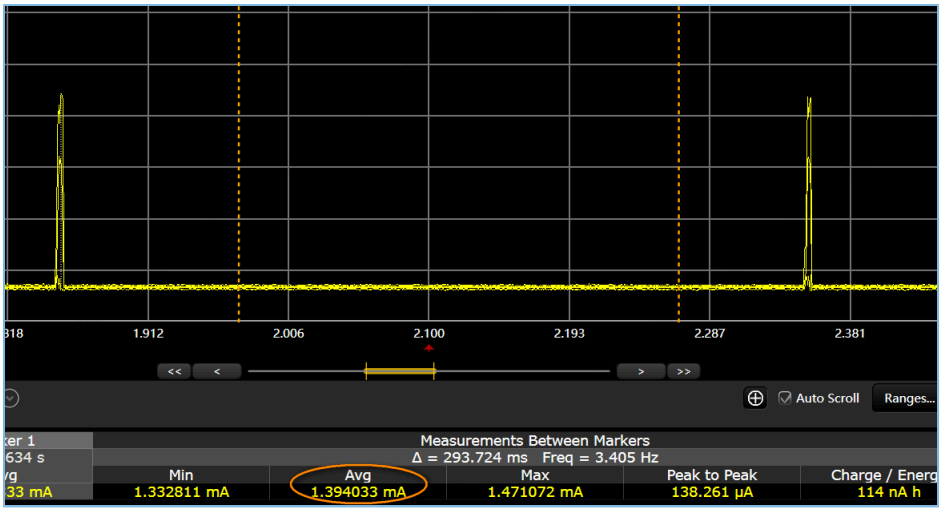

Figure 3-2 Power consumption waveform for SoC in idle mode

Reference power consumption data is shown as follows.

Table 3-3 Reference power consumption data for SoC in idle mode

Scenario	Power Supply	CPU Frequency (MHz)	Average Current (mA)
Idle mode	DC-DC	64	1.39
		16	1.14
	SYS_LDO	64	2.95
		16	2.30

3.4 Power Consumption in Active Mode

This section describes how to measure the total power consumption of GR533x SoC (including the COMM subsystem) when it is in active mode.

- Steps:

  1. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
  2. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
  3. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration". Please note that the SoC should be set to enter active mode when it is idle.
  4. Set the advertising interval to 1s, and advertising duration to 30s, as described in "Section 2.6.1 Bluetooth Advertising Parameters".
  5. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

  6. Set the sampling duration to 10s.
  7. Reset the SK Board and power on the SoC.
  8. Enter the **Data Logger** function page by clicking 

. Start recording power consumption with Keysight 14585A by clicking  (**Data Log**) at the page bottom.
  9. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  The power consumption waveform of the SoC when it is in active mode can be:

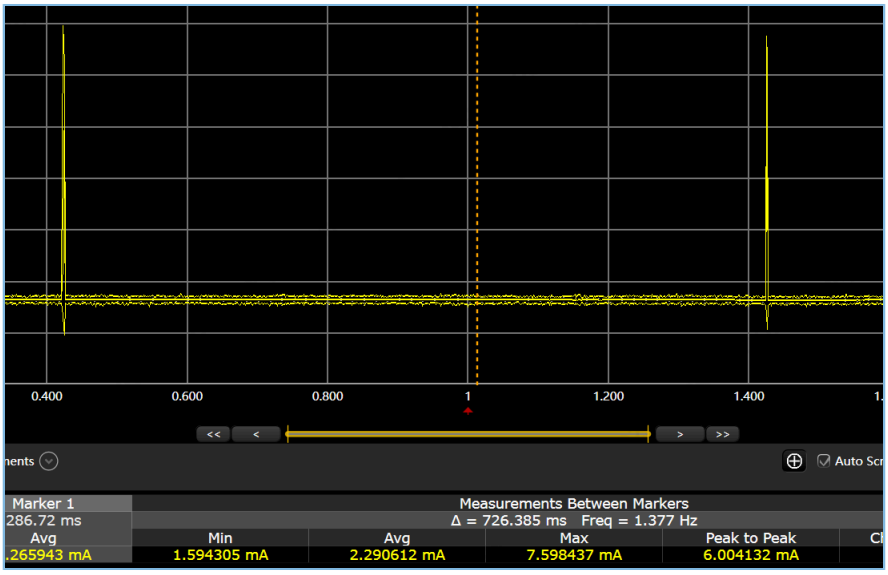

Figure 3-3 Power consumption waveform for SoC in active mode

Reference power consumption data is shown as follows.

Table 3-4 Reference power consumption data for SoC in active mode

Scenario	Power Supply	CPU Frequency (MHz)	Average Current (mA)
Active mode	DC-DC	64	2.36
		16	1.57
	SYS_LDO	64	5.34
		16	3.34

3.5 Advertising Power Consumption

3.5.1 Power Consumption by Advertising Section

The power consumption waveform by SoC advertising phase can be:

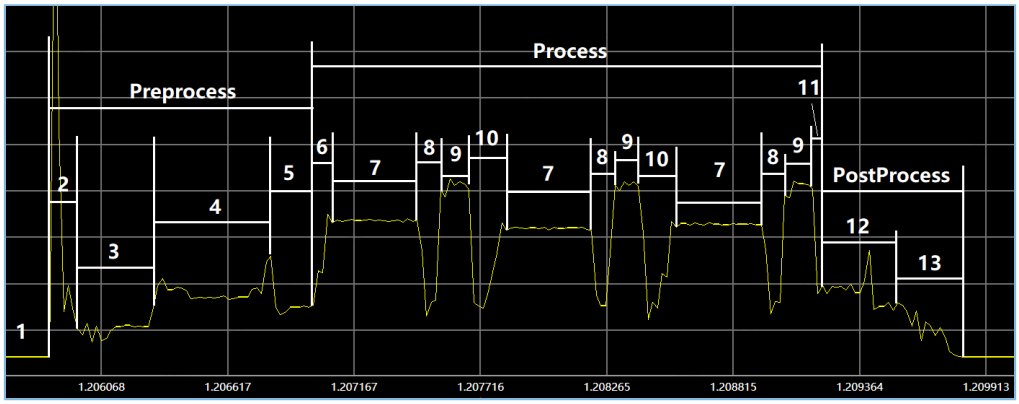

Figure 3-4 Power consumption waveform by SoC advertising section/phase

The sections and phases of an advertising process are described below.

Table 3-5 Advertising section/phase details

Section	Phase	Description
/	1	System in sleep mode
PreProcess	2	System wake-up (including DC-DC, SYS_LDO, and DIGCORE)
	3	Launching HFXO
	4	Warm boot
	5	System entering idle mode
Process	6	RF preparation
	7	TX
	8	TX switching to RX
	9	RX
	10	RX switching to TX
	11	RF termination
PostProcess	12	Checking whether the SoC can enter sleep mode
	13	The system enters sleep mode.

3.5.2 RF Power Consumption Measurement – Advertising

This section describes how to measure the power consumption of GR533x SoC in its RF active period during advertising.

- Required settings:

Table 3-6 Settings for power consumption measurement in RF active period during advertising

Item	Requirement
Advertising interval (ms)	1000
Advertising data (bytes)	31
RF PA	GR5331: UPA; GR533x: SPA
TX power (dBm)	0

- Steps:

1. Prepare the RF PA matching network for the SK Board based on the DUT RF PA type, by referring to “Section 2.3 Configuring RF PA Matching Network for SK Board”.
2. Connect the SK Board, Keysight N6705C, and the PC as described in “Section 2.4 Hardware Connection”.
3. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.

4. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration".
5. Set the RF_TX_PA_SELECT value based on the required RF PA type of the DUT in *custom_config.h* (in `ble_app_pcs\Src\config`).

```
// <o> RF TX PA select
// <1=> BLE_RF_TX_MODE_SPA_MODE  (-20~6 dBm TX power for GR5331/GR5330, -20~5 dBm TX power
 for GR5332)
// <2=> BLE_RF_TX_MODE_UPA_MODE  (-15~2 dBm TX power for GR5331/GR5330)
// <3=> BLE_RF_TX_MODE_HPA_MODE  (-10~15 dBm TX power for GR5332)
#ifndef RF_TX_PA_SELECT
#define RF_TX_PA_SELECT                 1
#endif
```

6. Set the advertising interval to 1s, advertising duration to 30s, and TX power to 0 dBm, as described in "Section 2.6.1 Bluetooth Advertising Parameters".
7. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Set the sampling duration to 10s.
9. Reset the SK Board and power on the SoC.
10. Enter the **Data Logger** function page by clicking 

. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
11. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data is shown as follows.

Table 3-7 Reference power consumption data in RF active period during advertising (GR5331)

Scenario	Power Supply	CPU Frequency (MHz)	Item	PreProcess	Process	PostProcess	TX	RX
Advertising (TX power = 0 dBm)	DC-DC	64	Average current (mA)	1.601	3.326	1.360	3.625	4.637
			Duration (ms)	1.167	2.212	0.553	0.369	0.123
			Current x duration (uc)	1.868	7.357	0.752	1.338	0.570
		16	Average current (mA)	1.309	3.068	1.059	3.236	4.264
			Duration (ms)	1.834	2.212	1.126	0.369	0.123

Scenario	Power Supply	CPU Frequency (MHz)	Item	PreProcess	Process	PostProcess	TX	RX
			Current x duration (uc)	2.401	6.787	1.193	1.194	0.525
	SYS_LDO	64	Average current (mA)	3.526	8.241	2.988	9.023	11.706
			Duration (ms)	1.167	2.212	0.553	0.369	0.123
			Current x duration (uc)	4.115	18.230	1.652	3.330	1.440
		16	Average current (mA)	2.808	7.449	2.393	7.832	11.020
			Duration (ms)	1.834	2.212	1.126	0.369	0.123
			Current x duration (uc)	5.150	16.477	2.695	2.890	2.535

Table 3-8 Reference power consumption data in RF active period during advertising (GR5332)

Scenario	Power Supply	CPU Frequency (MHz)	Item	PreProcess	Process	PostProcess	TX	RX
Advertising (TX power = 0 dBm)	DC-DC	64	Average current (mA)	1.661	4.690	1.394	5.870	4.951
			Duration (ms)	1.085	2.212	0.553	0.369	0.123
			Current x duration (uc)	1.802	10.374	0.771	2.166	0.609
		16	Average current (mA)	1.305	4.388	1.104	5.513	4.657
			Duration (ms)	1.834	2.212	1.126	0.369	0.123
			Current x duration (uc)	2.393	9.706	1.243	2.034	0.573
	SYS_LDO	64	Average current (mA)	3.423	11.810	2.900	15.107	12.399
			Duration (ms)	1.167	2.212	0.553	0.369	0.123
			Current x duration (uc)	3.995	26.124	1.604	5.575	1.525
		16	Average current (mA)	2.704	11.185	2.209	14.136	11.668
			Duration (ms)	1.834	2.212	1.126	0.369	0.123
			Current x duration (uc)	4.959	24.741	2.487	5.216	1.435

3.5.3 RF Power Consumption (by PA Type)

This section describes how to measure the power consumption of GR533x SoC in RF active period during advertising when different PA (UPA, SPA, or HPA) is used and different TX power is set.

Note:

- When SPA is used, you can set the system power mode to DC-DC or SYS_LDO (define SYSTEM_POWER_MODE to 0 or 1).
- When HPA is used, you can set the system power mode to SYS_LDO (define SYSTEM_POWER_MODE to 1) only.

3.5.3.1 Power Consumption (PA = UPA)

- Required settings:

Table 3-9 Settings for power consumption measurement in RF active period during advertising (PA = UPA)

Item	Requirement
SoC series	GR5331
Advertising interval (ms)	1000
Advertising data (bytes)	31
RF PA	UPA
TX power (dBm)	-15, 2

- Steps:

1. Prepare a five-component RF PA matching network for the SK Board, as detailed in "Section 2.3 Configuring RF PA Matching Network for SK Board".
2. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
3. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
4. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration".
5. Set the PA as UPA by setting the value of RF_TX_PA_SELECT to **2** in *custom_config.h* (in `ble_app_pcs\Src\config`).

```
// <o> RF TX PA select
// <1=> BLE_RF_TX_MODE_SPA_MODE  (-20~6 dBm TX power for GR5331/GR5330, -20~5 dBm TX power
 for GR5332)
// <2=> BLE_RF_TX_MODE_UPA_MODE  (-15~2 dBm TX power for GR5331/GR5330)
// <3=> BLE_RF_TX_MODE_HPA_MODE  (-10~15 dBm TX power for GR5332)
#ifndef RF_TX_PA_SELECT
#define RF_TX_PA_SELECT                2
#endif
```

6. Set the advertising interval to 1s, advertising duration to 30s, and the TX power to -15 dBm/2 dBm, as described in "Section 2.6.1 Bluetooth Advertising Parameters".
7. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Set the sampling duration to 10s.
9. Reset the SK Board and power on the SoC.

10. Enter the **Data Logger** function page by clicking  . Start recording power consumption with Keysight 14585A by clicking  (**Data Log**) at the page bottom.
11. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data is shown as follows.

Table 3-10 Reference power consumption data in RF active period during advertising (PA = UPA)

Scenario	Power Supply	Item	TX Power = -15 dBm		TX Power = 2 dBm	
			Process	TX	Process	TX
Advertising power consumption (PA = UPA)	DC-DC	Average current (mA)	2.762	2.628	3.542	3.864
		Duration (ms)	2.212	0.369	2.212	0.369
		Current x duration (uc)	6.110	0.970	7.835	1.426

3.5.3.2 Power Consumption (PA = SPA)

- Required settings:

Table 3-11 Settings for power consumption measurement in RF active period during advertising (PA = SPA)

Item	Requirement
SoC series	GR5331
Advertising interval (ms)	1000
Advertising data (bytes)	31
RF PA	SPA
TX power (dBm)	-20, 0, 5

- Steps:

1. Prepare a seven-component RF PA matching network for the SK Board, as detailed in "Section 2.3 Configuring RF PA Matching Network for SK Board".
2. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
3. Set VBAT as specified in Table 3-1, and power on the hardware devices.
4. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration".
5. Set the PA as SPA by setting the value of RF_TX_PA_SELECT to **1** in *custom_config.h* (in `ble_app_pcs\Src\config`).

```
// <o> RF TX PA select
// <1=> BLE_RF_TX_MODE_SPA_MODE  (-20~6 dBm TX power for GR5331/GR5330, -20~5 dBm TX power
 for GR5332)
// <2=> BLE_RF_TX_MODE_UPA_MODE  (-15~2 dBm TX power for GR5331/GR5330)
// <3=> BLE_RF_TX_MODE_HPA_MODE  (-10~15 dBm TX power for GR5332)
#ifndef RF_TX_PA_SELECT
#define RF_TX_PA_SELECT                 1
#endif
```

6. Set the advertising interval to 1s, advertising duration to 30s, and the TX power as required (-20 dBm/0 dBm/5 dBm), as described in "Section 2.6.1 Bluetooth Advertising Parameters".
7. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Set the sampling duration to 10s.
9. Reset the SK Board and power on the SoC.
10. Enter the **Data Logger** function page by clicking Data Logger. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
11. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data is shown as follows.

Table 3-12 Reference power consumption data in RF active period during advertising (PA = SPA)

Scenario	Power Supply	Item	TX Power = -20 dBm		TX Power = 0 dBm		TX Power = 5 dBm	
			Process	TX	Process	TX	Process	TX
Advertising power consumption (PA = SPA)	DC-DC	Average current (mA)	2.965	2.910	4.171	4.877	5.499	6.733
		Duration (ms)	2.212	0.369	2.212	0.369	2.212	0.369
		Current x duration (uc)	6.559	1.074	9.226	1.800	12.164	2.484
	SYS_LDO	Average current (mA)	7.032	6.835	9.945	11.602	13.209	16.183
		Duration (ms)	2.212	0.369	2.212	0.369	2.212	0.369
		Current x duration (uc)	15.555	2.522	21.998	4.281	29.218	5.972

3.5.3.3 Power Consumption (PA = HPA)

- Required settings:

Table 3-13 Settings for power consumption measurement in RF active period during advertising (PA = HPA)

Item	Requirement
SoC series	GR5332
Advertising interval (ms)	1000
Advertising data (bytes)	31
RF PA	HPA
TX power (dBm)	-10, 0, 6, 15
Power supply	SYS_LDO

- Steps:

1. Prepare a six-component RF PA matching network for the SK Board, as detailed in "Section 2.3 Configuring RF PA Matching Network for SK Board".
2. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
3. Set VBAT as specified in Table 3-1, and power on the hardware devices.
4. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration".
5. Set the PA as HPA by setting the value of RF_TX_PA_SELECT to **3** in *custom_config.h* (in `ble_app_pcs\Src\config`). When the PA is set as HPA, the macro SYSTEM_POWER_MODE shall be defined to 1 (SYSLDO MODE).

```
// <o> RF TX PA select
// <1=> BLE_RF_TX_MODE_SPA_MODE  (-20~6 dBm TX power for GR5331/GR5330, -20~5 dBm TX power
 for GR5332)
// <2=> BLE_RF_TX_MODE_UPA_MODE  (-15~2 dBm TX power for GR5331/GR5330)
// <3=> BLE_RF_TX_MODE_HPA_MODE  (-10~15 dBm TX power for GR5332)
#ifndef RF_TX_PA_SELECT
#define RF_TX_PA_SELECT                 3
#endif
```

6. Set the advertising interval to 1s, advertising duration to 30s, and the TX power as required (-10 dBm/0 dBm/6 dBm/15 dBm), as described in "Section 2.6.1 Bluetooth Advertising Parameters".
7. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Set the sampling duration to 10s.

9. Reset the SK Board and power on the SoC.
10. Enter the **Data Logger** function page by clicking Data Logger. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
11. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data is shown as follows.

Table 3-14 Reference power consumption data in RF active period during advertising (PA = HPA)

Scenario	Power Supply	Item	TX Power = -10 dBm		TX Power = 0 dBm		TX Power = 6 dBm		TX Power = 15 dBm	
			Process	TX	Process	TX	Process	TX	Process	TX
Advertising power consumption (PA = HPA)	SYS_LDO	Average current (mA)	5.297	12.433	18.595	25.606	22.821	32.745	54.331	87.301
		Duration (ms)	2.212	0.369	2.212	0.369	2.212	0.369	2.212	0.369
		Current x duration (uc)	11.717	4.588	41.132	9.449	50.480	12.083	120.18	32.214

3.6 Connection Power Consumption

3.6.1 Power Consumption by Connection Section

The power consumption waveform by connection section is shown below:

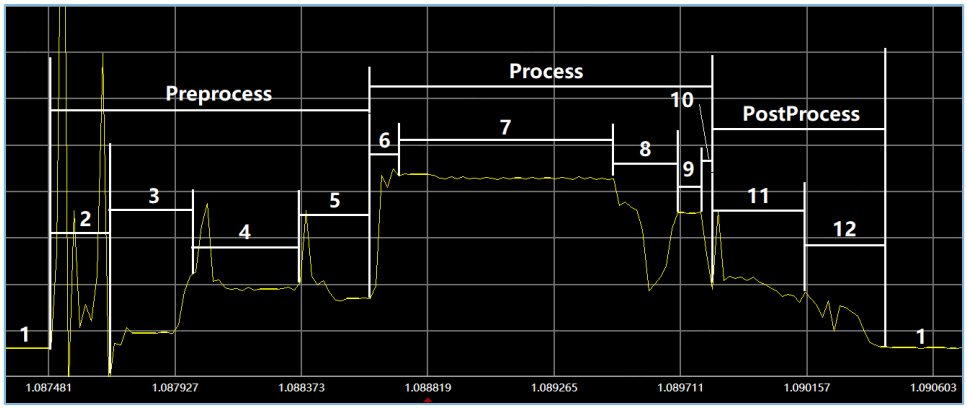

Figure 3-5 Power consumption waveform by SoC connection section/phase

The sections and phases of a connection process are described below.

Table 3-15 Connection section/phase details

Section	Phase	Description
/	1	System in sleep mode

Section	Phase	Description
PreProcess	2	System wake-up (including DC-DC, SYS_LDO, and DIGCORE)
	3	Launching HFXO
	4	Warm boot
	5	System in idle mode
Process	6	RF preparation
	7	RX
	8	RX switching to TX
	9	TX
	10	RF termination
PostProcess	11	Checking whether the SoC can enter sleep mode
	12	The system enters sleep mode.

3.6.2 RF Power Consumption Measurement – Connection

This section describes how to measure the power consumption of GR533x SoC in its RF active period during connection.

- Required settings:

Table 3-16 Settings for power consumption measurement in RF active period during connection

Item	Requirement
Connection parameter (ms)	100
Connection data (bytes)	0
Bluetooth LE PHY	1M-PHY, 2M-PHY
RF PA	GR5331: UPA; GR533x: SPA
TX power (dBm)	0

- Steps:

1. Prepare the RF PA matching network for the SK Board based on the DUT PA type, by referring to "Section 2.3 Configuring RF PA Matching Network for SK Board".
2. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
3. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
4. Configure the firmware for power consumption based on the scenario, by referring to "Section 2.5 Firmware Configuration".
5. Set the RF_TX_PA_SELECT value based on the required RF PA type of the DUT in *custom_config.h* (in `ble_app_pcs\Src\config`).

```
// <o> RF TX PA select
```

```
// <1=> BLE_RF_TX_MODE_SPA_MODE  (-20~6 dBm TX power for GR5331/GR5330, -20~5 dBm TX power
 for GR5332)
// <2=> BLE_RF_TX_MODE_UPA_MODE  (-15~2 dBm TX power for GR5331/GR5330)
// <3=> BLE_RF_TX_MODE_HPA_MODE  (-10~15 dBm TX power for GR5332)
#ifndef RF_TX_PA_SELECT
#define RF_TX_PA_SELECT                 1
#endif
```

6. Set the advertising interval to 1s, advertising duration to 30s, and TX power to 0 dBm, as described in "Section 2.6.1 Bluetooth Advertising Parameters".
7. Recompile the ble_app_pcs project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Reset the SK Board and power on the SoC.
9. Connect to the DUT with GRToolbox, and set the connection parameter to 100 ms (by entering the value "80"), as described in "Section 2.6.2 Bluetooth Connection Parameters". Set the PHY mode as required (1M-PHY/2M-PHY) in GRToolbox.
10. Set the sampling duration to 10s.
11. Enter the **Data Logger** function page by clicking Data Logger. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
12. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data is shown as follows.

Table 3-17 Reference power consumption data in RF active period during connection (GR5331)

Scenario	Power Supply	Bluetooth PHY Mode	Item	Process
RF active period during connection	DC-DC	1M-PHY	Average current (mA)	3.505
			Duration (ms)	0.532
			Current x duration (uc)	1.889
		2M-PHY	Average current (mA)	3.638
			Duration (ms)	0.471
			Current x duration (uc)	1.713

Table 3-18 Reference power consumption data in RF active period during connection (GR5332)

Scenario	Power Supply	Bluetooth PHY Mode	Item	Process
RF active period during connection	DC-DC	1M-PHY	Average current (mA)	4.182
			Duration (ms)	0.532
			Current x duration (uc)	2.225
		2M-PHY	Average current (mA)	4.334
			Duration (ms)	0.471
			Current x duration (uc)	2.041
	SYS_LDO	1M-PHY	Average current (mA)	14.487
			Duration (ms)	0.532
			Current x duration (uc)	7.707
		2M-PHY	Average current (mA)	14.682
			Duration (ms)	0.471
			Current x duration (uc)	6.915

3.7 Scanning Power Consumption

3.7.1 Power Consumption by Scanning Section

The power consumption waveform by scanning section is shown below:

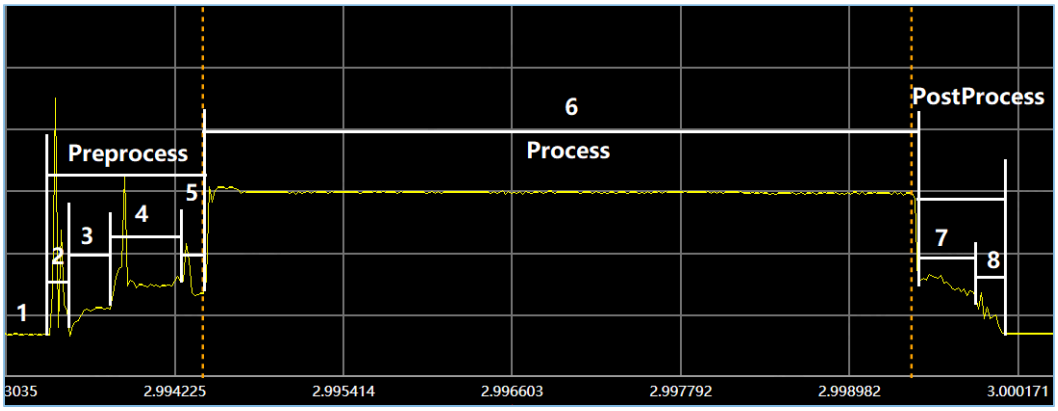

Figure 3-6 Power consumption waveform by SoC scanning section/phase

The sections and phases of a scanning process are described below.

Table 3-19 Power consumption waveform by SoC scanning section/phase

Section	Phase	Description
/	1	System in sleep mode
PreProcess	2	System wake-up (including DC-DC, SYS_LDO, and DIGCORE)

Section	Phase	Description
	3	Launching HFXO
	4	Warm boot
	5	System in idle mode
Process	6	RX
PostProcess	7	Checking whether the SoC can enter sleep mode
	8	The system enters sleep mode.

3.7.2 RF Power Consumption Measurement – Scanning

This section describes how to measure the RF power consumption of GR533x SoC during scanning.

- Required settings:

Table 3-20 Settings for power consumption measurement during scanning

Item	Requirement
SoC series	GR5331
Scanning interval (ms)	100
Discoverable duration (ms)	5
RF PA	UPA

- Steps:

Note:

To generate the firmware for measuring the RF power consumption during scanning, find the ble_app_cts_c example project (in SDK_Folder\projects\ble\ble_central\ble_app_cts_c) and make compilations according to the Step 1 described in "Section 2.5 Firmware Configuration".

---

1. Prepare a five-component RF PA matching network for the SK Board, as detailed in "Section 2.3 Configuring RF PA Matching Network for SK Board".
2. Connect the SK Board, Keysight N6705C, and the PC as described in "Section 2.4 Hardware Connection".
3. Set VBAT as specified in Table 3-1, and power on Keysight N6705C.
4. Configure the firmware for power consumption based on the scenario, by modifying *custom_config.h* (in ble_app_cts_c\Src\config), as described in "Section 2.5 Firmware Configuration".
5. Set the advertising interval to 100 ms, and discoverable duration to 5 ms in *user_app.c* (in ble_app_cts_c\Src\user).

```
/**@brief Gapm config data. */
#define APP_SCAN_INTERVAL   160      /**< Determines scan interval(in units of 0.625 ms). */
#define APP_SCAN_WINDOW     8       /**< Determines scan window(in units of 0.625 ms). */
```

- Set the scanning interval by configuring APP_SCAN_INTERVAL, in the unit of 0.625 ms. For example, when APP_SCAN_INTERVAL is set to **160**, the scanning interval will be 160 x 0.625 ms = 100 ms.
- Set the discoverable duration by configuring APP_SCAN_WINDOW, in the unit of 0.625 ms. For example, when APP_SCAN_WINDOW is set to **8**, the scanning interval will be 8 x 0.625 ms = 5 ms.

6. In *user_periph_setup.c* (in `ble_app_cts_c\Src\platform`), comment out the code of board_init() and app_uart_receive_async() in app_periph_init(), and set the SoC to enter sleep mode when it is idle.

```
void app_periph_init(void)
{
    SYS_SET_BD_ADDR(s_bd_addr);
    //board_init();
    //app_uart_receive_async(APP_UART_ID, s_uart_rx_buffer, UART_RX_BUFFER_SIZE);
    pwr_mgmt_mode_set(PMR_MGMT_SLEEP_MODE);
}
```

7. Recompile the ble_app_cts_c project to generate the firmware. Download the firmware to the DUT Flash with Keil or GProgrammer.

Tip:

To download firmware via J-Link, toggle the switch 5 and switch 6 of S3 to the side marked with **ON**, to connect the J-Link SWD with the GR533x SoC. After the firmware is downloaded, toggle these switches back to the left (the side printed with "1" and "6").

---

8. Set the sampling duration to 10s.
9. Reset the SK Board and power on the SoC.
10. Enter the **Data Logger** function page by clicking 

. Start recording power consumption with Keysight 14585A by clicking (**Data Log**) at the page bottom.
11. When the sampling duration ends, the power consumption (current) recorded during this period is displayed in Keysight 14585A.

- Reference measurement result:

  Reference power consumption data during the Process section is as follows:

Table 3-21 RF power consumption details during scanning (GR5331)

Power Supply	Average Current (mA)	Duration (ms)	Current x Duration (uc)
DC-DC	4.570	5	22.85

3.8 Power Consumption in Different Application Scenarios

This section describes how to measure the power consumption of the SoC when the advertising/connection interval is set to different values.

- Required settings:

Table 3-22 Settings for power consumption measurement in different application scenarios

Item	Requirement
Advertising interval (ms)	500, 1000, 2000
Connection interval (ms)	7.5, 30, 45, 100, 400, 1000
Advertising data (bytes)	31
Connection data (bytes)	0
Bluetooth PHY	1M-PHY, 2M-PHY
RF PA	GR5331: UPA; GR533x: SPA
TX power (dBm)	0

- Steps:
  - To measure the power consumption during advertising, see "Section 3.5.2 RF Power Consumption Measurement – Advertising".
  - To measure the power consumption during connection, see "Section 3.6.2 RF Power Consumption Measurement – Connection".
- Reference measurement result:

  Reference power consumption data in different scenarios is shown as follows.

Table 3-23 Reference power consumption data for GR5331 in different scenarios

Scenario	Power Supply	PHY	Average Current (μA)
ADV_500ms	DC-DC	1M-PHY	22.3
	SYS_LDO		48.6
ADV_1000ms	DC-DC	1M-PHY	12.4
	SYS_LDO		25.8
ADV_2000ms	DC-DC	1M-PHY	7.7
	SYS_LDO		14.5
CONN_7.5ms	DC-DC	1M-PHY	558.6
		2M-PHY	547.2
	SYS_LDO	1M-PHY	1182
		2M-PHY	1012
CONN_30ms	DC-DC	1M-PHY	144.1
		2M-PHY	136
	SYS_LDO	1M-PHY	299.7
		2M-PHY	296.2
CONN_45ms	DC-DC	1M-PHY	93.5

Scenario	Power Supply	PHY	Average Current (μA)
		2M-PHY	89.8
	SYS_LDO	1M-PHY	212.4
		2M-PHY	199.5
CONN_100ms	DC-DC	1M-PHY	47.8
		2M-PHY	44.4
	SYS_LDO	1M-PHY	98.3
		2M-PHY	95
CONN_400ms	DC-DC	1M-PHY	17.1
		2M-PHY	16.4
	SYS_LDO	1M-PHY	33.9
		2M-PHY	33.2
CONN_1000ms	DC-DC	1M-PHY	10.3
		2M-PHY	10.2
	SYS_LDO	1M-PHY	20.9
		2M-PHY	20.4

Table 3-24 Reference power consumption data for GR5332 in different scenarios

Scenario	Power Supply	PHY	Average Current (μA)
ADV_500ms	DC-DC	1M-PHY	28.6
	SYS_LDO		65.6
ADV_1000ms	DC-DC	1M-PHY	15.6
	SYS_LDO		34.4
ADV_2000ms	DC-DC	1M-PHY	9.4
	SYS_LDO		18.8
CONN_7.5ms	DC-DC	1M-PHY	567.3
		2M-PHY	561.4
	SYS_LDO	1M-PHY	1306
		2M-PHY	1204
CONN_30ms	DC-DC	1M-PHY	149.5
		2M-PHY	143.2
	SYS_LDO	1M-PHY	330.4
		2M-PHY	313.8
CONN_45ms	DC-DC	1M-PHY	103.7
		2M-PHY	98.3

Scenario	Power Supply	PHY	Average Current (μA)
	SYS_LDO	1M-PHY	229.5
		2M-PHY	313.1
CONN_100ms	DC-DC	1M-PHY	49.1
		2M-PHY	47.9
	SYS_LDO	1M-PHY	109
		2M-PHY	102.5
CONN_400ms	DC-DC	1M-PHY	17.3
		2M-PHY	16.8
	SYS_LDO	1M-PHY	36.7
		2M-PHY	36
CONN_1000ms	DC-DC	1M-PHY	10.7
		2M-PHY	10.6
	SYS_LDO	1M-PHY	22.2
		2M-PHY	22.3

3.9 Power Consumption at the Lowest Operating Voltage

This section describes how to measure the power consumption in different SoC power modes and the RF power consumption when GR533x operates at the lowest voltage (2.0 V).

- Required settings:

Table 3-25 Settings for power consumption measurement at the lowest SoC operating voltage

Item	Requirement
Supply voltage (V)	2.0
Advertising interval (ms)	1000
Advertising data (bytes)	31
RF PA	GR5331: UPA; GR533x: SPA
TX power (dBm)	0

3.9.1 Power Consumption in Different Power Modes

- Steps:

  To measure the power consumption in different power modes, the only difference is to set the operating voltage to 2.0 V, instead of the typical voltage.

  - To measure the power consumption when GR533x is in sleep mode at the lowest operating voltage, see “Section 3.2 Power Consumption in Sleep Mode”.

  - To measure the power consumption when GR533x is in idle mode at the lowest operating voltage, see "Section 3.3 Power Consumption in Idle Mode".
  - To measure the power consumption when GR533x is in active mode at the lowest operating voltage, see "Section 3.4 Power Consumption in Active Mode".

- Reference measurement result:

  Reference power consumption data in different power modes at the lowest operating voltage is shown as follows.

Table 3-26 Average current at the lowest GR533x operating voltage

Power Consumption Modes	Average Current
Sleep	2.36 μA
Idle	1.75 mA
Active	3.26 mA

3.9.2 RF Power Consumption

- Steps:

  To measure the RF power consumption at the lowest operating voltage, refer to "Section 3.5.2 RF Power Consumption Measurement – Advertising" for the steps in detail. The only difference is to set the voltage supply to 2.0 V.

- Reference measurement result:

  Reference RF power consumption data at the lowest operating voltage is shown as follows.

Table 3-27 RF power consumption details at the lowest operating voltage (GR5331)

Item	Process	TX	RX
Average current (mA)	5.09	5.55	7.29
Duration (ms)	2.212	/	/
Consumed power = current x duration (uc)	11.26	/	/

Table 3-28 RF power consumption details at the lowest operating voltage (GR5332)

Item	Process	TX	RX
Average current (mA)	7.26	9.23	7.64
Duration (ms)	2.212	/	/
Consumed power = current x duration (uc)	16.06	/	/