RX Family

Renesas Sensor Control Modules Firmware Integration Technology

Introduction

This application note explains the sensor control modules for HS300x (Renesas high performance relative humidity and temperature sensor), FS2012 (Renesas High Performance Flow Sensor Module), ZMOD4410&ZMOD4510 (Digital Gas Sensors) and I2C communication middleware for Renesas sensors using Firmware Integration Technology (FIT).

These control modules acquire the sensor data using the I2C bus control FIT module (IIC FIT Module). And calculate relative humidity value [%RH] and temperature value [°C] for HS300x sensor, flow value [SLPM(standard litter per minute) or SCCM(standard cubic centimeter per minute)] for FS2012 sensor and environmental gas value for ZMOD4410 and ZMOD4510.

Hereinafter, the modules described in this application note is abbreviated as following,

- The sensor control module for HS300x: HS300x FIT module

- The sensor control module for FS2012: FS2012 FIT module

- The sensor control module for ZMOD4410 and ZMOD 4510: ZMOD4XXX FIT module

- The I2C communication middleware module: COMMS FIT module

Target Device

- **Sensors:**
  - Renesas Electronics HS300x High Performance Relative Humidity and Temperature Sensor (HS300x sensor)
  - Renesas Electronics FS2012 Renesas High Performance Flow Sensor Module (FS2012 sensor)
  - Renesas Electronics Digital Gas Senser ZMOD4410 (ZMOD4410 Indoor Air Quality Platform) and ZMOD4510 (ZMOD4510 Outdoor Air Quality Platform)

- **RX Family MCUs:**
  MCUs supported the following IIC FIT module
  - I2C Bus Interface (RIIC) Module (RIIC FIT Module)
  - Simple I2C Module (SCI_IIC FIT Module) using Serial Communication Interface (SCI)

- **Operation confirmed MCU:**
  - RX65N (RIIC FIT Module, SCI_IIC FIT Module)

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Target Compiler

- Renesas Electronics C/C++ Compiler Package for RX Family

Reference Documents

- Renesas Electronics HS300x Datasheet (August 8, 2021) (R36DS0010EU0701)
- Renesas Electronics FS2012 Series Datasheet (August 24, 2018)
- Renesas Electronics ZMOD4410 Datasheet (June 30, 2021)
- Renesas Electronics ZMOD4510 Datasheet (June 30, 2021)
- RX Family I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
- RX Family Simple I2C Module Using Firmware Integration Technology (R01AN1691)
- RX65N User’s Manual: The latest version can be downloaded from the Renesas Electronics website.
- Technical Update/Technical News
  The latest information can be downloaded from the Renesas Electronics website.
- RX Family Compiler CC-RX User's Manual (R20UT3248)
  The latest versions can be downloaded from the Renesas Electronics website.

Contents

1. Overview of Renesas Sensor Control Modules

The Renesas sensor control modules described in this application note is a hardware abstraction layer of Renesas sensors. This hardware abstraction layer includes sensor API and communication middleware for various Renesas sensors. The software architecture of Renesas sensor hardware abstraction layer is shown below “Figure 1-1 Renesas sensor software architecture”.

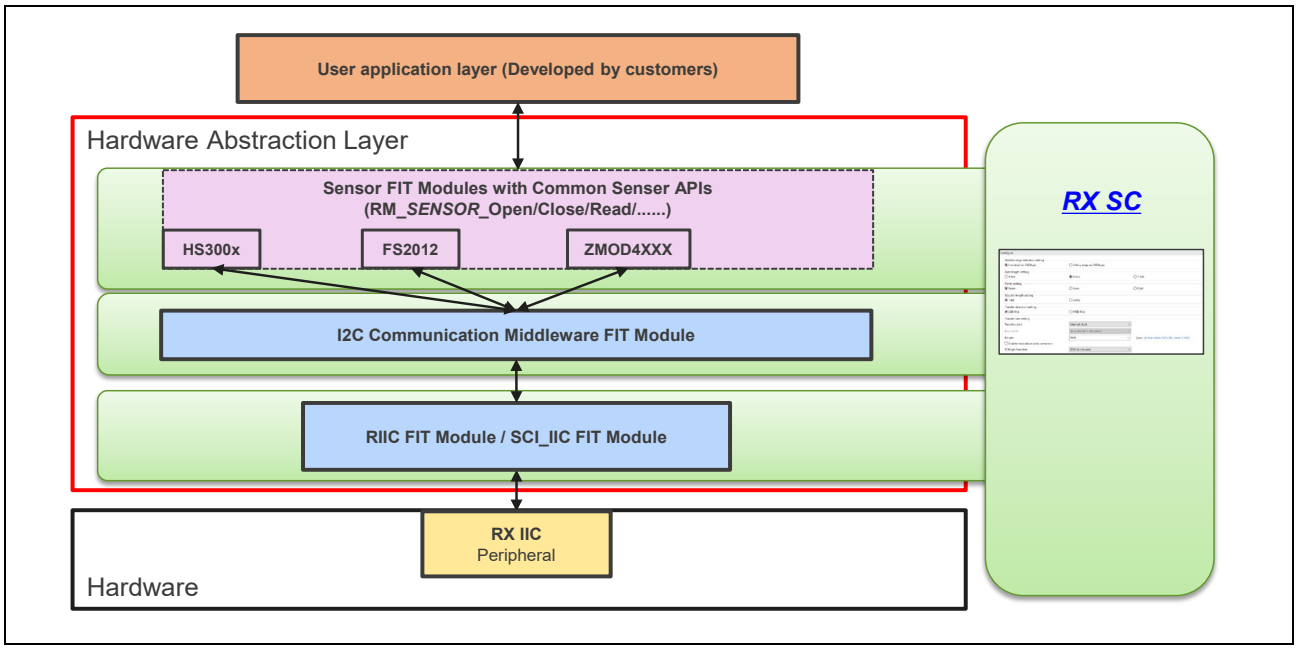


Figure 1-1 Renesas sensor software architecture

The hardware abstraction layer has three layers, “Sensor API”, “I2C communication middleware” and “RX IIC FIT module (RIIC FIT Module and SCI_IIC FIT Module).

The sensor APIs of HS300x sensor, FS2012 sensor, and ZMOD4410&4510 sensors are provided as “HS300x FIT module”, “FS2012 FIT module” and “ZMOD4XXX FIT module”, and the I2C communication middleware is provided as “I2C communication middleware FIT module”.

The “HS300x FIT module” , “FS2012 FIT module”, and “ZMOD4XXX FIT module” provide a method to receive sensor data of the HS300x, FS2012 and ZMOD4410&4510 sensors connected to the I2C bus of RX family MCUs via “I2C communication middleware FIT module”.

Table 1-1 shows the available Sensors.
Table 1-2 shows the available IIC FIT modules.

Table 1-1 Available Sensors

Available Sensors	Reference Datasheet
HS300x High Performance Relative Humidity and Temperature Sensor	HS300x Datasheet (August 9, 2021) (R36DS0010EU0701)
FS2012 High Performance Flow Sensor Module	FS2012 Series Datasheet (August 24, 2018)
ZMOD4410 Digital Gas Senser (ZMOD4410 Indoor Air Quality Platform)	ZMOD4410 Datasheet (June 30, 2021)
ZMOD4510 Digital Gas Sensor (ZMOD4510 Outdoor Air Quality Platform)	ZMOD4510 Datasheet (June 30, 2021)

Table 1-2 Available IIC FIT Modules

Available IIC FIT Modules	Reference Application Notes
RIIC FIT Module	I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
SCI_IIC FIT Module	Simple I2C Module Using Firmware Integration Technology (R01AN1691)

1.1 Outline of HS300x FIT Module

“Table 1-3 HS300x FIT module API Functions” lists the HS300x FIT module API functions.

Table 1-3 HS300x FIT module API Functions

Function	Description
RM_HS300X_Open ()	This function opens and configures the HS300x FIT module.
RM_HS300X_Close ()	This function disables specified HS300x control block.
RM_HS300X_MeasurementStart ()	This function starts a measurement.
RM_HS300X_Read ()	This function reads ADC data from HS300x sensor.
RM_HS300X_DataCalculate ()	This function calculates humidity [%RH] and temperature [Celsius] from ADC data.
RM_HS300X_ProgrammingModeEnter ()	This function places the HS300x into programming mode.
RM_HS300X_ResolutionChange ()	This function changes the HS300x resolution.
RM_HS300X_SensorIdGet ()	This function obtains the sensor ID of HS300x.
RM_HS300X_ProgrammingModeEixt ()	This function exits the HS300x programming mode.
rm_hs300x_callback ()	This function is callback function for HS300x FIT module.

1.2 Outline of FS2012 FIT Module

“Table 1-4 FS2012 FIT module API Functions” lists the API functions.

Table 1-4 FS2012 FIT module API Functions

Function	Description
RM_FS2012_Open ()	This function opens and configures the FS2012 Middle module.
RM_FS2012_Close ()	This function disables specified FS2012 control block.
RM_FS2012_Read ()	This reads ADC data from FS2012.
RM_FS2012_DataCalculate ()	This function calculates flow value [SLPM or SCCM] from ADC data.
rm_FS2012_callback ()	This function is callback function for FS2012 FIT module.

1.3 Outline of ZMOD4XXX FIT Module

"Table 1-5 ZMOD4XXX FIT module API Functions" lists the ZMOD4XXX FIT module API functions.

Table 1-5 ZMOD4XXX FIT module API Functions

Function	Description
RM_ZMOD4XXX_Open ()	This function opens and configures the ZMOD4XXX FIT module.
RM_ZMOD4XXX_Close ()	This function disables specified ZMOD4XXX control block.
RM_ZMOD4XXX_MeasurementStart ()	This function starts a measurement.
RM_ZMOD4XXX_MeasurementStop ()	This function stops a measurement.
RM_ZMOD4XXX_StatusCheck ()	This function read status of ZMOD4410 or ZMOD4510 sensor.
RM_ZMOD4XXX_Read ()	This function reads ADC data from ZMOD4410 or ZMOD4510 sensor.
RM_ZMOD4XXX_ Iaq1stGenDataCalculate ()	This function calculates IAQ (Indoor Air Quality) 1st Gen. values from ADC data.
RM_ZMOD4XXX_ Iaq2ndGenDataCalculate ()	This function calculates IAQ (Indoor Air Quality) 2nd Gen. values from ADC data.
RM_ZMOD4XXX_OdorDataCalculate ()	This function calculates Odor values from ADC data.
RM_ZMOD4XXX_ SulfurOdorDataCalculate ()	This function calculates Sulfur Odor values from ADC data.
RM_ZMOD4XXX_ Oaq1stGenDataCalculate ()	This function calculates OAQ 1st Gen. values from ADC data.
RM_ZMOD4XXX_ Oaq2ndGenDataCalculate ()	This function calculates OAQ 2nd Gen. values from ADC data.
RM_ZMOD4XXX_ TemperatureAndHumiditySet ()	This function sets temperature and humidity to ZMOD4410 or ZMOD4510 sensor.
rm_zmod4xxx_comms_i2c_callback ()	This function is i2c callback function for ZMOD4XXX FIT module.
Rm_zmod4xxx_irq_callback()	This function is irq callback function for ZMOD4XXX FIT module.

1.4 Outline of COMMS (I2C communication middleware) FIT Module

"Table 1-6 I2C communication middleware FIT module API Functions" lists the API functions.

Table 1-6 I2C communication middleware FIT module API Functions

Function	Description
RM_COMMS_I2C_Open ()	The function opens and configures the COMMS FIT module.
RM_COMMS_I2C_Close ()	This function disables specified COMMS FIT module.
RM_COMMS_I2C_Read ()	The function performs a read from I2C device.
RM_COMMS_I2C_Write ()	The function performs a write from the I2C device.
RM_COMMS_I2C_WriteRead ()	The function performs a write to, then a read from the I2C device.
rm_comms_i2c_callback ()	This function is callback function for COMMS FIT module called in I2C driver callback function.

1.5 How to combine sensor control modules and RX IIC FIT modules

HS300x FIT module, FS2012 FIT module, ZMOD4XXX FIT module and COMMS FIT module can control simultaneously multiple sensors on any channel of any I2C bus.

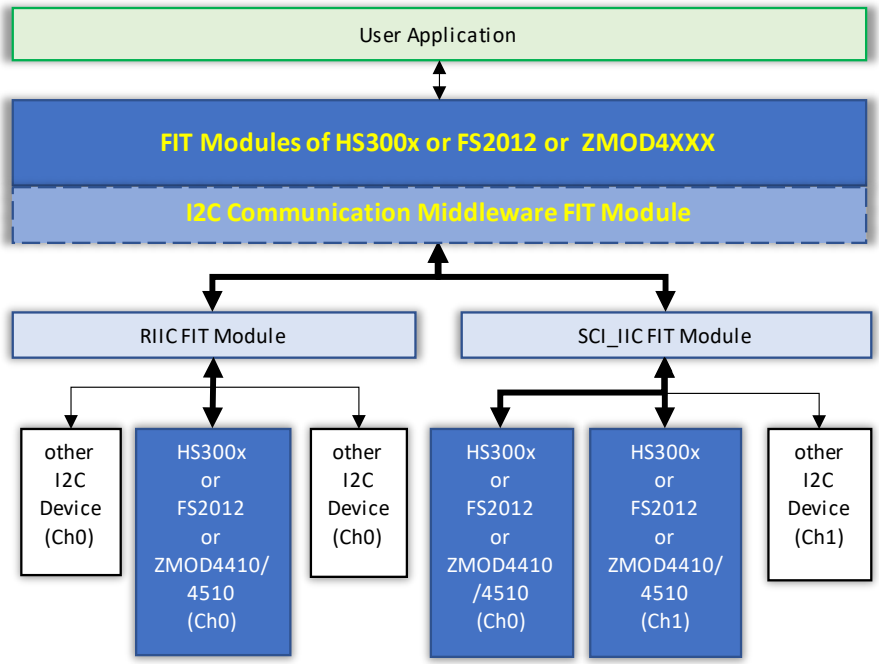
However, the sensors using same slave address cannot be connected to a same channel of I2C bus. Therefore, only one HS300x sensor or one FS2012 sensor or one ZMOD4410 or one ZMOD4510 can be connected to a same channel of the I2C bus.

Figure 1-2 shows the relationship of HS300x FIT module, FS2012 FIT module, ZMOD4XXX FIT module and COMMS FIT module, RX IIC FIT modules and the I2C devices.

The I2C communication middleware FIT module is a driver interface function layer to absorb the difference between the HS300x/FS2012/ZMOD4XXX FIT modules and RX IIC FIT modules.

The initialization processing of these FIT modules opens the module and sets control structure values according to configurations set by user. The initialization of I2C bus need to be done in user application in advanced of above initialization. Depending on sensor connection to IIC bus in user system, the R_RIIC_Open() of RIIC FIT module or R_SCI_IIC_Open() of SCI_IIC FIT module is used for initialization of I2C bus.

For the configuration related to this FIT module, refer to "2.7 Configuration Overview".



Since each I2C bus/channel is configured for each HS300x or FS2012 or ZMOD4410 or ZMOD4510 sensor, multiple HS300x or FS2012 or ZMOD4410 or ZMOD4510 sensors can be controlled simultaneously.

The RIIC FIT module and SCI_IIC FIT module can be controlled simultaneously.

However, since only a slave address is used for HS300x or FS2012 or ZMOD4410 or ZMOD4510 sensor, only one HS300x or FS2012 or ZMOD4410 or ZMOD4510 sensor can be connected on a same channel of the I2C bus.

Figure 1-2 Example of Combination of Sensor (HS300x or FS2012 or ZMOD4410 or ZMOD4510) FIT Modules and IIC FIT Modules

1.6 Terminology/Abbreviation

Table 1-7 Terminology/Abbreviation Lists

Terminology/Abbreviation	Description
HS300x Sensor	Indicates HS300x Relative Humidity and Temperature Sensor.
FS2012 Sensor	Indicates FS2012 High Performance Flow Sensor Module.
ZMOD4410 Sensor	Indicates Digital Gas Senser ZMOD4410 (Indoor Air Quality Platform)
ZMOD4510 Sensor	Indicates Digital Gas Senser ZMOD4510 (Outdoor Air Quality Platform)
HS300x FIT Module	Indicates HS300x Relative Humidity and Temperature Sensor control module.
FS2012 FIT Module	Indicates Air Velocity Sensor control module.
ZMOD4XXX FIT Module	Indicates ZMOD4410 and ZMOD 4510 Digital Gas Sensor control module.
I2C communication middleware (COMMS) FIT Module	Indicates communication driver interface function layer module.
I2C Bus Control FIT Module IIC FIT Module	Indicates RIIC FIT Module or/and SCI_IIC FIT Module.
ReST	Repeated Start Condition
SP	Stop Condition
ST	Start Condition

1.7 Operating Test Environment

This section describes for detailed the operating test environments of these FIT modules.

Table 1-8 Operation Test Environment

Item	Contents
Integrated Development Environment	Renesas Electronics e2 studio 2021-10
C Compiler	Renesas Electronics C/C++ compiler for RX family V.3.03.00 Compiler options: The integrated development environment default settings are used, with the following option added. -lang = c99
Endian Order	Little-endian
Module Version	r_riic_rx Ver.2.49 r_sci_iic_rx Ver.2.49
Board Used	RX65N Envision Kit (RTK5RX65N2C00000BR) Relative Humidity Sensor Pmod™ Board (US082-HS3001EVZ) Gas Mass Flow Sensor Pmod™ Board (US082-FS2012EVZ) TVOC and Indoor Air Quality Sensor Pmod™ Board (US082-ZMOD4410EVZ) Refrigeration Air Quality Sensor Pmod™ Board (US082-ZMOD4510EVZ) Interposer Board to convert Type2/3 to Type 6A PMOD standard (US082-INTERPEVZ)

1.8 Notes/Restrictions

- The operation by single master control has been confirmed. The operation by multi-master control is unconfirmed. When using it in multi-master control, evaluate it sufficiently.
- Operation has been confirmed only when the data endian is little endian.
- For the notes and restrictions of the IIC FIT modules, refer to each application note.

2. API Information

2.1 Hardware Requirements

The MCU used must support one or both of the following functions.

- I2C Bus Interface (RIIC)
- Serial Communication Interface (SCI)：Simple I2C bus mode

2.2 Software Requirements

The FIT modules are dependent upon the following packages:

- Board Support Package Module (r_bsp) Ver.6.21 or higher
- RIIC FIT Module (r_riic_rx) Ver.2.49 or higher
- SCI_IIC FIT Module (r_sci_iic_rx) Ver.2.49 or higher

2.3 Supported Toolchains

The FIT modules are tested and work with the following toolchain:

- Renesas RX Toolchain v.3.03.00 or higher

2.4 Usage of Interrupt Vector

The FIT modules do not use interrupts. However, the IIC FIT modules to be used use interrupts. Refer to each application note for detail information.

2.5 Header Files

All API calls and their supporting interface definitions are located as following.

- HS300x FIT Module
  r_hs300x_if.h
  rm_hs300x_api.h
  rm_hs300x.h
- FS2012 FIT Module
  r_fs2012_if.h
  rm_fsxxxx_api.h
  rm_fs2012.h
- ZMOD4XXX FIT Module
  r_zmod4xxx_if.h
  rm_zmod4xxx_api.h
  rm_zmod4xxx.h
- I2C communication middleware FIT Module
  r_comms_i2c_if.h
  rm_comms_api.h
  rm_comms_i2c.h

2.6 Integer Types

The projects for these FIT modules use ANSI C99. These types are defined in stdint.h.

2.7 Configuration Overview

The configuration options in these FIT modules are specified in
r_hs300x_rx_config.h and rm_hs300x_instance.c for HS300x FIT module,
r_fs2012_rx_config.h and rm_fs2012_instance.c for FS2012 FIT module,
r_zmod4xxx_rx_config.h and rm_zmod4xxx_instance.c for ZMOD4XXX FIT Module,
r_comms_i2c_rx_config.h and rm_comms_i2c_rx_instance.c.

It is also necessary to set the IIC FIT modules to be used. Refer to each application note for detail information.

2.7.1 HS300x FIT module configuration (r_hs3000_rx_config.h)

The following explains the option names and setting values of this FIT module. The configuration settings shown in following table are set on Smart Configurator.

Configuration options	Description (Smart Configurator display)
RM_HS300X_CFG_PARAM_CHECKING_ENABLE	Specify whether to include code for API parameter checking. Selection: BSP Enabled Disabled Default: BSP
RM_HS300X_CFG_DEVICE_NUM_MAX	Specify maximum numbers of HS300x sensors. Selection: 1 - 2 Default: 1
RM_HS300X_CFG_DATA_BOTH_HUMIDITY_TEMPERATURE	Specify HS300x sensor data type. Selection: Humidity only Both humidity and temperature Default: Both humidity and temperature
RM_HS300X_CFG_PROGRAMMING_MODE	Specify programming mode on or off. Selection: Disabled (0) Enabled (1) Default: Disabled (0)
RM_HS300X_CFG_DEVICE0_COMMS_INSTANCE	Specify using communication line instance for device0. (Note 1) Selection: Comms0 - Comms4 Default: Comms0 (g_comms_i2c_device0)
RM_HS300X_CFG_DEVICE0_CALLBACK	Specify user callback function name. Selection: None (Need user to input.) Default: hs300x_user_callback0
RM_HS300X_CFG_DEVICE1_COMMS_INSTANCE	Specify using communication line instance for device1. (Note 1) Selection: Comms0 - Comms4 Default: Comms1 (g_comms_i2c_device1)
RM_HS300X_CFG_DEVICE1_CALLBACK	Specify user callback function name. Selection: None (Need user to input.) Default: hs300x_user_callback1

Note 1: Do not set same “Comms(x)” number for sensor device 0 and sensor device 1.

2.7.2 FS2012 FIT module configuration (r_fs2012_rx_config.h)

The following explains the option names and setting values of this FIT module. The configuration settings shown in following table are set on Smart Configurator.

Configuration options	Description (Smart Configurator display)
RM_FS2012_CFG_PARAM_CHECKING_ENABLE	Specify whether to include code for API parameter checking. Selection: BSP Enabled Disabled Default: BSP
RM_FS2012_CFG_DEVICE_NUM_MAX	Specify maximum numbers of FS2012 sensors. Selection: 1 - 2 Default: 1
RM_FS2012_CFG_DEVICE_TYPE	Specify device type of FS2012 Sensor. (Note 2) Selection: FS2012-1020-NG FS2012-1100-NG Default: FS2012-1020-NG
RM_FS2012_CFG_DEVICE0_COMMS_INSTANCE	Specify using communication line instance for device0 (Note 1) Selection: Comms0 - Comms4 Default: Comms0 (g_comms_i2c_device0)
RM_FS2012_CFG_DEVICE0_CALLBACK	Specify user callback function name. Selection: None (Need user to input) Default: fs2012_user_callback0
RM_FS2012_CFG_DEVICE1_COMMS_INSTANCE	Specify using communication line instance for device1 (Note 1) Selection: Comms0 - Comms4 Default: Comms1 (g_comms_i2c_device1)
RM_FS2012_CFG_DEVICE1_CALLBACK	Specify user callback function name. Selection: None (Need user to input) Default: fs2012_user_callback1

Note 1: Do not set same “Comms(x)” number for sensor device 0 and sensor device 1. The “x” = 0-4.

Note 2: FS2012-1020-NG is 0 to 2 SLPM (Standard liter er minute) calibrated gas flow sensor mounted on a circuit board with a flow housing, FS2012-1100-NG is 0 to 10 SLPM (Standard liter er minute) calibrated gas flow sensor mounted on a circuit board with a flow housing. This FIT module only supports FS2012-1020-NG and FS2012-1100-NG currently.

2.7.3 ZMOD4xxx FIT module configuration (r_zmod4xxx_rx_config.h)

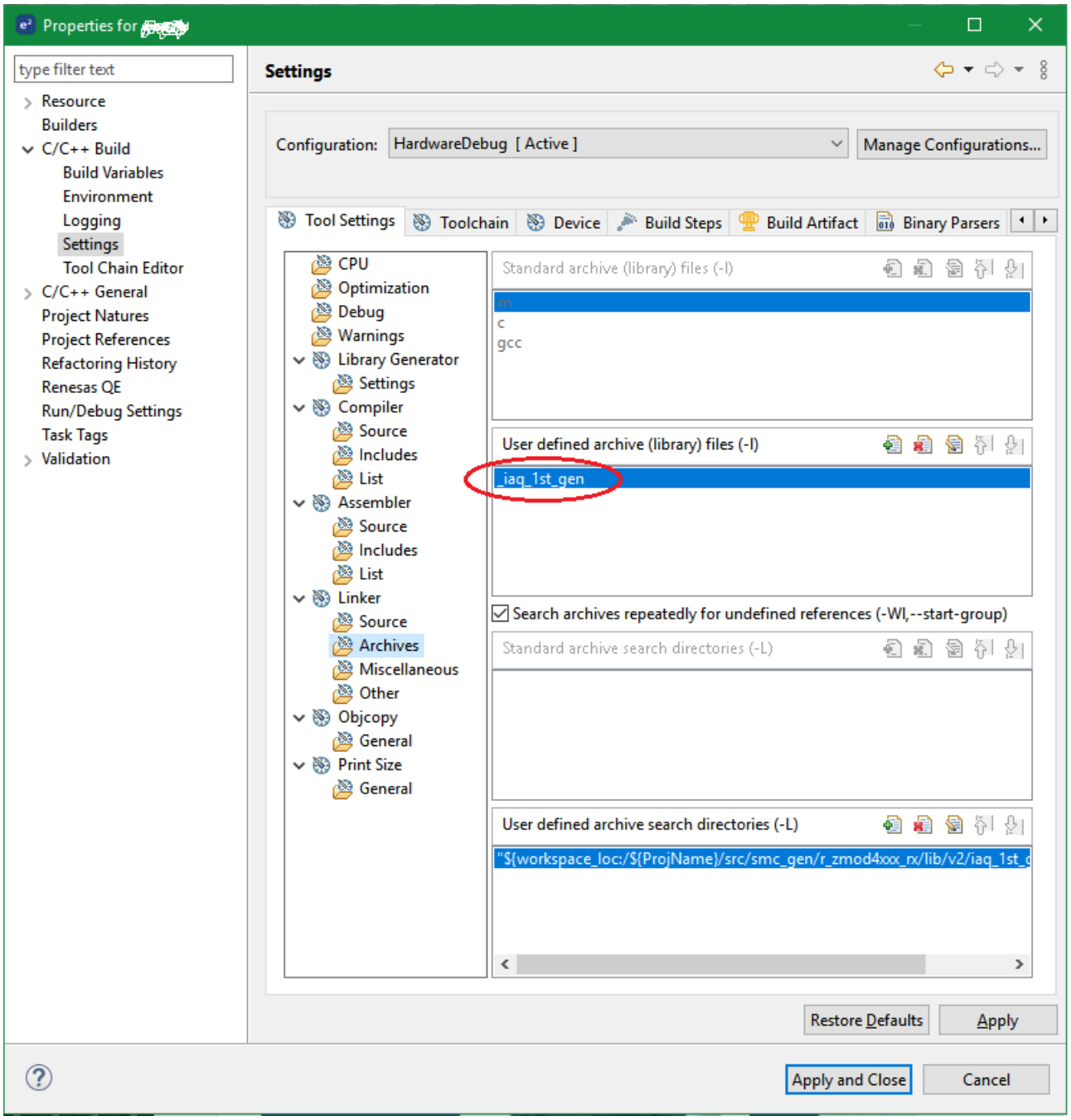
The following explains the option names and setting values of this FIT module. The configuration settings shown in following table are set on Smart Configurator.

Configuration options	Description (Smart Configurator display)
RM_ZMOD4XXX_CFG_PARAM_CHECKING_ENABLE	Specify whether to include code for API parameter checking. Selection: BSP Enabled Disabled Default: BSP
RM_ZMOD4XXX_CFG_DEVICE_NUM_MAX	Specify maximum numbers of ZMOD4XXX sensors. Selection: 1-2 Default: 1
RM_ZMOD4XXX_CFG_DEVICE0_OPERATION_MODE	Specify operation mode of ZMOD4410 and ZMOD4510 sensors. (Note 2) Selection: Not selected IAQ 1st Gen. (Continuous) IAQ 1st Gen. (Low Power) IAQ 2nd Gen. Odor Sulfur-based Odor OAQ 1st Gen. OAQ 2nd Gen. Default: Not selected
RM_ZMOD4XXX_CFG_DEVICE0_COMMS_INSTANCE	Specify used communication line number for ZMOD4410 and ZMOD4510 sensor device0. (Note 1) Selection: Comms0 - 4 Default: Comms0 (g_comms_i2c_device0)
RM_ZMOD4XXX_CFG_DEVICE0_COMMS_I2C_CALLBACK	Specify I2C callback function for ZMOD4410 and ZMOD4510 sensor device0. Selection: None Default: zmod4xxx_user_i2c_callback0 (Need user to input.)
RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE	Enable IRQ from ZMOD4410 and ZMOD4510 sensor device0. Selection: Enabled Disabled Default: Disabled
RM_ZMOD4XXX_CFG_DEVICE0_IRQ_CALLBACK	Specify IRQ Callback function for ZMOD4410 and ZMOD4510 sensor device0. Selection: None Default: zmod4xxx_user_irq_callback0 (Need user to input.)
RM_ZMOD4XXX_CFG_DEVICE0_IRQ_NUMBER	Specify IRQ number for ZMOD4410 and ZMOD4510 sensor device0 Selection: IRQ_NUM_0 - IRQ_NUM_15 Default: IRQ_NUM_0
RM_ZMOD4XXX_CFG_DEVICE0_IRQ_TRIGGER	Specify IRQ trigger for ZMOD4410 and ZMOD4510 sensor device0. Selection: IRQ_TRIG_LOWLEV IRQ_TRIG_FALLING IRQ_TRIG_RISING IRQ_TRIG_BOTH_EDGE Default: IRQ_TRIG_RISING
RM_ZMOD4XXX_CFG_DEVICE0_IRQ_PRIORITY	Specify IRQ interrupt priority for ZMOD4410 and ZMOD4510 sensor device0. Selection: IRQ_PRI_0 - IRQ_PRI_15 Default: IRQ_PRI_10
RM_ZMOD4XXX_CFG_DEVICE1_OPERATION_MODE	Specify operation mode of ZMOD4410 and ZMOD4510 sensors. (Note 2) Selection: Not selected IAQ 1st Gen. (Continuous) IAQ 1st Gen. (Low Power)

	IAQ 2nd Gen. Odor Sulfur-based Odor OAQ 1st Gen. OAQ 2nd Gen. Default: Not selected
RM_ZMOD4XXX_CFG_DEVICE1_COMMS_INSTANCE	Specify used communication line number for ZMOD4410 and ZMOD4510 sensor device1. (Note 1) Selection: Comms0 - 4 Default: Comms0 (g_comms_i2c_device0)
RM_ZMOD4XXX_CFG_DEVICE1_COMMS_I2C_CALLBACK	Specify I2C callback function for ZMOD4410 and ZMOD4510 sensor device1. Selection: None Default: zmod4xxx_user_i2c_callback0 (Need user to input.)
RM_ZMOD4XXX_CFG_DEVICE1_IRQ_ENABLE	Enable IRQ from ZMOD4410 and ZMOD4510 sensor device1. Selection: Enabled Disabled Default: Disabled
RM_ZMOD4XXX_CFG_DEVICE1_IRQ_CALLBACK	Specify IRQ Callback function for ZMOD4410 and ZMOD4510 sensor device1. Selection: None Default: zmod4xxx_user_irq_callback1 (Need user to input.)
RM_ZMOD4XXX_CFG_DEVICE1_IRQ_NUMBER	Specify IRQ number for ZMOD4410 and ZMOD4510 sensor device1 Selection: IRQ_NUM_0 - IRQ_NUM_15 Default: IRQ_NUM_0
RM_ZMOD4XXX_CFG_DEVICE1_IRQ_TRIGGER	Specify IRQ trigger for ZMOD4410 and ZMOD4510 sensor device1. Selection: IRQ_TRIG_LOWLEV IRQ_TRIG_FALLING IRQ_TRIG_RISING IRQ_TRIG_BOTH_EDGE Default: IRQ_TRIG_RISING
RM_ZMOD4XXX_CFG_DEVICE1_IRQ_PRIORITY	Specify IRQ interrupt priority for ZMOD4410 and ZMOD4510 sensor device1. Selection: IRQ_PRI_0 - IRQ_PRI_15 Default: IRQ_PRI_10

Note 1: Be sure to specify a valid communication line number.

Note 2: When creating a project using “GCC for Renesas RX” toolchain with the “Make the double data type 64-bits wide” of “Additional CPU Option” is enabled, the library files for this option are needed to set by user itself. The library files are attached in sub folders under “..\r_zmod4xxx_rx\lib\” in ZMOD4XXX FIT module. “_64bits” is added in the name of these library files. Replace the library file name with “*_64bits” file name in following figure of “Settings” of “C/C++ Build” in properties of the project after generating the code.


Properties for
type filter text
Resource
Builders
C/C++ Build
Build Variables
Environment
Logging
Settings
Tool Chain Editor
C/C++ General
Project Natures
Project References
Refactoring History
Renesas QE
Run/Debug Settings
Task Tags
Validation
Settings
Configuration: HardwareDebug [Active]
Manage Configurations...
Tool Settings
Toolchain
Device
Build Steps
Build Artifact
Binary Parsers
CPU
Optimization
Debug
Warnings
Library Generator
Settings
Compiler
Source
Includes
List
Assembler
Source
Includes
List
Linker
Source
Archives
Miscellaneous
Other
Objcopy
General
Print Size
General
Standard archive (library) files (-l)
m
c
gcc
User defined archive (library) files (-l)
_iaq_1st_gen
Search archives repeatedly for undefined references (-Wl,--start-group)
Standard archive search directories (-L)
User defined archive search directories (-L)
"${workspace_loc:/${ProjName}/src/smc_gen/r_zmod4xxx_rx/lib/v2/iaq_1st_c
Restore Defaults
Apply
Apply and Close
Cancel

2.7.4 I2C communication middleware FIT Module Configuration (r_comms_i2c_rx_config.h)

The following explains the option names and setting values of this FIT module. The configuration settings shown in following table are set on Smart Configurator.

Configuration	Description (Smart Configurator display)
COMMS_I2C_CFG_PARAM_CHECKING_ENABLE	Specify whether to include code for API parameter checking. Selection: BSP Enabled Disabled Default: BSP
COMMS_I2C_CFG_DEVICE_NUM_MAX	Set the numbers (max.) of I2C devices. Selection: Unused, 1-5 Default: 1
COMMS_I2C_CFG_RTOS_BLOCKING_SUPPORT_ENABLE	Specify blocking operation of RTOS project. Selection: Enabled Disabled Default: Disabled
COMMS_I2C_CFG_RTOS_BUS_LOCK_SUPPORT_ENABLE	Specify bus locked operation of RTOS project. Selection: Enabled Disabled Default: Disabled
COMMS_I2C_CFG_BUS(x)_DRIVER_TYPE (“x” = 0-4)	Specify the driver type of IIC bus. Selection: Not selected RX FIT RIIC RX FIT SCI IIC Default: Not selected
COMMS_I2C_CFG_BUS(x)_DRIVER_CH (“x” = 0-4)	Specify the channel number of the IIC bus. Selection: None Default: 0 (Need user to input)
COMMS_I2C_CFG_BUS(x)_SLAVE_ADDR (“x” = 0-4)	Specify the slave address of the IIC bus. Selection: None Default: 0x00 (Need user to input)
COMMS_I2C_CFG_BUS(x)_ADDR_MODE (“x” = 0-4)	Specify the slave address mode of the IIC bus. Only support 7bit address mode. Selection: 7 bit address mode Default: 7 bit address mode
COMMS_I2C_CFG_BUS(x)_CALLBACK_ENABLE (“x” = 0-4)	Specify the enable callback function of the IIC bus. Selection: Enabled Disabled Default: Disabled
COMMS_I2C_CFG_BUS(x)_CALLBACK (“x” = 0-4)	Specify Callback function of the IIC bus. Selection: None Default: comms_i2c_user_callback0 (Need user to input)
COMMS_I2C_CFG_BUS(x)_BLOCKING_TIMEOUT (“x” = 0-4)	Specify the blocking timeout of RTOS project. Selection: None Default: 0xFFFFFFFF (Need user to input)
COMMS_I2C_CFG_BUS(x)_TIMEOUT (“x” = 0-4)	Specify the bus timeout of RTOS project. Selection: None Default: 0xFFFFFFFF (Need user to input)

2.8 Code Size

Typical code sizes associated with this FIT module are listed below.

The ROM (code and constants) and RAM (global data) sizes are determined by the build-time configuration options described in “2.7 Configuration Overview”. The table lists reference values when the C compiler’s compile options are set to their default values, as described in “2.3 Supported Toolchains”.
The compiler option default values.

- optimization level: 2,
- optimization type: for size
- data endianness: little-endian

The code size varies depending on the C compiler version and compile options.
The values in the table below are confirmed under the following conditions.

- Module Version: r_riic_rx Ver.2.49 and r_sci_iic_rx Ver.2.49
- Compiler Version:
  Renesas Electronics C/C++ Compiler Package for RX Family V3.03.00
  (The option of “-lang = c99” is added to the default settings of the integrated development environment.)
- Configuration Options: Default settings

OS supporting	MCU	FIT Module	Category	Numbers	Condition
Non	RX65N	HS300x	ROM	493 bytes	Programming mode disabled
			RAM	28 bytes	
		FS2012	ROM	196 bytes	
			RAM	20 bytes	
		ZMOD4XXX	ROM	4,708 bytes	ZMOD4410 IAQ 2nd Gen. The code size is different depended on the selected operation mode.
			RAM	541 bytes	
		COMMS	ROM	899 bytes	Maximum values when COMMS is used combined with each of above three FIT modules
			RAM	73 bytes	
FreeRTOS	RX65N	HS300x	ROM	493 bytes	Programming mode disabled
			RAM	28 bytes	
		FS2012	ROM	196 bytes	
			RAM	20 bytes	
		ZMOD4XXX	ROM	4,708 bytes	ZMOD4410 IAQ 2nd Gen. The code size is different depended on the selected operation mode.
			RAM	541 bytes	
		COMMS	ROM	1,160 bytes	Maximum values when COMMS is used combined with each of above three FIT modules
			RAM	105 bytes	

2.9 Parameters

The API function arguments are shown below.

The structures of “configuration structure” and “control structure” are used as parameters type. These structures are described along with the API function prototype declaration.

The configuration structure is used for the initial configuration of HS300x FIT module, FS2012 FIT module, ZMOD4XXX FIT module and COMMS FIT module during the module open API call. The configuration structure is used purely as an input into each module.

The control structure is used as a unique identifier for each module instance of HS300x FIT module, FS2012 FIT module, ZMOD4XXX FIT module and COMMS FIT module. It contains memory required by the module. Elements in the control structure are owned by the associated module and must not be modified by the application. The user allocates storage for a control structure, often as a global variable, then sends a pointer to it into the module open API call for a module.

2.9.1 Configuration Structure and Control Structure of HS300x FIT Module

(1) Configuration Struct rm_hs300x_cfg_t

This structure is located in “rm_hs300x_api.h” file.

```
/** HS300X Configuration */
typedef struct st_rm_hs300x_cfg
{
    rm_comms_instance_t const * p_instance;  ///< Pointer to Communications Middleware instance.
    void const          * p_context;                ///< Pointer to the user-provided context.
    void const          * p_extend;             ///< Pointer to extended configuration by instance of interface.
    void (* p_callback)(rm_hs300x_callback_args_t * p_args);      ///< Pointer to callback function.
} rm_hs300x_cfg_t;
```

(2) Control Struct rm_hs300x_ctrl_t

This is HS300x FIT module control block and allocates an instance specific control block to pass into the HS300x API calls. This structure is implemented as “rm_hs300x_instance_ctrl_t” located in “rm_hs300x.h” file.

```
/** HS300x Control Block */
typedef struct rm_hs300x_instance_ctrl
{
    uint32_t                        open;             ///< Open flag
    rm_hs300x_cfg_t const     * p_cfg;              ///< Pointer to HS300X Configuration
    rm_comms_instance_t const * p_comms_i2c_instance;    ///< Pointer of I2C Communications
Middleware instance structure
    void const                      * p_context;        ///< Pointer to the user-provided context

    /* Pointer to callback and optional working memory */
    void (* p_callback)(rm_hs300x_callback_args_t * p_args);
} rm_hs300x_instance_ctrl_t;
```

2.9.2 Configuration Structure and Control Structure of FS2012 FIT Module

(1) Configuration Struct rm_fsxxxx_cfg_t

This structure is located in “rm_fsxxxx_api.h” file.

```
/** FSXXXX Configuration */
typedef struct st_rm_fsxxxx_cfg
{
    rm_comms_instance_t const * p_instance;  ///< Pointer to Communications Middleware instance.
    void const               * p_context;          ///< Pointer to the user-provided context.
    void const               * p_extend;          ///< Pointer to extended configuration by instance of interface.
    void (* p_callback)(rm_fsxxxx_callback_args_t * p_args);        ///< Pointer to callback function.
} rm_fsxxxx_cfg_t;
```

(2) Control Struct rm_fsxxxx_ctrl_t

This is FS2012 FIT module control block and allocates an instance specific control block to pass into the FS2012 API calls. This structure is implemented as “rm_fs2012_instance_ctrl_t” located in “rm_fs2012.h” file.

```
/** FS2012 Control Block */
typedef struct rm_fs2012_instance_ctrl
{
    uint32_t                    open;           ///< Open flag
    rm_fsxxxx_cfg_t const     * p_cfg;          ///< Pointer to FS2012 Configuration
    rm_comms_instance_t const * p_comms_i2c_instance;    ///< Pointer of I2C Communications
Middleware instance structure
    void const                * p_context;      ///< Pointer to the user-provided context

    /* Pointer to callback and optional working memory */
    void (* p_callback)(rm_fsxxxx_callback_args_t * p_args);
} rm_fs2012_instance_ctrl_t;
```

2.9.3 Configuration Structure and Control Structure of ZMOD4xxx FIT Module

(1) Configuration Struct rm_zmod4xxx_cfg_t

This structure is located in “rm_zmod4xxx_api.h” file.

```
/** ZMOD4XXX configuration block */
typedef struct st_rm_zmod4xxx_cfg
{
    rm_comms_instance_t const * p_comms_instance;          ///< Pointer to Communications Middleware
instance.    void const               * p_irq_instance;                    ///< Pointer to IRQ instance.
    void const               * p_context;                          ///< Pointer to the user-provided context.
    void const               * p_extend;          ///< Pointer to extended configuration by instance of interface.
    void (* p_comms_callback)(rm_zmod4xxx_callback_args_t * p_args);///< I2C Communications callback
    void (* p_irq_callback)(rm_zmod4xxx_callback_args_t * p_args);       ///< IRQ callback
} rm_zmod4xxx_cfg_t;
```

(2) Control Struct rm_zmod4xxx_ctrl_t

This is ZMOD4XXX FIT module control block and allocates an instance specific control block to pass into the ZMOD4XXX API calls. This structure is implemented as “rm_zmod4xxx_instance_ctrl_t” located in “rm_zmod4xxx.h” file.

```
/** ZMOD4XXX control block */
typedef struct st_rm_zmod4xxx_instance_ctrl
{
    uint32_t open;                                          ///< Open flag
    uint8_t  buf[RM_ZMOD4XXX_MAX_I2C_BUF_SIZE];      ///< Buffer for I2C communications
    uint8_t  register_address;                              ///< Register address to access
    rm_zmod4xxx_status_params_t      status;                ///< Status parameter
    volatile rm_zmod4xxx_event_t     event;                 ///< Callback event
    rm_zmod4xxx_init_process_params_t init_process_params;   ///< For the initialization process.
    rm_zmod4xxx_cfg_t const        * p_cfg;                 ///< Pointer of configuration block
    rm_comms_instance_t const      * p_comms_i2c_instance;     ///< Pointer of I2C Communications
Middleware instance structure    rm_zmod4xxx_lib_extended_cfg_t  * p_zmod4xxx_lib;              ///<
Pointer of ZMOD4XXX Lib extended configuration

    void const * p_irq_instance;                            ///< Pointer to IRQ instance.
    void const * p_context;                                 ///< Pointer to the user-provided context

    /* Pointer to callback and optional working memory */
    void (* p_comms_callback)(rm_zmod4xxx_callback_args_t * p_args);///< I2C Communications callback
    void (* p_irq_callback)(rm_zmod4xxx_callback_args_t * p_args);       ///< IRQ callback
} rm_zmod4xxx_instance_ctrl_t;
```

2.9.4 Configuration Structure and Control Structure of COMMS FIT Module

(1) Configuration Struct rm_comms_cfg_t

This structure is located in “rm_comms_api.h” file.

```
/** Communications middleware configuration block */
typedef struct st_rm_comms_cfg
{
    uint32_t            semaphore_timeout;      ///< timeout for callback.
    void (* p_callback)(rm_comms_callback_args_t * p_args);     ///< Pointer to callback function, mostly
used if using non-blocking functionality.
    void const          * p_lower_level_cfg;    ///< Pointer to lower level driver configuration structure.
    void const          * p_extend;             ///< Pointer to extended configuration by instance of
interface.
    void const          * p_context;            ///< Pointer to the user-provided context
} rm_comms_cfg_t;
```

(2) Control Struct rm_comms_ctrl_t

This is COMMS FIT module control block and allocates an instance specific control block to pass into the COMMS API calls. This structure is implemented as “rm_comms_i2c_instance_ctrl_t” located in “rm_comms_i2c.h” file.

```
/** Communications middleware control structure. */
typedef struct st_rm_comms_i2c_instance_ctrl
{
    rm_comms_cfg_t const                * p_cfg;            ///< middleware configuration.
    rm_comms_i2c_bus_extended_cfg_t     * p_bus;            ///< Bus using this device;
    void                                * p_lower_level_cfg; ///< Used to reconfigure I2C driver
    uint32_t                            open;               ///< Open flag.
    uint32_t                            transfer_data_bytes; ///< Size of transfer data.
    uint8_t                             * p_transfer_data;  ///< Pointer to transfer data buffer.

    /* Pointer to callback and optional working memory */
    void (* p_callback)(rm_comms_callback_args_t * p_args);

    void const                          * p_context;        ///< Pointer to the user-provided context
} rm_comms_i2c_instance_ctrl_t;
```

2.10 Return Values

The API function return values are shown below.

This enumeration is listed in fsp_common_api.h which is included in RX BSP (Board Support Package Module) Ver.6.21 or higher.

```
typedef enum e_fsp_err
{
    FSP_SUCCESS = 0,

    FSP_ERR_ASSERTION               = 1,       ///< A critical assertion has failed
    FSP_ERR_INVALID_POINTER         = 2,       ///< Pointer points to invalid memory location
    FSP_ERR_INVALID_ARGUMENT        = 3,       ///< Invalid input parameter
    FSP_ERR_INVALID_CHANNEL         = 4,       ///< Selected channel does not exist
    FSP_ERR_INVALID_MODE            = 5,       ///< Unsupported or incorrect mode
    FSP_ERR_UNSUPPORTED             = 6,       ///< Selected mode not supported by this API
    FSP_ERR_NOT_OPEN                = 7,       ///< Requested channel is not configured or API not open
    FSP_ERR_IN_USE                  = 8,       ///< Channel/peripheral is running/busy
    FSP_ERR_OUT_OF_MEMORY           = 9,       ///< Allocate more memory in the driver's cfg.h
    FSP_ERR_HW_LOCKED               = 10,      ///< Hardware is locked
    FSP_ERR_IRQ_BSP_DISABLED        = 11,      ///< IRQ not enabled in BSP
    FSP_ERR_OVERFLOW                = 12,      ///< Hardware overflow
    FSP_ERR_UNDERFLOW               = 13,      ///< Hardware underflow
    FSP_ERR_ALREADY_OPEN            = 14,      ///< Requested channel is already open in a different
configuration
    FSP_ERR_APPROXIMATION           = 15,      ///< Could not set value to exact result
    FSP_ERR_CLAMPED                 = 16,      ///< Value had to be limited for some reason
    FSP_ERR_INVALID_RATE            = 17,      ///< Selected rate could not be met
    FSP_ERR_ABORTED                 = 18,      ///< An operation was aborted
    FSP_ERR_NOT_ENABLED             = 19,      ///< Requested operation is not enabled
    FSP_ERR_TIMEOUT                 = 20,      ///< Timeout error
    FSP_ERR_INVALID_BLOCKS          = 21,      ///< Invalid number of blocks supplied
    FSP_ERR_INVALID_ADDRESS         = 22,      ///< Invalid address supplied
    FSP_ERR_INVALID_SIZE            = 23,      ///< Invalid size/length supplied for operation
    FSP_ERR_WRITE_FAILED            = 24,      ///< Write operation failed
    FSP_ERR_ERASE_FAILED            = 25,      ///< Erase operation failed
    FSP_ERR_INVALID_CALL            = 26,      ///< Invalid function call is made
    FSP_ERR_INVALID_HW_CONDITION    = 27,      ///< Detected hardware is in invalid condition
    FSP_ERR_INVALID_FACTORY_FLASH   = 28,      ///< Factory flash is not available on this MCU
    FSP_ERR_INVALID_STATE           = 30,      ///< API or command not valid in the current state
    FSP_ERR_NOT_ERASED              = 31,      ///< Erase verification failed
    FSP_ERR_SECTOR_RELEASE_FAILED = 32,        ///< Sector release failed
    FSP_ERR_NOT_INITIALIZED         = 33,          ///< Required initialization not complete
    FSP_ERR_NOT_FOUND               = 34,          ///< The requested item could not be found
    FSP_ERR_NO_CALLBACK_MEMORY    = 35,        ///< Non-secure callback memory not provided for non-
secure callback
    FSP_ERR_BUFFER_EMPTY            = 36,          ///< No data available in buffer

    /* Start of RTOS only error codes */
    FSP_ERR_INTERNAL                = 100,         ///< Internal error
    FSP_ERR_WAIT_ABORTED            = 101,          ///< Wait aborted

    /* Start of Sensor specific */
    FSP_ERR_SENSOR_INVALID_DATA           = 0x30000,   ///< Data is invalid.
    FSP_ERR_SENSOR_IN_STABILIZATION       = 0x30001,   ///< Sensor is stabilizing.
    FSP_ERR_SENSOR_MEASUREMENT_NOT_FINISHED = 0x30002,  ///< Measurement is not finished.

    /* Start of COMMS specific */
    FSP_ERR_COMMS_BUS_NOT_OPEN          = 0x40000,   ///< Bus is not open.
} fsp_err_t;
```

2.11 Adding the FIT Module to Your Project

This module must be added to each project in which it is used. Renesas recommends using “Smart Configurator” described in (1) or (3). However, “Smart Configurator” only supports some RX devices. Please use the methods of (2) or (4) for unsupported RX devices.

(1) Adding the FIT module to your project using “Smart Configurator” in e² studio

By using the “Smart Configurator” in e² studio, the FIT module is automatically added to your project. Refer to “Renesas e² studio Smart Configurator User Guide (R20AN0451)” for details.

(2) Adding the FIT module to your project using “FIT Configurator” in e² studio

By using the “FIT Configurator” in e² studio, the FIT module is automatically added to your project. Refer to “Adding Firmware Integration Technology Modules to Projects (R01AN1723)” for details.

(3) Adding the FIT module to your project using “Smart Configurator” on CS+

By using the “Smart Configurator Standalone version” in CS+, the FIT module is automatically added to your project. Refer to “Renesas e² studio Smart Configurator User Guide (R20AN0451)” for details.

(4) Adding the FIT module to your project in CS+

In CS+, please manually add the FIT module to your project. Refer to “Adding Firmware Integration Technology Modules to CS+ Projects (R01AN1826)” for details.

If you use Smart Configurator, both RIIC FIT module and SCI_IIC FIT module will be added. Manually remove the unnecessary FIT module.

3. HS300x API Functions

3.1 RM_HS300X_Open ()

This function opens and configures the HS300x FIT module. This function must be called before calling any other HS300x API functions. The RIIC FIT module or / and SCI_IIC FIT module be used must be initialized in advance.

Format

```
fsp_err_t        RM_HS300X_Open(
        rm_hs300x_ctrl_t * const p_ctrl,
        rm_hs300x_cfg_t const * const p_cfg
);
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

p_cfg

Pointer to configuration structure.
The members of this structure are shown in 2.9.1(1) Configuration Struct rm_hs300x_cfg_t

Return Values

FSP_SUCCESS	HS300x successfully configured.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_ALREADY_OPEN	Module is already open. This module can only be opened once.

Properties

Prototyped in rm_hs300x.h

Description

This function opens and configures the HS300x FIT module.

This function copies the contents in “p_cfg” structure to the member “p_ctrl->p_cfg” in “p_ctrl” structure.

This function does configurations by setting the members of “p_ctrl” structure as following:

- Sets related instance of COMMS FIT module
- Sets callback and context
- Sets open flag

This function calls open API of COMMS FIT module to open communication middleware after all above initializations are done.

Special Notes

None

3.2 RM_HS300X_Close ()

This function disables specified HS300x control block.

Format

fsp_err_t RM_HS300X_Close (rm_hs300x_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

Return Values

FSP_SUCCESS	Successfully closed.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_hs300x.h

Description

This function calls close API of COMMS FIT module to close communication middleware.

This function clears open flag after all above are done.

Special Notes

None

3.3 RM_HS300X_MeasurementStart ()

This function starts a measurement.

Format

fsp_err_t RM_HS300X_MeasurementStart (rm_hs300x_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_hs300x.h

Description

This function sends the slave address to HS300x sensor and start a measurement.

The function should be called when start a measurement and when measurement data is stale data.

The write API of COMMS FIT module is called in this function to send the slave address to HS300x sensor.

Special Notes

None

3.4 RM_HS300X_Read()

This function reads ADC data from HS300x sensor.

Format

```
fsp_err_t RM_HS300X_Read (
        rm_hs300x_ctrl_t * const p_ctrl,
        rm_hs300x_raw_data_t * const p_raw_data
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

p_raw_data

Pointer to raw data structure for storing the read ADC data from HS300x sensor.

```
/** HS300X raw data */
typedef struct st_rm_hs300x_raw_data
{
   uint8_t humidity[2];          ///< Upper 2 bits of 0th element are data status
   uint8_t temperature[2];       ///< Lower 2 bits of 1st element are mask
} rm_hs300x_raw_data_t;
```

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options are invalid.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_hs300x.h

Description

This function reads ADC data from HS300x sensor.

The read API of COMMS FIT module is called in this function.

The ADC data read from HS300x sensor is stored in “p_raw_data” structure. The read data length is defined according to GUI configuration setting as 4 bytes (both humidity and temperature) or 2 bytes (humidity only).

Special Notes

None

3.5 RM_HS300X_DataCalculate ()

This function calculates humidity [%RH] and temperature [Celsius] from ADC data.

Format

```
fsp_err_t RM_HS300X_DataCalculate (
        rm_hs300x_ctrl_t * const     p_ctrl,
        rm_hs300x_raw_data_t * const p_raw_data,
        rm_hs300x_data_t * const     p_hs300x_data
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

p_raw_data

Pointer to raw data structure for storing the read ADC data from HS300x sensor.

```
/** HS300X raw data */
typedef struct st_rm_hs300x_raw_data
{
   uint8_t humidity[2];          ///< Upper 2 bits of 0th element are data status
   uint8_t temperature[2];       ///< Lower 2 bits of 1st element are mask
} rm_hs300x_raw_data_t;
```

p_hs300x_data

Pointer to HS300x sensor measurement results data structure.

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_INVALID_DATA	Data is invalid.

Properties

Prototyped in rm_hs300x.h

Description

This function calculates the relative humidity value [%RH] and temperature value in degrees Celsius [°C] from the ADC data stored in “p_raw_data” and stores the calculated results to “p_hs300x_data” structure.

The status of raw data is shown in the upper 2 bits of p_raw_data-> humidity[0]. The raw data is invalid (e.g., stale data) if the status bits do not equal “0b00”. This function checks the status calculating. This function will skip calculation if the raw data is invalid.

The calculation method is based on the following formula given in the HS300x Datasheet. The temperature [°C] range is -40 to +125.

$$Humidity\,[\%RH] = \left(\frac{Humidity\,[13:0]}{2^{14}-1} \right) * 100$$

$$Temperature\,[^{o}C] = \left(\frac{Temperature\,[15:2]}{2^{14}-1} \right) * 165 - 40$$

The “p_hs300x_data” structure is defined as following.

```
/** HS300X sensor data block */
typedef struct st_rm_hs300x_sensor_data
{
    int16_t integer_part;
    int16_t decimal_part;          ///< To two decimal places
} rm_hs300x_sensor_data_t;

/** HS300X data block */
typedef struct st_rm_hs300x_data
{
    rm_hs300x_sensor_data_t humidity;
    rm_hs300x_sensor_data_t temperature;
} rm_hs300x_data_t;
```

Therefore, user application needs to combine the integer_part and decimal_part to a float number for humidity and temperature usage.

Special Notes

None

3.6 RM_HS300X_ProgrammingModeEnter ()

This function sends commands to place the HS300x into programming mode.

Format

fsp_err_t RM_HS300X_ProgrammingModeEnter (rm_hs300x_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

Return Values

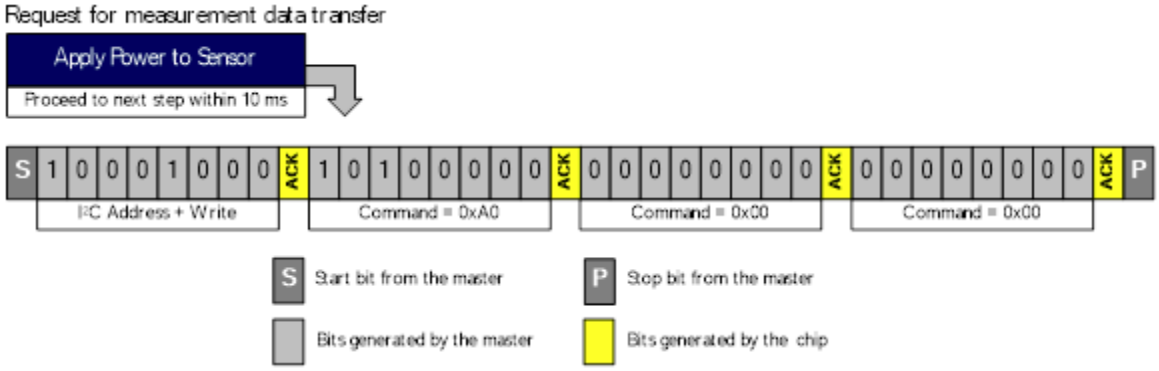
FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_ABORTED	Communication is aborted.
FSP_ERR_TIMEOUT	Communication is timeout.

Properties

Prototyped in rm_hs300x.h

Description

This function sends a sequence of commands shown in below figure to place the HS300x into programming mode. This function must be called within 10ms after applying power to the sensor (HS300x).



The sequence of commands is that the master must send the I2C address and a “Write” bit followed by the command 0xA0|0x00|0x00. The detail information is described in “6.8 Accessing the Non-volatile Memory” of HS300x Datasheet Revision April 22, 2020.

Special Notes

This function must be called within 10ms after applying power to the HS300x sensor. This function performs for blocking.

3.7 RM_HS300X_ResolutionChange ()

This function sends commands to change the HS300x resolution.

Format

```
fsp_err_t RM_HS300X_ResolutionChange (
        rm_hs300x_ctrl_t * const p_ctrl,
        rm_hs300x_data_type_t const data_type,
        rm_hs300x_resolution_t const resolution
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

data_type

Data type of HS300x.

```
/** Data type of HS300X */
typedef enum e_rm_hs300x_data_type
{
   RM_HS300X_HUMIDITY_DATA = 0,
   RM_HS300X_TEMPERATURE_DATA,
} rm_hs300x_data_type_t;
```

resolution

Resolution of HS300x.

```
/** Resolution type of HS300X */
typedef enum e_rm_hs300x_resolution
{
   RM_HS300X_RESOLUTION_8BIT = 0,
   RM_HS300X_RESOLUTION_10BIT,
   RM_HS300X_RESOLUTION_12BIT,
   RM_HS300X_RESOLUTION_14BIT,
} rm_hs300x_resolution_t;
```

Return Values

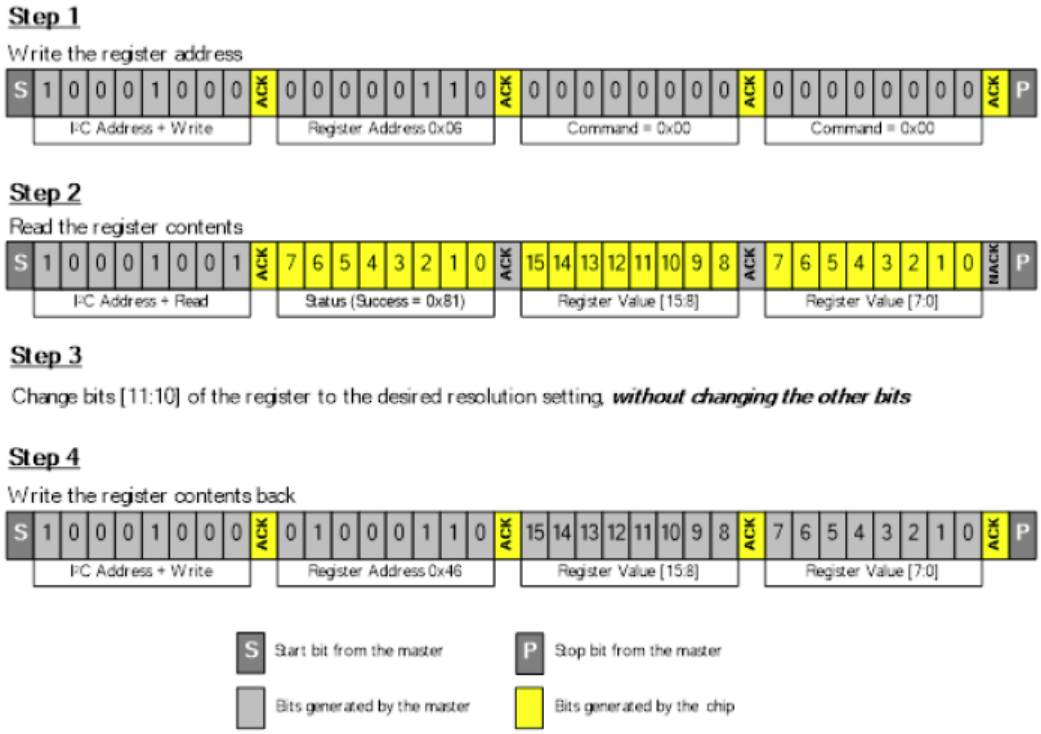
FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_INVALID_MODE	Module is not the programming mode.
FSP_ERR_ABORTED	Communication is aborted.
FSP_ERR_TIMEOUT	Communication is timeout.

Properties

Prototyped in rm_hs300x.h

Description

This function changes measurement resolutions of the HS300x to 8, 10, 12, or 14-bits by writing to the non-volatile memory. The procedure to change or set the resolution is shown in below figure.



The detail information is described in “6.9 Setting the Measurement Resolution” of HS300x Datasheet Revision April 22, 2020.

Special Notes

This function must be called after calling the RM_HS300X_ProgrammingModeEnter function. This function performs for blocking.

3.8 RM_HS300X_SensorIdGet ()

This function obtains the sensor ID of HS300x.

Format

```
fsp_err_t RM_HS300X_SensorIdGet (
        rm_hs300x_ctrl_t * const p_ctrl,
        uint32_t * const p_sensor_id
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

p_sensor_id

Data type of HS300x.

```
/** Data type of HS300X */
typedef enum e_rm_hs300x_data_type
{
   RM_HS300X_HUMIDITY_DATA = 0,
   RM_HS300X_TEMPERATURE_DATA,
} rm_hs300x_data_type_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_INVALID_MODE	Module is not the programming mode.
FSP_ERR_ABORTED	Communication is aborted.
FSP_ERR_TIMEOUT	Communication is timeout.

Properties

Prototyped in rm_hs300x.h

Description

This function writes ID registers address 0x1E and 0x1F then reads the ID numbers.

The detail information is described in “6.10Reading the HS300x ID Number” of HS300x Datasheet Revision April 22, 2020.

Special Notes

This function must be called after calling the RM_HS300X_ProgrammingModeEnter function. This function performs for blocking.

3.9 RM_HS300X_ProgrammingModeEixt ()

This function sends commands to exit the HS300x programming mode.

Format

fsp_err_t RM_HS300X_ProgrammingModeExit (rm_hs300x_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.1(2) Control Struct rm_hs300x_ctrl_t.

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_INVALID_MODE	Module is not entering the programming mode.
FSP_ERR_UNSUPPORTED	Programming mode is not supported.

Properties

Prototyped in rm_hs300x.h

Description

This function sends the I2C address and a Write bit, followed by the command: 0x80|0x00|0x00 to exit from programming mode, return to normal sensor operation and perform measurements.

The detail information is described in “6.8 Accessing the Non-volatile Memory” of HS300x Datasheet Revision April 22, 2020.

Special Notes

This function must be called within 10ms after applying power to the HS300x sensor. This function performs for blocking.

3.10 rm_hs300x_callback ()

This is callback function for HS300x FIT module.

Format

void rm_hs300x_callback (rm_comms_callback_args_t * p_args)

Parameters

p_args

Pointer to callback parameter definition.

```
/** Communications middleware callback parameter definition */
typedef struct st_rm_comms_callback_args
{
   void const     * p_context;
   rm_comms_event_t event;
} rm_comms_callback_args_t;
```

Return Values

None

Properties

Prototyped in rm_hs300x.h

Description

This callback function is called in COMMS FIT module callback function.

The member “event” in “rm_hs300x_callback_args_t” structure which is a member of “rm_hs300x_instance_ctrl_t” structure is set according to COMMS FIT module events status “p_args->event”.

The events of HS300x FIT module are

```
typedef enum e_rm_hs300x_event
{
   RM_HS300X_EVENT_SUCCESS = 0,
   RM_HS300X_EVENT_ERROR,
} rm_hs300x_event_t;
```

And the events of COMMS FIT module are

```
typedef enum e_rm_comms_event
{
   RM_COMMS_EVENT_OPERATION_COMPLETE = 0,
   RM_COMMS_EVENT_ERROR,
} rm_comms_event_t;
```

The “event” of “rm_hs300x_callback_args_t” structure is set to “RM_HS300X_EVENT_SUCCESS” when the COMMS FIT module events status is “RM_COMMS_EVENT_OPERATION_COMPLETE” otherwise set to “RM_HS300X_EVENT_ERROR”.

Special Notes

None.

3.11 Usage Example of HS300x FIT Module

```
#include "r_smc_entry.h"
#include "r_hs300x_if.h"
#include "r_comms_i2c_if.h"
#if COMMS_I2C_CFG_DRIVER_I2C
#include "r_riic_rx_if.h"
#endif
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
#include "r_sci_iic_rx_if.h"
#endif

/* Sequence */
typedef enum e_demo_sequence
{
   DEMO_SEQUENCE_1 = (1),
   DEMO_SEQUENCE_2,
   DEMO_SEQUENCE_3,
   DEMO_SEQUENCE_4,
   DEMO_SEQUENCE_5,
   DEMO_SEQUENCE_6,
} demo_sequence_t;

/* Callback status */
typedef enum e_demo_callback_status
{
   DEMO_CALLBACK_STATUS_WAIT = (0),
   DEMO_CALLBACK_STATUS_SUCCESS,
   DEMO_CALLBACK_STATUS_REPEAT,
} demo_callback_status_t;

/* See Developer Assistance in the project */
void g_comms_i2c_bus0_quick_setup(void);
void g_hs300x_sensor0_quick_setup(void);

void       start_demo(void);
static void demo_err(void);

static volatile demo_callback_status_t  gs_demo_callback_status;
static volatile rm_hs300x_data_t        gs_hs300x_data;

/* Quick setup for g_comms_i2c_bus0. */
void g_comms_i2c_bus0_quick_setup(void)
{
   i2c_master_instance_t * p_driver_instance = (i2c_master_instance_t *)
g_comms_i2c_bus0_extended_cfg.p_driver_instance;

   /* Open i2c driver */
   if(COMMS_DRIVER_I2C == p_driver_instance->driver_type)
   {
#if COMMS_I2C_CFG_DRIVER_I2C
      riic_return_t ret;
      riic_info_t * p_i2c_info = (riic_info_t *)p_driver_instance->p_info;
```

```
        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_RIIC_Open(p_i2c_info);
        if (RIIC_SUCCESS != ret)
        {
          demo_err();
        }
#endif
    }
    else if(COMMS_DRIVER_SCI_I2C == p_driver_instance->driver_type)
    {
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
        sci_iic_return_t ret;
        sci_iic_info_t * p_i2c_info = (sci_iic_info_t *) p_driver_instance->p_info;

        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_SCI_IIC_Open(p_i2c_info);
        if (SCI_IIC_SUCCESS != ret)
        {
          demo_err();
        }
#endif
    }
}

void hs300x_user_callback0(rm_hs300x_callback_args_t * p_args)
{
    if (RM_HS300X_EVENT_SUCCESS == p_args->event)
    {
        gs_demo_callback_status = DEMO_CALLBACK_STATUS_SUCCESS;
    }
    else
    {
        gs_demo_callback_status = DEMO_CALLBACK_STATUS_REPEAT;
    }
}

/* Quick setup for g_hs300x_sensor0. */
void g_hs300x_sensor0_quick_setup(void)
{
    fsp_err_t err;

    /* Open HS300X sensor instance, this must be done before calling any HS300X API */
    err = g_hs300x_sensor0.p_api->open(g_hs300x_sensor0.p_ctrl, g_hs300x_sensor0.p_cfg);
    if (FSP_SUCCESS != err)
    {
        demo_err();
    }
}

void start_demo(void)
{
    fsp_err_t             err;
    rm_hs300x_raw_data_t    raw_data;
    demo_sequence_t         sequence = DEMO_SEQUENCE_1;
```

```
/* Open the Bus */
g_comms_i2c_bus0_quick_setup();

/* Open HS300X */
g_hs300x_sensor0_quick_setup();

while (1)
{
   switch(sequence)
   {
      case DEMO_SEQUENCE_1 :
      {
         /* Clear status */
         gs_demo_callback_status = DEMO_CALLBACK_STATUS_WAIT;

         /* Start the measurement */
         err = g_hs300x_sensor0.p_api->measurementStart(g_hs300x_sensor0.p_ctrl);
         if (FSP_SUCCESS == err)
         {
            sequence = DEMO_SEQUENCE_2;
         }
         else
         {
            demo_err();
         }
      }
      break;

      case DEMO_SEQUENCE_2 :
      {
         switch(gs_demo_callback_status)
         {
            case DEMO_CALLBACK_STATUS_WAIT :
               break;
            case DEMO_CALLBACK_STATUS_SUCCESS :
               sequence = DEMO_SEQUENCE_3;
               break;
            case DEMO_CALLBACK_STATUS_REPEAT :
               sequence = DEMO_SEQUENCE_1;
               break;
            default :
               demo_err();
               break;
         }
      }
      break;

      case DEMO_SEQUENCE_3 :
      {
         /* Clear status */
         gs_demo_callback_status = DEMO_CALLBACK_STATUS_WAIT;

         /* Read data */
```

```
    err = g_hs300x_sensor0.p_api->read(g_hs300x_sensor0.p_ctrl, &raw_data);
    if (FSP_SUCCESS == err)
    {
        sequence = DEMO_SEQUENCE_4;
    }
    else
    {
        demo_err();
    }
}
break;

case DEMO_SEQUENCE_4 :
{
    switch(gs_demo_callback_status)
    {
        case DEMO_CALLBACK_STATUS_WAIT :
            break;
        case DEMO_CALLBACK_STATUS_SUCCESS :
            sequence = DEMO_SEQUENCE_5;
            break;
        case DEMO_CALLBACK_STATUS_REPEAT :
            sequence = DEMO_SEQUENCE_3;
            break;
        default :
            demo_err();
            break;
    }
}
break;

case DEMO_SEQUENCE_5 :
{
    /* Calculate data */
    err = g_hs300x_sensor0.p_api->dataCalculate(g_hs300x_sensor0.p_ctrl,
                                    &raw_data,
                                    (rm_hs300x_data_t *)&gs_hs300x_data);
    if (FSP_SUCCESS == err)
    {
        sequence = DEMO_SEQUENCE_6;
        /* Sensor data is valid. Describe the process by referring to the calculated sensor data. */
    }
    else if (FSP_ERR_SENSOR_INVALID_DATA == err)
    {
        sequence = DEMO_SEQUENCE_3;
        /* Sensor data is invalid. */
    }
    else
    {
        demo_err();
    }
}
break;
```

```
            case DEMO_SEQUENCE_6 :
            {
               /* Wait 4 seconds. See table 4 on the page 6 of the datasheet. */
               R_BSP_SoftwareDelay(4, BSP_DELAY_SECS);
               sequence = DEMO_SEQUENCE_1;
            }
            break;

            default :
               demo_err();
               break;
         }
      }
   }

   static void demo_err(void)
   {
      while(1)
      {
         // nothing
      }
}
```

4. FS2012 API Functions

4.1 RM_FS2012_Open ()

This function opens and configures the FS2012 FIT module. This function must be called before calling any other FS2012 API functions. The RIIC FIT module or / and SCI_IIC FIT module be used must be initialized in advance.

Format

```
fsp_err_t RM_FS2012_Open (
        rm_fsxxxx_ctrl_t * const p_ctrl,
        rm_fsxxxx_cfg_t const * const p_cfg
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.2(2)Control Struct rm_fsxxxx_ctrl_t.

p_cfg

Pointer to configuration structure.
The members of this structure are shown in 2.9.2(1)Configuration Struct rm_fsxxxx_cfg_t.

Return Values

FSP_SUCCESS	FS2012 successfully configured.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_ALREADY_OPEN	Module is already open. This module can only be opened once.

Properties

Prototyped in rm_fs2012.h

Description

This function opens and configures the FS2012 FIT module.

This function copies the contents in “p_cfg” structure to the member “p_ctrl->p_cfg” in “p_ctrl” structure.

This function does configurations by setting the members of “p_ctrl” structure as following:

- Sets related instance of COMMS FIT module
- Sets callback and context
- Sets open flag

This function calls open API of COMMS FIT module to open communication middleware after all above initializations are done.

Special Notes

None

4.2 RM_FS2012_Close()

This function disables specified FS2012 control block.

Format

fsp_err_t RM_FS2012_Close (rm_fsxxxx_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.2(2)Control Struct rm_fsxxxx_ctrl_t.

Return Values

FSP_SUCCESS	Successfully closed.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_fs2012.h

Description

This function calls close API of COMMS FIT module to close communication middleware.

This function clears open flag after all above are done.

Special Notes

None

4.3 RM_FS2012_Read()

This function reads ADC data from FS2012 sensor.

Format

```
fsp_err_t RM_FS2012_Read (
        rm_fsxxxx_ctrl_t * const p_ctrl,
        rm_fsxxxx_raw_data_t * const p_raw_data
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.2(2)Control Struct rm_fsxxxx_ctrl_t.

p_raw_data

Pointer to raw data structure for storing the read ADC data from FS2012 sensor.

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_fs2012.h

Description

This function reads ADC data from FS2012 sensor.

The read API of COMMS FIT module is called in this function.

The ADC data read from FS2012 sensor is stored in “p_raw_data” structure. The read data length is 2 bytes according to FS2012 datasheet.

The detail information is described in “7. I2C Sensor Interface” of FS2012 Series Datasheet Revision August 24, 2018.

Special Notes

None

4.4 RM_FS2012_DataCalculate ()

This function calculates flow value [SLPM or SCCM] from ADC data.

Format

```
fsp_err_t RM_FS2012_DataCalculate (
        rm_fsxxxx_ctrl_t * const     p_ctrl,
        rm_fsxxxx_raw_data_t * const p_raw_data,
        rm_fsxxxx_data_t * const     p_fs2012_data
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.2(2)Control Struct rm_fsxxxx_ctrl_t.

p_raw_data

Pointer to raw data structure for storing the read ADC data from FS2012 sensor.

p_fs2012_data

Pointer to FS2012 sensor measurement results data structure.

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_fs2012.h

Description

This function calculates the flow value [SLPM or SCCM] from the ADC data stored in “rm_fsxxxx_raw_data_t p_raw_data” and stores the calculated results to “rm_fsxxxx_data_t p_fs2012_data” structure.

The “rm_fsxxxx_raw_data_t” and “rm_fsxxxx_data_t” structures are defined as following.

```
/** FSXXXX raw data */
typedef struct st_rm_fsxxxx_raw_data
{
uint8_t adc_data[5];
} rm_fsxxxx_raw_data_t;

** FSXXXX data block */
typedef struct st_rm_fsxxxx_data
{
   rm_fsxxxx_sensor_data_t flow;
   uint32_t               count;
} rm_fsxxxx_data_t;

/** FSXXXX sensor data block */
typedef struct st_rm_fsxxxx_sensor_data
{
   int16_t integer_part;
   int16_t decimal_part;            ///< To two decimal places
} rm_fsxxxx_sensor_data_t;
```

This function calculates the flow value [SLPM or SCCM] from the count value according to the following.

The entire output of the FS2012 is 2 bytes. The flow rate for gas and liquid parts is calculated as follows:

Output Data

- Number of bytes to read out: 2
- First returned byte: MSB
- Second returned byte: LSB

Gas Part Configurations (FS2012-1020-NG and FS2012-1100-NG)

- Conversion to SLPM (Standard liter er minute)
- Flow in SLPM = [(MSB << 8) + LSB] / 1000

The detail information is described in “8. Calculating Flow Sensor Output” of FS2012 Series Datasheet Revision August 24, 2018.

Special Notes

None

4.5 rm_FS2012_callback ()

This is callback function for FS2012 FIT module.

Format

void rm_fs2012_callback (rm_comms_callback_args_t * p_args)

Parameters

p_args

Pointer to callback parameter definition.

```
/** Communications middleware callback parameter definition */
typedef struct st_rm_comms_callback_args
{
   void const     * p_context;
   rm_comms_event_t event;
} rm_comms_callback_args_t;
```

Return Values

None

Properties

Prototyped in rm_fs2012.h

Description

This callback function is called in COMMS FIT module callback function.
The member “event” in “rm_fsxxxx_callback_args_t” structure which is a member of “rm_fs2012_instance_ctrl_t ” structure is set according to COMMS FIT module events status “p_args->event”.
The events of FS2012 FIT module are

```
typedef enum e_rm_fsxxxx_event
{
   RM_FSXXXX_EVENT_SUCCESS = 0,
   RM_FSXXXX_EVENT_ERROR,
} rm_fsxxxx_event_t;
```

And the events of COMMS FIT module are

```
typedef enum e_rm_comms_event
{
   RM_COMMS_EVENT_OPERATION_COMPLETE = 0,
   RM_COMMS_EVENT_ERROR,
} rm_comms_event_t;
```

The “event” of “rm_fsxxxx_callback_args_t” structure is set to “RM_FSXXXX_EVENT_SUCCESS” when the COMMS FIT module events status is “RM_COMMS_EVENT_OPERATION_COMPLETE” otherwise set to “RM_FSXXXX_EVENT_ERROR”.

Special Notes

None

4.6 Usage Example of FS2012 FIT Module

```
#include "r_smc_entry.h"
#include "r_fs2012_if.h"
#include "r_comms_i2c_if.h"
#if COMMS_I2C_CFG_DRIVER_I2C
#include "r_riic_rx_if.h"
#endif
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
#include "r_sci_iic_rx_if.h"
#endif

typedef enum e_demo_sequence
{
    DEMO_SEQUENCE_1 = (1),
    DEMO_SEQUENCE_2,
    DEMO_SEQUENCE_3,
    DEMO_SEQUENCE_4,
    DEMO_SEQUENCE_5,
    DEMO_SEQUENCE_6,
} demo_sequence_t;

typedef enum e_demo_callback_status
{
    DEMO_CALLBACK_STATUS_WAIT = (0),
    DEMO_CALLBACK_STATUS_SUCCESS,
    DEMO_CALLBACK_STATUS_REPEAT,
} demo_callback_status_t;

/* See Developer Assistance in the project */
void g_comms_i2c_bus0_quick_setup(void);
void g_fs2012_sensor0_quick_setup(void);

void        start_demo(void);
static void demo_err(void);

static volatile demo_callback_status_t  gs_demo_callback_status;
static volatile rm_fsxxxx_data_t        gs_fs2012_data;

/* Quick setup for g_comms_i2c_bus0. */
void g_comms_i2c_bus0_quick_setup(void)
{
    i2c_master_instance_t * p_driver_instance = (i2c_master_instance_t *)
g_comms_i2c_bus0_extended_cfg.p_driver_instance;

    /* Open i2c driver */
    if(COMMS_DRIVER_I2C == p_driver_instance->driver_type)
    {
#if COMMS_I2C_CFG_DRIVER_I2C
        riic_return_t ret;
        riic_info_t * p_i2c_info = (riic_info_t *)p_driver_instance->p_info;

        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_RIIC_Open(p_i2c_info);
        if (RIIC_SUCCESS != ret)
        {
           demo_err();
        }
#endif
    }
```

```
    else if(COMMS_DRIVER_SCI_I2C == p_driver_instance->driver_type)
    {
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
        sci_iic_return_t ret;
        sci_iic_info_t * p_i2c_info = (sci_iic_info_t *) p_driver_instance->p_info;

        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_SCI_IIC_Open(p_i2c_info);
        if (SCI_IIC_SUCCESS != ret)
        {
           demo_err();
        }
#endif
    }
}

/* TODO: Enable if you want to use a callback */
void fs2012_user_callback0(rm_fsxxxx_callback_args_t * p_args)
{
    if (RM_FSXXXX_EVENT_SUCCESS == p_args->event)
    {
        gs_demo_callback_status = DEMO_CALLBACK_STATUS_SUCCESS;
    }
    else
    {
        gs_demo_callback_status = DEMO_CALLBACK_STATUS_REPEAT;
    }
}

/* Quick setup for g_fs2012_sensor0. */
void g_fs2012_sensor0_quick_setup(void)
{
    fsp_err_t err;

    /* Open FS2012 sensor instance, this must be done before calling any FSXXXX API */
    err = g_fs2012_sensor0.p_api->open(g_fs2012_sensor0.p_ctrl,
g_fs2012_sensor0.p_cfg);
    if (FSP_SUCCESS != err)
    {
       demo_err();
    }
}

void start_demo(void)
{
    fsp_err_t            err;
    rm_fsxxxx_raw_data_t raw_data;
    demo_sequence_t      sequence = DEMO_SEQUENCE_1;

    /* Open the Bus */
    g_comms_i2c_bus0_quick_setup();

    /* Open FS2012 */
    g_fs2012_sensor0_quick_setup();

    while (1)
    {
        switch (sequence)
        {
```

```
            case DEMO_SEQUENCE_1 :
            {
                /* Clear status */
                gs_demo_callback_status = DEMO_CALLBACK_STATUS_WAIT;

                /* Read FS2012 ADC Data */
                err = g_fs2012_sensor0.p_api->read(g_fs2012_sensor0.p_ctrl, &raw_data);
                if (FSP_SUCCESS == err)
                {
                    sequence = DEMO_SEQUENCE_2;
                }
                else
                {
                    demo_err();
                }
            }
            break;

            case DEMO_SEQUENCE_2 :
            {
                switch (gs_demo_callback_status)
                {
                    case DEMO_CALLBACK_STATUS_WAIT :
                        break;
                    case DEMO_CALLBACK_STATUS_SUCCESS :
                        sequence = DEMO_SEQUENCE_3;
                        break;
                    case DEMO_CALLBACK_STATUS_REPEAT :
                        sequence = DEMO_SEQUENCE_1;
                        break;
                    default :
                        demo_err();
                        break;
                }
            }
            break;

            case DEMO_SEQUENCE_3 :
            {
                /* Calculate data from ADC data */
                err = g_fs2012_sensor0.p_api->dataCalculate(g_fs2012_sensor0.p_ctrl,
                                                            &raw_data,
                                                            (rm_fsxxxx_data_t
*)&gs_fs2012_data);
                if (FSP_SUCCESS == err)
                {
                    sequence = DEMO_SEQUENCE_4;
                    /* Sensor data is valid. Describe the process by referring to the
calculated sensor data. */
                }
                else
                {
                    demo_err();
                }
            }
            break;

            case DEMO_SEQUENCE_4 :
            {
```

```
                /* FS2012 sample rate. See table 4 on the page 5 of the datasheet. */
                /* Gas : 409.6ms, Liquid : 716.8ms */
                R_BSP_SoftwareDelay(409600, BSP_DELAY_MICROSECS);
                sequence = DEMO_SEQUENCE_1;
            }
            break;

            default :
                demo_err();
                break;
        }
    }
}

static void demo_err(void)
{
    while(1)
    {
        // nothing
    }
}
```

5. ZMOD4XXX API Functions

5.1 RM_ZMOD4XXX_Open ()

This function opens and configures the ZMOD4XXX FIT module. This function must be called before calling any other ZMOD4XXX API functions. The RIIC FIT module or / and SCI_IIC FIT module be used must be initialized in advance.

Format

```
fsp_err_t RM_ZMOD4XXX_Open (
        rm_zmod4xxx_ctrl_t * const p_api_ctrl,
        rm_zmod4xxx_cfg_t const * const p_cfg
);
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_cfg

Pointer to configuration structure.
The members of this structure are shown in 2.9.3(1) Configuration Struct rm_zmod4xxx_cfg_t

Return Values

FSP_SUCCESS	ZMOD4xxx successfully configured.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_ALREADY_OPEN	Module is already open. This module can only be opened once.
FSP_ERR_UNSUPPORTED	Unsupported product ID.
FSP_ERR_TIMEOUT	communication is timeout.
FSP_ERR_ABORTED	communication is aborted.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function opens and configures the ZMOD4XXX FIT module.

This function copies the contents in “p_cfg” structure to the member “p_api_ctrl->p_cfg” in “p_api_ctrl” structure. This function does configurations by setting the members of “p_api_ctrl” structure as following:

- Sets related instance of COMMS FIT module
- Sets ZMOD4XXX library specification
- Sets parameters of callback and context
- Sets open flag

This function calls following after all above initializations are done.

- Opens API of COMMS FIT module to open communication middlewareOpens IRQ open
- Initializes the sensor device (ZMOD4410 or ZMOD4510)
- Initializes the used sensor library

Special Notes

None

5.2 RM_ZMOD4XXX_Close ()

This function disables specified ZMOD4XXX control block. This function should be called when the sensor is closed.

Format

fsp_err_t RM_ZMOD4XXX_Close (rm_zmod4xxx_ctrl_t * const p_api_ctrl)

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

Return Values

FSP_SUCCESS	Successfully closed.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calls closing API of COMMS FIT module to close communication middleware and IRQ close function.

This function clears open flag after all above are done.

Special Notes

None

5.3 RM_ZMOD4XXX_MeasurementStart ()

This function starts a measurement and should be called when a measurement is started.

Format

fsp_err_t RM_ZMOD4XXX_MeasurementStart (rm_zmod4xxx_ctrl_t * const p_api_ctrl)

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_TIMEOUT	communication is timeout.
FSP_ERR_ABORTED	communication is aborted.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function sends the measurement start to command register of ZMOD4410 or ZMOD4510 sensor and starts a measurement after the “event” in “p_api_ctrl” structure is cleared.

Special Notes

When starting the next measurement after previous measurement is finished, a delay time is needed. The delay time is depended on the selected operation mode. The detail information of delay time value can be found in “case DEMO_SEQUENCE_8 :” in “void start_demo(void)” function described in 5.15 Usage Example of ZMOD4XXX FIT Module.

5.4 RM_ZMOD4XXX_MeasurementStop ()

This function stops a measurement and should be called when a measurement is to be stopped.

Format

fsp_err_t RM_ZMOD4XXX_MeasurementStop (rm_zmod4xxx_ctrl_t * const p_api_ctrl)

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options are invalid.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_TIMEOUT	communication is timeout.
FSP_ERR_ABORTED	communication is aborted.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function sends the measurement stop to command register of ZMOD4410 or ZMOD4510 sensor and stops a measurement.

Special Notes

None

5.5 RM_ZMOD4XXX_StatusCheck ()

This function reads the status of sensor and should be called when polling is used.

Format

fsp_err_t RM_ZMOD4XXX_StatusCheck (rm_zmod4xxx_ctrl_t * const p_api_ctrl);

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

Return Values

FSP_SUCCESS	Successfully data decoded.
FSP_ERR_ASSERTION	Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_TIMEOUT	communication is timeout.
FSP_ERR_ABORTED	communication is aborted.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function reads measurement status of ZMOD4410 and ZMD4510 sensor from sensor register. This function returns either measurement success or 100ms timeout.

Special Notes

None

5.6 RM_ZMOD4XXX_Read ()

This read ADC data from ZMOD4410 or ZMOD4510 sensor. This function should be called when measurement finished.

Format

```
fsp_err_t RM_ZMOD4XXX_Read (
        rm_zmod4xxx_ctrl_t * const p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const p_raw_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure for storing ADC data read from sensor. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_TIMEOUT	Communication is timeout.
FSP_ERR_ABORTED	Communication is aborted.
FSP_ERR_SENSOR_MEASUREMENT_NOT_FINISHED	Measurement is not finished.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function checks measurement status by either polling or using busy/interrupt pin. After the measurement status is confirmed as finished, this function reads ADC data and stores data to “p_raw_data” structure.

Special Notes

None

5.7 RM_ZMOD4XXX_Iaq1stGenDataCalculate ()

This function calculates IAQ 1st Gen. values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_Iaq1stGenDataCalculate (
        rm_zmod4xxx_ctrl_t * const              p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const          p_raw_data,
        rm_zmod4xxx_iaq_1st_data_t * const      p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing IAQ 1st Gen. calculation result.
This structure is declared as below.

```
/** ZMOD4XXX IAQ 1st gen data structure */
typedef struct st_rm_zmod4xxx_iaq_1st_data
{
   float rmox;          ///< MOx resistance.
   float rcda;          ///< CDA resistance.
   float iaq;           ///< IAQ index.
   float tvoc;          ///< TVOC concentration (mg/m^3).
   float etoh;          ///< EtOH concentration (ppm).
   float eco2;          ///< eCO2 concentration (ppm).
} rm_zmod4xxx_iaq_1st_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates IAQ results using ZMOD4410 IAQ 1st Gen. library and stores the results into the “rm_zmod4xxx_iaq_1st_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.8 RM_ZMOD4XXX_Iaq2ndGenDataCalculate ()

This function calculates IAQ 2nd Gen. values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_Iaq2ndGenDataCalculate (
        rm_zmod4xxx_ctrl_t * const              p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const          p_raw_data,
        rm_zmod4xxx_iaq_2nd_data_t * const      p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing IAQ 2nd Gen. calculation result.
This structure is declared as below.

```
/** ZMOD4XXX IAQ 2nd gen data structure */
typedef struct st_rm_zmod4xxx_iaq_2nd_data
{
   float rmox[13];          ///< MOx resistance.
   float log_rcda;          ///< log10 of CDA resistance.
   float iaq;               ///< IAQ index.
   float tvoc;              ///< TVOC concentration (mg/m^3).
   float etoh;              ///< EtOH concentration (ppm).
   float eco2;              ///< eCO2 concentration (ppm).
} rm_zmod4xxx_iaq_2nd_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates IAQ results using ZMOD4410 IAQ 2nd Gen. library and stores the results into the “rm_zmod4xxx_iaq_2nd_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.9 RM_ZMOD4XXX_OdorDataCalculate ()

This function calculates Odor values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_OdorDataCalculate (
        rm_zmod4xxx_ctrl_t * const          p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const      p_raw_data,
        rm_zmod4xxx_odor_data_t * const     p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing Odor calculation result.
This structure is declared as below.

```
/** ZMOD4XXX Odor structure */
typedef struct st_rm_zmod4xxx_odor_data
{
   bool  control_signal;      ///< Control signal input for odor lib.
   float odor;                ///< Concentration ratio for odor lib.
} rm_zmod4xxx_odor_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates Odor results from r_mox and odor parameters using ZMOD4410 Odor library and stores the results into the “rm_zmod4xxx_odor_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.10 RM_ZMOD4XXX_SulfurOdorDataCalculate ()

This function calculates Sulfur Odor values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_SulfurOdorDataCalculate (
        rm_zmod4xxx_ctrl_t * const                  p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const              p_raw_data,
        rm_zmod4xxx_sulfur_odor_data_t * const      p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing Sulfur Odor calculation result.
This structure is declared as below.

```
/** ZMOD4XXX Sulfur-Odor structure */
typedef struct st_rm_zmod4xxx_sulfur_odor_data
{
   float rmox[9];                          ///< MOx resistance.
   float intensity;                        ///< odor intensity rating ranges from 0.0 to 5.0 for sulfur lib
   rm_zmod4xxx_sulfur_odor_t odor;         ///< sulfur_odor classification for lib
} rm_zmod4xxx_sulfur_odor_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates Sulfur Odor results from ADC data using ZMOD4410 Sulfur Odor library and stores the results into the “rm_zmod4xxx_sulfur_odor_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.11 RM_ZMOD4XXX_Oaq1stGenDataCalculate ()

This function calculates OAQ 1st Gen. values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_Oaq1stGenDataCalculate (
        rm_zmod4xxx_ctrl_t * const              p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const          p_raw_data,
        rm_zmod4xxx_oaq_1st_data_t * const      p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing OAQ 1st Gen. calculation result.
This structure is declared as below.

```
/** ZMOD4XXX OAQ 1st gen data structure */
typedef struct st_rm_zmod4xxx_oaq_1st_data
{
   float rmox[15];          ///< MOx resistance
   float aiq;               ///< Air Quality
} rm_zmod4xxx_oaq_1st_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates AQI results from ADC data using ZMOD4510 OAQ 1st Gen. library and stores the results into the “rm_zmod4xxx_oaq_1st_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.12 RM_ZMOD4XXX_Oaq2ndGenDataCalculate ()

This function calculates OAQ 2nd Gen. values from ADC data.

Format

```
fsp_err_t RM_ZMOD4XXX_Oaq2ndGenDataCalculate (
        rm_zmod4xxx_ctrl_t * const                p_api_ctrl,
        rm_zmod4xxx_raw_data_t * const            p_raw_data,
        rm_zmod4xxx_oaq_2nd_data_t * const  p_zmod4xxx_data
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

p_raw_data

Pointer to raw data structure which ADC data read from sensor is stored in. This structure is declared as below.

```
/** ZMOD4XXX raw data structure */
typedef struct st_rm_zmod4xxx_raw_data
{
   uint8_t adc_data[32];
} rm_zmod4xxx_raw_data_t;
```

p_zmod4xxx_data

Pointer to calculation result data structure storing OAQ 2nd Gen. calculation result.
This structure is declared as below.

```
/** ZMOD4XXX OAQ 2nd gen data structure */
typedef struct st_rm_zmod4xxx_oaq_2nd_data
{
   float    rmox[8];                ///< MOx resistance.
   float    ozone_concentration;    ///< The ozone concentration in part-per-billion
   uint16_t fast_aqi;               ///< 1-minute average of the Air Quality Index according to the EPA standard based on ozone
   uint16_t epa_aqi;                ///< The Air Quality Index according to the EPA standard based on ozone
} rm_zmod4xxx_oaq_2nd_data_t;
```

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.
FSP_ERR_SENSOR_IN_STABILIZATION	Module is stabilizing.
FSP_ERR_UNSUPPORTED	Operation mode is not supported.

Properties

Prototyped in rm_zmod4xxx.h

Description

This function calculates OAQ results from ADC data using ZMOD4510 OAQ 2nd Gen. library and stores the results into the “rm_zmod4xxx_oaq_2nd_data_t *p_zmod4xxx_data) structure.

Special Notes

None

5.13 RM_ZMOD4XXX_TemperatureAndHumiditySet ()

This function sets relative humidity (in %RH) and temperature (in °C) values for OAQ 2nd Gen calculation.

Format

```
fsp_err_t RM_ZMOD4XXX_TemperatureAndHumiditySet (
        rm_zmod4xxx_ctrl_t * const      p_api_ctrl,
        float                           temperature,
        float                           humidity
)
```

Parameters

p_api_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.3(2) Control Struct rm_zmod4xxx_ctrl_t.

tmperature

Temperature value (in °C) set to “p_api_ctrl -> temperature”.

humidity

Humidity value (in %RH) set to “p_api_ctrl -> humidity”.

Return Values

FSP_SUCCESS	Successfully started.
FSP_ERR_ASSERTION	Null pointer passed as a parameter.
FSP_ERR_NOT_OPEN	Module is not open.

Properties

Prototyped in rm_zmod4xxx.h

Description

In OAQ 2nd Gen operation, an additional temperature and humidity measurement is recommended, and the algorithm has an auto-compensation included. This function sets environmental relative humidity (in %RH) and temperature (in °C) values for OAQ 2nd Gen calculation. This function should be called before RM_ZMOD4XXX_Oaq2ndGenDataCalculate () is called for calculation.

The detail information is described in “5.5 Environmental Temperature and Humidity” of ZMOD4510 Datasheet Revision June 30, 2021.

Special Notes

None

5.14 rm_zmod4xxx_comms_i2c_callback ()

This is callback function for ZMOD4XXX FIT module.

Format

void rm_zmod4xxx_comms_i2c_callback (rm_comms_callback_args_t * p_args)

Parameters

p_args

Pointer to callback parameter definition.

```
/** Communications middleware callback parameter definition */
typedef struct st_rm_comms_callback_args
{
    void const     * p_context;
    rm_comms_event_t event;
} rm_comms_callback_args_t;
```

Return Values

None

Properties

Prototyped in rm_zmod4xxx.h

Description

This callback function is called in COMMS FIT module callback function.
The member “event” in “rm_zmod4xxx_callback_args_t” structure which is a member of “rm_zmod4xxx_instance_ctrl_t” structure is set according to COMMS FIT module events status “p_args->event”.
The events of ZMO4XXX FIT module are

```
/** Event in the callback function */
typedef enum e_rm_zmod4xxx_event
{
    RM_ZMOD4XXX_EVENT_SUCCESS = 0,
    RM_ZMOD4XXX_EVENT_MEASUREMENT_COMPLETE,
    RM_ZMOD4XXX_EVENT_MEASUREMENT_NOT_COMPLETE,
    RM_ZMOD4XXX_EVENT_ERROR,
} rm_zmod4xxx_event_t;
```

And the events of COMMS FIT module are

```
typedef enum e_rm_comms_event
{
    RM_COMMS_EVENT_OPERATION_COMPLETE = 0,
    RM_COMMS_EVENT_ERROR,
} rm_comms_event_t;
```

The “event” of “rm_zmod4xxx_callback_args_t” structure is set to “RM_ZMOD4XXX_EVENT_SUCCESS” when the COMMS FIT module events status is “RM_COMMS_EVENT_OPERATION_COMPLETE” otherwise set to “RM_ZMOD4XXX_EVENT_ERROR”. After above judgement, the “event” of “rm_zmod4xxx_callback_args_t” structure is changed to “RM_ZMOD4XXX_EVENT_MEASUREMENT_COMPLETE” or “RM_ZMOD4XXX_EVENT_MEASUREMENT_NOT_COMPLETE” after checking the “status” of “rm_zmod4xxx_callback_args_t”.

Special Notes

None.

5.15 Usage Example of ZMOD4XXX FIT Module

```
#include "r_zmod4xxx_if.h"
#include "r_comms_i2c_if.h"
#if COMMS_I2C_CFG_DRIVER_I2C
#include "r_riic_rx_if.h"
#endif
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
#include "r_sci_iic_rx_if.h"
#endif

typedef enum e_demo_sequence
{
   DEMO_SEQUENCE_1 = (1),
   DEMO_SEQUENCE_2,
   DEMO_SEQUENCE_3,
   DEMO_SEQUENCE_4,
   DEMO_SEQUENCE_5,
   DEMO_SEQUENCE_6,
   DEMO_SEQUENCE_7,
   DEMO_SEQUENCE_8,
   DEMO_SEQUENCE_9,
} demo_sequence_t;

typedef enum e_demo_callback_status
{
   DEMO_CALLBACK_STATUS_WAIT = (0),
   DEMO_CALLBACK_STATUS_SUCCESS,
   DEMO_CALLBACK_STATUS_REPEAT,
} demo_callback_status_t;

void g_comms_i2c_bus0_quick_setup(void);
void g_zmod4xxx_sensor0_quick_setup(void);
void start_demo(void);
void demo_err(void);

static volatile demo_callback_status_t  gs_i2c_callback_status = DEMO_CALLBACK_STATUS_WAIT;
#if RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE
static volatile demo_callback_status_t  gs_irq_callback_status = DEMO_CALLBACK_STATUS_WAIT;
#endif
```

```
static volatile rm_zmod4xxx_iaq_1st_data_t      gs_iaq_1st_gen_data;
static volatile rm_zmod4xxx_iaq_2nd_data_t      gs_iaq_2nd_gen_data;
static volatile rm_zmod4xxx_odor_data_t         gs_odor_data;
static volatile rm_zmod4xxx_sulfur_odor_data_t  gs_sulfur_odor_data;
static volatile rm_zmod4xxx_oaq_1st_data_t      gs_oaq_1st_gen_data;
static volatile rm_zmod4xxx_oaq_2nd_data_t      gs_oaq_2nd_gen_data;

void zmod4xxx_user_i2c_callback0(rm_zmod4xxx_callback_args_t * p_args)
{
    if (RM_ZMOD4XXX_EVENT_ERROR != p_args->event)
    {
        gs_i2c_callback_status = DEMO_CALLBACK_STATUS_SUCCESS;
    }
    else
    {
        gs_i2c_callback_status = DEMO_CALLBACK_STATUS_REPEAT;
    }
}

/* TODO: Enable if you want to use a IRQ callback */
void zmod4xxx_user_irq_callback0(rm_zmod4xxx_callback_args_t * p_args)
{
#if RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE
    FSP_PARAMETER_NOT_USED(p_args);

    gs_irq_callback_status = DEMO_CALLBACK_STATUS_SUCCESS;
#else
    FSP_PARAMETER_NOT_USED(p_args);
#endif
}

/* Quick setup for g_zmod4xxx_sensor0. */
void g_zmod4xxx_sensor0_quick_setup(void)
{
    fsp_err_t err;

    /* Set the pin for IRQ */
#if RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE
    R_ICU_PinSet();
#endif
```

```
    /* Open ZMOD4XXX sensor instance, this must be done before calling any ZMOD4XXX API */
    err = g_zmod4xxx_sensor0.p_api->open(g_zmod4xxx_sensor0.p_ctrl, g_zmod4xxx_sensor0.p_cfg);
    if (FSP_SUCCESS != err)
    {
        demo_err();
    }
}

/* Quick setup for g_comms_i2c_bus0. */
void g_comms_i2c_bus0_quick_setup(void)
{
    i2c_master_instance_t * p_driver_instance = (i2c_master_instance_t *)
g_comms_i2c_bus0_extended_cfg.p_driver_instance;

    /* Open i2c driver */
    if(COMMS_DRIVER_I2C == p_driver_instance->driver_type)
    {
#if COMMS_I2C_CFG_DRIVER_I2C
        riic_return_t ret;
        riic_info_t * p_i2c_info = (riic_info_t *)p_driver_instance->p_info;

        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_RIIC_Open(p_i2c_info);
        if (RIIC_SUCCESS != ret)
        {
            demo_err();
        }
#endif
    }
    else if(COMMS_DRIVER_SCI_I2C == p_driver_instance->driver_type)
    {
#if COMMS_I2C_CFG_DRIVER_SCI_I2C
        sci_iic_return_t ret;
        sci_iic_info_t * p_i2c_info = (sci_iic_info_t *) p_driver_instance->p_info;

        p_i2c_info->ch_no = (uint8_t) p_driver_instance->driver_channel;
        ret = R_SCI_IIC_Open(p_i2c_info);
        if (SCI_IIC_SUCCESS != ret)
        {
```

```
            demo_err();
        }
#endif
    }
}

void start_demo(void)
{
    fsp_err_t              err;
    rm_zmod4xxx_raw_data_t  raw_data;
    demo_sequence_t        sequence = DEMO_SEQUENCE_1;
    rm_zmod4xxx_lib_type_t  lib_type = g_zmod4xxx_sensor0_extended_cfg.lib_type;
    float                          temperature = 20.0F;
    float                          humidity = 50.0F;

    /* Clear status */
    gs_i2c_callback_status = DEMO_CALLBACK_STATUS_WAIT;
#if RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE
    gs_irq_callback_status = DEMO_CALLBACK_STATUS_WAIT;
#endif

    /* Open the Bus */
    g_comms_i2c_bus0_quick_setup();

    /* Open ZMOD4XXX */
    g_zmod4xxx_sensor0_quick_setup();

    while(1)
    {
        switch(sequence)
        {
            case DEMO_SEQUENCE_1 :
            {
                /* Clear status */
                gs_i2c_callback_status = DEMO_CALLBACK_STATUS_WAIT;

                /* Start measurement */
                err = g_zmod4xxx_sensor0.p_api->measurementStart(g_zmod4xxx_sensor0.p_ctrl);
                if (FSP_SUCCESS == err)
                {
```

```
                sequence = DEMO_SEQUENCE_2;
            }
            else
            {
                demo_err();
            }
        }
        break;

        case DEMO_SEQUENCE_2 :
        {
            /* Check I2C callback status */
            switch (gs_i2c_callback_status)
            {
                case DEMO_CALLBACK_STATUS_WAIT :
                    break;
                case DEMO_CALLBACK_STATUS_SUCCESS :
                    sequence = DEMO_SEQUENCE_3;
                    break;
                case DEMO_CALLBACK_STATUS_REPEAT :
                    sequence = DEMO_SEQUENCE_1;
                    break;
                default :
                    demo_err();
                    break;
            }
        }
        break;

#if RM_ZMOD4XXX_CFG_DEVICE0_IRQ_ENABLE
        case DEMO_SEQUENCE_3 :
        {
            /* Check IRQ callback status */
            switch (gs_irq_callback_status)
            {
                case DEMO_CALLBACK_STATUS_WAIT :
                    break;
                case DEMO_CALLBACK_STATUS_SUCCESS :
                    gs_irq_callback_status = DEMO_CALLBACK_STATUS_WAIT;
                    sequence = DEMO_SEQUENCE_5;
```

```
                break;
            default :
                demo_err();
                break;
        }
    }
    break;
#else
    case DEMO_SEQUENCE_3 :
    {
        /* Clear status */
        gs_i2c_callback_status = DEMO_CALLBACK_STATUS_WAIT;

        /* Get status */
        err = g_zmod4xxx_sensor0.p_api->statusCheck(g_zmod4xxx_sensor0.p_ctrl);
        if (FSP_SUCCESS == err)
        {
            sequence = DEMO_SEQUENCE_4;
        }
        else
        {
            demo_err();
        }
    }
    break;

    case DEMO_SEQUENCE_4 :
    {
        /* Check I2C callback status */
        switch (gs_i2c_callback_status)
        {
            case DEMO_CALLBACK_STATUS_WAIT :
                break;
            case DEMO_CALLBACK_STATUS_SUCCESS :
                sequence = DEMO_SEQUENCE_5;
                break;
            case DEMO_CALLBACK_STATUS_REPEAT :
                sequence = DEMO_SEQUENCE_3;
                break;
            default :
```

```
                demo_err();
                break;
            }
        }
        break;
#endif
        case DEMO_SEQUENCE_5 :
        {
            /* Clear status */
            gs_i2c_callback_status = DEMO_CALLBACK_STATUS_WAIT;

            /* Read data */
            err = g_zmod4xxx_sensor0.p_api->read(g_zmod4xxx_sensor0.p_ctrl, &raw_data);
            if (FSP_SUCCESS == err)
            {
                sequence = DEMO_SEQUENCE_6;
            }
            else if (FSP_ERR_SENSOR_MEASUREMENT_NOT_FINISHED == err)
            {
                sequence = DEMO_SEQUENCE_3;

                /* Delay 50ms */
                R_BSP_SoftwareDelay(50, BSP_DELAY_MILLISECS);
            }
            else
            {
                demo_err();
            }
        }
        break;

        case DEMO_SEQUENCE_6 :
        {
            /* Check I2C callback status */
            switch (gs_i2c_callback_status)
            {
                case DEMO_CALLBACK_STATUS_WAIT :
                    break;
                case DEMO_CALLBACK_STATUS_SUCCESS :
                    sequence = DEMO_SEQUENCE_7;
```

```
                break;
            case DEMO_CALLBACK_STATUS_REPEAT :
                sequence = DEMO_SEQUENCE_5;
                break;
            default :
                demo_err();
                break;
        }
    }
    break;

    case DEMO_SEQUENCE_7 :
    {
        /* Calculate data */
        switch (lib_type)
        {
            case RM_ZMOD4410_LIB_TYPE_IAQ_1ST_GEN_CONTINUOUS :
            case RM_ZMOD4410_LIB_TYPE_IAQ_1ST_GEN_LOW_POWER :
                err = g_zmod4xxx_sensor0.p_api->iaq1stGenDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
                                                       &raw_data,
                                                       (rm_zmod4xxx_iaq_1st_data_t*)&gs_iaq_1st_gen_data);
                break;
            case RM_ZMOD4410_LIB_TYPE_IAQ_2ND_GEN :
                err = g_zmod4xxx_sensor0.p_api->iaq2ndGenDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
                                                       &raw_data,
                                                       (rm_zmod4xxx_iaq_2nd_data_t*)&gs_iaq_2nd_gen_data);
                break;
            case RM_ZMOD4410_LIB_TYPE_ODOR :
                err = g_zmod4xxx_sensor0.p_api->odorDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
                                                  &raw_data,
                                                  (rm_zmod4xxx_odor_data_t*)&gs_odor_data);
                break;
            case RM_ZMOD4410_LIB_TYPE_SULFUR_ODOR :
                err = g_zmod4xxx_sensor0.p_api->sulfurOdorDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
                                                        &raw_data,

(rm_zmod4xxx_sulfur_odor_data_t*)&gs_sulfur_odor_data);
                break;
            case RM_ZMOD4510_LIB_TYPE_OAQ_1ST_GEN :
                err = g_zmod4xxx_sensor0.p_api->oaq1stGenDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
```

```
                                                &raw_data,
                                                (rm_zmod4xxx_oaq_1st_data_t*)&gs_oaq_1st_gen_data);
                    break;
                case RM_ZMOD4510_LIB_TYPE_OAQ_2ND_GEN :
                 err = g_zmod4xxx_sensor0.p_api->temperatureAndHumiditySet(g_zmod4xxx_sensor0.p_ctrl,
                                                                           temperature,
                                                                           humidity);
                 if (err != FSP_SUCCESS)
                 {
                      demo_err();
                 }
                   err = g_zmod4xxx_sensor0.p_api->oaq2ndGenDataCalculate(g_zmod4xxx_sensor0.p_ctrl,
                                                &raw_data,

(rm_zmod4xxx_oaq_2nd_data_t*)&gs_oaq_2nd_gen_data);
                    break;
                default :
                    demo_err();
                    break;
            }

            if (FSP_SUCCESS == err)
            {
                /* Gas data is valid. Describe the process by referring to each calculated gas data. */
            }
            else if (FSP_ERR_SENSOR_IN_STABILIZATION == err)
            {
                /* Gas data is invalid. Sensor is in stabilization. */
            }
            else
            {
                demo_err();
            }

            sequence = DEMO_SEQUENCE_8;
        }
        break;

        case DEMO_SEQUENCE_8 :
        {
```

```
            switch (lib_type)
            {
               case RM_ZMOD4410_LIB_TYPE_IAQ_1ST_GEN_CONTINUOUS :
               case RM_ZMOD4410_LIB_TYPE_ODOR :
                  sequence = DEMO_SEQUENCE_3;
                  break;
               case RM_ZMOD4410_LIB_TYPE_IAQ_1ST_GEN_LOW_POWER :
                  /* See Table 3 in the ZMOD4410 Programming Manual. */
                  R_BSP_SoftwareDelay(5475, BSP_DELAY_MILLISECS);
                  sequence = DEMO_SEQUENCE_1;
                  break;
               case RM_ZMOD4410_LIB_TYPE_IAQ_2ND_GEN :
               case RM_ZMOD4410_LIB_TYPE_SULFUR_ODOR :
               case RM_ZMOD4510_LIB_TYPE_OAQ_2ND_GEN :
                  /* IAQ 2nd Gen : See Table 4 in the ZMOD4410 Programming Manual. */
                  /* Sulfur Odor : See Table 6 in the ZMOD4410 Programming Manual. */
                 /* OAQ 2nd Gen : See Table 4 in the ZMOD4510 Programming Manual. */
                  R_BSP_SoftwareDelay(1990, BSP_DELAY_MILLISECS);
                  sequence = DEMO_SEQUENCE_1;
                  break;
               case RM_ZMOD4510_LIB_TYPE_OAQ_1ST_GEN :
                sequence = DEMO_SEQUENCE_1;
                  break;
               default :
                  demo_err();
                  break;
            }
         }
         break;

         default :
         {
            demo_err();
         }
         break;
      }
   }
}

void demo_err(void)
```

```
{
   while(1)
   {
      // nothing
   }
}
```

6. COMMS (I2C communication middleware) API Functions

6.1 RM_COMMS_I2C_Open()

This function opens and configures the COMMS (I2C communication middleware) FIT module.

Format

```
fsp_err_t RM_COMMS_I2C_Open (
        rm_comms_ctrl_t * const p_ctrl,
        rm_comms_cfg_t const * const p_cfg
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.4(2)Control Struct rm_comms_ctrl_t.

p_cfg

Pointer to configuration structure.
The members of this structure are shown in 2.9.4(1)Configuration Struct rm_comms_cfg_t.

Return Values

FSP_SUCCESS	: Communications Middle module successfully configured.
FSP_ERR_ASSERTION	: Null pointer, or one or more configuration options is invalid.
FSP_ERR_ALREADY_OPEN	: Module is already open. This module can only be opened once.
FSP_ERR_COMMS_BUS_NOT_OPEN	: I2C driver is not open.

Properties

Prototyped in rm_comms_i2c.h

Description

This function opens and configures the COMMS FIT module.

This function copies the contents in “p_cfg” structure to the member “p_ctrl->p_cfg” in “p_cfg” structure.

This function does configurations by setting the members of “p_ctrl” structure as following:

- Sets bus configuration
- Sets lower-level driver configuration
- Sets callback and context
- Sets open flag

Special Notes

“R_RIIC_Open()” or “R_SCI_IIC_Open()” must be called before calling this function.

Please refer to following documents for detail of “R_RIIC_Open ()” API and “R_SCI_IIC_Open ()” API:

- RX Family I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
- RX Family Simple I2C Module Using Firmware Integration Technology (R01AN1691)

In addition, if use RTOS, a semaphore for blocking the bus and a mutex for locking the bus must be created before calling this function. Please make sure to use the semaphore and the mutex that are members of the variables “g_comms_i2c_bus(x)_extended_cfg” (x : 0 – 4)

Please refer to the following example.

```
/* Create a semaphore for blocking if a semaphore is not NULL */
```

```
    if (NULL != g_comms_i2c_bus0_extended_cfg.p_blocking_semaphore)
    {
#if BSP_CFG_RTOS_USED == 1          // FreeRTOS
*(g_comms_i2c_bus0_extended_cfg.p_blocking_semaphore->p_semaphore_handle)
            = xSemaphoreCreateCounting((UBaseType_t) 1, (UBaseType_t) 0);
#elif BSP_CFG_RTOS_USED == 5        // ThreadX
        tx_semaphore_create(g_comms_i2c_bus0_extended_cfg.p_blocking_semaphore-
>p_semaphore_handle,
                            g_comms_i2c_bus0_extended_cfg.p_blocking_semaphore->p_semaphore_name,
                            (ULONG) 0);
#endif
    }

    /* Create a recursive mutex for bus lock if a recursive mutex is not NULL */
    if (NULL != g_comms_i2c_bus0_extended_cfg.p_bus_recursive_mutex)
    {
#if BSP_CFG_RTOS_USED == 1          // FreeRTOS
        *(g_comms_i2c_bus0_extended_cfg.p_bus_recursive_mutex->p_mutex_handle)
            = xSemaphoreCreateRecursiveMutex();
#elif BSP_CFG_RTOS_USED == 5        // ThreadX
        tx_mutex_create(g_comms_i2c_bus0_extended_cfg.p_bus_recursive_mutex->p_mutex_handle,
                        g_comms_i2c_bus0_extended_cfg.p_bus_recursive_mutex->p_mutex_name,
                        TX_INHERIT);
#endif
    }
```

6.2 RM_COMMS_I2C_Close()

This function disables specified COMMS FIT module.

Format

fsp_err_t RM_COMMS_I2C_Close (rm_comms_ctrl_t * const p_ctrl)

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.4(2)Control Struct rm_comms_ctrl_t.

Return Values

FSP_SUCCESS	: Communications Middle module successfully configured.
FSP_ERR_ASSERTION	: Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	: Module is not open.

Properties

Prototyped in rm_comms_i2c.h

Description

This function clears current device on bus and open flag.

Special Notes

None

6.3 RM_COMMS_I2C_Read()

This function performs a read from I2C device.

Format

```
fsp_err_t RM_COMMS_I2C_Read (
        rm_comms_ctrl_t * const p_ctrl,
        uint8_t * const p_dest,
        uint32_t const bytes
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.4(2)Control Struct rm_comms_ctrl_t.

p_dest

Pointer to the buffer to store read data.

bytes

Number of bytes to read.

Return Values

FSP_SUCCESS	: Communications Middle module successfully configured.
FSP_ERR_ASSERTION	: Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	: Module is not open.
FSP_ERR_INVALID_CHANNEL	: Invalid channel.
FSP_ERR_INVALID_ARGUMENT	: Invalid argument.
FSP_ERR_IN_USE	: Bus is busy.

Properties

Prototyped in rm_comms_i2c.h

Description

This function calls internal function “rm_comms_i2c_bus_read()” to start read operation from I2C bus which is RIIC bus or SCI bus depending on the device (sensor) connection.

The internal function “rm_comms_i2c_bus_read()” does bus re-configuration according to contents in “p_ctrl”. Then it calls “R_RIIC_MasterReceive()” API of RIIC FIT module when the device (sensor) is connected to RIIC bus, calls “R_SCI_IIC_MasterReceive()” API of SCI_IIC FIT module when the device (sensor) is connected to SCI bus.

The receive pattern of “R_RIIC_MasterReceive()” and “R_SCI_IIC_MasterReceive()” is set as master reception. In this pattern, the master (RX MCU) receives data from the slave.

Please refer to following documents for detail of “R_RIIC_MasterReceive()” API and “R_SCI_IIC_MasterReceive()” API:

- RX Family I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
- RX Family Simple I2C Module Using Firmware Integration Technology (R01AN1691)

Special Notes

None

6.4 RM_COMMS_I2C_Write()

This function performs a write from the I2C device.

Format

```
fsp_err_t RM_COMMS_I2C_Write (
        rm_comms_ctrl_t * const p_ctrl,
        uint8_t * const p_src,
        uint32_t const bytes
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.4(2)Control Struct rm_comms_ctrl_t.

p_src

Pointer to the buffer to store writing data.

bytes

Number of bytes to write.

Return Values

FSP_SUCCESS	: Communications Middle module successfully configured.
FSP_ERR_ASSERTION	: Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	: Module is not open.
FSP_ERR_INVALID_CHANNEL	: Invalid channel.
FSP_ERR_INVALID_ARGUMENT	: Invalid argument.
FSP_ERR_IN_USE	: Bus is busy.

Properties

Prototyped in rm_comms_i2c.h

Description

This function calls internal function “rm_comms_i2c_bus_write()” to start write operation to I2C bus which is RIIC bus or SCI bus depending on device (sensor) connection.

The internal function “rm_comms_i2c_bus_write()” does bus re-configuration according to contents in “p_ctrl”. Then it calls “R_RIIC_MasterSend()” API of RIIC FIT module when the device (sensor) is connected to RIIC bus, calls “R_SCI_IIC_MasterSend()” API of SCI_IIC FIT module when the device (sensor) is connected to SCI bus.

Please refer to following documents for detail of “R_RIIC_MasterSend()” API and “R_SCI_IIC_MasterSend()” API:

- RX Family I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
- RX Family Simple I2C Module Using Firmware Integration Technology (R01AN1691)

Special Notes

None

6.5 RM_COMMS_I2C_WriteRead()

This function performs a write to, then a read from the I2C device.

Format

```
fsp_err_t RM_COMMS_I2C_WriteRead (
        rm_comms_ctrl_t * const          p_ctrl,
        rm_comms_write_read_params_t const write_read_params
)
```

Parameters

p_ctrl

Pointer to control structure.
The members of this structure are shown in 2.9.4(2)Control Struct rm_comms_ctrl_t.

write_read_params

Parameters structure for writeRead API.

```
/** Struct to pack params for writeRead */
typedef struct st_rm_comms_write_read_params
{
   uint8_t * p_src;          ///< pointer to buffer for storing write data
   uint8_t * p_dest;         ///< pointer to buffer for storing read data
   uint8_t   src_bytes;      ///< number of write data
   uint8_t   dest_bytes;     ///< number of read data
} rm_comms_write_read_params_t;
```

Return Values

FSP_SUCCESS	: Communications Middle module successfully configured.
FSP_ERR_ASSERTION	: Null pointer, or one or more configuration options is invalid.
FSP_ERR_NOT_OPEN	: Module is not open.
FSP_ERR_INVALID_CHANNEL	: Invalid channel.
FSP_ERR_INVALID_ARGUMENT	: Invalid argument.
FSP_ERR_IN_USE	: Bus is busy.

Properties

Prototyped in rm_comms_i2c.h

Description

This function calls internal function “rm_comms_i2c_bus_write_read ()” to start writing to I2C bus, then reading from I2C bus with re-start. The I2C bus is RIIC bus or SCI bus depending on device (sensor) connection.

The internal function “rm_comms_i2c_bus_write_read ()” does bus re-configuration according to contents in “p_ctrl”. Then it calls “R_RIIC_MasterReceive()” API of RIIC FIT module when the device (sensor) is connected to RIIC bus, calls “R_SCI_IIC_MasterReceive()” API of SCI_IIC FIT module when the device (sensor) is connected to SCI bus. The receive pattern of “R_RIIC_MasterReceive()” and “R_SCI_IIC_MasterReceive()” is set as master transmit/receive. In this pattern, the master (RX MCU) transmits data to the slave. After the transmission completes, a restart condition is generated, and the master receives data from the slave.

Please refer to following documents for detail of “R_RIIC_MasterReceive()” API and “R_SCI_IIC_MasterReceive()” API:

- RX Family I2C Bus Interface (RIIC) Module Using Firmware Integration Technology (R01AN1692)
- RX Family Simple I2C Module Using Firmware Integration Technology (R01AN1691)

Special Notes

None.

6.6 rm_comms_i2c_callback

This is callback function for COMMS FIT module called in I2C driver callback function.

Format

```
void rm_comms_i2c_callback (rm_comms_ctrl_t const * p_api_ctrl)
```

Parameters

p_ctrl

Pointer to instance control structure.

```
/** Communications middleware control structure. */
typedef struct st_rm_comms_i2c_instance_ctrl
{
    rm_comms_cfg_t const           * p_cfg; ///< middleware configuration.
    rm_comms_i2c_bus_extended_cfg_t * p_bus; ///< Bus using this device;
    void    * p_lower_level_cfg;           ///< Used to reconfigure I2C driver
    uint32_t  open;                        ///< Open flag.
    uint32_t  transfer_data_bytes;         ///< Size of transfer data.
    uint8_t * p_transfer_data;             ///< Pointer to transfer data buffer.

    /* Pointer to callback and optional working memory */
    void (* p_callback)(rm_comms_callback_args_t * p_args);

    void const * p_context;          ///< Pointer to the user-provided context
} rm_comms_i2c_instance_ctrl_t;
```

Return Values

None

Properties

Prototyped in rm_comms_i2c.h

Description

This callback function is common callback function called in I2C driver callback function.
The member “event” in “rm_comms_callback_args_t” structure which is a member of “rm_comms_cfg_t” structure is set by local function “rm_comms_i2c_bus_callbackErrorCheck” according to I2C bus status.
The events of COMMS FIT module are

```
typedef enum e_rm_comms_event
{
    RM_COMMS_EVENT_OPERATION_COMPLETE = 0,
    RM_COMMS_EVENT_ERROR,
} rm_comms_event_t;
```

The “event” of “rm_comms_callback_args_t” structure is set to “RM_COMMS_EVENT_OPERATION_COMPLETE” otherwise set to “RM_COMMS_EVENT_ERROR”.
For RTOS application, local function “rm_comms_i2c_process_in_callback” is used for releasing semaphore and call user callback function.

Special Notes

None.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	June 30, 2021	-	First Release
1.10	Sep 30, 2021	-	Added description of programming mode features of HS300X FIT module Added description of FS2012 and ZMOD4XXX FIT modules
1.20	Dec 9, 2021	-	Changed description of supporting to usage of multiple ZMOD4XXX sensors in a project Other minor changes

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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