Environmental Sensors

This document describes the Environmental Sensors Evaluation Kit (ES-EVK) for the following sensors:

- ZMOD4410 for TVOC and IAQ
- RRH46410 for TVOC and IAQ
- ZMOD4510 for O_3, NO_2, and OAQ
- ZMOD4450 for RAQ
- HS3001 and HS4001 for RHT
- FS3000 for Air Velocity
- RRH62000 for PM, TVOC, and RHT

All sensors share the same evaluation kit platform in hardware and software.

The Environmental Sensors Evaluation Software allows Windows®-based operating systems to communicate with the EVK's microcontroller via a USB connection on the user's computer. The software and additional related documentation are available on each Renesas sensor web page.

The EVK's Communication Board (ESCom) handles the interface between the user's computer and the sensor modules mounted on the sensor boards ("daughter boards").

The evaluation kit uses an ARM®-based Renesas RA4M2 MCU on the communication board to handle the USB protocol, translate communications, and synchronize communications with the I²C interface. The sensor board includes necessary decoupling capacitors; however, I²C pull-up resistors for the sensor boards are not assembled or mounted on the ESCom communication board, but on the provided Renesas sensor boards only.

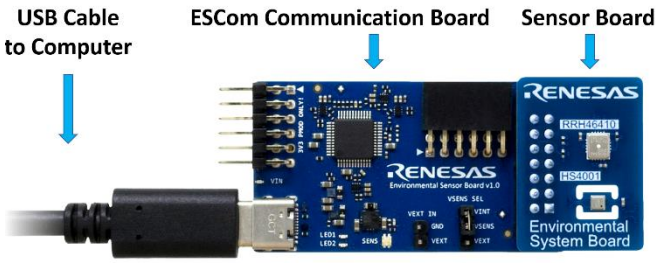
Kit Content

- Environmental Sensor Communication board (ESCom)
- Sensor board with either:
  - ZMOD4410 + HS4001
  - ZMOD4510 + HS3001
  - RRH46410 + HS4001
  - ZMOD4450
  - FS3000
  - RRH62000
- USB cable (Type-A to Type-C)

Features

- User-friendly EVK expedites configuration and evaluation of the Renesas environmental sensors for air quality, gasses, humidity, temperature and particulate matter
- Supports all methods of operation for each sensor, including ultra-low power and AI technology for accurate and consistent sensor outputs
- Sensor-dependent algorithmic output and, if applicable, referring to international standards
- Operates with Renesas provided software; either with executable Graphic User Interface (GUI) or alternatively with programming examples
- The modular design of the EVK allows simple connection of PMOD boards for different environmental sensor derivatives and easy integration with other sensor products via the I²C interface
- The required Environmental Sensors Evaluation Software (ES-Eval) is available for free download on the Renesas website
  - Provides background information on air quality sensing and how to use the sensor firmware
- Additional pins to measure power consumption and supply voltage

Evaluation Kit



Note: Product images in this document are representations. Actual product configurations and versions are subject to change.

Important Equipment Warning: Ensure the correct connection of all cables. Supplying the board using the wrong polarity could result in damage to the board and/or the equipment. Check that all jumpers have been placed as specified in this document.

Contents

Figures

Tables

1. Setup

1.1 Initial Startup

To set up and operate the Evaluation Kit (EVK), refer to the *Quick Start Guide* included in the kit.

1.2 Required User Equipment

By default, the internal supply voltage for powering the sensor board is generated from the USB voltage supplied by the user's computer via the USB cable. If there is a need for currents higher than the defined USB Standard (typically 500mA at 5V), an external voltage supply source can be used instead of the internally generated voltage supply provided on the communication board.

The external supply powers only the sensor modules and not the communication board itself. The supply must meet the following requirements:

- Voltage 1.8V to 3.3V
- Current supply capability must meet the requirements of the connected sensors

1.3 User Computer Requirements

1.3.1. Computer Requirements

Windows®-based computer is required for interfacing with the EVK and configuring the gas sensor modules. The user must download and install the *Environmental Sensors Evaluation Software* (ES-Eval).

The computer must meet the following requirements:

- 1GB RAM
- Hard drive with at least 1GB free space
- 1 USB port
- Windows 7, 8, 10, or 11
- Internet access for initial download of the drivers and software

***Important*:** Before installing and activating the software, assemble and connect the hardware for the kit to the user's computer according to steps 1 to 3 in section 1.5.

1.4 Software Installation and Setup

Complete the following procedure to download and install *the Environmental Sensors Evaluation Software* (ES-Eval) with the kit connected:

1. Download the *Environmental Sensors Evaluation Software* (ES-Eval) file. This file can also be downloaded from any Renesas sensor product page.
2. Double-click on the executable *Installer* file to start and follow the installation steps.

1.5 EVK Hardware Connections and Initial Power-up

Set up the EVK hardware before using the software by completing the following procedure:

1. Refer to Figure 1 and Table 1 to determine the correct jumper settings for the ESCom communication board. This jumper selects either the user programmable internal supply or a user supplied voltage as supply for the connected sensors.
   - If the internal voltage supply (default USB) is used, ensure that the jumper is connected to V_{INT} and V_{SENS} on the K2 connector.
   - If using an external supply, ensure that the jumper is connected to V_{EXT} and V_{SENS} on the K2 connector. In this case, without connecting the external supply to the communication board, verify that the external voltage supply setting does not exceed the voltage supply specifications – a minimum of 1.8V or a maximum of 3.3V. With the external supply off, connect the external voltage to the 2-pin "VEXT In" header (jumper K5) with the orientation indicated in Figure 2.

     Note: The external power does not support the 5V pin on the 14-pin connector.
2. Connect the environmental sensor board on the 14-pin connector on the communication board ensuring the proper orientation of the sensor board is as shown in the *Evaluation Kit* image on page 1.

   Note: In the case where two or more devices with the same I²C address have been connected to the ESCom board, all devices will respond to commands send by the *Environmental Sensors Evaluation Software* (ES-Eval) and overlap of signal results may happen, which will lead to undefined results.
3. Insert the USB-C cable into the P1 connector on the communication board and connect it to an available USB port on the user's computer.
4. Activate the software as described in section 1.4.
5. If the internal voltage is used, the ES-Eval activates the internal voltage after the sensor has been started.
6. Verify that the D2 LED is on and illuminated blue. This indicates that the sensor voltage is in the valid range.

The communication board provides additional PMOD connectors for usage with other Renesas products. For more information on additional PMOD connector options and their usage, contact Renesas support.

- PMOD Connector (Female) for additional sensors via I²C interface
- PMOD Connector (Male) for Renesas MCU EVKs

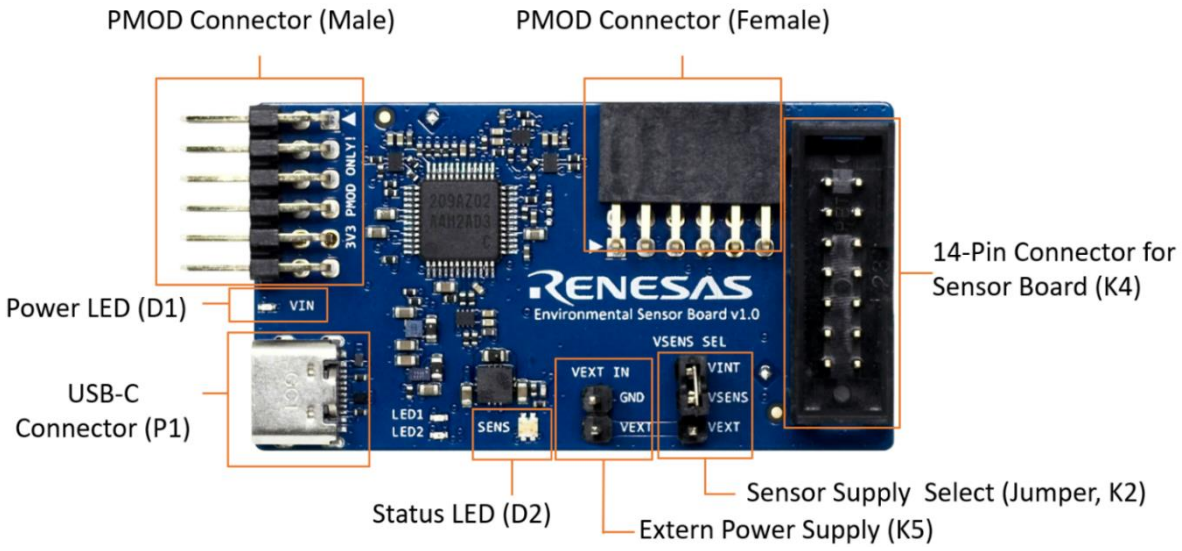
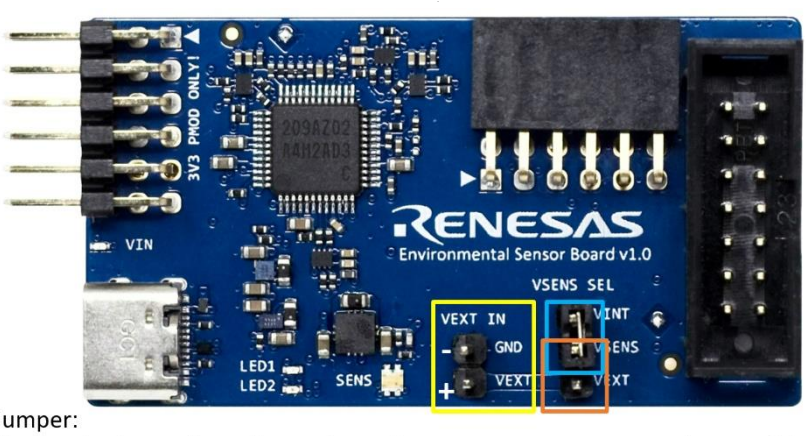


Figure 1. Jumper Settings and Connectors on the Environmental Sensor Communication Board

Table 1. Evaluation Kit Connection Descriptions

Connector	Type	Description
K2	3-pin header	This jumper selects either the internal or external voltage supply. For the proper position for the jumper, see Figure 2. It is also possible to measure the current drawn by the sensor. For this feature, ensure all other electrical components on the sensor board are physically removed.
PMOD	PMOD (Male)	This connector can be used to connect the ESCom to a Renesas MCU Development Kit and communicate with the sensors connected via the K4 or the PMOD (socket) Connector.
PMOD	PMOD (Female)	This connector can be used to connect a Renesas PMOD sensor to the ESCom board. Check the Renesas website for information about the available PMOD devices.
K4	14-pin connector	Port for connecting the environmental sensor boards to the ESCom communication board.
K5	2-pin header	Connector for an optional external power supply (see Figure 2).
D1	Power LED	LED illuminates blue if the communication board is powered correctly.
D2	Status LED	LED illuminates blue if the ESCom is properly connected and the kit software is started. It blinks green when an actual communication with a sensor takes place.
P1	USB-C	USB-C cable connector for connecting the communication board to the user's computer.



K2 Jumper:

- If using the internal supply, set the K2 jumper to connect VINT and VSENS (blue)
- If using the external supply, set the K2 jumper to connect VEXT and VSENS (orange) and connect the supply with K5 pins (yellow)

Figure 2. Jumper Settings on the Communication Board for Internal or External Supply Voltage

Figure 3. Using a 14-Pin Ribbon Cable to Increase Distance between Communication and Sensor Board

2. Usage Guide

After starting the ES-Eval software, the initial window is displayed as shown in Figure 4. The initial display in all operation modes consists of the following blocks:

- Measurement Control
- Sensor Select
- Algorithm Select & Configuration
- Signal Analysis
- Plot Control
- Plot Visualization

Note: The ES-EVAL automatically checks upon start if an ESCom firmware update is available. It is recommended to always use the latest firmware for the Communication Board, which can be installed by using the latest ES-EVAL.

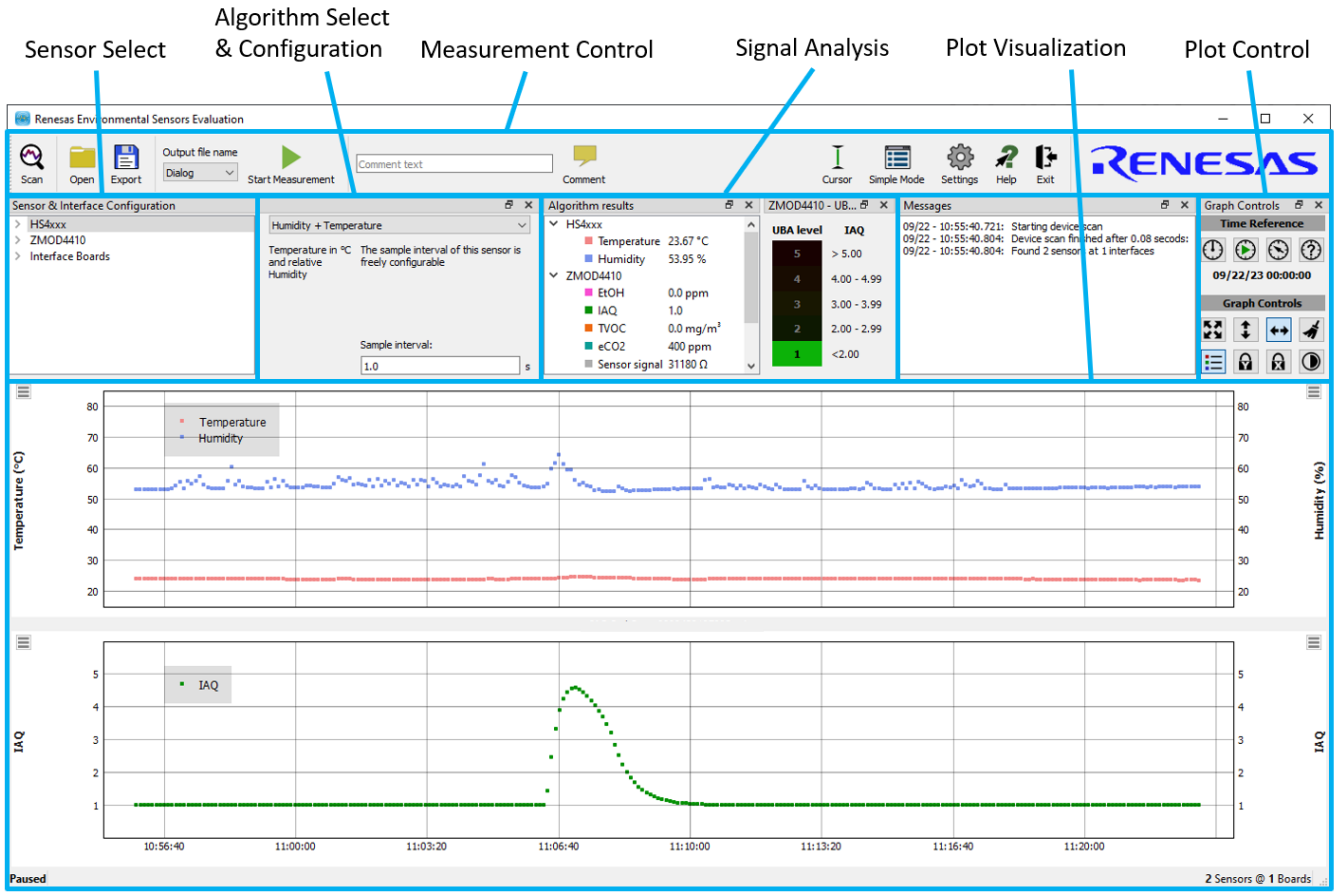
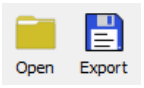
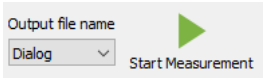
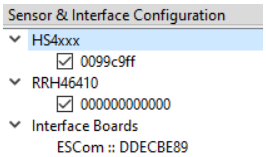
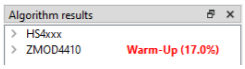
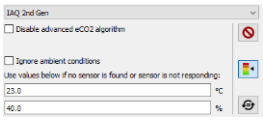
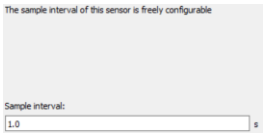


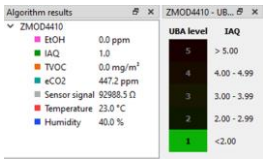
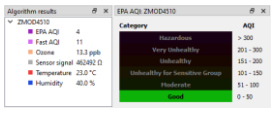
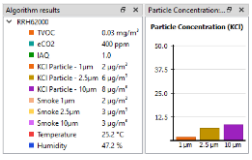
Figure 4. Initial Display during Measurement (Exemplary for ZMOD4410 and HS4001)

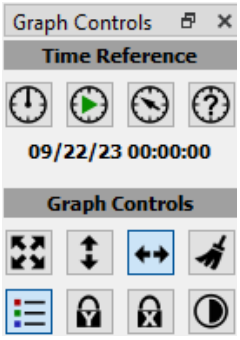
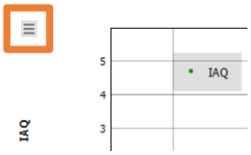
Depending on the sensor and operation mode, the user may see slightly different options. The available user options for all measurement modes are described in Table 2

Table 2. Analysis Tab User Options

Display Section	Button/Action	Description
Measurement Control		Scan the bus for sensors connected to the ESCom board.
		This “Open” option allows the loading of previously recorded csv files into the EVK software when having the same csv file column structure. In case raw data are included it allows post-processing of previously recorded CSV files with the latest algorithms. For this usage, it is not necessary to connect the EVK hardware. The “Export” can be used to export a data file that was loaded and post-processed with the latest GUI algorithms.
		Clicking the “Start Measurement” button starts running a continuous measurement and changes the button function to ”Stop Measurement.” Clicking the button again stops the measurement. All data captured during the measurement session is stored in a CSV formatted output file. The name of the output file can be selected either with an auto-name format or customized file name. The sensor results will be saved in a comma-separated file (CSV) which is user-selected via the file and path selection dialog when the sensor is started. This CSV file contains multiple sensor parameters (the sensor tracking number, the production lot number, calibration parameters, etc.) In addition, typically all raw sensor signals (for example, resistances) for each measurement step and temperature are recorded. *Note*: Additional information and parameters are usually used for debugging and validation only and the focus needs to be on the relevant parameters, such as the algorithm results.
		A comment (for example, “Start gas exposure”) can be added to the recorded data. After clicking the “Comment” button, a position in the graph must be clicked to place the comment. Use the ESC key to escape this function.
		In this section it is possible to: ▪ Activate cursor in the visualization plot ▪ Open a dialog for more settings such as default log parameters ▪ Switch to a Simple Mode to display results without any graphs ▪ Provide help for GUI controls (first click “Help” then click the object you want information about) ▪ Exit the software
Sensor Select		This widget is used to select sensors for configuration and to configure whether they are shown in the GUI and logged in the graph. After a bus scan, all sensors and interface boards detected on the computer are listed here. Measurement data is collected for all sensors and logged in the output file. To remove a sensor or sensor type from data acquisition, right-click on the corresponding element and chose ‘remove’. A new bus scan is required to add the sensors again. In addition, the first of each sensor type is displayed in the graphs. The checkbox in front of each sensor is used to enable or disable plot visualization. *Note*: Only one sensor of each type can be plotted.

Display Section	Button/Action	Description
Algorithm Select & Configuration		If a “Warm-Up” time is needed, it will be displayed to the user. Therefore, the first measurements of the algorithm will be taken for this warm-up. This field also indicates how much time has been completed during this period. Raw sensor signals and algorithm results are shown on the plots during this time, but full algorithm performance is only given after warm-up. *Note*: This does not cover the full stabilization of the sensor module but rather covers only the first minutes during startup. After warm-up, the “Signal Analyzes” field shows the measurement results from all active sensors.
		If a sensor is not needed for a measurement, it can be disabled (power down). A second click on this button will re-enable the sensor.
		In the event that multiple operation methods are available, these will be displayed and activated here. It is also possible to deactivate a sensor if it is required for the measurement and data collection. For gas sensor operation, temperature and humidity compensations are recommended. This is enabled by default in case a temperature/humidity sensor is connected, such as the HS3001 or HS4001. If a temperature or humidity sensor is not found or ignored, the settings for the parameters can be set manually in this field. **Additional parameters for ZMOD4410 and RRH46410**: Renesas’ patented smart algorithm provides eCO_2 readings with high accuracy when activated (default). However, for demonstration reasons it may be useful to disable the eCO_2 algorithm in the section “Demonstration Modes” to see fast CO_2 changes directly related to the VOC level.
		When using a Renesas HS temperature and humidity sensor, the temperature result will be displayed in Celsius (°C) and the humidity in % RH, respectively. The sampling interval of the HS can be adjusted as needed with the shortest possible sampling interval of 0.5s.

Display Section	Button/Action	Description
Signal Analysis		**The following algorithm results are given for ZMOD4410 and RRH46410**: ▪ IAQ 2nd Gen (Absolute and Relative): The IAQ rating from the Federal German Environmental Agency (UBA) ranging from 1 (Clean Hygienic Air) to 5 (Unacceptable Conditions) and is based on an absolute TVOC reading (mg/m^3 or Ethanol equivalent in ppm). Also, a relative IAQ indicates general changes in air quality: • 0 to 100 Improvement in Air Quality (air gets cleaner) • 100 No change in Air Quality • 100 to 500 Degradation in Air Quality (air gets more polluted) ▪ PBAQ: The PBAQ operation mode complies with typical Public Building Air Quality standards. It focuses on high accurate TVOC concentrations in the typical indoor environments and is given in absolute numbers (mg/m^3) and as relative output (same scale as IAQ 2nd Gen). Also, a relative PBAQ output indicates general changes in air quality: • 0 to 100 Improvement in Air Quality (air gets cleaner) • 100 No change in Air Quality • 100 to 500 Degradation in Air Quality (air gets more polluted) ▪ Sulfur Odor Discrimination: Identifies bad sulfur odors. The algorithm output is classified as “acceptable” and “bad” with an intensity indicator ranging from 1 (clean air) to 5 (very strong)
		**The following algorithm results is given for ZMOD4510**: The first 50 measurement samples will be taken for sensor stabilization. During this time, the “Algorithm Result” section will indicate the completion progress and will continually show the sensor resistance. After stabilization, the ozone and nitrogen dioxide concentrations are given (in ppb) and the AQI is shown in six categories according to the EPA Air Quality Standard: ▪ 0 to 50 Good Air Quality ▪ 51 to 100 Moderate Air Quality ▪ 101 to 150 Unhealthy Air Quality for Sensitive Groups ▪ 151 to 200 Unhealthy Air Quality ▪ 201 to 300 Very Unhealthy Air Quality ▪ > 300 Hazardous Air Quality
		The following algorithm results are given for HS3001 and HS4001: Temperature (°C) and Humidity (RH). Returns the values for relative humidity (RH) in % and temperature in °C in the selected sample interval.
		**The following algorithm results are given for RRH62000**: The All-in-one Air Quality Module includes sensing elements for Particle Measurement (PM1, PM2.5, and PM10), TVOC, IAQ, eCO_2, Temperature, and Humidity. The PM measurement has two output options: KCl (Potassium Chloride, a typical calibration particle nuclei) and Smoke (Cigarette smoke, used for calibration).

Display Section	Button/Action	Description
Plot Control		**Time Reference**: Choose the time reference for the X axes. ▪ Start of Day (of current measurement) ▪ Start of Measurement ▪ Manually pick a time in the graph using the mouse ▪ User defined reference time stamp **Graph Controls**: Button explanation from left to right for the top row: ▪ The 1st button auto fits all the data on the X and Y axes ▪ The 2nd button fits the Y axis to display all Data ▪ The 3rd button allows hovering the mouse to open a menu that provides control on the X-range being displayed ▪ The 4th button will delete all current data from the plots (memory). The data in the csv measurement file will remain. Button explanation from left to right for the bottom row: ▪ Button 1 enables/disables the legend for the plot visualization ▪ Button2 locks/unlocks the Y axes so that it is unaffected by mouse operations ▪ Button 3 locks/unlocks the X axes so that it is unaffected by mouse operations ▪ The 4th button switches between bright and dark to improve contrast. This display mode will also be used in the Simple Mode view.
Plot Visualization		The lower half of the graphical user interface provides a visualization of the data. It shows the plots for the options selected. Also, in the upper left and right corners of each graph, multiple parameters can be chosen from to active/deactivate curves for sensor output of the corresponding axis.

2.1 Error Codes

Most common error messages are explained in Table 3.

Table 3. Most Common Errors

Error Code	Description and Solution
Error: Failed to open file <*filename*>	The selected data-file could not be opened for writing. Check that the selected file is not locked by another application and that you have write access to the folder the data files should be stored in.
The RRH46410 cannot be used with the HiCom communication board.	The RRH46410 cannot work with the older HiCom communication board due to missing clock stretching.
<SENSOR> / <UID>: Sequence failed: <DETAILS>	There was an error executing the measurement sequence for sensor <SENSOR> with unique ID <UID>. Additional details of the error are displayed <DETAILS>. The ES-Eval software will try to recover the error automatically and continue measurements. If the same error occurs in subsequent measurements, try to stop and restart the measurement. If unsuccessful, try to reconnect the interface board.

3. Schematics, BOM, and Pin Connector

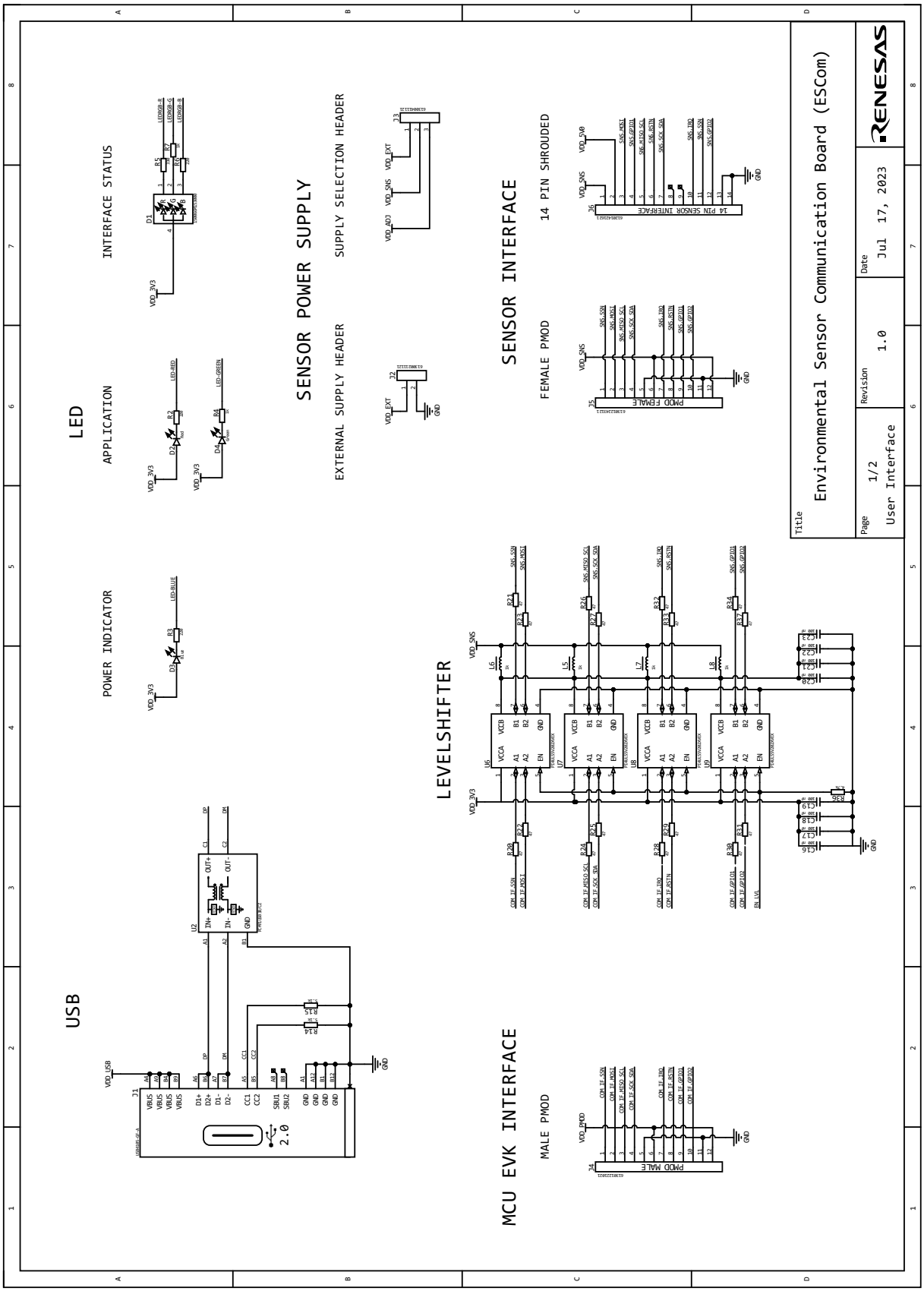


Figure 5. ESCom Communication Board Schematic – Page 1

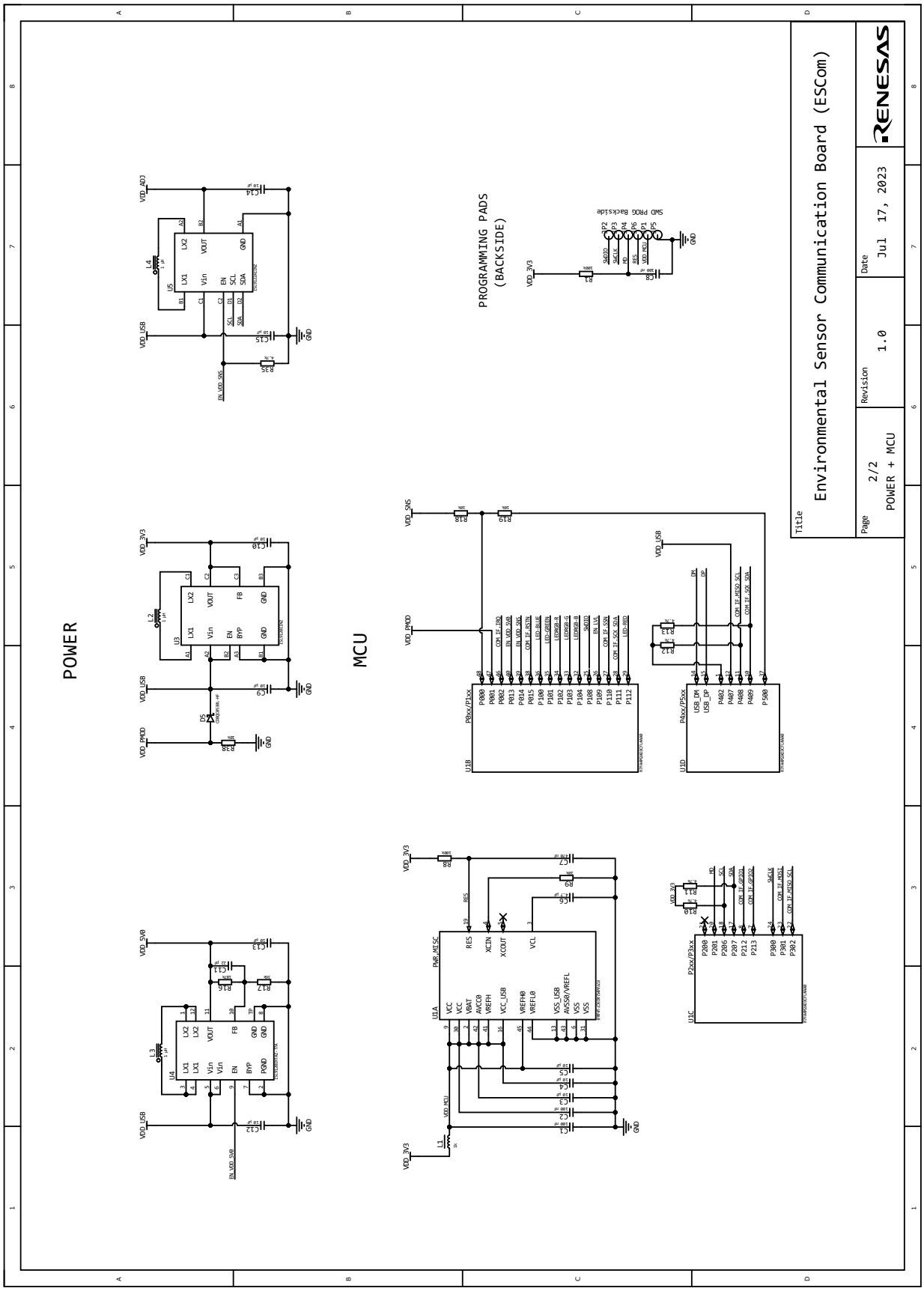


Figure 6. ESCom Communication Board Schematic – Page 2

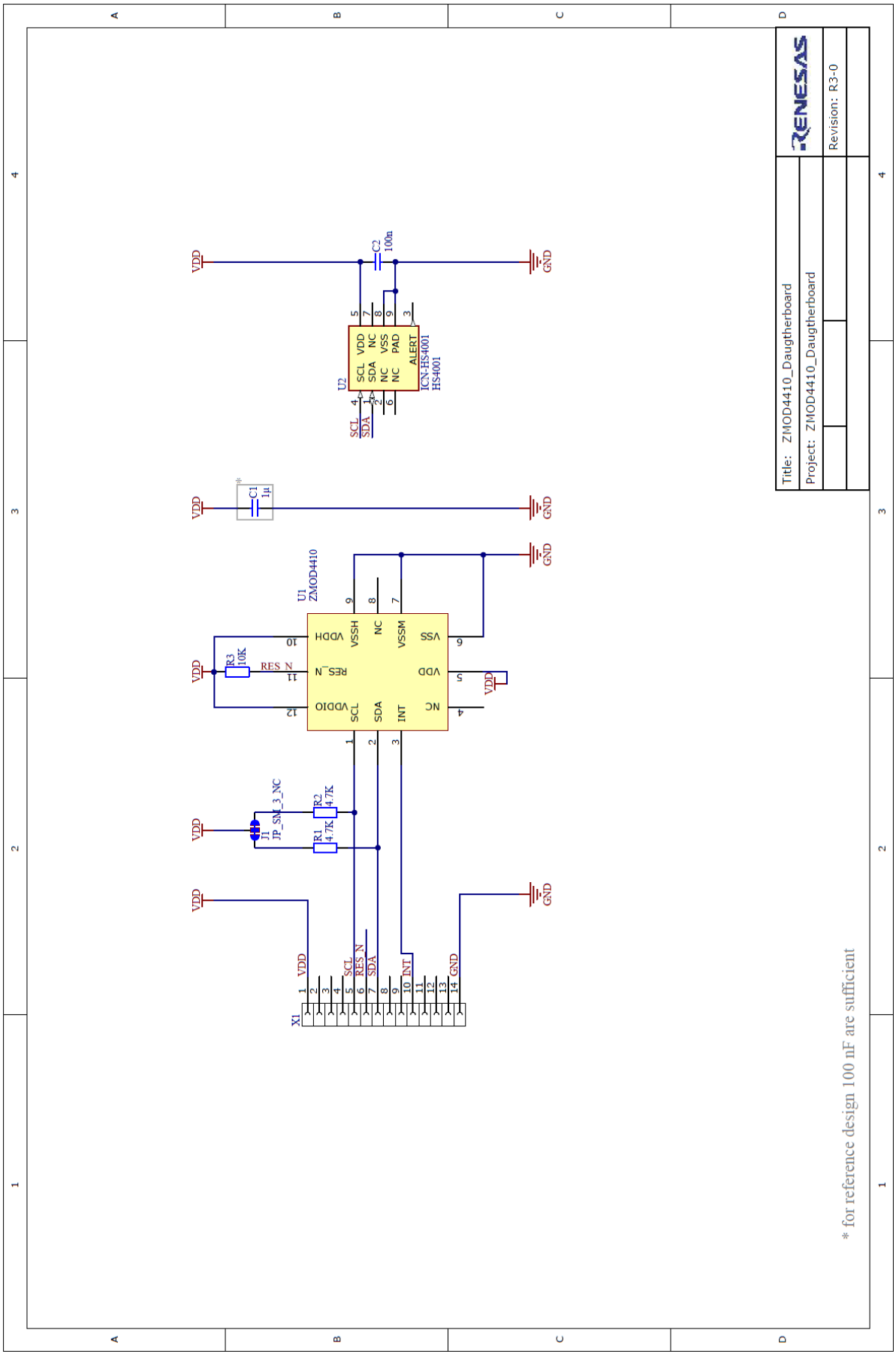


Figure 7. Sensor Board Schematic for ZMOD4410 and HS4001

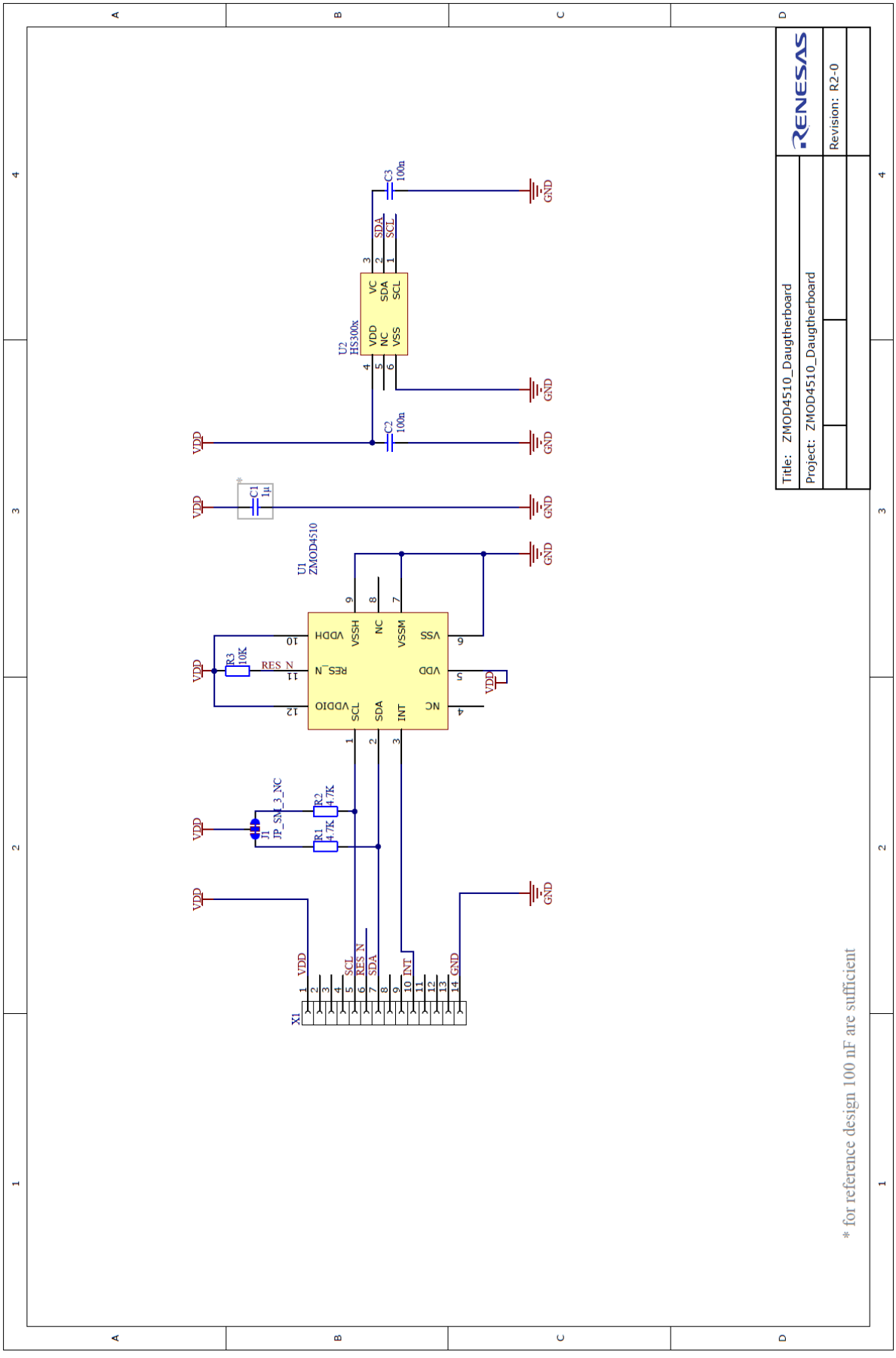


Figure 8. Sensor Board Schematic for ZMOD4510 and HS3001

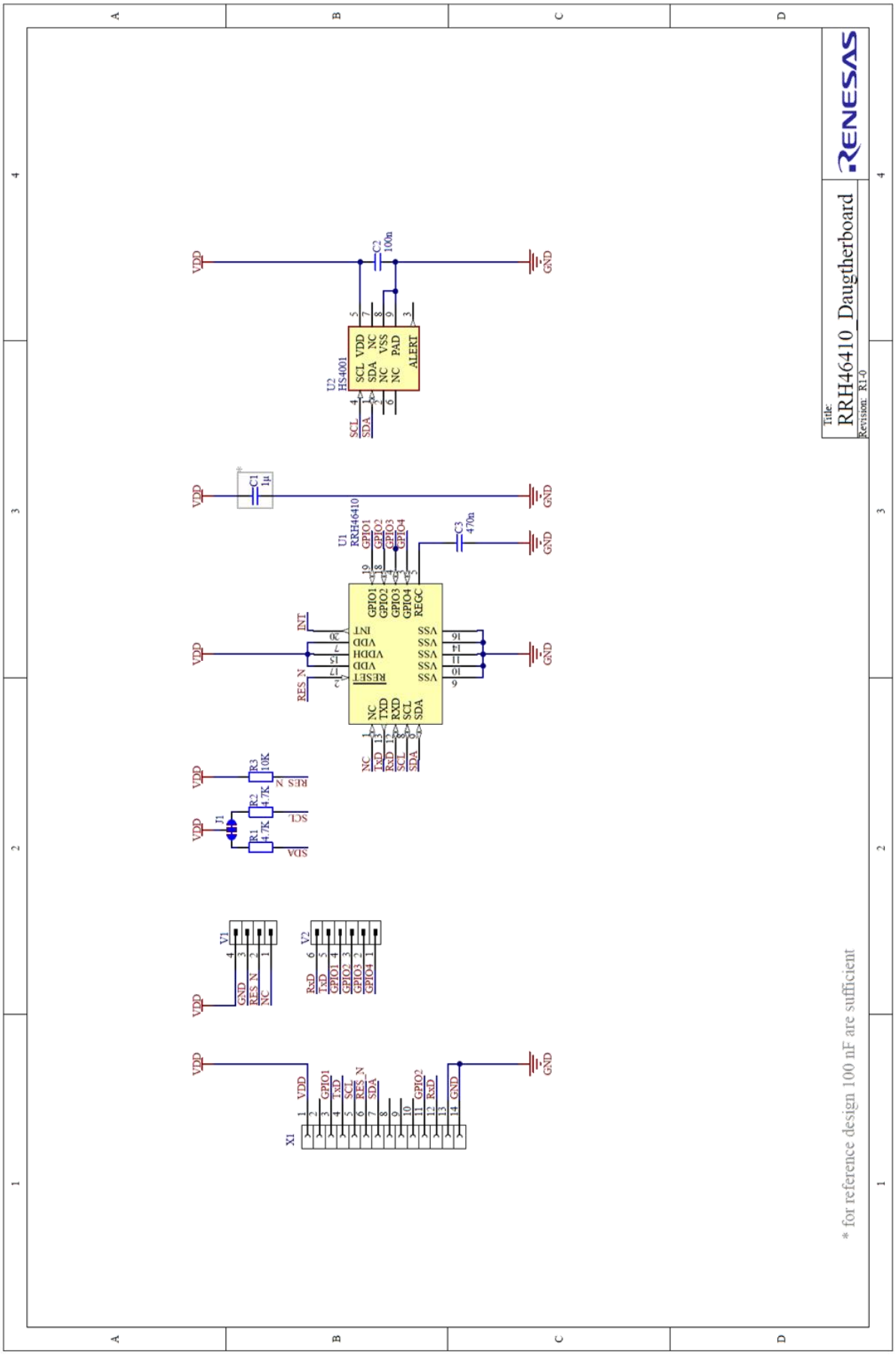


Figure 9. Sensor Board Schematic for RRH46410 and HS4001

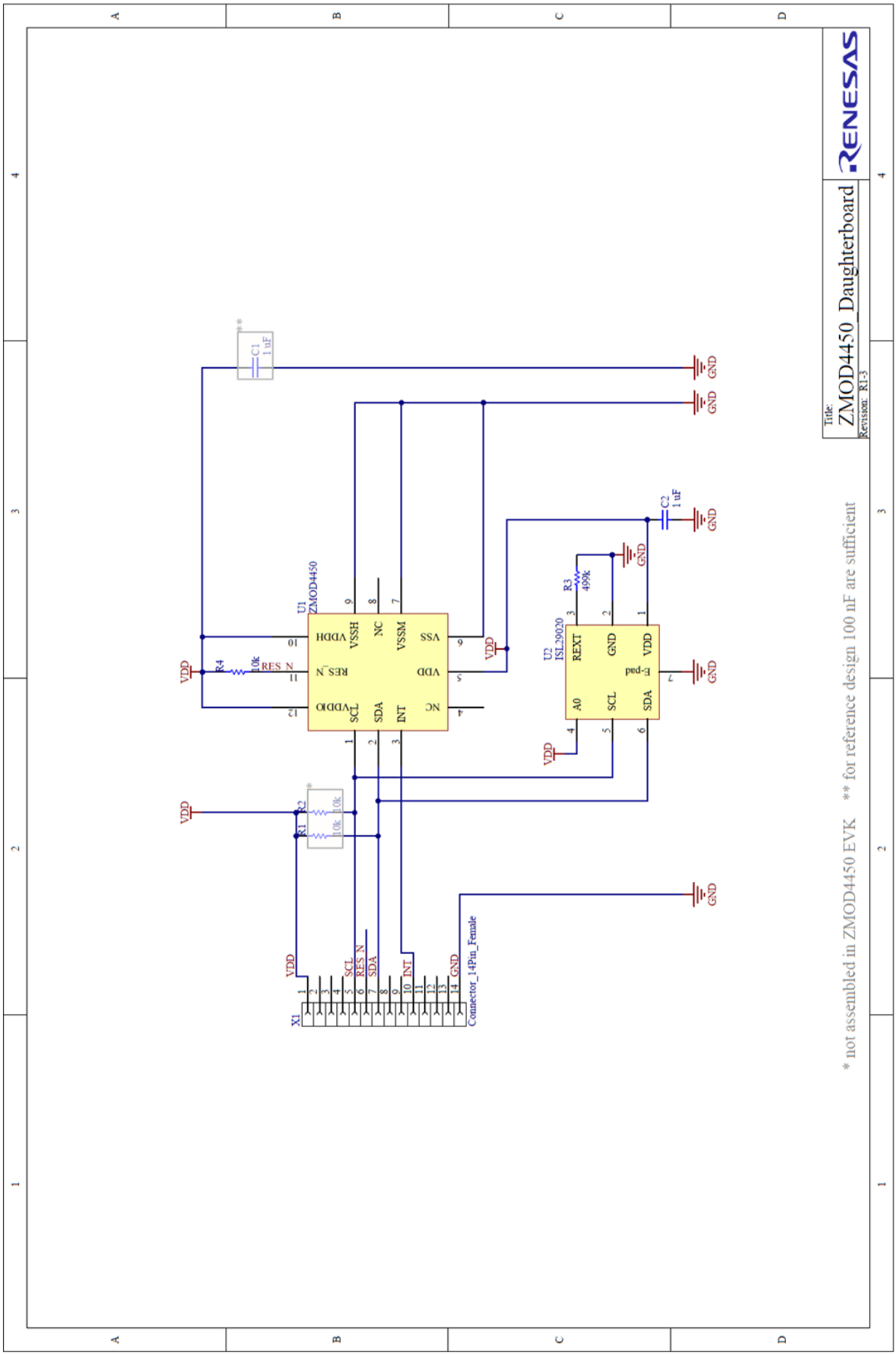


Figure 10. Sensor Board Schematic for ZMOD4450

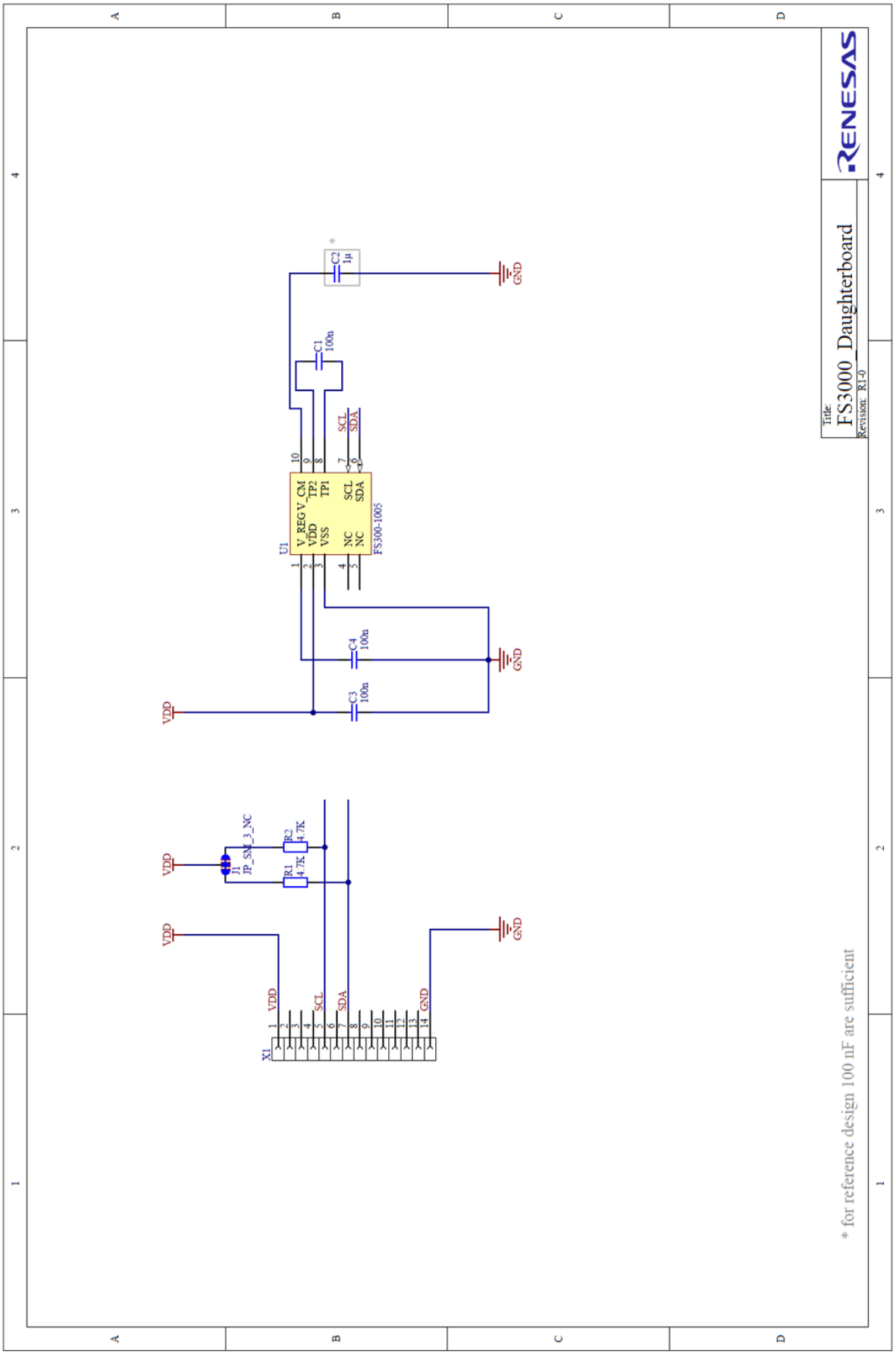


Figure 11. Sensor Board Schematic for FS3000

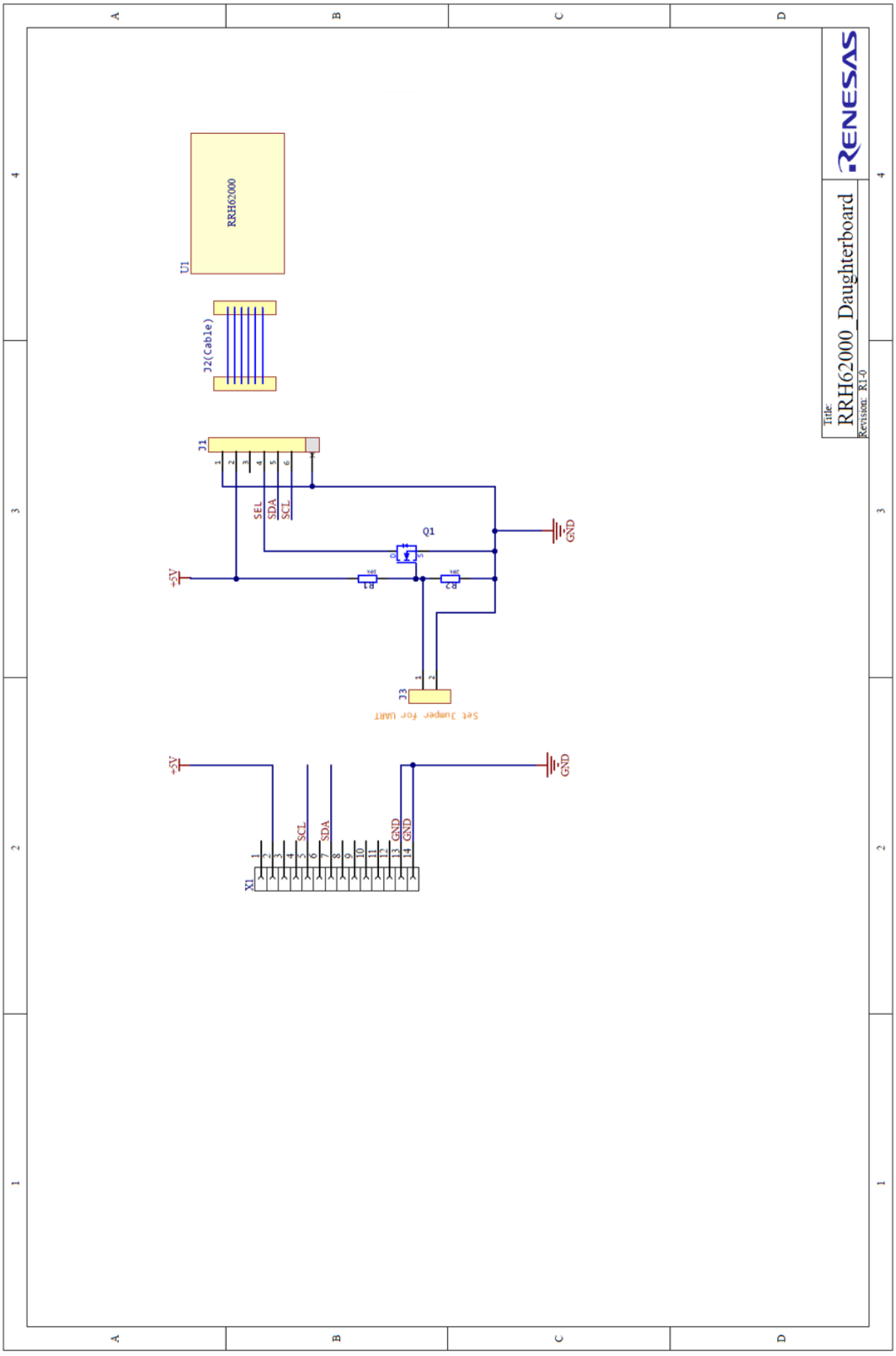


Figure 12. Sensor Board Schematic for RRH62000

Table 4. PIN Configuration on Connector X1

Pin Number	Pin Description
1	VDD
2	5V
3	N.C.
4	N.C.
5	SCL / TX
6	RES_N
7	SDA / RX
8	N.C.
9	N.C.
10	INT
11	N.C.
12	N.C.
13	GND
14	GND

4. Board Layout

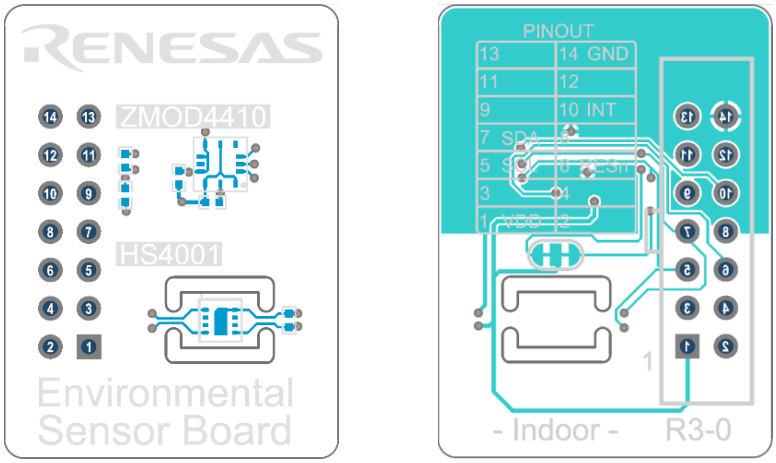


Figure 13. Sensor Board ZMOD4410 Layout with PIN Configuration

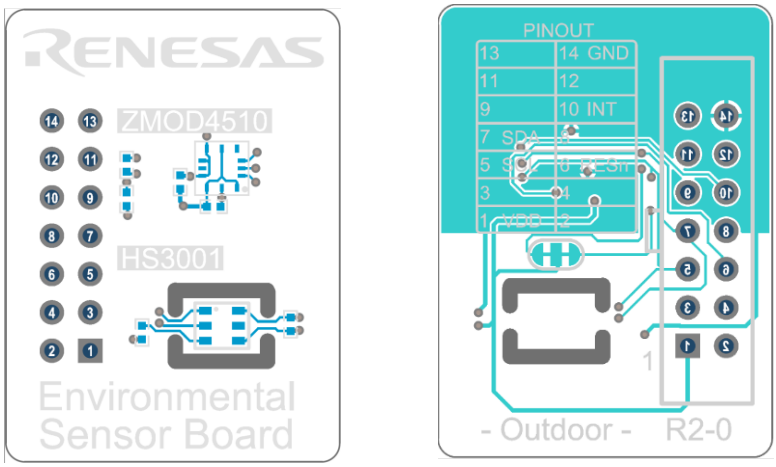


Figure 14. Sensor Board ZMOD4510 Layout with PIN Configuration

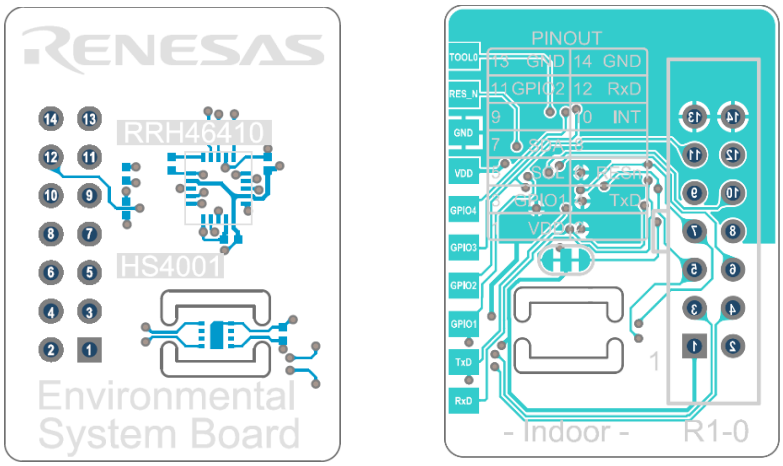


Figure 15. Sensor Board RRH46410 Layout with PIN Configuration and Additional Side Pads

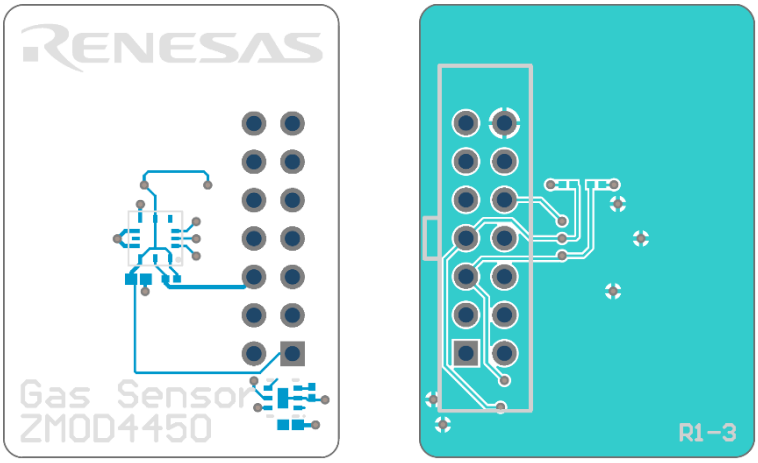


Figure 16. Sensor Board ZMOD445010 Layout with PIN Configuration

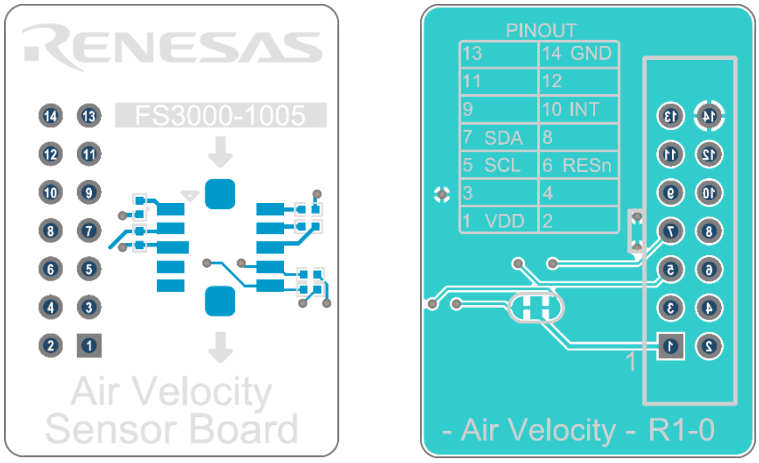


Figure 17. Sensor Board FS3000 Layout with PIN Configuration

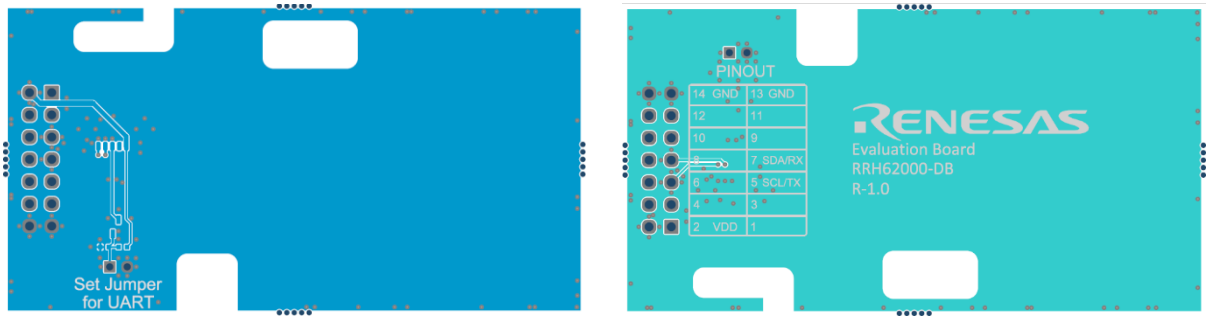


Figure 18. Sensor Board RRH62000 Layout with PIN Configuration

5. Ordering Information

Part Number	Description
ZMOD4410-EVK-HC or HS4000-EVK	Evaluation Kit including the ZMOD4410 Sensor Board, HS4001 Temperature/Humidity Sensor, ESCom Board (USB Interface), and USB-C Cable.
ZMOD4510-EVK-HC or HS3000-EVK	Evaluation Kit including the ZMOD4510 Sensor Board, HS3001 Temperature/Humidity Sensor, ESCom Board (USB Interface), and USB-C Cable.
RRH46410-EVK	Evaluation Kit including the RRH46410 Sensor Board, HS4001 Temperature/Humidity Sensor, ESCom Board (USB Interface), and USB-C Cable.
ZMOD4450-EVK-HC	Evaluation Kit including the ZMOD4450 Sensor Board, HiCom Board (USB Interface), and USB Cable.
FS3000-EVK	Evaluation Kit including the FS3000 Sensor Board, ESCom Board (USB Interface), and USB-C Cable.
RRH62000-EVK	Evaluation Kit including the RRH62000 Sensor Board, ESCom Board (USB Interface), and USB-C Cable.

6. Revision History

Revision	Date	Description
1.03	Jul 30, 2024	▪ Added support for the RRH62000 sensor module.
1.02	May 16, 2024	▪ Added support for the ZMOD4450 RAQ sensor module. ▪ Completed other minor changes.
1.01	Mar 19, 2024	Added support for the FS3000 sensor module.
1.00	Dec 17, 2023	Initial release.

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