

# EU078

## Outdoor Sensor for Automatic Home or Building HVAC System

September 2020

# Automatic Home or Building HVAC System Platform

## Outdoor Sensor Unit<sup>1</sup>

Please see EU076 for problem definition with existing / retrofit buildings, complete solution proposal and benefits.

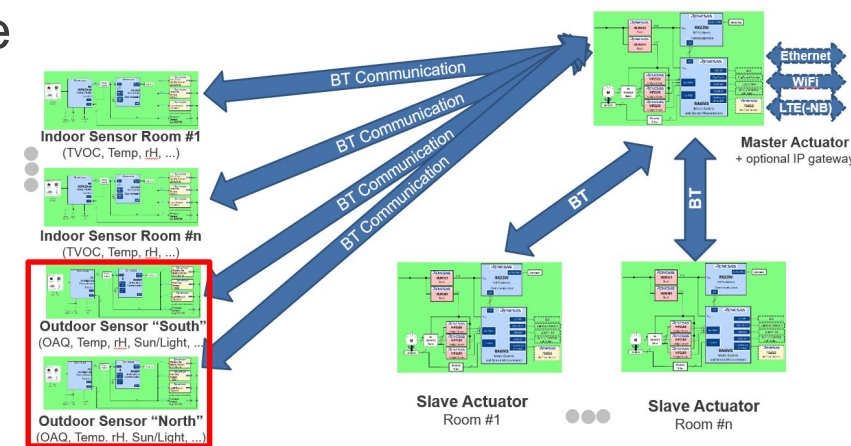
This is the **Outdoor Sensor Unit** as part of the proposed platform concept:

- determines Outdoor Air Quality, Temperature, Humidity, Light/Sun
- communicates with Master Actuator Unit by Bluetooth Mesh
- may also be maintenance-free sensors by using Energy Harve

Overall goals:

achieve optimum air quality in all rooms

- avoid mold
- improve energy efficiency
- improve user experience and comfortability



NOTE <sup>1</sup>: Renesas does not have any plans to provide *end products* to the market; you, our *customers* are the experts in developing and providing such and Renesas does not claim to have the competency to do. Hence, this is just a proposal for a *potential* realization.

Note: For solution kit also see EU045 Air Quality Sensor.

EU078



# Outdoor Sensor for Automatic Home or Building HVAC System

## ■ Overview

The outdoor sensor unit(s) provides outdoor data from one or multiple bearings (North, East, West, South) to the master actuator.

This can be one, or all, of the following data:

- Outdoor Air Quality (OAQ according to the Environmental Protection Agency)
- Temperature and relative humidity (degrees, percentage)
- Light/sun (lux)
- Barometric pressure (mbar)

In addition, a simple GUI can be implemented via capacitive touch or push button(s), and/or a low power LCD (i.e., eInk) to display local sensor values and enter data. A more sophisticated GUI may also be achieved via a master actuator, IP gateway or smartphone. A real-time clock (RTC) could easily be added to switch between different operation modes, depending on the day, time, holiday, etc. All RTCs could also be synchronized within the system.

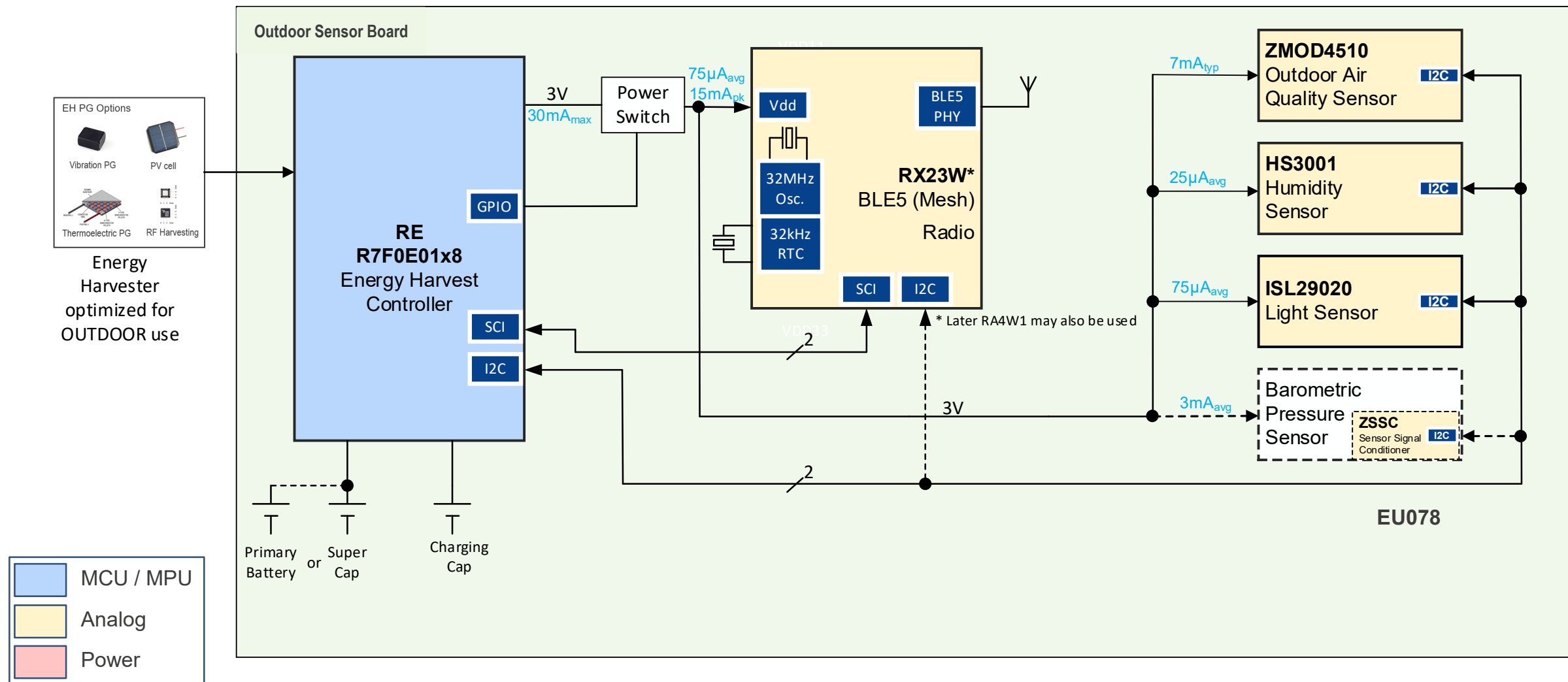
## ■ System Benefits

- The RX23W MCU enables Bluetooth 5 mesh communication
- The energy harvesting controller, the RE01 series, can be used for power supply. It combines the control of charging and discharging dedicated capacitors and/or rechargeable batteries of different sources with a powerful Arm® core MCU. These harvesters could be one of the following:
  - Solar cell (i.e. using the natural or artificial room lighting)
  - Thermal harvester (e.g. from a radiator or hot pipe)
  - Vibration harvester (e.g. from machines/motors)
  - RF harvester (i.e. taking away some of the near field energy from a close-by RF transmitter)

EU078



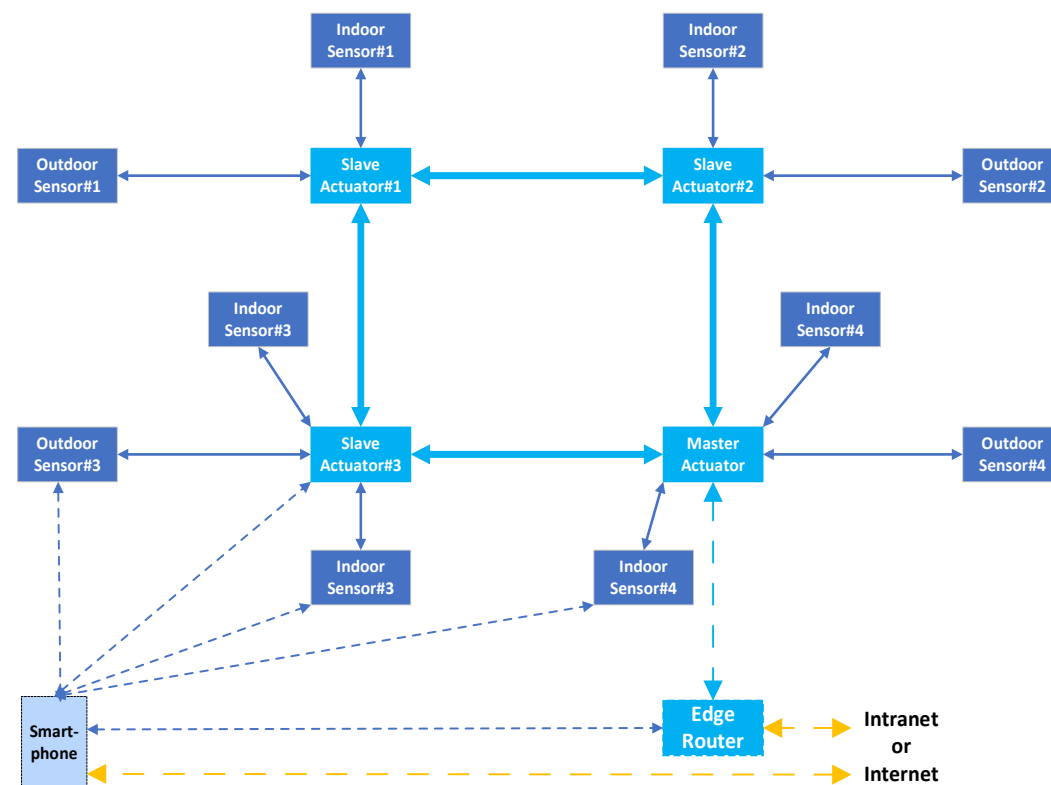
# Outdoor Sensor for Automatic Home or Building HVAC System



# Automatic Home or Building HVAC System Platform

## Major advantages of Bluetooth 5 Mesh

- secure communication (Diffie-Hellmann Key Exchange, AES128 etc.)
- bidirectional packet data flow
- low power (can go down to  $\mu\text{A}$  average while being connected)
- no need for additional wiring
- automatic routing (with no setup for the routing itself)
- scalability of speed vs. range:
  - for four times range or
  - double speed option depending on location.



EU078



# Outdoor Sensor for Automatic Home or Building HVAC System

Device Category	P/N	Key Features
MCU	RX23W	Bluetooth® 5.0 Radio w/ RX v2 core with Mesh option
	RE01/256kB	Energy Harvest Controller (Arm® Cortex M0+ based)
Analog	HS300x	Humidity sensor with industry-leading accuracy, response time, and excellent stability
	ISL29020	Integrated Digital Ambient Light Sensor: Ultra-Low Lux, Low Power, I2C I/F
	ZMOD4510	Outdoor Air Quality Sensor Module (NOx, O <sub>3</sub> )
	ZSSC3224	High End 24-Bit Sensor Signal Conditioner IC

# RX23W – 32-bit MCU for Bluetooth 5.0 Low Energy

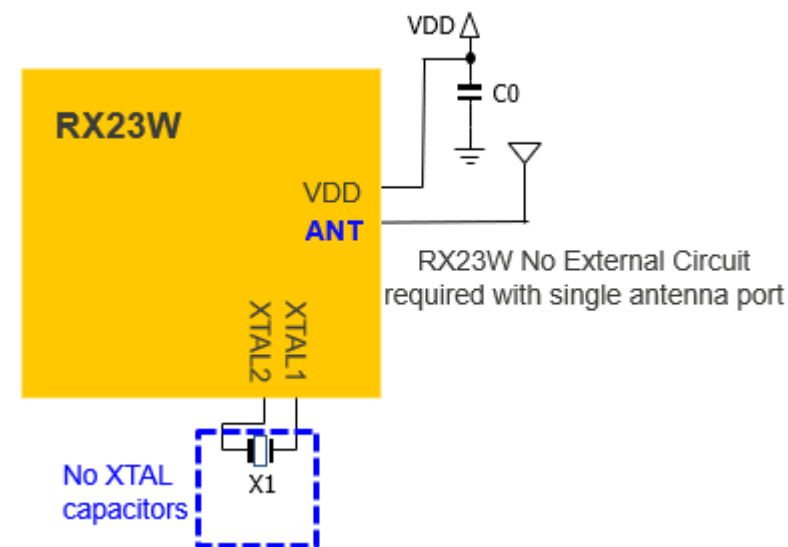
54 MHz RXv2 Core with FPU, Low Power Design, RTC and Encryption Functions

## Support for Multiple Communication Functions

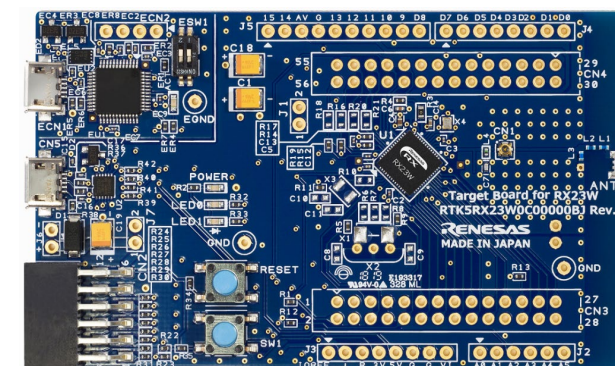
- Bluetooth Low Energy (1Channel)
- An RF transceiver and link layer compliant with the Bluetooth 5.0 Low Energy specification, also supports Bluetooth 4.2
- LE 1M PHY, LE 2M PHY, LE Coded PHY (125 kbps and 500 kbps), and LE Advertising extension support
- On-chip Bluetooth-dedicated AES-CCM (128-bit blocks) encryption circuit
- USB 2.0 host/function/On-The-Go (OTG) (one channel), full-speed = 12 Mbps, low-speed = 1.5 Mbps, isochronous transfer, and Battery Charger supported
- CAN (one channel) compliant to ISO11898-1: Transfer at up to 1 Mbps

## High Performance and Low Power Design

- Operation from single 1.8 to 3.6V supply, up to 512KB Flash and 64KB RAM
- Capacitive Touch Sensing Unit: 12Keys (Self), 36 Keys (Mutual)
- Max. operating frequency: 54 MHz, Capable of 88.56 DMIPS in operation at 54 MHz
- Enhanced DSP and FPU modules
- RTC capable of operating on the battery backup power supply
- Security: 128- or 256-bit key length of AES for ECB, CBC, GCM, others. TRNG and Safe management of Keys, IEC60730 Compliant



Low Cost System Block



Target Board for RX23W – RTK5RX23W0C00000B

Part #	ROM (Kbytes)	RAM (Kbytes)	Security Functions	Package
<a href="#">R5F523W8ADNG#30</a>	512	64	N/A	QFN/56/0.4
R5F523W7ADNG#30	384	64	N/A	QFN/56/0.4
R5F523W8BDNG#30	512	64	Available	QFN/56/0.4
R5F523W7BDNG#30	384	64	Available	QFN/56/0.4



# RE01 – SOTB™ 64-MHz Arm® Cortex®- M0+ Core

Innovative SOTB™ Technology to Realizes Both Ultra-low Active and Ultra-low Standby Current

## Innovative Ultra-low Power

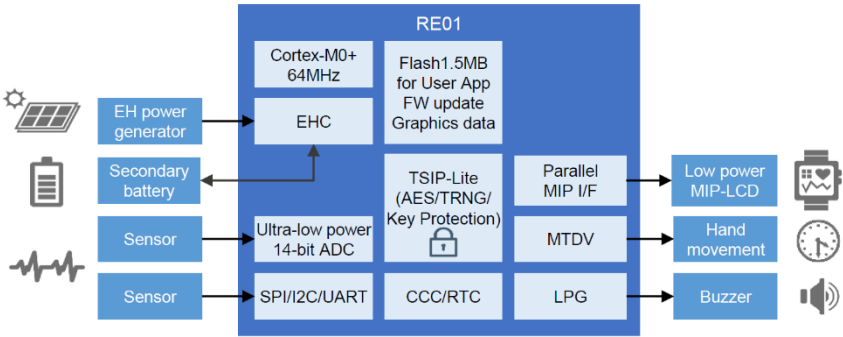
- Both ultra-low active current and ultra-low standby current
- High-speed operation (maximum 64MHz) at low voltage (1.62V)
- Ultra-low power consumption 14-bit ADC (approx. 4uA), flash (rewrite at less than 1mA)
- Energy harvesting control circuit and back-bias voltage control enables battery-less and maintenance free operation

## Intelligent for IoT Device

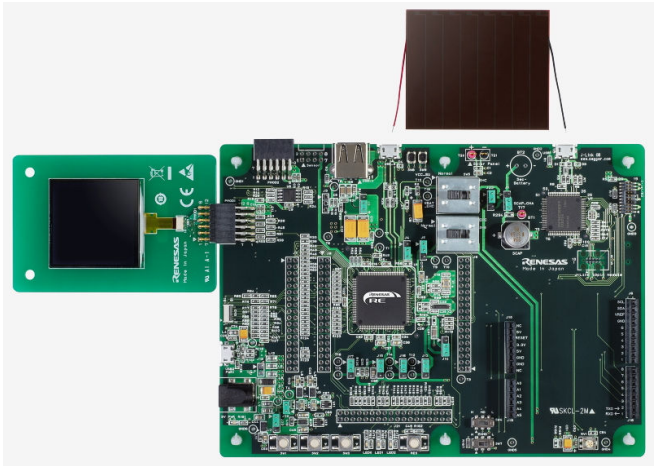
- 64MHz Arm® Cortex®-M0+ CPU 1.5M Flash with BGO and 256K SRAM
- MIP LCD controller and 2D graphic engine
- TSIP-Lite security function

## Rich Peripherals

- Various analog circuits: 14-bit ADC, 12-bit DAC, comparator, temperature sensor and 3 channels LED driver
- Communication functions: USB 2.0, SPI, QSPI, 5 CHs SCI, 2 CHs I²C



Wearable / Hybrid Watch Example



Evaluation Kit RE01 1500KB Board

Part #	Flash/SRAM	TSIP-Lite	MLCD	Package
R7F0E017D2DBN	1.5M/256K	Yes	Yes	SXBG0156MA-A 4.5 × 4.3 mm, 0.3-mm pitch
R7F0E016D2DBN	1.5M/256K	No	Yes	
R7F0E015D2CFB	1.5M/256K	Yes	Yes	PLQP0144KA-B 20 × 20 mm, 0.5-mm pitch
R7F0E014D2CFB	1.5M/256K	No	Yes	
<a href="#">R7F0E011D2CFP</a>	1.5M/256K	Yes	No	PLQP0100KB-B 14 × 14 mm, 0.5-mm pitch
R7F0E010D2CFP	1.5M/256K	No	No	



# HS300X – Relative Humidity and Temperature Sensor

High Accuracy Humidity and Temperature Measurement for Environmental Monitoring

## High Accuracy

- $\pm 1.5\%$  RH accuracy (HS3001)
- $\pm 0.2^{\circ}\text{C}$  temperature accuracy (HS3001, HS3002)

## Excellent Stability

- 0.1% RH per year drift
- MEMS silicon-carbide sensor technology

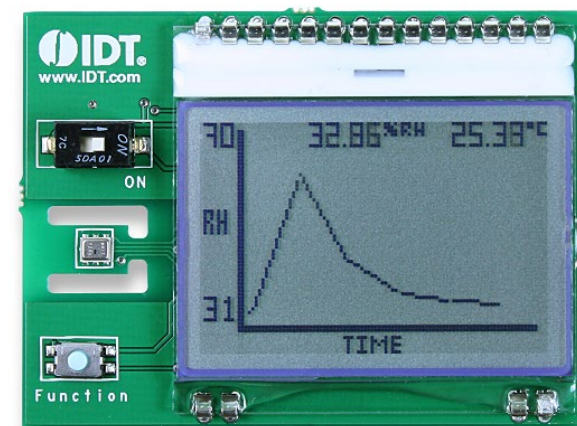
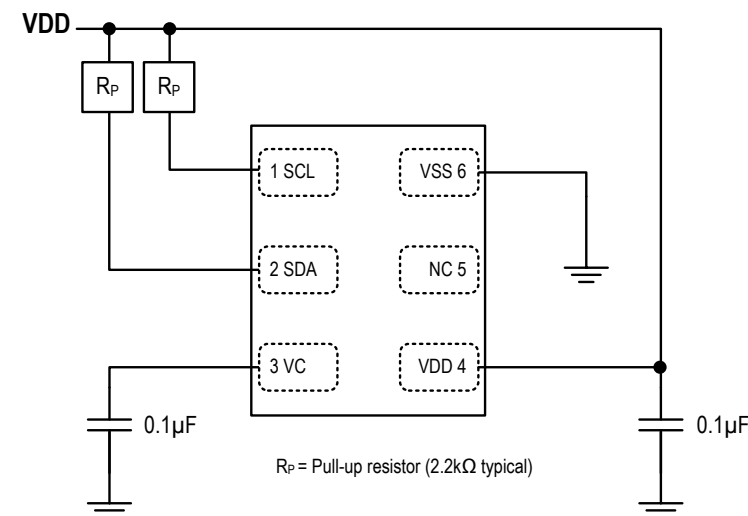
## Fast Response

- Less than 4 seconds humidity response, in still air
- Less than 2 seconds temperature response

## Extended Supply Voltage

- 2.3V to 5.5V, 24.4 $\mu\text{A}$  at 3.3V (one RH+Temp per second)
- 1.8V custom order

Part #	Feature	Package
<a href="#">HS3001</a>	$\pm 1.5\%$ RH	3 $\times$ 2.41 $\times$ 0.8 LGA
HS3002	$\pm 1.8\%$ RH	3 $\times$ 2.41 $\times$ 0.8 LGA
HS3003	$\pm 2.8\%$ RH	3 $\times$ 2.41 $\times$ 0.8 LGA
HS3004	$\pm 3.8\%$ RH	3 $\times$ 2.41 $\times$ 0.8 LGA



SDAH02 Evaluation Kit

# ISL29020 – Integrated Digital Ambient Light Sensor

Ultra-Low Lux, Low Power, Integrated Ambient and Infrared Light-to-Digital Converter

## Integrated functions and small package

- 6 pin 2.0 x 2.1 x 0.7mm ODFN
- On-chip 16-bit ADC
- I<sup>2</sup>C (SMBus compatible) Interface, 0x44 or 0x45 hardwired

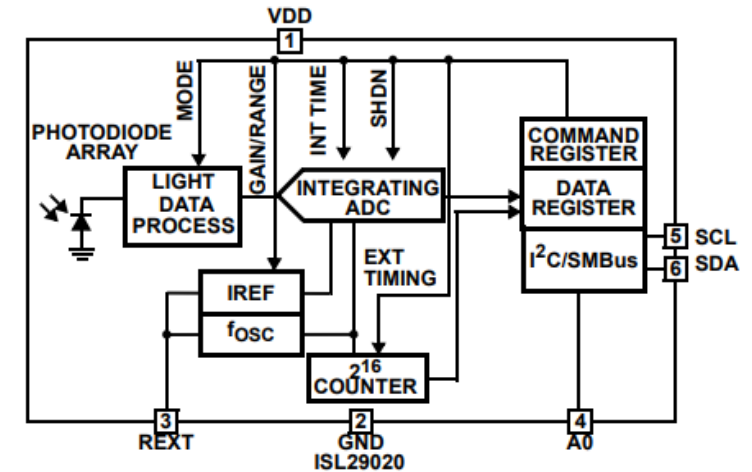
## High Performance

- Adjustable sensitivity up to 65 counts per lux
- Measurement range: 0.0015 to 64,000lux with four selectable ranges
- Close to human eye response with excellent IR/UV rejection
- Operation across -40 to +85°C

## Low Power Design

- Normal operation 65uA
- 0.5uA maximum shutdown current
- 1.7 – 3.6V supply

### Block Diagram



ISL290xxIROZ-EVALZ evaluation board

Part #	ALS Sensing	A0 I2C address Pin	Package
<a href="#">ISL29020IROZ-T7</a>	Yes	Yes	6 Ld 2x2.1 ODFN



# ZMOD4510 – Outdoor Air Quality Sensor Platform

## O<sub>3</sub> / NO<sub>2</sub> Sensor for Outdoor Air Quality Application

### Flexible Measure Target

- Measurement of OAQ (O<sub>3</sub> , NO<sub>2</sub>)

### Low Power

- Very low average power consumption
- Excellent for low-voltage and low-power battery applications

### Easy to Use

- ZMOD4510 Evaluation Kit
- Manuals, application notes, blog, and white papers
- Instructional videos
- Programming libraries, example codes, and algorithm support to optimize performance

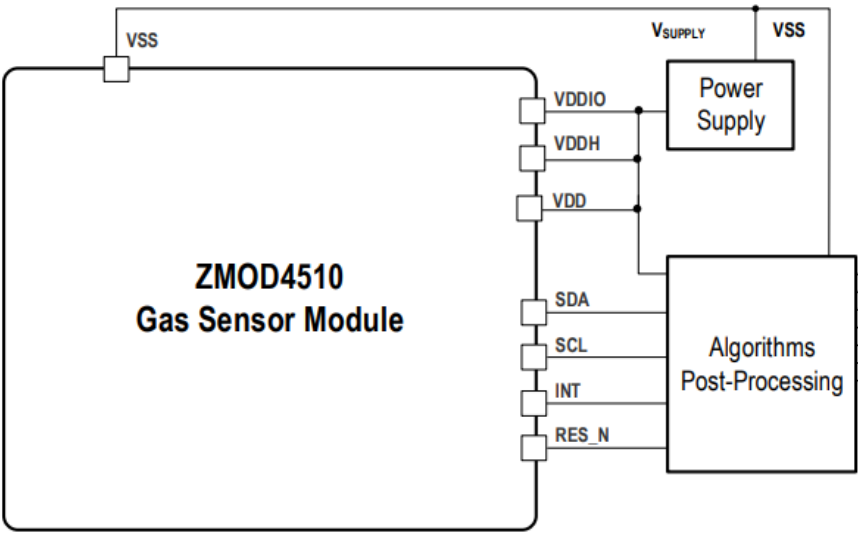


Table 6. Air Quality Index Levels Described by the EPA\*

Air Quality Index (AQI)	Level of Concern and Air Quality Condition	NO <sub>2</sub> Concentration [ppb]	O <sub>3</sub> Concentration [ppb]	Color Code
0 to 50	Good	0 to 53	0 to 62	Green
51 to 100	Moderate	54 to 100	63 to 124	Yellow
101 to 150	Unhealthy for Sensitive Groups	101 to 360	125 to 164	Orange
151 to 200	Unhealthy	361 to 649	165 to 204	Red
201 to 300	Very unhealthy	650 to 1249	205 to 404	Purple
301 to 500	Hazardous	1250 to 2050	405 to 604	Maroon

Part #	Operation Condition	Package
<a href="#">ZMOD4510</a>	1.7-3.6V -40° to +65°	3.0 × 3.0 × 0.7mm, 12-LGA

Measuring OAQ with ZMOD4510

# ZSSC3224 – Sensor Signal Conditioner

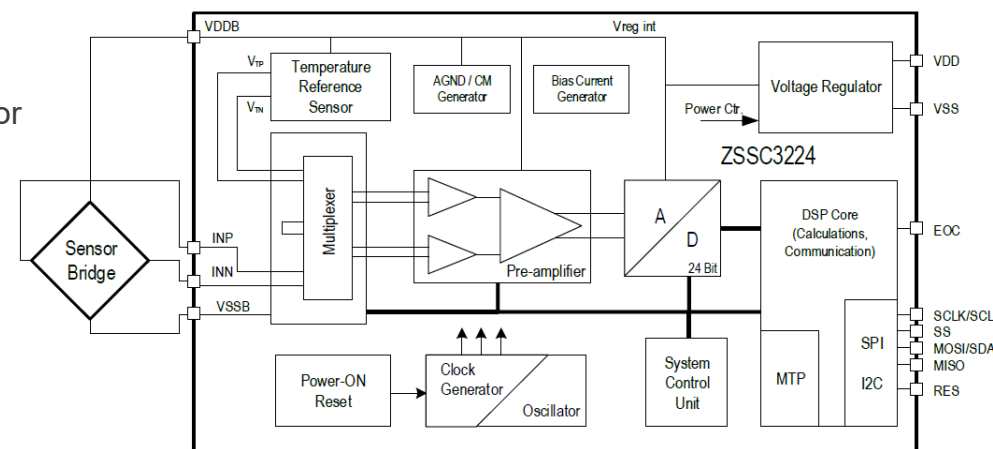
## High End 24-Bit Sensor Signal Conditioner IC

## Features

- Flexible, programmable analog front-end design; up to 24-bit analog-to-digital converter (ADC)
- Fully programmable gain amplifier for optimizing sensor signals: gain range 6.6 to 216 (linear)
- Internal auto-compensated temperature sensor
- Digital compensation of individual sensor offset; 1st and 2nd order digital compensation of sensor gain as well as 1st and 2nd order temperature gain and offset drift
- Programmable interrupt operation
- High-speed sensing: e.g. 18-bit conditioned sensor signal measurement rate  $>200\text{s}^{-1}$
- Typical sensor elements can achieve an accuracy of better than  $\pm 0.10\%$  FSO\*\* at  $-40$  to  $85^{\circ}\text{C}$

## Applications

- Barometric altitude measurement for portable navigation or emergency call systems; altitude measurement for car navigation
- Weather forecast
- Fan control
- Industrial, pneumatic, and liquid pressure
- High-resolution temperature measurements
- Object-temperature radiation (via thermopile)



## ZSSC3224 Block Diagram

Part #	Operation Condition	MSL Rating	Package
<a href="#">ZSSC3224BI3R</a>	1.68-3.6V -40°C to +85°C	MSL1	24-PQFN
ZSSC3224BI1B	(see above)	Not applicable	die, thickness 304μm
ZSSC3224BI2B	(see above)	Not applicable	die, thickness 725μm (without backlapping)

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