EU077
Indoor Sensor for Automatic Home or Building HVAC System

September 2020

Automatic Home or Building HVAC System Platform

Indoor Sensor Unit[1]

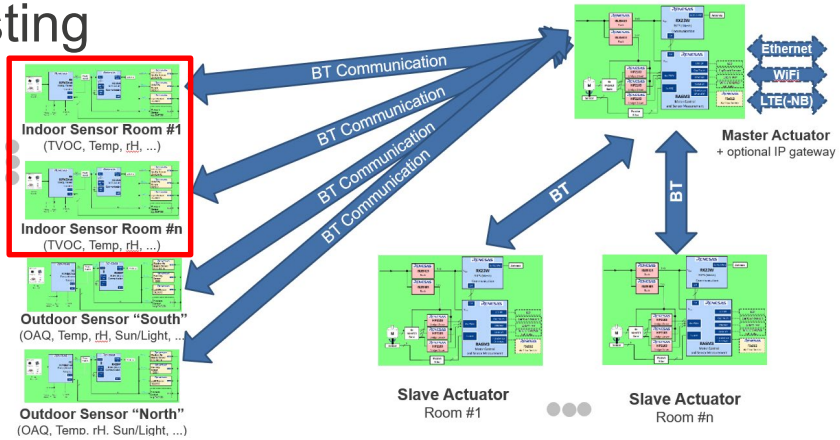
Please see EU076 for problem definition with existing / retrofit buildings, complete solution proposal and benefits.

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

- determines Indoor Air Quality, Temperature, Humidity, Light and Motion detection
- communicates with Master Actuator Unit by Bluetooth Mesh
- may also be maintenance-free sensors by using Energy Harvesting

Overall goals:
achieve optimum air quality in all rooms

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



NOTE [1]: 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.

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Indoor Sensor for Automatic Home or Building HVAC System

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- **Overview**

The indoor sensor unit(s) for automatic home or building HVAC systems provide local data on each room or section via a Bluetooth® mesh to the master actuator. This can be one, or all, of the following data:

- Indoor Air Quality (TVOC, eCO_2, and IAQ according to the German Environment Agency, or UBA)
- Temperature and relative humidity (degrees, percentage)
- Light (lux)
- Barometric pressure (mbar)
- Motion detection

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)

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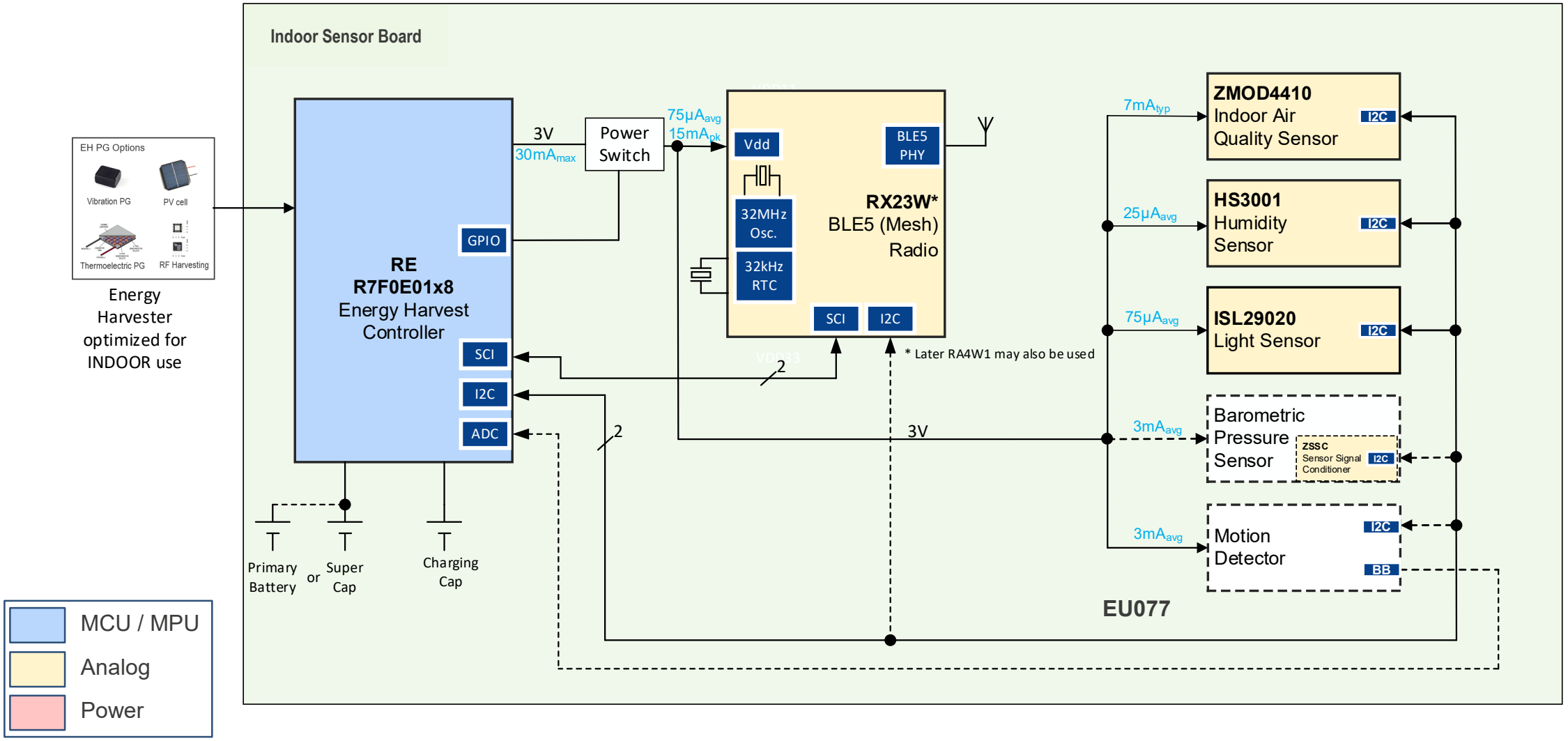

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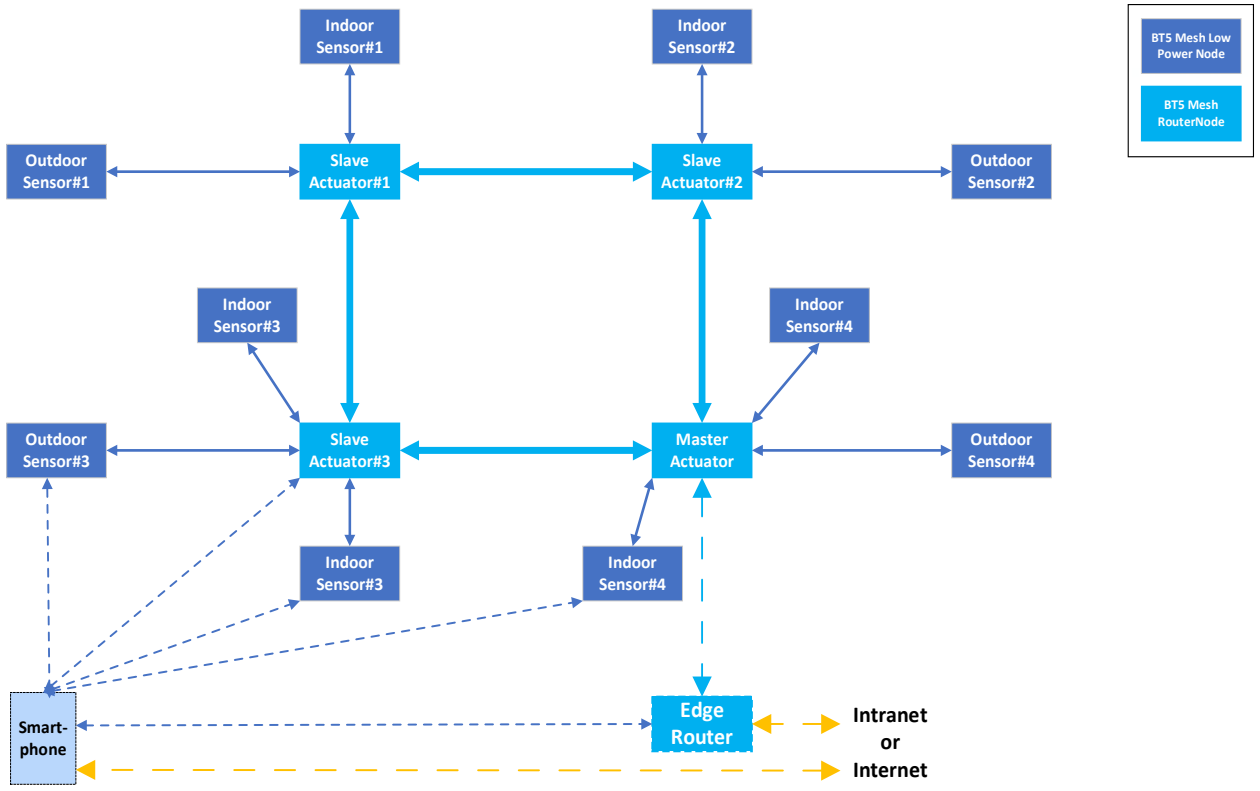
Major advantages of Bluetooth 5 Mesh

- secure communication (Diffie-Hellmann Key Exchange, AES128 etc.)
- bidirectional packet data flow
- low power (can go down to µA 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.



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Indoor 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	HS3001	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
	ZMOD4410	Indoor Air Quality Sensor Module (TVOC, eCO_2)
	ZSSC3224	High End 24-Bit Sensor Signal Conditioner IC

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RX23W – 32-bit MCU for Bluetooth 5.0 Low Energy

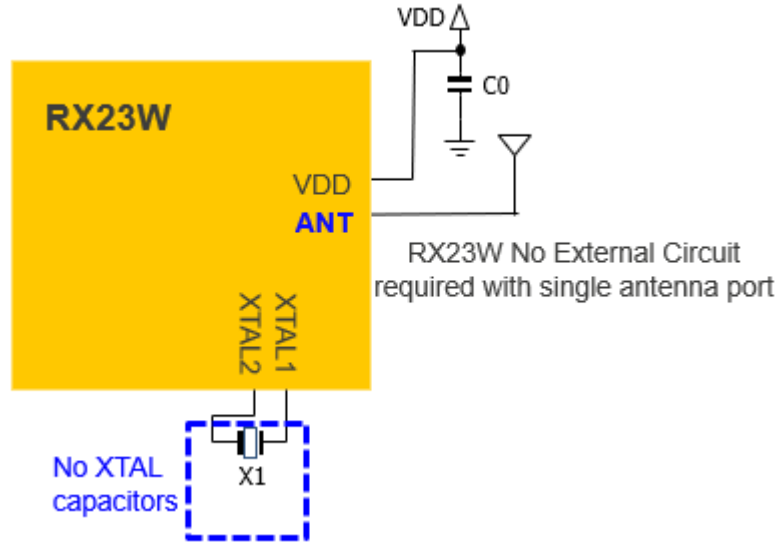
54 MHz RXv2 Core with FPU, Low Power Design, RTC and Encryption Functions

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

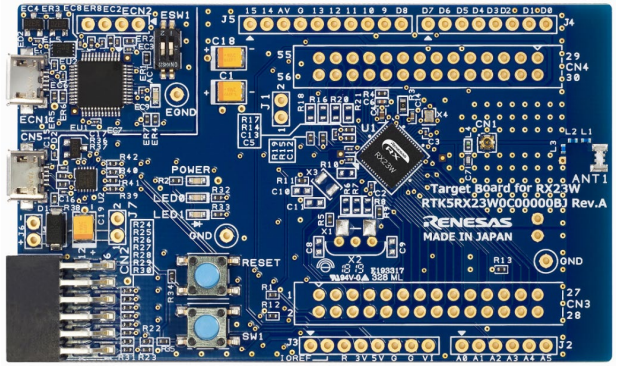
High Performance and Low Power Design

- 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

Part #	ROM (Kbytes)	RAM (Kbytes)	Security Functions	Package
R5F523W8ADNG#30	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



Target Board for RX23W – RTK5RX23W0C00000B

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

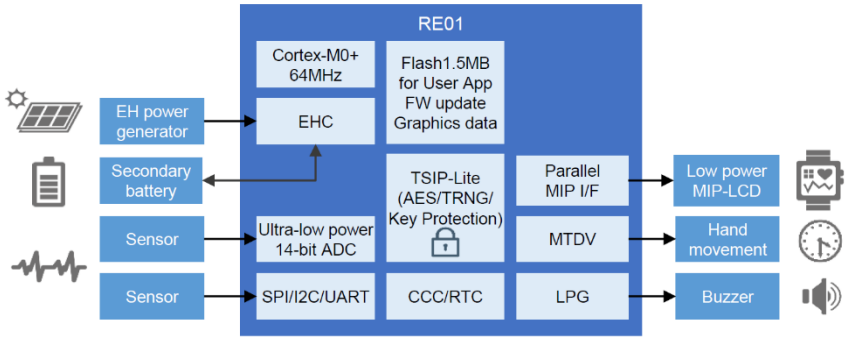
Intelligent for IoT Device

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

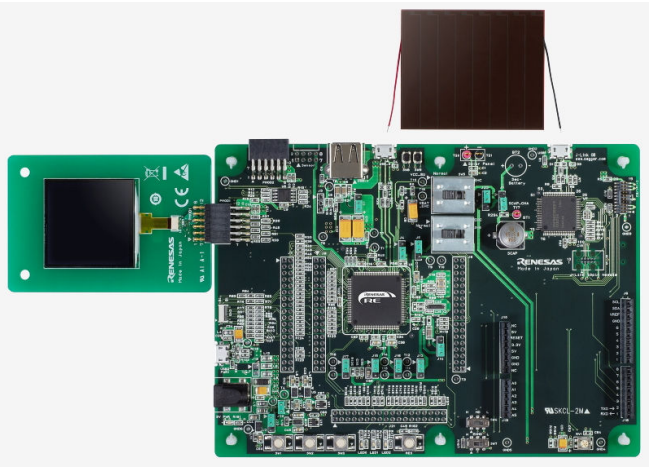
Rich Peripherals

- 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 I^2C

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	
R7F0E011D2CFP	1.5M/256K	Yes	No	PLQP0100KB-B 14 × 14 mm, 0.5-mm pitch
R7F0E010D2CFP	1.5M/256K	No	No	



Wearable / Hybrid Watch Example



Evaluation Kit RE01 1500KB Board

HS300X – Relative Humidity and Temperature Sensor

High Accuracy Humidity and Temperature Measurement for Environmental Monitoring

High Accuracy

- ±1.5%RH accuracy (HS3001)
- ±0.2°C temperature accuracy (HS3001, HS3002)

Excellent Stability

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

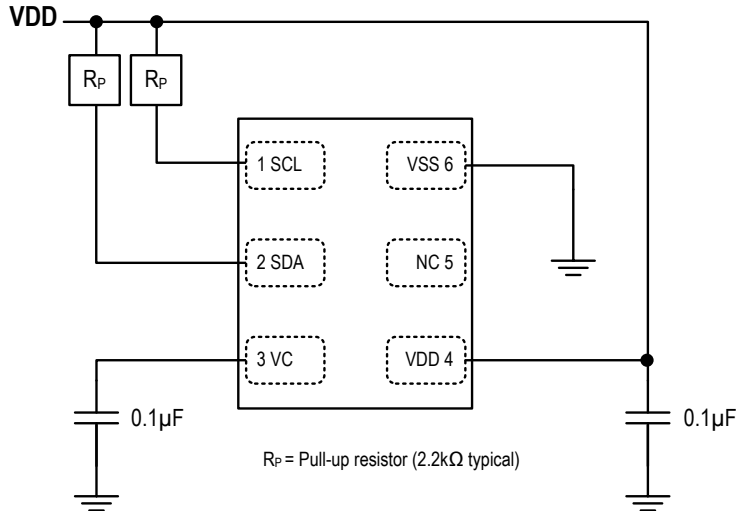
Fast Response

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

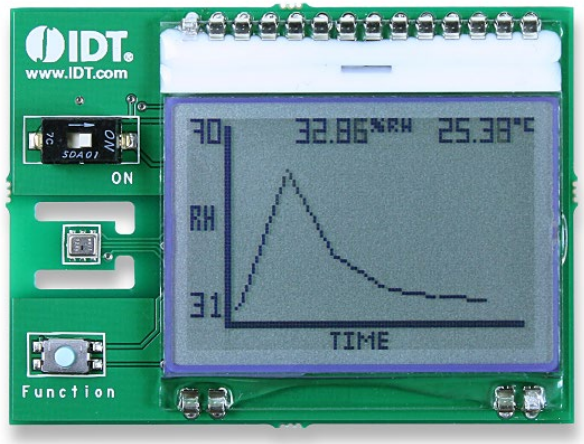
Extended Supply Voltage

- 2.3V to 5.5V, 24.4µA at 3.3V (one RH+Temp per second)
- 1.8V custom order

Part #	Feature	Package
HS3001	±1.5%RH	3×2.41×0.8 LGA
HS3002	±1.8%RH	3×2.41×0.8 LGA
HS3003	±2.8%RH	3×2.41×0.8 LGA
HS3004	±3.8%RH	3×2.41×0.8 LGA



Typical Operating Circuit



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
- I²C (SMBus compatible) Interface, 0x44 or 0x45 hardwired

High Performance

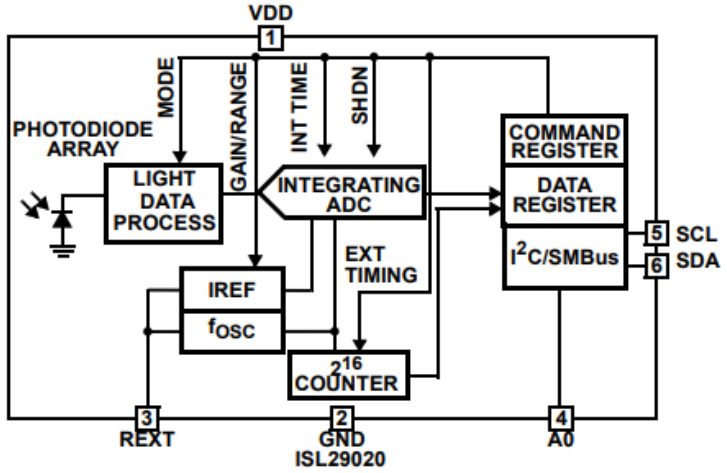
- Adjustable sensitivity up to 65 counts per lux
- Measurement range: 0.0015 to 64,000lux with four selectable ranges
- Close to human eye response with excellent IR/UV rejection
- Operation across -40 to +85°C

Low Power Design

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

Part #	ALS Sensing	A0 I2C address Pin	Package
ISL29020IROZ-T7	Yes	Yes	6 Ld 2x2.1 ODFN

Block Diagram



ISL290xxIROZ-EVALZ evaluation board

ZMOD4410 – Indoor Air Quality Sensor Platform

TVOC Sensor for Indoor Air Quality Application

Flexible Measure Target

- Measurement of total organic compounds (TVOC)
- Concentrations and indoor air quality (IAQ)
- Module algorithm estimates carbon dioxide level (eCO2)
- Algorithm to set a control signal to trigger an external action based on IAQ and odor change
- Configurable alarm/interrupt output with static and adaptive Levels

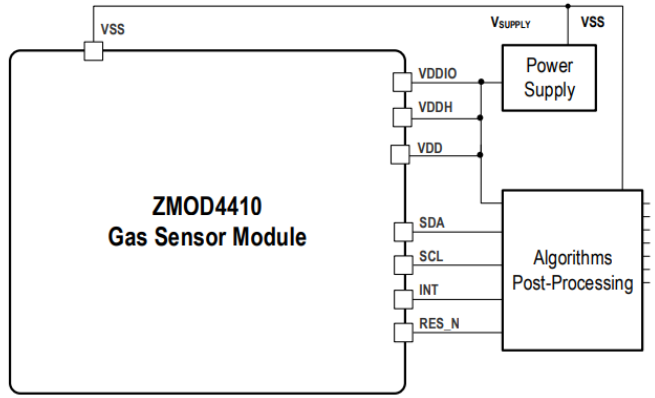
Low Power

- Very low average power consumption down to 1mW
- Excellent for low-voltage and low-power battery applications

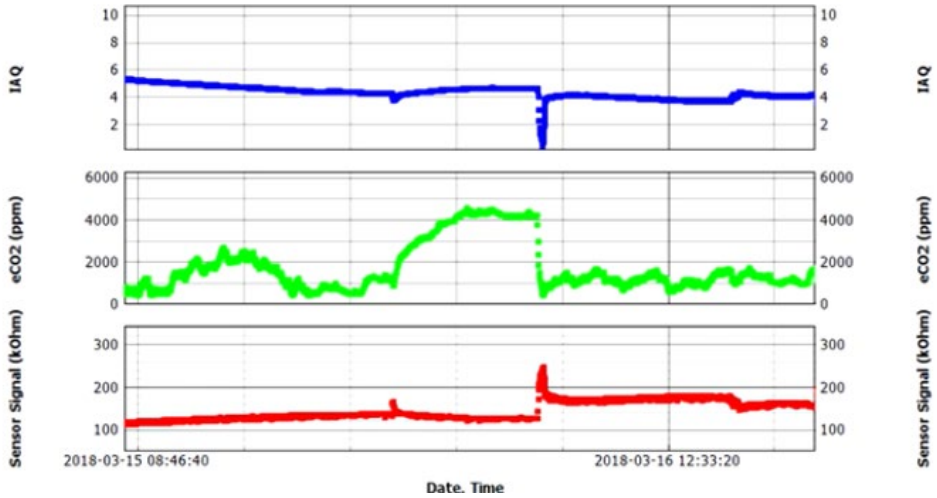
Easy to Use:

- ZMOD4410 Evaluation Kit
- Manuals, application notes, blog, and white papers
- Instructional videos
- Programming libraries, example codes, and algorithm support to optimize performance
- Third-party certification for compliance with well-accepted international IAQ standards

Part #	Operation Condition	Package
ZMOD4410AI1V ZMOD4410AI1R	1.7-3.6V -40° to +65° Est. CO2 400-5000ppm Ethanol in air 0-1000ppm	3.0 × 3.0 × 0.7mm, 12-LGA



ZMOD4410 typical application



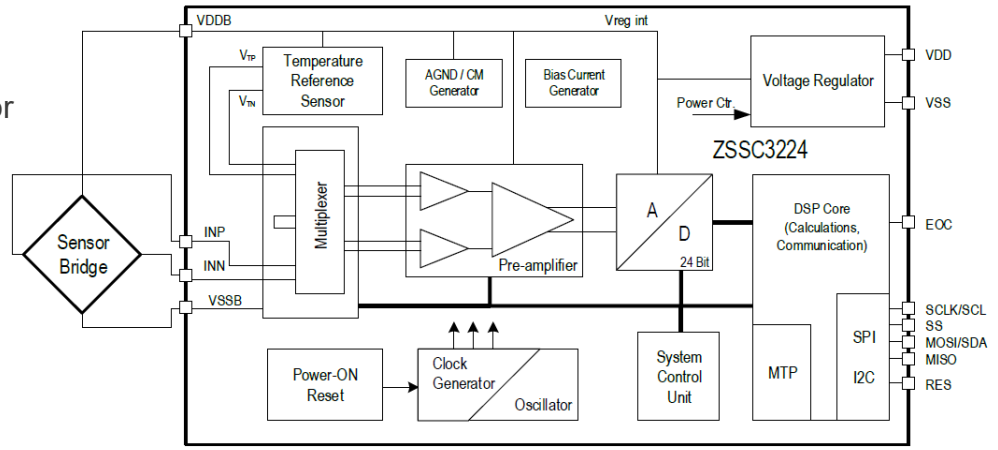
Measuring IAQ and Est CO2 level with ZMOD4410

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 >200s-1
- Typical sensor elements can achieve an accuracy of better than ±0.10% FSO** at -40 to 85°C



ZSSC3224 Block Diagram

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)

Part #	Operation Condition	MSL Rating	Package
ZSSC3224BI3R	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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