



US064 IoT Sensor Board with Machine Learning & Bluetooth® Low Energy

August 2020

IoT Sensor Board with Machine Learning & Bluetooth® Low Energy

- **Overview**

This is a reference design for a versatile Internet of Things (IoT) sensor board solution. It targets applications in industrial predictive maintenance, smart home/IoT appliances with gesture recognition, wearables (activity tracking), and mobile for innovative human machine interface, or HMI, (FingerSense) solutions. This reference design was developed with Renesas partner [Qeexo](#), who provided their Automated Machine Learning platform (AutoML) for edge devices.

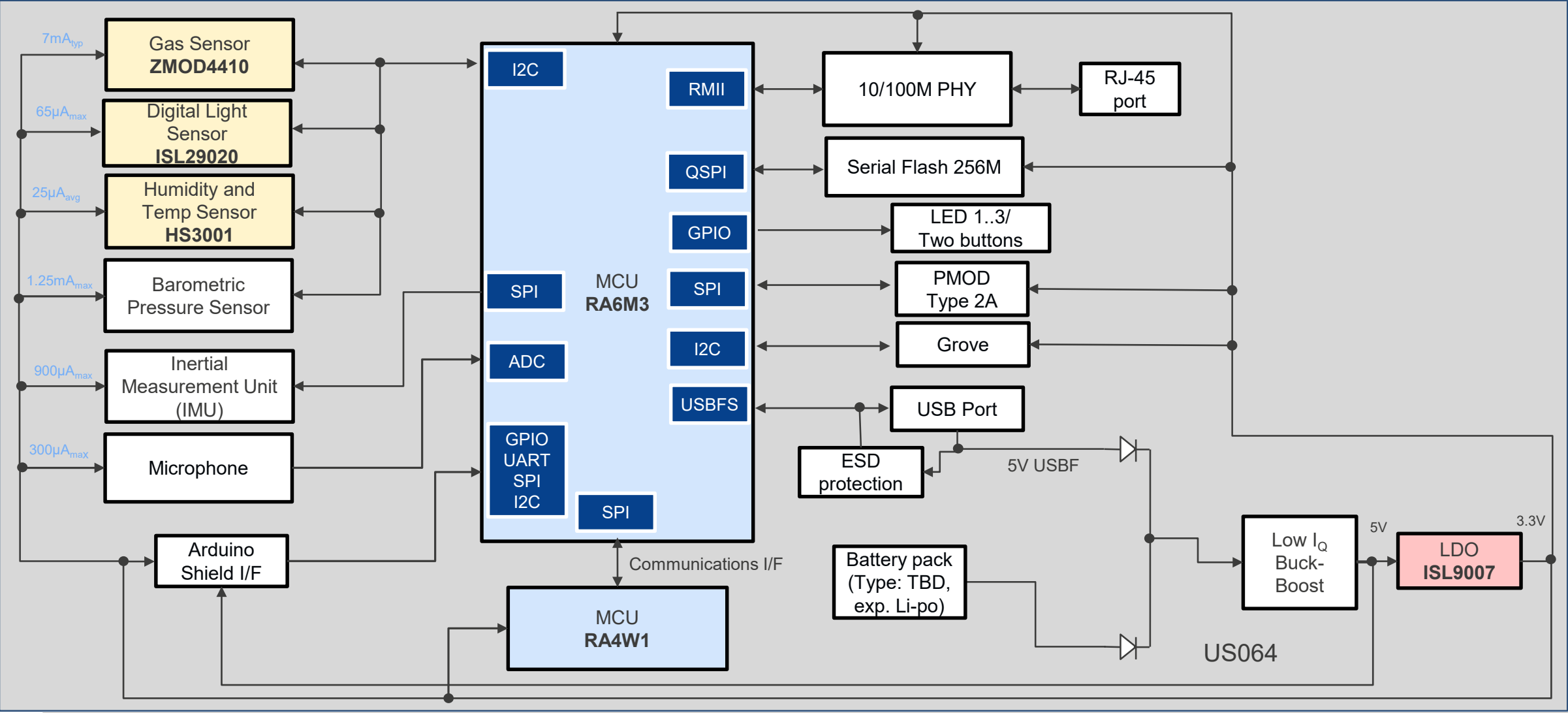
- **System Benefits**

- Features an IoT-specified microcontroller (MCU) supporting operations at 120MHz with 2M embedded Flash
- Solutions include an air quality sensor, light sensor, temperature and humidity sensor, a 6-axis inertial measurement unit, and a microphone
- Arduino shield pinout allows for extension of other functions, such as a BG96 cellular shield that supports CAT-M1 and NB-IoT frequencies, as well as 2G, GPS and additional sensors

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IoT Sensor Board with Machine Learning & Bluetooth® Low Energy

MCU / MPU Analog Power



IoT Sensor Board with Machine Learning & Bluetooth® Low Energy

Device Category	P/N	Key Features
MCU	RA6M3	120MHz Arm® Cortex®-M4 high performance MCU with USB high-speed, Ethernet and TFT controller
	RA4W1	48MHz Arm® Cortex®-M4 Bluetooth® 5.0 Low Energy single chip MCU
Power	ISL9007	High current LDO with low I _Q and high PSRR
Analog	ZMOD4410	Leading high sensitivity and long term stability, enables customer to release product families via SW changes, international accepted definition of Indoor Air Quality (IAQ), calculation of estimated carbon dioxide (eCO ₂).
	HS3001	Silicon-carbide capacitive sensing element, excellent stability against aging, temperature sensor accuracy of ±0.2°C.
	ISL29020	A low power, high sensitivity, light-to-digital sensor with I ² C interface

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RA6M3 – Ultra-Low Power 120-MHz Arm® Cortex®- M4 Core

Fully Featured for Applications That Need HMI/Control/Security/Graphical and Capacitive Touch

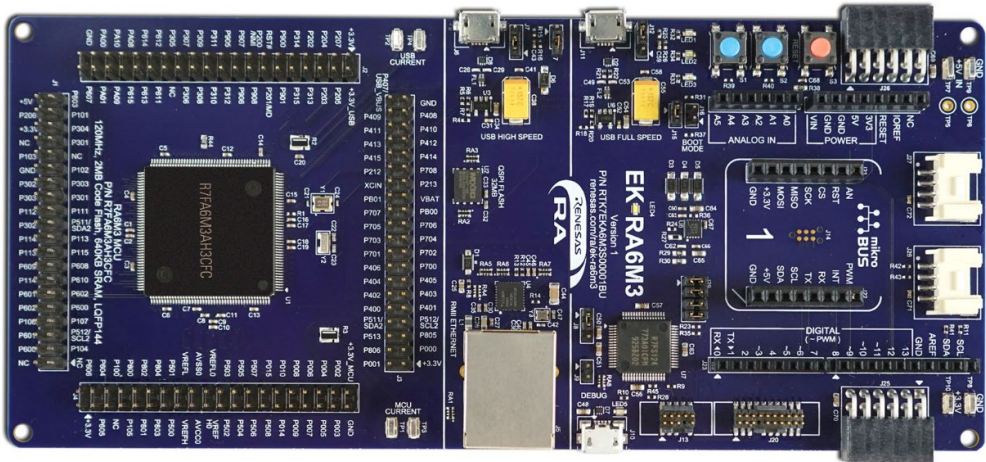
- High Performance
- 120MHz Arm® Cortex®-M4 CPU
- Highly Integrated Capabilities
- 1MB-2MB Flash Memory and 640kB SRAM
 - 128-bit unique ID
 - 12-Bit ADC (x2)
 - 12-Bit DAC
- Communication Interfaces
- USB 2.0 (Full Speed/High Speed)
 - Ethernet controller with DMA
 - SCI x10/SPIx2/IICx3

- HMI Interface
- Capacitive Touch Sensing Unit (18ch.)
 - Graphics LCD Controller
- Security and Encryption
- AES128/192/256, 3DES/ARC4, SHA1/SHA224/SHA256/MD5, GHASH, RSA/DSA/ECC
 - True Random Number Generator (TRNG)

Part #	Flash Memory	RAM	Temp	Package
R7FA6M3AH3CFC#AA0	2MB	640KB	40~105°C	176 LQFP
R7FA6M3AF3CFC#AA0	1MB	640KB	40~105°C	176 LQFP

FLASH / RAM	2MB / 640KB	RA6M3	RA6M3	RA6M3	RA6M3	RA6M3
	1MB / 640KB	RA6M3	RA6M3	RA6M3	RA6M3	RA6M3
Pin Count		100pin	144pin	145pin	176pin	176pin
Package		LQFP	LQFP	LGA	LQFP	BGA
Size		14x14	20x20	7x7	24x24	13x13
Pitch		0.5mm	0.5mm	0.5mm	0.5mm	0.8mm

Flash/ RAM/ Package Table



RTK7EKA6M3S00001BU

RA4W1 – 48-MHz Arm® Cortex®- M4 Core for BLE 5.0

Bluetooth® 5.0 Low Energy Single Chip MCU for IoT Applications

High Performance

- 48MHz 32-bit Arm® Cortex®-M4 core with FPU
- 512KB Flash, 96KB SRAM and 8KB data Flash

Full Functionality of Bluetooth 5.0 Low Energy

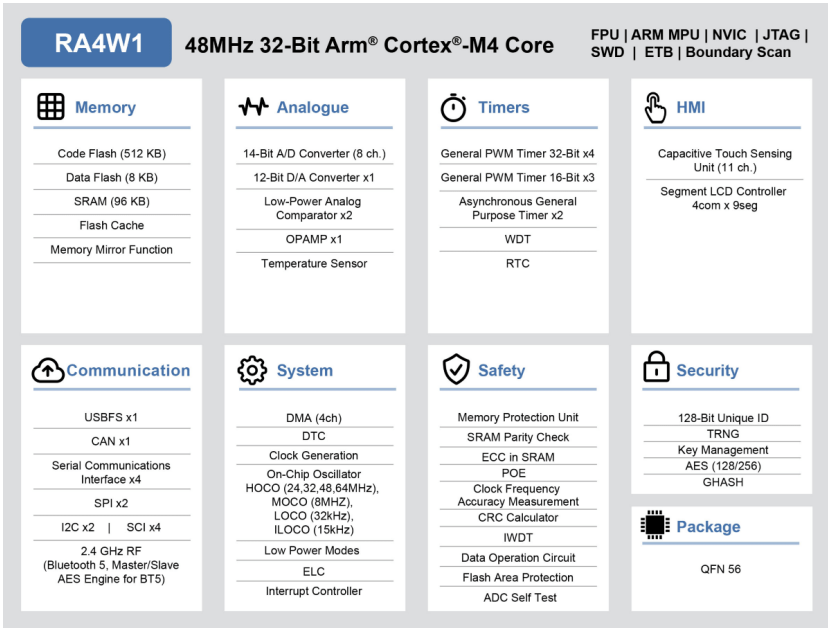
- 2.4 GHz radio with Bluetooth 5.0 Low Energy
- LE 1M, 2M, coded PHY, and LE advertising extension
- Secure crypto engine (AES128 / 256, GHASH, TRNG)

Highly Integrated Capabilities

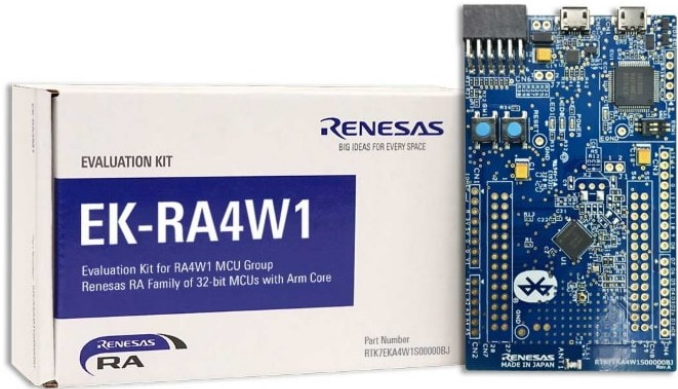
- 14-Bit ADC (8 ch.)
- 12-Bit DAC (1 ch.) and temperature sensor
- Low power analog comparator (2 ch), Op amp x 1
- USB 2.0 (Full Speed)/CAN/SCI x 4/SPI x 2 /IIC x 2
- GPT 32-bit (4 ch)/GPT 16-bit (3 ch)/AGT 16-bit (2 ch)/WDT/RTC

HMI Interface and Small Package

- Capacitive touch sensing unit (11 ch.)
- Segment LCD controller - up to 9 segments x 4 commons
- 7x7mm QFN 56 pin package



RA4M2 Block Diagram



EK-RA4W1

Part #	Flash Memory	RAM	Temp	Package
R7FA4W1AD2CNG	512KB	96KB	40~85°C	56 QFN

ISL9007 – V_{IN} 2.3V to 6.5V/400mA LDO

High Current LDO with Low I_Q and High PSSR

High Performance

- Excellent load regulation: <0.1% voltage change across full range of load current
- Very high PSRR: 75dB @ 1kHz

Wide Input Voltage and Stable Output Voltage

- $\pm 1.8\%$ V_{OUT} accuracy over all operating conditions
- Wide input voltage capability: 2.3V to 6.5V
- Low output noise: typically 30 μ VRMS @ 100 μ A (2.5V)

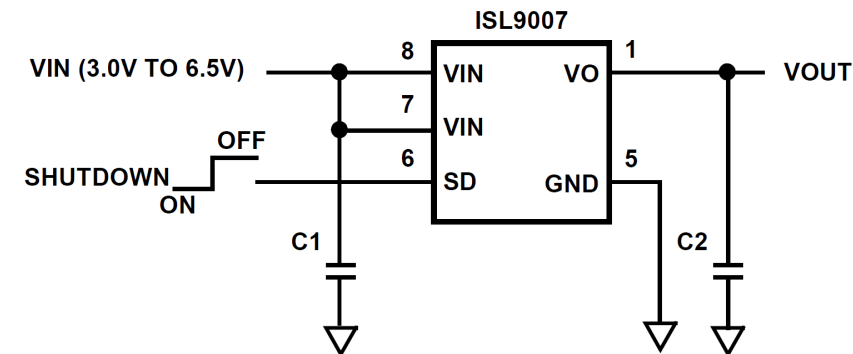
High Efficiency

- Very low quiescent current: 50 μ A
- Low dropout voltage: typically 200mV @ 300mA
- Low output noise: typically 30 μ VRMS @ 100 μ A (2.5V)
- Shutdown pin turns off LDO for 1 μ A (max) standby current

Excellent Safety

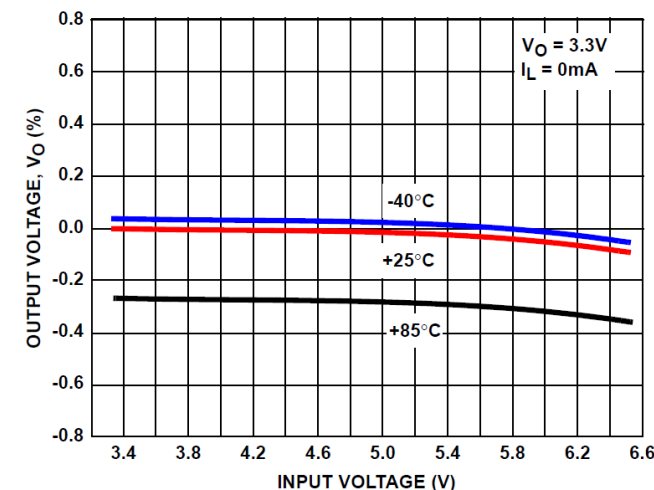
- Current limit and overheat protection
- Soft-start to limit input current surge during enable

Part #	Vout (V)	Temp.(°C)	Package
ISL9007IUNZ	3.3	-40 to +85	8Ld MSOP
ISL9007IUKZ	2.85	-40 to +85	8Ld MSOP
ISL9007IUJZ	2.8	-40 to +85	8Ld MSOP
ISL9007IUFZ	2.5	-40 to +85	8Ld MSOP
ISL9007IUCZ	1.8	-40 to +85	8Ld MSOP



C₁, C₂: 1 μ F X5R CERAMIC CAPACITOR

Typical Application Circuit



Output Voltage vs Input Voltage(3.3V Output)

ZMOD4410 – Indoor Air Quality Sensor Platform

TVOC Sensor for Indoor Air Quality Applications

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

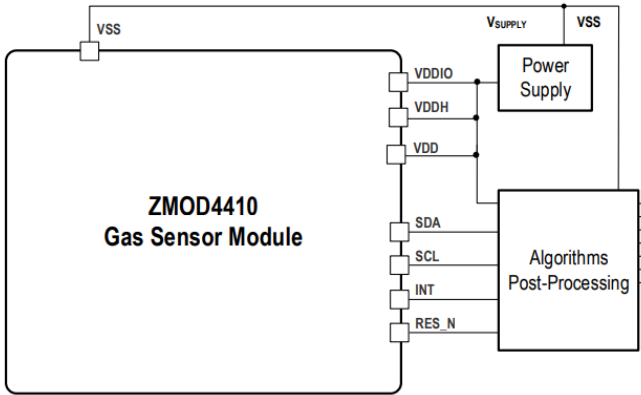
Low Power

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

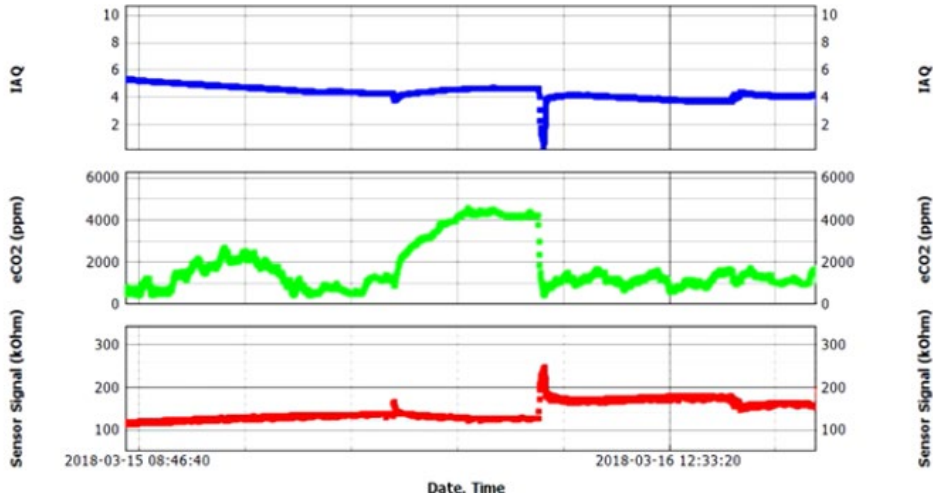
Easy to Use

- 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

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

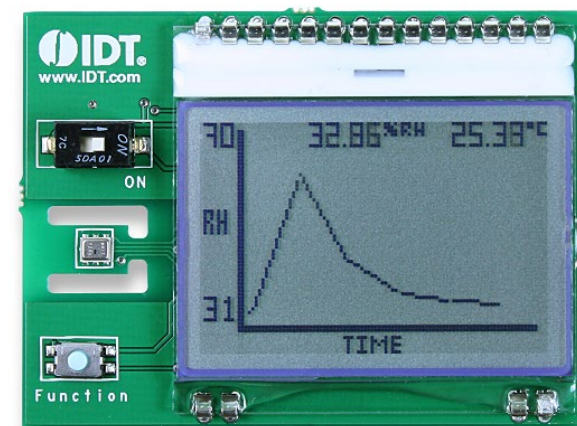
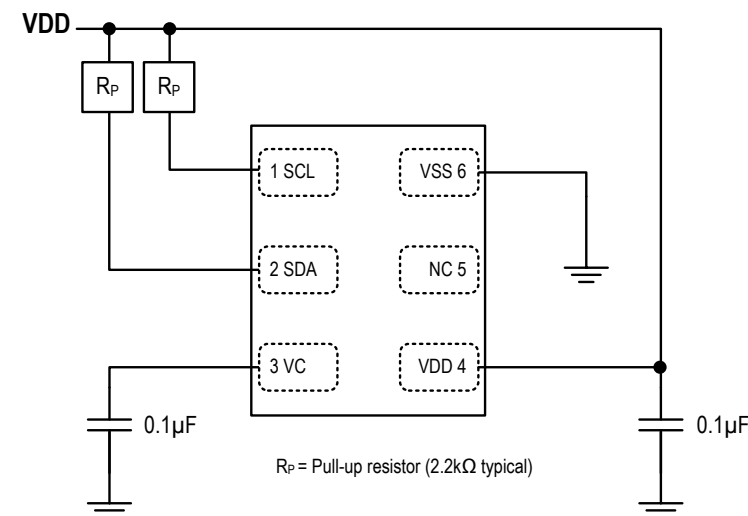
Fast Response

- 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 μA at 3.3V (one RH+Temp per second)
- 1.8V custom order

Part #	Feature	Package
HS3001	$\pm 1.5\%$ 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 - Digital Ambient Light Sensor with Interrupt

Low Power, High Sensitivity, Integrated Light Sensor with I²C (SMBus Compatible) Interface

Integrated Functions and Small Package

- Variable conversion resolution up to 16-bits
- I²C (SMBus compatible) output interface
- 2.0mmx2.1mmx0.7mm 6 Ld ODFN Package

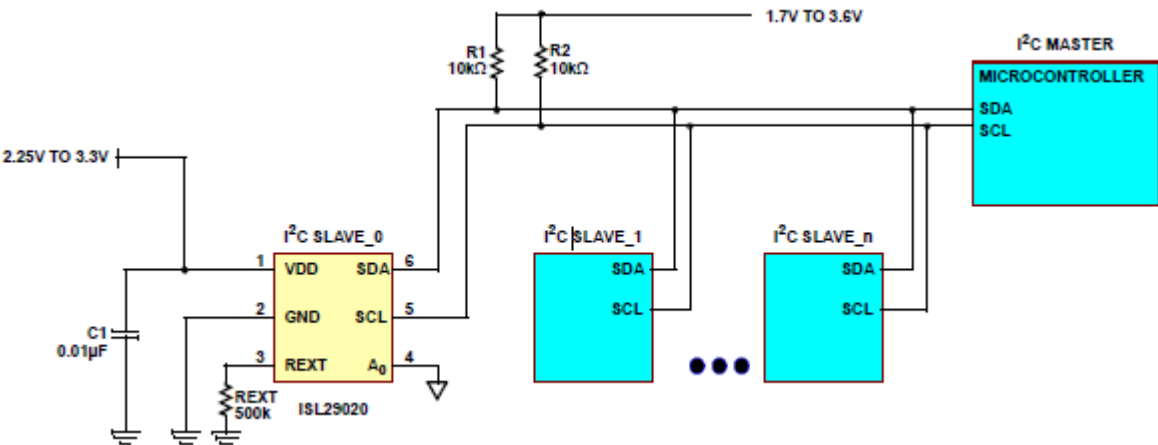
Easy to Use

- Adjustable sensitivity up to 65 counts per lux
- Measurement range: 0.015 to 64,000 lux with four selectable ranges
- Simple output code directly proportional to lux
- No complex algorithms needed
- Works under various light sources, including sunlight
- Operation across -40 to +85°C

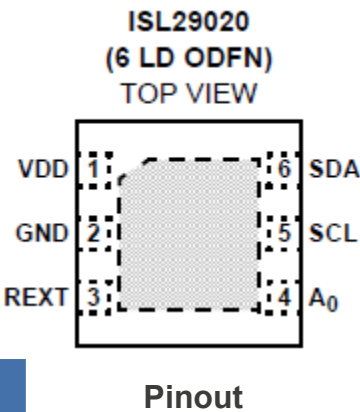
Low Power Design

- 65µA max operating current
- 0.5µA max shutdown current
- Software shutdown and automatic shutdown
- Ideal spectral response
- Close to human eye response
- Excellent IR and UV rejection

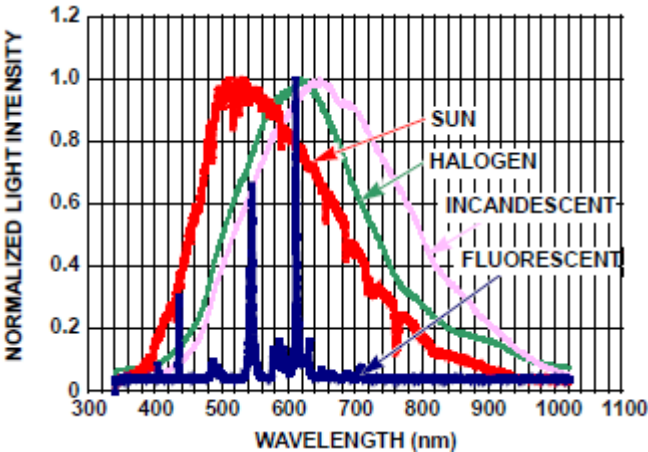
Part #	ALS Sensing	Interrupt Pin	Package
ISL29020IROZ-T7	Yes	No	6 Ld 2x2.1 ODFN



Typical Operating Circuits



Pinout



Spectral Response of Light Sources

[Renesas.com/win](https://www.renesas.com/win)