RE EMBEDDED CONTROLLERS
SILICON ON THIN BURIED OXIDE RENESAS'S NEXT GENERATION ULTRA LOW POWER PROCESS

RENESAS ELECTRONICS EUROPE
JUNE 2020

BIG IDEAS FOR EVERY SPACE **RENESAS**

AGENDA

- Introduction
- What is Silicon on Thin Buried Oxide
- Renesas RE Embedded Controller Roadmap
  - RE detailed features
- Features of RE Embedded Controllers
  - Unique Low Power features
  - Energy Harvesting support
- Summary

BIG IDEAS FOR EVERY SPACE

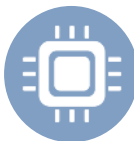# RENESAS PRODUCT PORTFOLIO

Analog/Power/SOC Devices

Power
- Industrial & Automotive
- IGBT, diodes and Intelligent Power Modules

Analog
- Industrial & Automotive
- DC to DC, Fuel gauge, charging, CMOS Image Sensors, Optical Image Stabilizer, SL BLDC Motor

SOC/ASIC
- Powertrain Control
- ASSP for USM, USB PD and PLC
- Custom ASICs
- ASIC, broad IP portfolio in 40 nm, 28 nm, 16 nm

Microcontroller Devices and Solutions

Renesas R-Car

Scalable Automotive solutions for Infotainment, Cluster and ADAS
- 47000 DMIPs, Multimedia, SoC

RENESAS RH850

Automotive High end solution
- 1344 DMIPS, Real Time

RENESAS RA

Industry standard
- Industrial, and consumer solutions
- Enhanced security

RENESAS RE

Ultra Low Power Controllers
- Wearables, sensor and Energy Harvesting
- 20 - 35 µA/MHz, 140 nA standby

RENESAS RX

Proprietary Industrial consumer
- 480 DMIPS, FPU, DSC
- 100 µA/MHz, 350 nA standby

RENESAS RZ

Industrial Automotive solutions
- 25000 DMIPS, Linux, Android
- Industrial connectivity

RENESAS RL78

16-bit Industrial & Automotive,
- 44 DMIPS, True Low Power
- 66 µA/MHz, 220 nA standby

Microcontroller Platform

RENESAS synergy™

RENESAS SYNERGY™ PLATFORM

Solutions Gallery

Software
- Development Tools
- Synergy Software Package
- Software Add Ons

Hardware
- Kits
- Microcontrollers

- Integrated Software, Development Tools, MCUs, Solutions
- Industrial 130 nm and 40 nm

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RENESAS MCU/MPU LINEUP

8/16bit MCU	32bit MCU				32/64bit MPU
Renesas Core	Arm® Core				

RL78 — Low Power

Features:
Ultra-low energy
Low pin count lineup available

Max operating frequency:
20-32MHz

Applications:
General-purpose
Sensor
Motor Control
LCD Display
Bluetooth® Low Energy
Sub-GHz Wireless
Communication
Security

RX — Power Efficiency

Features:
Superior power efficiency
High-capacity flash memories
Broad lineup

Max operating frequency:
32-240MHz

Applications:
General-purpose
Motor Control
Security
Capacitive Touch
Battery Powered
LCD Control
Industrial Network
Cloud Connectivity

RA — Arm® Ecosystem

Features:
High efficiency
Security

Max operating frequency:
48-200MHz

Applications:
Motor Control
LCD Control
Network
Capacitive Touch
Security

RE — Arm® Ecosystem

Features:
Ultra Low Energy
Low Voltage operation
Large memory
Energy Harvesting
Security

Max operating frequency:
64MHz

Applications:
Building Automation
Home Automation
IoT Sensors
Medical
User Interfaces
Wearables

Renesas Synergy™ — Qualified Platform

Features:
Qualified software and tools

Max operating frequency:
32-240MHz

Applications:
Motor Control
LCD Control
Network
IoT Devices
Security

RZ — High Performance

Features:
Multi-core up to 8 cores
Linux or RTOS available
High-capacity on-chip RAM
DRP[*1] image processing acceleration

Max operating frequency:
125MHz-1.5GHz

Applications:
HMI
HD Graphics
AI Inferencing
Machine Vision
Industrial Network
Real-time Control
*1 DRP: Dynamically Reconfigurable Processor

BIG IDEAS FOR EVERY SPACE **RENESAS**

RE01– A step change in MCU Power Consumption

Less than 20 µA / MHz active mode brings new opportunities for low power applications in an ever more connected world

Process Control

Building Automation

Medical
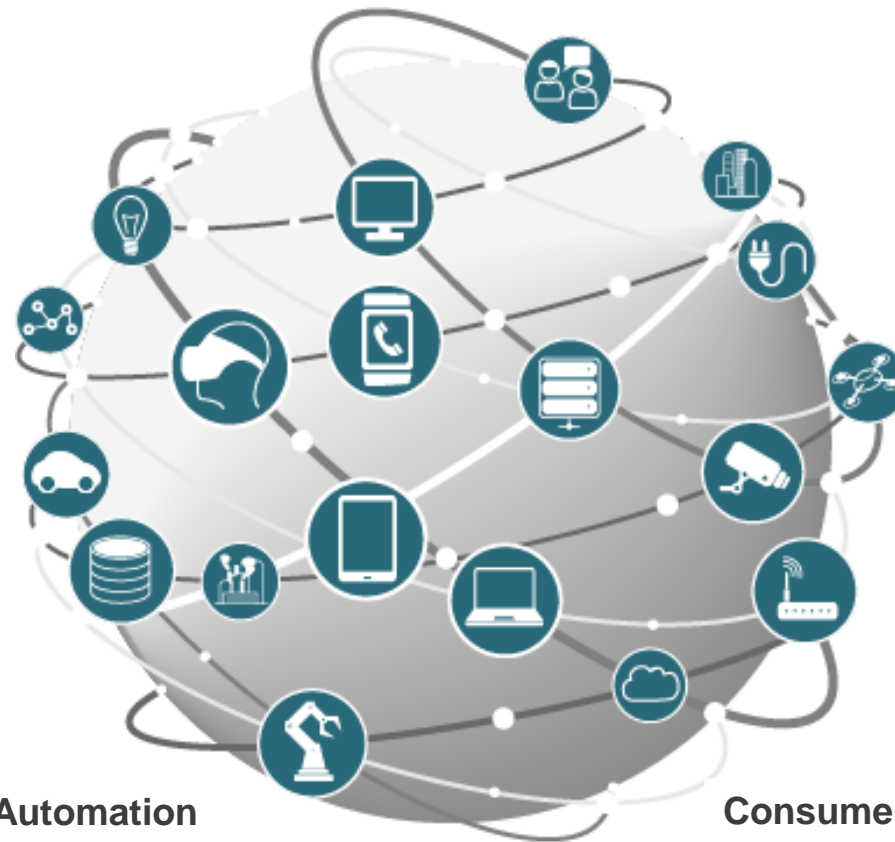
Wearables

Home Automation

Consumer products

BIG IDEAS FOR EVERY SPACE

SOTB™ – <u>S</u>ilicon <u>O</u>n <u>T</u>hin <u>B</u>uried Oxide
DISRUPTIVE EXTREME LOW-POWER TECHNOLOGY

- Enables Microcontroller with market leading low power capability
  - ULP benchmark of 705
- Breaks away from todays silicon restrictions
  - Low active power ≠ Low leakage ≠ high performance
  - Process choice not restricted by desired operating conditions
- Ultra Low Power consumption
  - Active Current: 12 - 35 µA per MHz of operation
  - Standby Current: 100 nA
  - SRAM data retention: Less than 12nA per 32KB of SRAM
  - 4 µA ADC operation @ 32 KHz
  - Unique energy harvesting controller

Silicon on Thin Buried Oxide breaks "the rules" and provides a unique combination low power capabilities

BIG IDEAS FOR EVERY SPACE
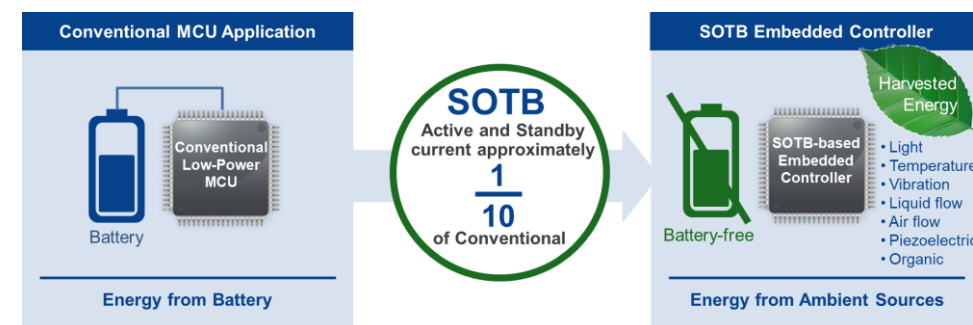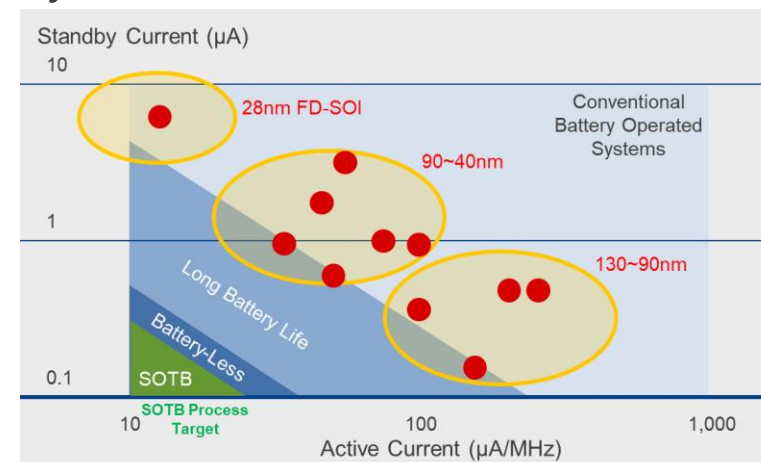
SOTB™ – Silicon On Thin Buried Oxide
DISRUPTIVE EXTREME LOW-POWER TECHNOLOGY

- A Unique process technology targeted at reducing power consumption
- Exclusively from Renesas and protected by many patents
- SOTB breaks previous trade-off between getting either low active current or low standby current

No Compromises		Max. Frequency		Active Current		Standby Current	
		Higher	Lower	High	Low	High	Low
Conventional Technology	Larger Geometry		■	■			■
Conventional Technology	Smaller Geometry	■			■	■	
SOTB Technology		■			■		■

SOTB is the Recipe for Very Capable, Extremely Low-Power Applications
Low Active and low Standby Power
High speed operation
High Integration

BIG IDEAS FOR EVERY SPACE RENESAS

RE ZERO ENERGY EMBEDDED CONTROLLERS
IMPLEMENTED ON SOTB

Embedded Controllers implemented on Renesas's unique, ultra low power, Silicon on Thin Buried Oxide (SOTB)   process technology

- Low active and low standby current
- Low voltage operation (1.62v) at high speed (64 MHz)
- Unique ultra low power peripherals
- Ultra Low Power analogue and digital peripherals
- Unique support for Energy Harvesting
- RE provides an ideal solution for any low power Applications

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RE FAMILY ROADMAP
IMPLEMENTED ON SOTB

- **1st product RE01** (Flash1.5MB/RAM256KB) 156WLBGA(CSP), 100/144LQFP

- **2nd product RE01** (Flash256KB/RAM128KB) 72WLBGA(CSP), 64/100LQFP, 56QFN

- **3rd product RE01** (Flash1.5MB/RAM256KB with BLE 5.0) 64QFN - coming towards the end of 2020

Phase 2
Sensor Fusion + EH + RF

RE3 Series Planning
Cortex-M33

RE3xB (BLE) Planning

RE3x Planning

Phase 1
Extreme Low Power

RE0 Series
Cortex-M0+

RE01
1.5MB/256KB
156WLBGA(CSP)
144/100LQFP

RE01
256KB/128KB
72WLBGA(CSP)
64,100LQFP,
56QFN,

RE01B(BLE)
1.5MB/256KB
64QFN

Phase1: Establishment of Battery Maintenance-less IoT Edge Market
Phase2: Improvement of data analysis processing performance by M33

| 2019 | 2020 | 2021 | 2022 |

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RE01 1.5 MB SOTB EMBEDDED CONTROLLER
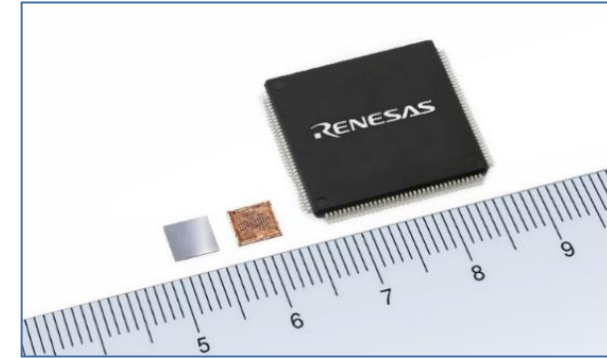
- CPU: Arm Cortex-M0+
- Operating frequency: Up to 32 MHz, and up to 64 MHz in boost mode
- Memory: Up to 1.5 MB flash, 256 KB SRAM
- Current consumption
  - Active: 15* - 35 µA/MHz
  - Deep Standby: 140 nA with real-time clock source and reset manager
  - Software Standby: 600 nA with retention of core logic and 256 KB SRAM data, real-time clock source, reset manager
  - SRAM data retention: Less than 12nA per 32KB of SRAM
- Energy Harvesting Controller (EHC):
- Trusted Secure IP (TSIP)
- 1 Msps 14-bit ADC, 1.6K Samples/sec @ 32 KHz 4µA consumption
- Tiny 156 pin WLBGA package 4.2 x 4.5 mm^2

*Bypass of internal LDO mode

RE01 – 1.5 MBYTE EMBEDDED CONTROLLER
ULTRA LOW POWER MCU WITH ENERGY HARVESTING CONTROLLER

RENESAS RE

Features

- Operating Voltage : 1.62V to 3.6V
- Operating temperature : -40°C to 85°C
- GPIO pins: up to 110 pins
- External clock oscillators
  - 8 to 32 MHz, 32.768 kHz
- PLL : 32, 48, 64 MHz
- On-chip clock oscillators
  - LOCO 32.768 kHz
  - MOCO 2 MHz
  - HOCO 24/32/48/64 MHz
- Ultra-low power by SOTB
  - 35uA/MHz Active (internal LDO mode)
  - 15uA/MHz Active (ext. DCDC mode)
  - 500nA Standby with 32KB RAM retention
  - 120nA Deep standby
- Energy Harvesting Controller (5uA bootup)
- Ultra-low power ADC (at 4uA)
- Ultra-low power HMI (2DG + 8-bit MIP)
- Crypto engine for security with Root of Trust
- Packages : WLBGA156, LQFP144/100

64-MHz ARM® Cortex®-M0+ CPU | RE01 | DIV | NVIC | SWD | MTB

Memory
- Code Flash (1.5 MB)
- SRAM (256 KB)

Analog
- 14-Bit A/D Converter (18 ch.)
- 12-Bit D/A Converter x 1
- Vref out
- Analog Comparator x1
- Temperature Sensor
- Motor Driver for Watches

Timing & Control
- General PWM Timer 32-Bit x 2
- General PWM Timer 16-Bit x 4
- Asynchronous 16-bit AGT x 2
- CCC
- 8-bit Timer x 2
- Low Speed Clock Timer
- RTC

HMI
- Memory In Pixel Display parallel Interface
- 2D Graphics Data Conversion Circuit
- LED driver

Connectivity
- USART w/o FIFO x 5 w/ FIFO x2
- SPI x2
- IIC x2
- QSPI x 1
- USB x 1

System & Power Management
- DMA Controller x 4
- Data Transfer Controller
- Event Link Controller
- Low Power Modes
- Multiple Clocks
- CCC
- SysTick
- Energy Harvesting Controller

Safety
- Flash Access Window
- ADC Diagnostics
- ADC Disconnection Detection
- Clock Accuracy Circuit
- CRC Calculator
- Data Operation Circuit
- Port Output Enable for GPT
- Independent WDT

Security & Encryption
- TSIP - Lite
- 128-Bit Unique ID
- TRNG
- AES (128/256)
- Hidden Root Key
- Flash Access Window
- Flash ID Code Protection
- MPU x 4

BIG IDEAS FOR EVERY SPACE   **RENESAS**

RE01 256K SOTB EMBEDDED CONTROLLER

- CPU: Arm Cortex-M0+
- Operating frequency: Up to 32 MHz, and up to 64 MHz in boost mode
- Frequency Lock Loop (FLL) enables 0.5 % HOCO accuracy -40 –> +85 degrees C
- Memory: 256 KB flash, 128 KB SRAM
- Ultra low Current consumption
    - Active: 12* - 25 µA/MHz
    - Deep Standby 100nA
                (350nA with full real-time clock and reset manager)
    - SRAM data retention: Less than 12nA per 32KB of SRAM
- Unique Low power peripherals
    - Wake Up Timer with 30 nA operation
    - RTC with 100 nA operation
    - 1 Msps 14-bit ADC, 1.6K Samples/sec @ 32 KHz 4µA consumption
- Energy Harvesting Controller (EHC)
- Trusted Secure IP (TSIP)
- Tiny 72 pin WLBGA package 2.9 x 3.1 mm^2

*Bypass of internal LDO mode

BIG IDEAS FOR EVERY SPACE

RE01-256K MICROCONTROLLER
ULTRA LOW POWER MCU WITH ENERGY HARVESTING CONTROLLER

RENESAS RE

Features

- Operating Voltage : 1.62V to 3.6V
- Operating temperature : -40°C to 85°C
- GPIO pins: up to 74
- External clock oscillators
  - 8 to 32 MHz, 32.768 kHz
- On-chip clock oscillators
  - LOCO 32.768 kHz
  - MOCO 2 MHz
  - HOCO 24/32/48/64 MHz
- Ultra-low power by SOTB
  - 25uA/MHz Active (internal LDO mode)
  - 12uA/MHz Active (ext. DCDC mode)
  - 400nA Standby with 32KB RAM retention
  - 100nA Deep standby
- Energy Harvesting Controller (5uA bootup)
- Ultra-low power HMI (2DG + 8-bit MIP)
- Ultra-low power ADC (at 4uA)
- Crypto engine for security with Root of Trust
- Packages : WLBGA72, LQFP64/100, QFN56,

64-MHz ARM® Cortex®-M0+ CPU | **RE01** | *DIV | NVIC | SWD | MTB*

Memory
- Code Flash (256KB)
- SRAM (128 KB)

Analog
- 14-Bit A/D Converter (18 ch.)
- Vref out
- Temperature Sensor

Timing & Control
- General PWM Timer 32-Bit x 2
- General PWM Timer 16-Bit x 4
- Asynchronous 16-bit AGT x 2
- Asynchronous 32-bit AGT x 2
- WUPT | LST
- CCC
- 8-bit Timer x 2
- RTC

HMI
- Memory In Pixel Display parallel Interface
- 2D Graphics Data Conversion Circuit
- Key Interrupt

Connectivity
- USART w/o FIFO x 5 w/ FIFO x2
- SPI x2
- IIC x2
- QSPI x 1

System & Power Management
- DMA Controller x 4
- Data Transfer Controller
- Event Link Controller
- Low Power Modes
- Multiple Clocks
- CCC
- SysTick
- Energy Harvesting Controller

Safety
- Flash Access Window
- ADC Diagnostics
- ADC Disconnection Detection
- Clock Accuracy Circuit
- CRC Calculator
- Data Operation Circuit
- Port Output Enable for GPT
- Independent WDT

Security & Encryption
- TSIP - Lite
- 128-Bit Unique ID
- TRNG
- AES (128/256)
- Hidden Root Key
- Flash Access Window
- Flash ID Code Protection
- MPU x 4

BIG IDEAS FOR EVERY SPACE **RENESAS**

		RE01_256KB (NOTE) Flash/SRAM=256KB/128KB(Under development)				RE01_1.5MB Flash/SRAM=1.5MB/256KB (MP)		
Pin count		100	64	72	56	156	144	100
Current consumption	while(1) Disabled Peripheral	25uA/MHz@32MHz				35uA/MHz@32MHz		
	Standby current	400nA@1.8V (typ) 500nA@3.3V (typ)				500nA@1.8V (typ) 800nA@3.3V (typ)		
PKG		LQFP	WLBGA		QFN	WLBGA	LQFP	LQFP
Code Flash / SRAM		256KB / 128KB				1.5MB / 256KB		
CPU Freq		Up to 64MHz (Boost mode), up to 32MHz (Normal mode), up to 32kHz (Low leakage mode)						
Clock		MainOSC, SubOSC, HOCO, MOCO, LOCO (PLL is not available)				PLL, MainOSC, SubOSC, HOCO, MOCO, LOCO		
Timers	GPT32/16	6ch						
	AGT 16bit asynchronous timer	2ch						
	AGTW 32bit asynchronous timer	2ch				NA		
	TMR,RTC,CCC,WDT,IWDT	2ch,1ch,1ch,1ch,1ch						
Serial communication	SCI(UART/IIC/SPI)	5ch (w/o FIFO) + 2ch (w FIFO)						
	RIIC	2ch	1ch	2ch	1ch	2ch		
	SPI	1ch(128bit buffer) + 1ch (32bit buffer)						
	QSPI	1ch						
	USB	NA				1ch		
Analog	S14AD 14bit ADC	12ch	8ch	12ch	7ch	18ch		12ch
	R12DA 12bit DAC	NA				1ch		
	TEMP Sensor	1ch						
	Analog Comparator	NA				1ch		
	VREF	1ch						
	LED (for watch)	NA				3ch		NA
HMI	MIP-LCD parallel IF	Supported						
	Motor driver (watch movement)	NA				3ch		NA
Graphic	GDT 2D Graphic	Supported						
Security	TSIP-Lite (AES/TRNG/Key protection)	Supported(Option) / Not Supported						

BIG IDEAS FOR EVERY SPACE

RE01 GROUP LINEUP
SCHEDULE IS SUBJECT TO CHANGE

- RE01_1.5MB Mass production Today
- RE01_256KB limited samples available now for some package options MP starts from 3Q '20.

Precuts,		56 QFN	64 LQFP	72 WLBGA	100 LQFP	144 LQFP	156 WLBGA
ROM/ RAM	TSIP (Security)	7 x 7mm 0.4mm pitch	10 x 10 mm 0.5mm pitch	3.16x2.88 mm 0.3mm pitch	14 x 14 mm 0.5mm pitch	20 x 20mm 0.5m pitch	4.27 × 4.47mm 0.3mm pitch
1.5MB/ 256KB	Yes	-	-	-	R7F0E015D2CFP MP NOW	R7F0E015D2CFB MP NOW	R7F0E017D2DBN MP NOW
	No	-	-	-	R7F0E014D2CFP MP NOW	R7F0E014D2CFB MP NOW	R7F0E016D2DBN MP NOW
256KB/ 128KB	Yes	R7F0E01182DNG Sample Avl MP '21_Q1	R7F0E01182CFM Sample Avl MP '20_Q3	R7F0E01182DBR Sample'20Q2 MP '21_Q1	R7F0E01182CFP Sample Avl MP '20_Q3	-	-
	No	R7F0E01082DNG MP '21_Q1	R7F0E01082CFM MP '20_Q3	R7F0E01082DBR MP '21_Q1	R7F0E01082CFP MP '20_Q3	-	-

BIG IDEAS FOR EVERY SPACE

RE01 EMBEDDED CONTROLLER
ULTRA LOW POWER BLE MCU WITH ENERGY HARVESTING CONTROLLER

Preliminary Specification
Samples   Q4 2020

Features

- Operating temperature range: -40°C up to 85°C
- GPIO pins: 26
- Main clock oscillator （MOSC）
  - ✓ 8 to 32 MHz when VCC = 1.62 – 3.6 V
- Sub-clock oscillator （SOSC） 32.768 kHz
- High-speed on-chip oscillator （HOCO）
  - ✓ 24, 32, 48, 64 MHz when VCC = 1.62 – 3.6 V
- Middle speed on-chip OSC （MOCO）   2 MHz
- PLL from MOSC – Output Up to 64 MHz
- Low-speed on-chip oscillator （LOCO）   32.768 kHz
- Clock correction circuit (SOSC / LOCO)
- Independent watchdog timer OCO 16 kHz
- Packages QFN64

64-MHz ARM® Cortex®-M0+ CPU   **RE01B**   DIV | NVIC | SWD | MTB

Memory
- Code Flash (1.5 MB)
- SRAM (256 KB)

Analog
- 14-Bit A/D Converter (18 ch.)
- Vref out
- Temperature Sensor

Timing & Control
- General PWM Timer 32-Bit x 1
- General PWM Timer 16-Bit x 1
- Asynchronous 16-bit AGT x 2
- 8-bit Timer x 2
- Low Speed Clock Timer
- RTC

HMI
- 2D Graphics Data Conversion Circuit

Connectivity
- Serial Communications Interface w/ FIFO x 2
- SPI
- IIC
- BLE 5.0

System & Power Management
- DMA Controller
- Data Transfer Controller
- Event Link Controller
- Low Power Modes
- Multiple Clocks
- CCC
- SysTick
- Energy Harvesting Controller

Safety
- Flash Area Protection
- ADC Diagnostics
- Clock Correction Circuit
- Clock Accuracy Circuit
- CRC Calculator
- Data Operation Circuit
- Port Output Enable for GPT
- IWDT & WDT

Security & Encryption
- TSIP - Lite
- 128-Bit Unique ID
- TRNG
- AES (128/256)
- MPU x 4

BIG IDEAS FOR EVERY SPACE

RE01 EMBEDDED CONTROLLER

ULTRA LOW POWER MCU WITH ENERGY HARVESTING CONTROLLER

Preliminary Specification
Available 2021

Features

- Operating temperature range: TBC
- GPIO pins: TBC
- Main clock oscillator（MOSC）
- Sub-clock oscillator（SOSC）32.768 kHz
- High-speed on-chip oscillator（HOCO）
- Middle speed on-chip OSC（MOCO）
- Low-speed on-chip oscillator（LOCO）
- Clock correction circuit (SOSC / LOCO)
- Independent watchdog timer OCO
- Packages TBC

100-MHz ARM® Cortex®-M33 CPU | RE3x | TZ | NVIC | SWD | MTB

Memory
- Code Flash (512 KB)
- SRAM (256 KB)

Analog
- 14-Bit A/D Converter (20 ch.)
- Vref out
- 12-Bit D/A Converter x 1
- Low-Power Analog Comparator x1
- Temperature Sensor

Timing & Control
- General PWM Timer 32-Bit x 2
- General PWM Timer 16-Bit x 4
- Asynchronous 16-bit AGT x 2
- Asynchronous 32-bit AGT x 2
- WUPT | LST
- 8-bit Timer x 2
- RTC

HMI
- LCD Display 32 X 4 / 28 x 8
- LED driver
- Cap Touch

Connectivity
- Serial Communications Interface x 7 2 x FIFO
- SPI x2
- IIC x2
- QSPI x 1
- USB x 1

System & Power Management
- DMA Controller
- Data Transfer Controller
- Event Link Controller
- Low Power Modes
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BIG IDEAS FOR EVERY SPACE

RE01 EMBEDDED CONTROLLER
ULTRA LOW POWER BLE MCU WITH ENERGY HARVESTING CONTROLLER

Preliminary Specification
Available 2021

RENESAS RE

Features

- Operating temperature range: TBC
- GPIO pins: TBC
- Main clock oscillator (MOSC)
- Sub-clock oscillator (SOSC) 32.768 kHz
- High-speed on-chip oscillator (HOCO)
- Middle speed on-chip OSC (MOCO)
- Low-speed on-chip oscillator (LOCO)
- Clock correction circuit (SOSC / LOCO)
- Independent watchdog timer OCO
- Packages TBC

100-MHz ARM® Cortex®-M33 CPU   RE3xB   TZ | NVIC | SWD | MTB

Memory
- Code Flash (2.0 MB)
- SRAM (512 KB)

Analog
- 14-Bit A/D Converter (20 ch.)
- Vref out
- 12-Bit D/A Converter x 1
- Low-Power Analog Comparator x1
- Temperature Sensor

Timing & Control
- General PWM Timer 32-Bit x 2
- General PWM Timer 16-Bit x 4
- Asynchronous 16-bit AGT x 2
- Asynchronous 32-bit AGT x 2
- WUPT
- LST
- 8-bit Timer x 2
- RTC

HMI
- LCD Display 32 X 4 / 28 x 8
- LED driver
- Cap Touch

Connectivity
- Serial Communications Interface x 7 2 x FIFO
- SPI x2
- IIC x2
- QSPI x 1
- USB x 1
- BLE 5.0 x 1

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BIG IDEAS FOR EVERY SPACE   **RENESAS**
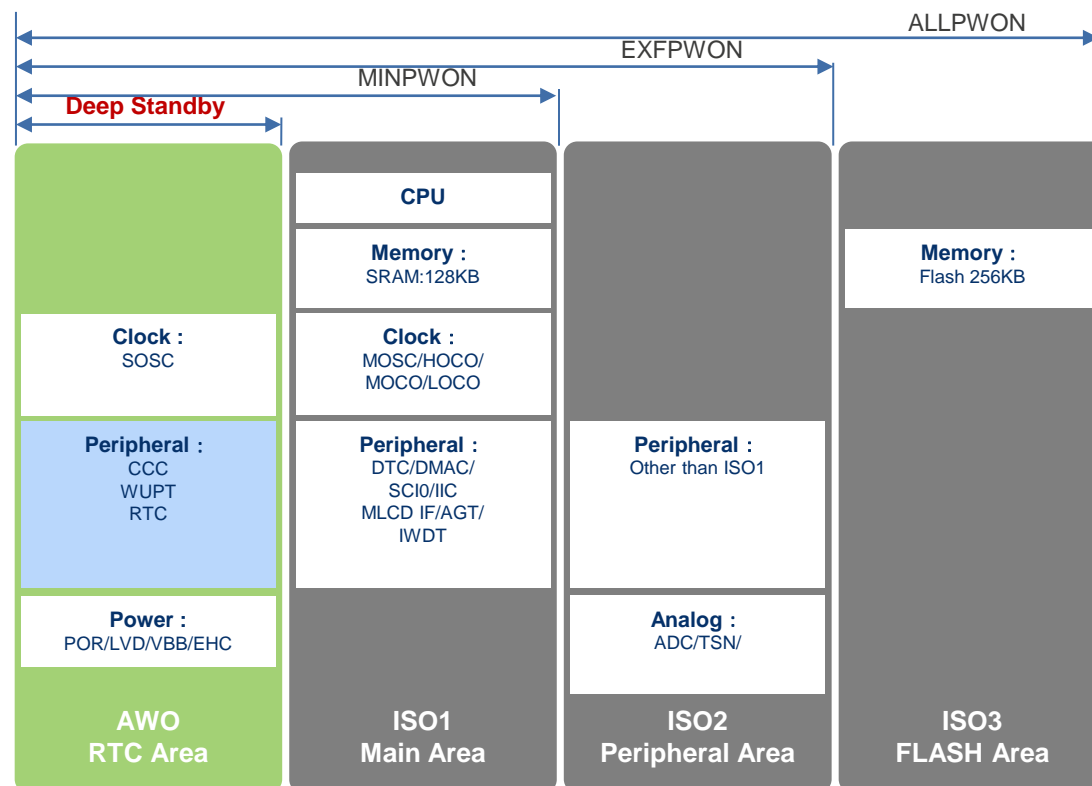
RE01 LOW POWER SYSTEM (256K VERSION)

- **Power supply modes enable to turn off the power of each power domain**

Power Supply Mode↓	AWO	ISO1	ISO2	ISO3
ALLPWON	On	On	On	On
EXFPWON	On	On	On	Off
MINPWON	On	On	Off	Off
Deep-standby	On	Off	Off	Off

Diagram labels:
- ALLPWON
- EXFPWON
- MINPWON
- **Deep Standby**

AWO / RTC Area:
- Clock : SOSC
- Peripheral : CCC / WUPT / RTC
- Power : POR/LVD/VBB/EHC

ISO1 / Main Area:
- CPU
- Memory : SRAM:128KB
- Clock : MOSC/HOCO/MOCO/LOCO
- Peripheral : DTC/DMAC/ SCI0/IIC MLCD IF/AGT/ IWDT

ISO2 / Peripheral Area:
- Peripheral : Other than ISO1
- Analog : ADC/TSN/

ISO3 / FLASH Area:
- Memory : Flash 256KB

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RE01 LOW POWER SYSTEM (256K VERSION)

OPERATING MODES

Measurement Conditions
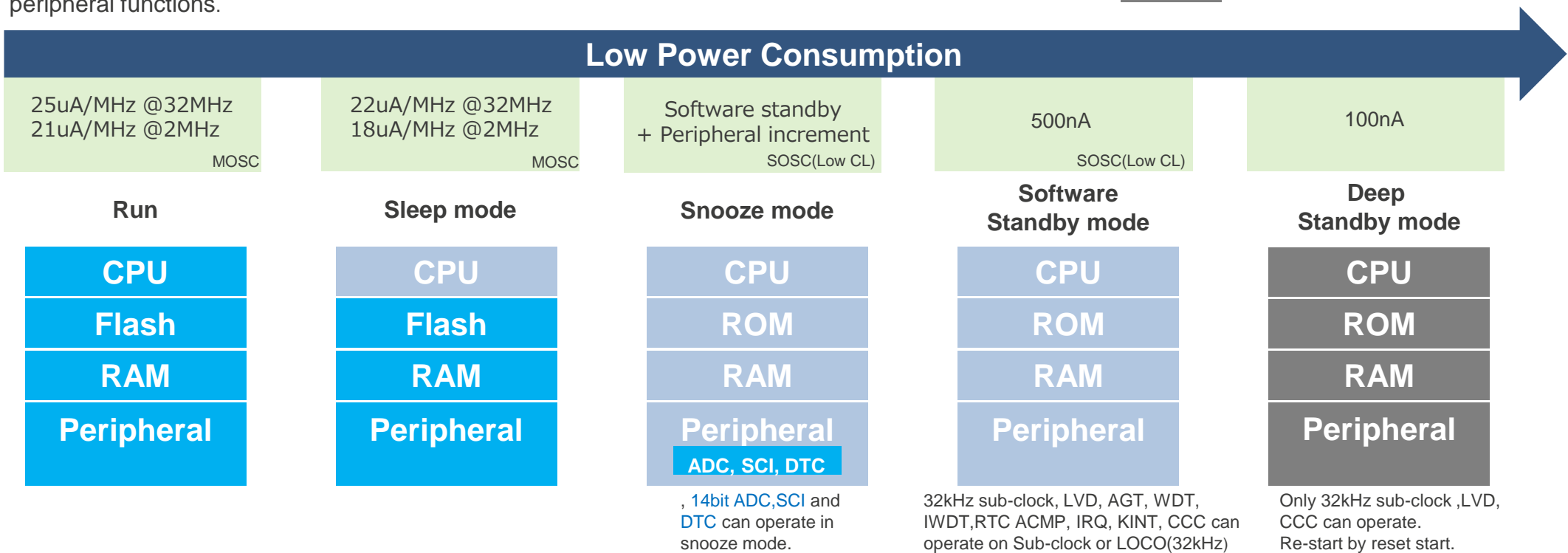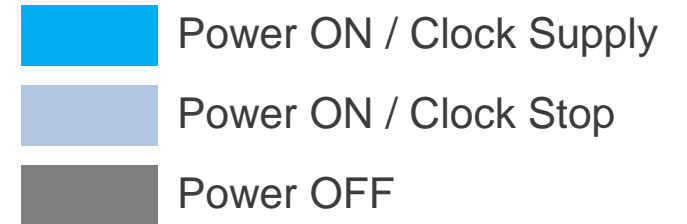VCC: 3.3V
Program: while(1) operation (peripheral clock signal stopped)
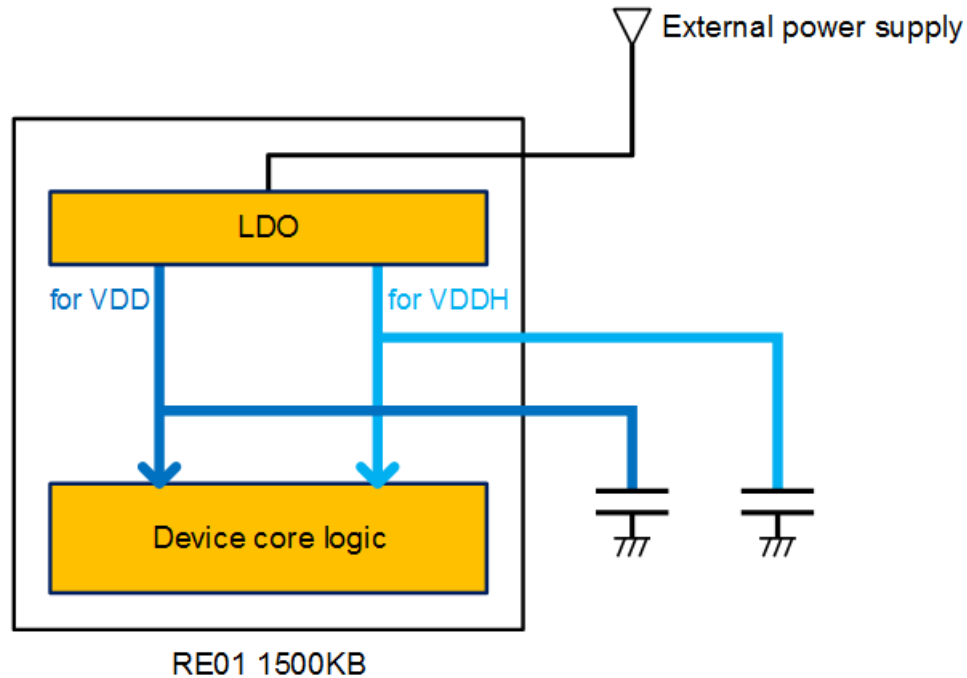Program execution from flash @ 32 MHz, execution from SRAM @ 2 MHz)
Test conditions: Peripheral clock divided by 64
Current consumption in nomal operation depends on the code executed and the number of operating peripheral functions.

■ Power ON / Clock Supply
■ Power ON / Clock Stop
■ Power OFF

Low Power Consumption →

| 25uA/MHz @32MHz 21uA/MHz @2MHz MOSC | 22uA/MHz @32MHz 18uA/MHz @2MHz MOSC | Software standby + Peripheral increment SOSC(Low CL) | 500nA SOSC(Low CL) | 100nA |

| **Run** | **Sleep mode** | **Snooze mode** | **Software Standby mode** | **Deep Standby mode** |

CPU	**CPU**	**CPU**	**CPU**	**CPU**
Flash	**Flash**	**ROM**	**ROM**	**ROM**
RAM	**RAM**	**RAM**	**RAM**	**RAM**
Peripheral	**Peripheral**	**Peripheral** **ADC, SCI, DTC**	**Peripheral**	**Peripheral**

Snooze mode: , 14bit ADC,SCI and DTC can operate in snooze mode.

Software Standby mode: 32kHz sub-clock, LVD, AGT, WDT, IWDT,RTC ACMP, IRQ, KINT, CCC can operate on Sub-clock or LOCO(32kHz)

Deep Standby mode: Only 32kHz sub-clock ,LVD, CCC can operate. Re-start by reset start.

BIG IDEAS FOR EVERY SPACE

RENESAS

RE01 POWER SUPPLY OPTIONS
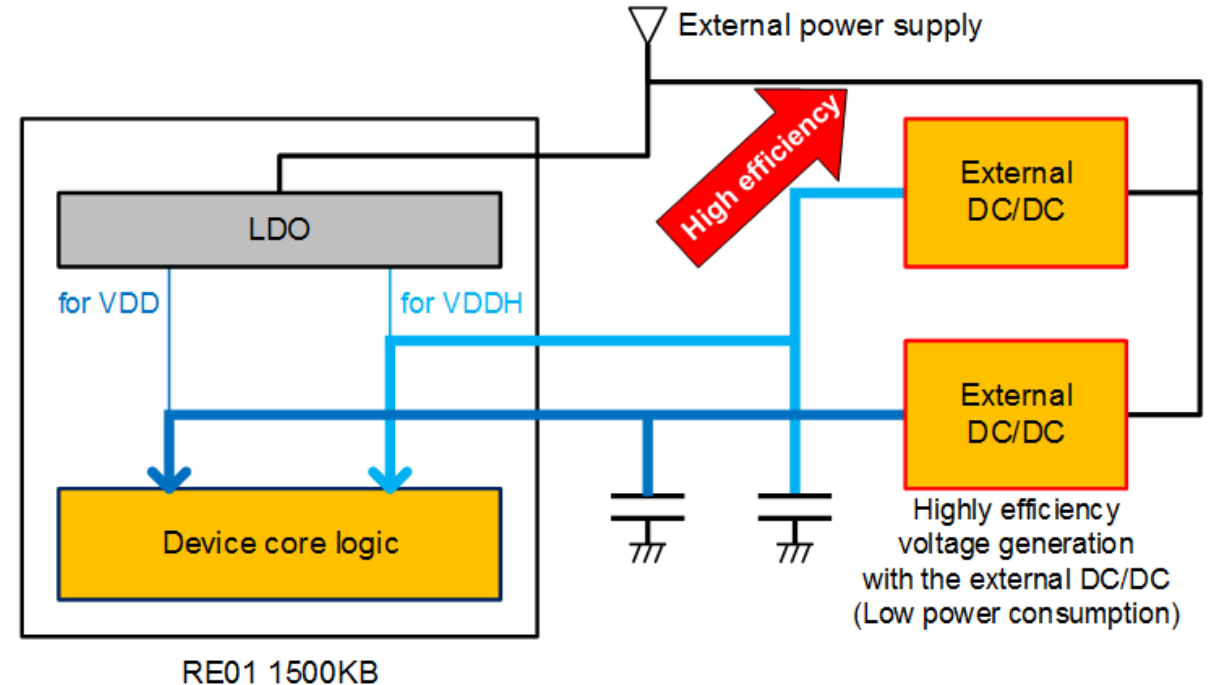
ISL9123 recommended

Using the internal LDO (Normal case)

Internal LDO Mode
RE01-256K   25 µA/MHz
RE01- 1.5M 35 µA/MHz

Controlled by LDO Cut register LDOCUT

Low power consumption by the external DC/DC
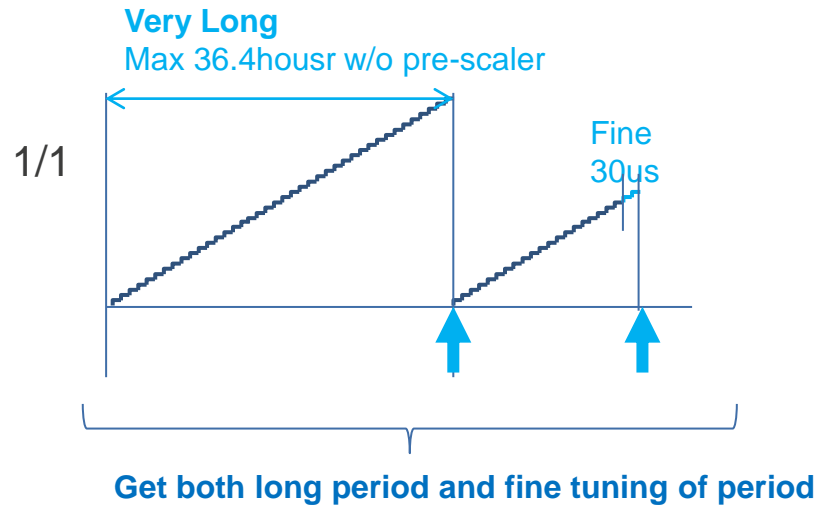
Internal LDO OFF, external DC-DC
RE01-256K   12 µA/MHz
RE01- 1.5M 15 µA/MHz

BIG IDEAS FOR EVERY SPACE   RENESAS

RE01 ASYNCHRONOUS 32 BIT TIMER (AGT-32)

AGTW x 2ch

32bit counter

32bit=4,294,967,296count

Very Long
Max 36.4housr w/o pre-scaler

1/1

Fine
30us

Get both long period and fine tuning of period

Ideal solution to applications that need to stay asleep for long periods of time with minimum power consumption such as IoT sensors
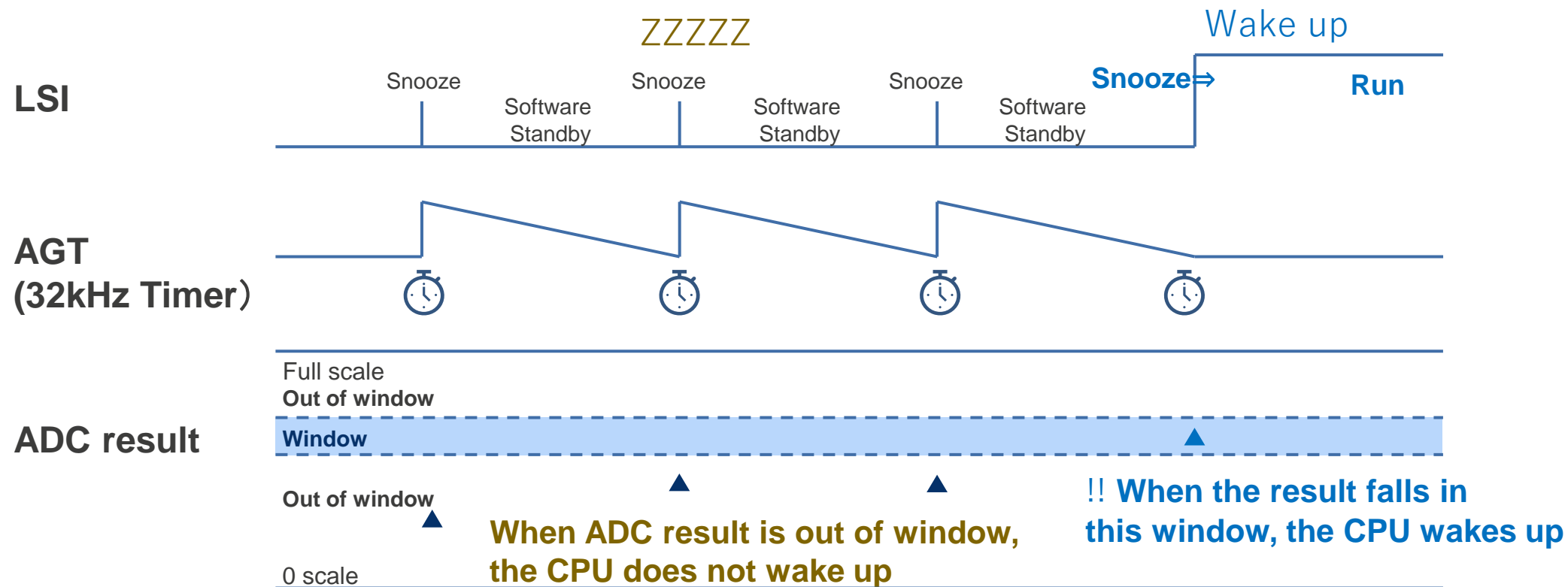
- **AGT -32 offers huge range of timeouts**
  - **Max Timeout 36.4 hrs, 30 uS resolution**
  - **Max timeout 194 days, 3.9 mS resolution**
  - **400 nA Icc SSTBY + 38 nA AGT-32 = 438 nA@ 1.8v**

Also available Ultra low power wake Up Timer WUPT, available in deep standby
100 nA (DSTBY)+ 100 nA (SOSC) + 30 nA = 230 nA@1.8v
Max timeout 36.4 hrs accurate to 30 uS resolution

RE01-256K only

BIG IDEAS FOR EVERY SPACE

RE01 LOW POWER SYSTEM - SNOOZE MODE

- **In intermitted operation, snooze mode enables to avoid unnecessary wake up which causes waste of power.**

ZZZZZ

Wake up

LSI

Snooze | Snooze | Snooze | **Snooze⇒** | **Run**

Software Standby | Software Standby | Software Standby

AGT (32kHz Timer)

ADC result

Full scale
Out of window

Window

Out of window

When ADC result is out of window, the CPU does not wake up

!! **When the result falls in this window, the CPU wakes up**

0 scale

BIG IDEAS FOR EVERY SPACE

RE01 SUPPLY VOLTAGE FLEXIBILITY

- Supports **independent digital and analog IO power domains** to support connection to external devices with different operating voltages
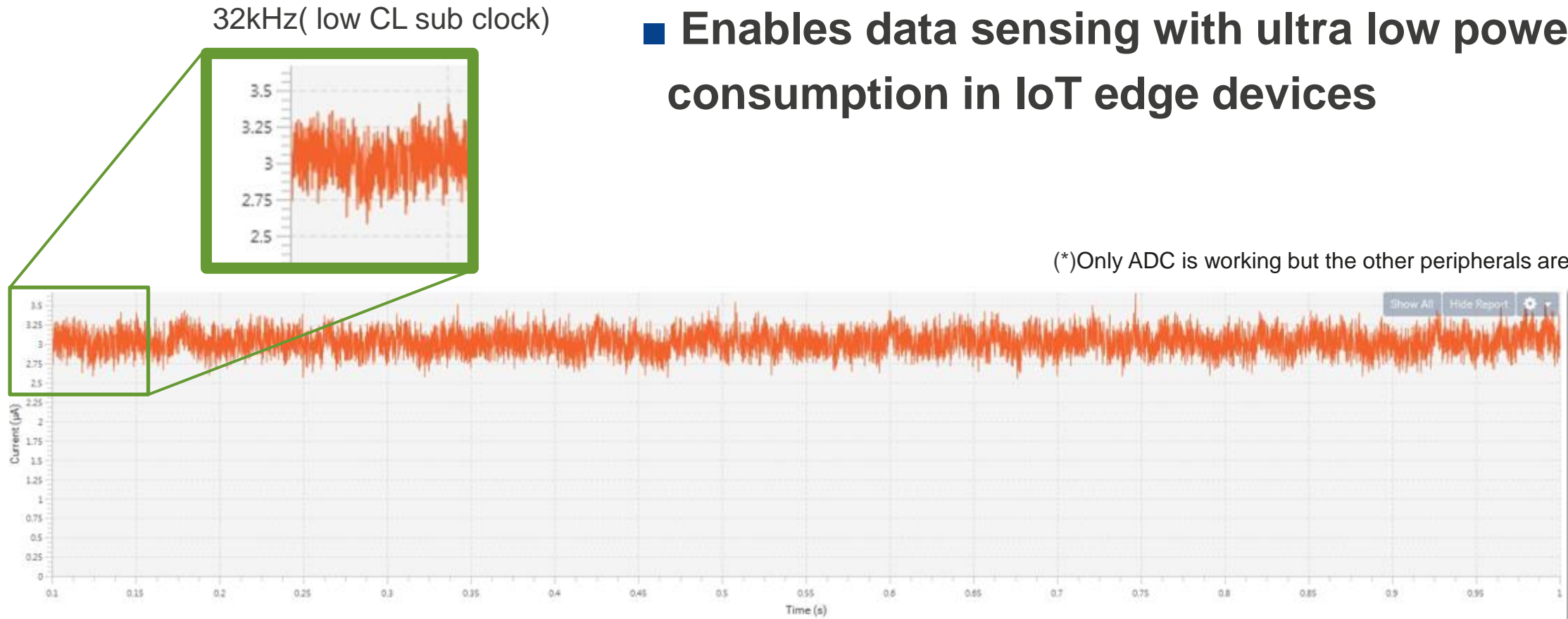- **No external level shifters** are needed
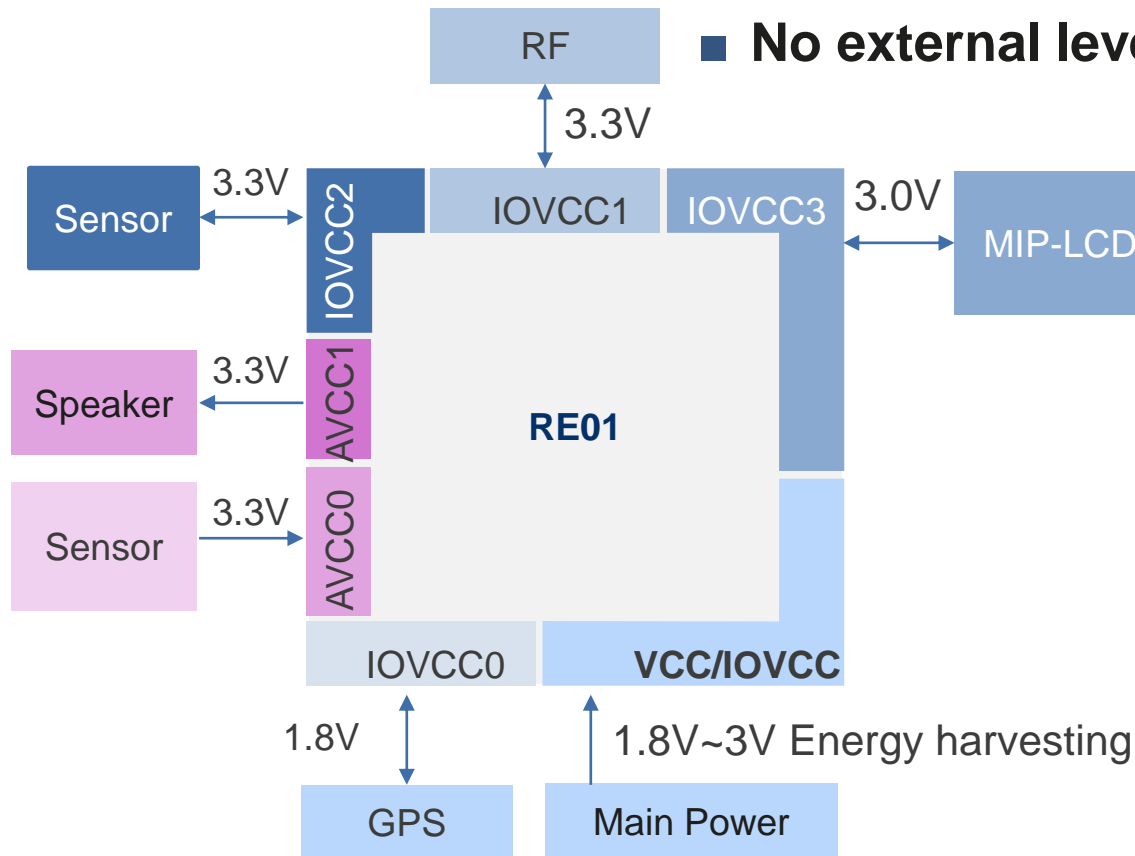
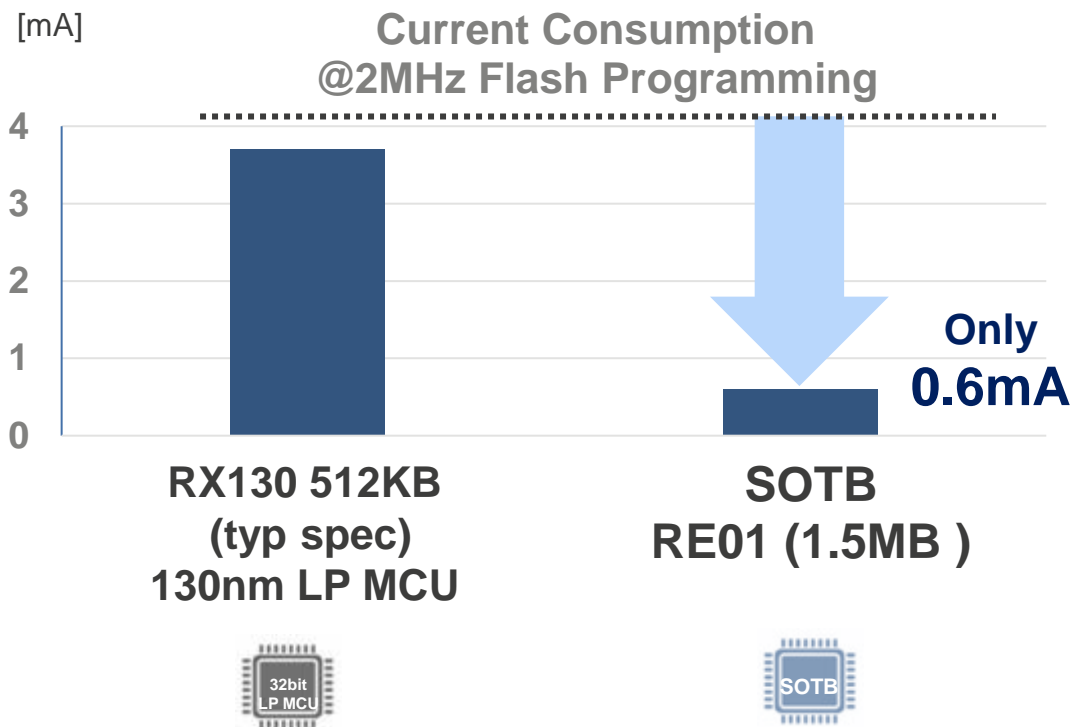| Item	Value	Unit
Power Supply voltage for System (VCC/IOVCC)	1.62 to 3.6V	System
Power Supply voltage for IO0 (IOVCC0)	1.62 to 3.6V	General I/O and SPI etc…
Power Supply voltage for IO1 (IOVCC1)	1.62 to 3.6V	General I/O and MIP etc…
Power Supply voltage for IO2 (IOVCC2)	1.62 to 3.6V	General I/O
Power Supply voltage for Analog-IP (AVCC0)	1.62 to 3.6V	14bADC,TSN,VREF
Power Supply voltage for Analog-IP (AVCC1)	1.62 to 3.6V	DAC, ACMP
Power Supply voltage for USB (USBVCC)	3.0 to 3.6V	USB transceiver

RE01 – 1.5 Mbyte

BIG IDEAS FOR EVERY SPACE

RE01 ULTRA LOW POWER, ALWAYS-ON SENSING

- **4µA（32kHz low CL) ***

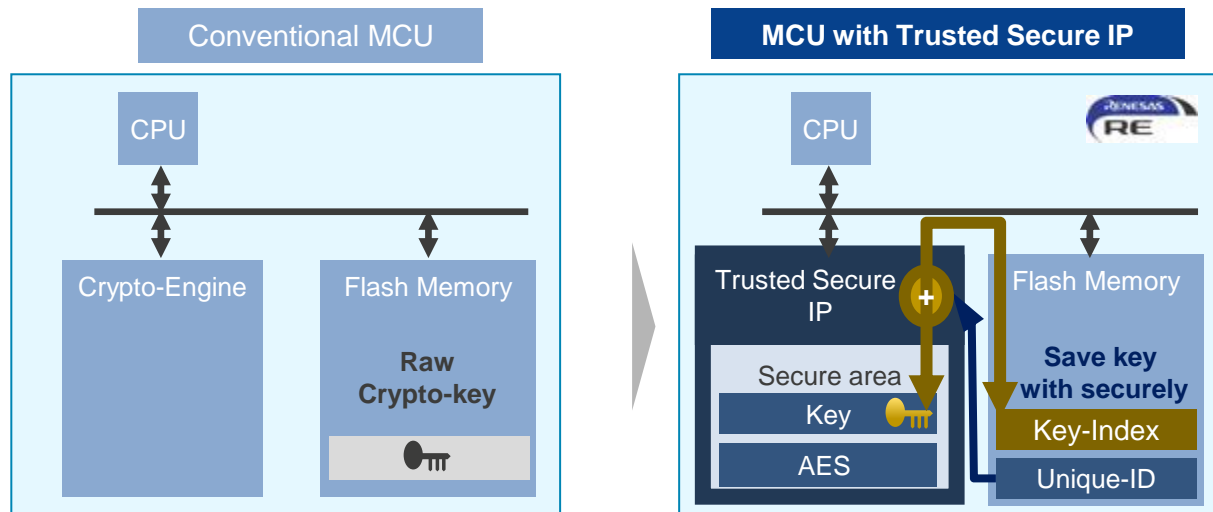- **Enables data sensing with ultra low power consumption in IoT edge devices**

32kHz(low CL sub clock)

(*)Only ADC is working but the other peripherals are stopped

BIG IDEAS FOR EVERY SPACE

RE01 ULTRA LOW POWER FLASH PROGRAMMING

Current Consumption
@2MHz Flash Programming

[mA]

RX130 512KB
(typ spec)
130nm LP MCU

SOTB
RE01 (1.5MB)

Only
0.6mA

- **Flash programing with only 0.6mA**

- **Reducing battery depletion concerns for Over-The-Air IoT FW updates**

BIG IDEAS FOR EVERY SPACE

RE01 SECURITY - TSIP （TRUSTED SECURE IP）

Conventional MCU

- CPU
- Crypto-Engine
- Flash Memory
  - **Raw Crypto-key**

MCU with Trusted Secure IP

- CPU
- Trusted Secure IP
  - Secure area
    - Key
    - AES
- Flash Memory
  - **Save key with securely**
    - Key-Index
    - Unique-ID

- Trusted Secure IP creates secure area inside the RE by monitoring and controlling unauthorized access. It secures the operation of the encryption engine and of any encryption keys.

- When storing the encryption key outside the TSIP, it is encrypted and scrambled with the unique ID to make it unusable outside one

Security features on RE01

| IP	function		details
TSIP	AES	Key length	128bit/256bit
		Hidden Root Key	Supported
		Modes	ECB, CBC, CTR, CMAC, CCM, GCM, XTS
	TRNG		128bit/256bit
	Unique-ID		Used to generate key index
	Access management		Prevent unauthorized access
Flash	Flash area protection		Used for secure-boot and secure-OTA to protect authentication program.
	Flash ID code protection		ID code protection for the flash programming from a host device

BIG IDEAS FOR EVERY SPACE

ENERGY HARVESTING CONTROLLER (EHC)

- Multiple power source & charge storage element management
- Autonomous & reliable startup sequence managing inrush current issues
- Overcharge prevention
- Charge detection
- Reverse current protection
- Quick start function
- Simultaneous charge mode for battery/secondary storage and temporary storage/capacitor
- Small start up current 5uA by active management of MCU blocks

BIG IDEAS FOR EVERY SPACE
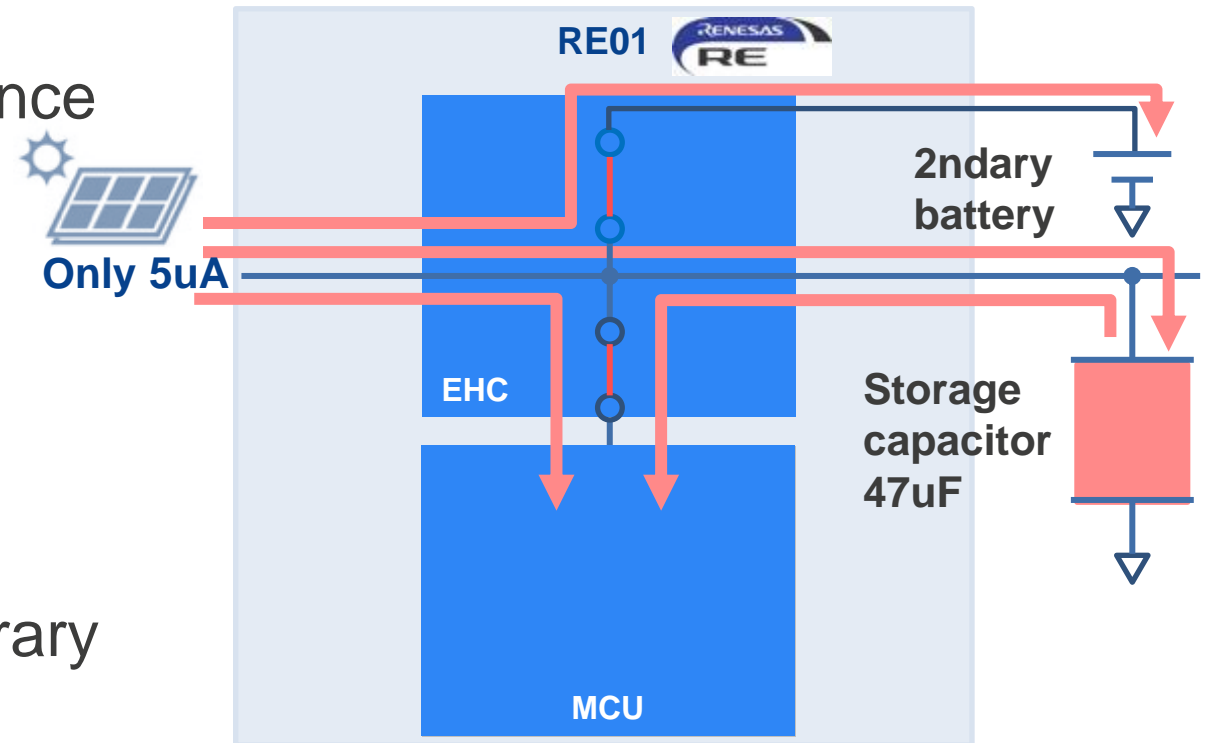
EVALUATION BOARD FOR RE01 GROUP
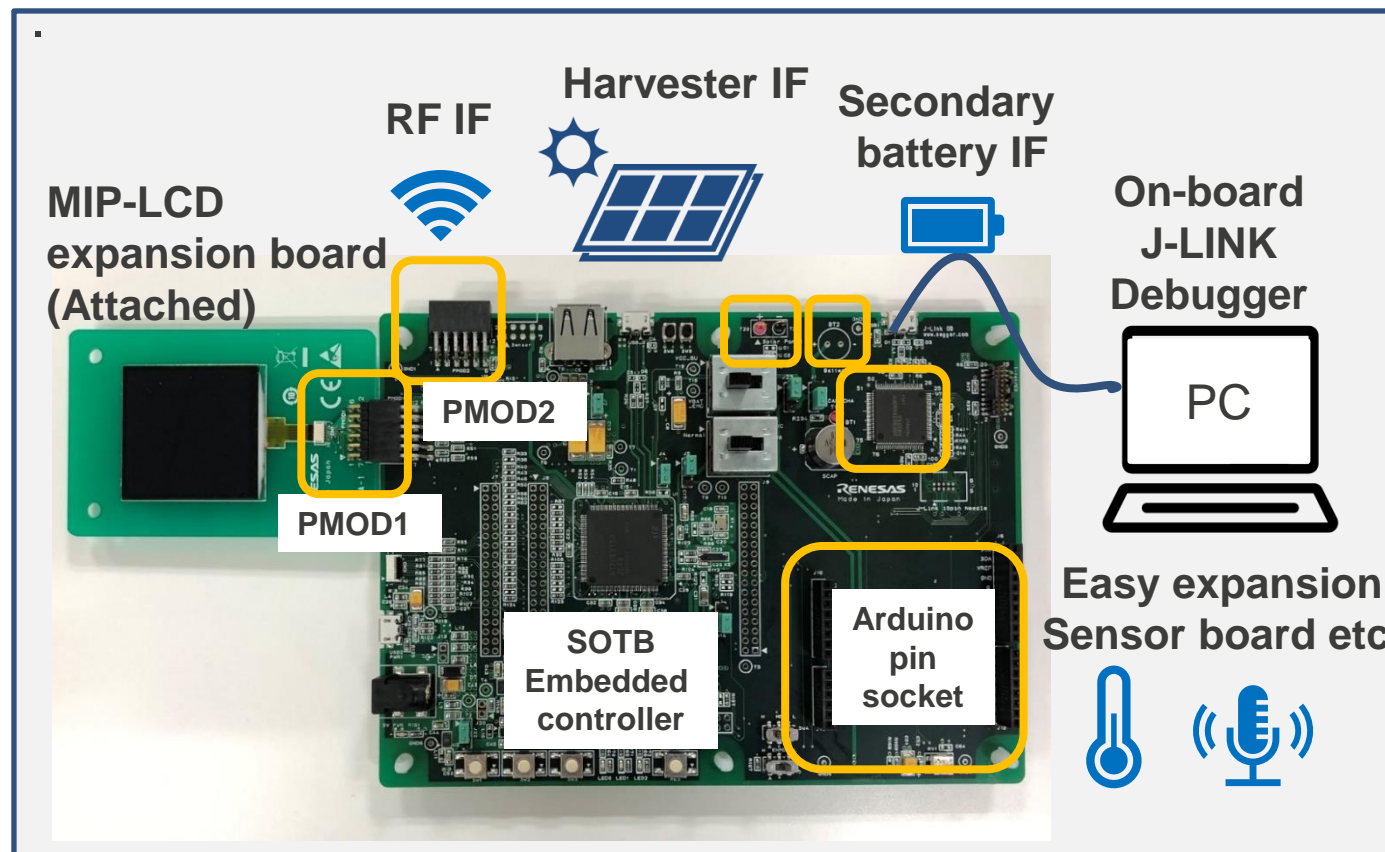
EVB specification

Items	Specification
MCU	R7F0E015D2CFB
Crystal oscillator	SOTB main : 32MHz SOTB sub : 32.768kHz
Debug I/F	USB for J-Link OB
Harvester I/F	Harvester I/F x1, Battery I/F x1
Arduino compatible I/F	2.54mm pitch: 10pin x 1, 8pin x 2 ,6pin x 1
USB serial I/F	Driver : USB I/F IC (Part No: FT230XQ)
PMOD connector	PMOD1 : SPI communication/ MIP-LCD expansion board PMOD2 : QSPI communication
On board memory	SPI serial flash : 64Mbit

Order Code : RTK70E015DS00000BE

INTEGRATED DEVELOPMENT ENVIRONMENT

- IAR is recommended. GCC will also be supported.

		IAR EWARM IAR C/C++ **IAR SYSTEMS**	Renesas e2 studio GCC ARM **e² studio**
IAR I-Jet		✔	NA
SEGGER J-Link		✔	✔
Renesas E2		NA	✔

BIG IDEAS FOR EVERY SPACE **RENESAS**

SUMMARY

- Renesas want to enable a new generation of low power applications using the unique low power SOTB process

- The RE enables a new generation of ultra low power applications reducing the size of batteries or increasing product lifetime

- The unique capabilities of the RE with both low active and standby currents as well as high performance at low voltages enable new types of low power applications

- Energy Harvesting applications become possible

- The 1.5 Mbyte RE01 is available now in mass production and samples of the 256K version are also available

Learn more at www.renesas.com/SOTB

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