RENESAS
BIG IDEAS FOR EVERY SPACE

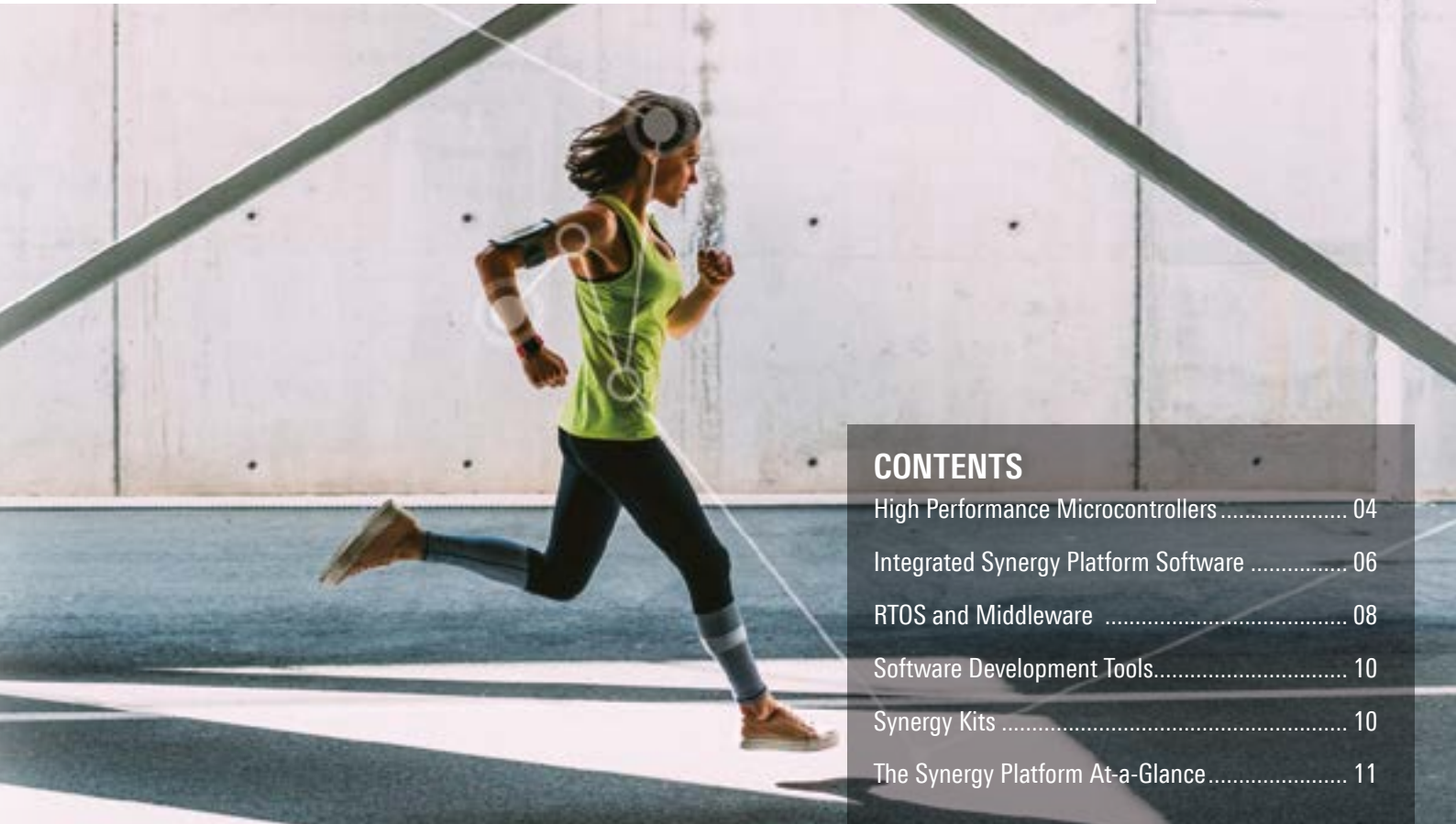# RENESAS SYNERGY™ PLATFORM

Integrated software, scalable MCUs, and comprehensive tools that make development faster and easier

**Renesas Synergy**™

# START AHEAD

**Get to market faster and easier with Renesas Synergy™.
As the first fully qualified MCU software and hardware platform,
we help you reach more people, sooner.**

## CONTENTS

## Accelerate Development

Let us take care of everything below the API so you can focus on differentiating your product.

## Reduce Total Cost of Ownership

Lower your costs from start to finish – technology, development, and maintenance are all included.

## Eliminate Barriers to Entry

Innovate without facing obstacles of upfront costs, complicated licensing, or starting from square one.

**renesas.com/synergy**

## What is the Renesas Synergy Platform?

The Renesas Synergy Platform is a complete, qualified system solution. It includes software, a scalable family of microcontrollers, and development tools.

With this comprehensive, proven platform, engineering teams can begin IoT application software development at the API level, saving them months of time and effort. It also ensures that their product innovations rest on a solid, robust technology foundation optimized for MCU-based product designs.
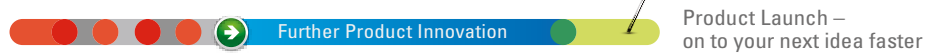
## Accelerate time to market.

Because the Synergy Platform's standardized API eliminates the need to wrestle with low-level middleware and network stacks, engineers can now focus on developing and implementing innovative, differentiated products and solutions.

**TRADITIONAL DESIGN PROCESS** – MONOTONOUS, REPETITIVE, AND TIME CONSUMING

| Hardware Design | Driver SW Design | Middleware Design | Integration w/RTOS | Cloud Connect | Application Code | System Test | Product Launch |
| --- | --- | --- | --- | --- | --- | --- | --- |

**THE RENESAS SYNERGY DESIGN CYCLE**

Further Product Innovation

Product Launch – on to your next idea faster

## RENESAS SYNERGY™ PLATFORM

### Solutions Gallery

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

### Hardware
- Kits
- Microcontrollers

Performance and capabilities for the highest quality embedded system products
# HIGH-PERFORMANCE MICROCONTROLLERS

The Renesas Synergy Platform includes four different series of upward software-, architecture-, and pin-compatible Synergy MCUs. The advanced S7 Series (High Performance), S5 Series (High Integration), S3 Series (High Efficiency), and S1 Series (Ultra Low Power) MCUs utilize the popular ARM® Cortex®-M CPU architecture. The devices implement easy connectivity, rock-solid security, dependable safety, and facilitate the creation of easy-to-use human-machine interfaces.

The high-performance 240 MHz S7 Series MCUs feature high-speed connectivity and industry-leading flash memory density.

**S7**

### KEY FEATURES

- Cortex-M4, 240 MHz, 2.7 V to 3.6 V, 75 µA/MHz
- 40-nm high-performance process
- Operating temperature range -40° C to 105° C
- USBHS, IEEE 1588 PTP Ethernet MAC, QSPI External Memory Bus
- 4 MB and 3 MB Flash, 640 KB SRAM, Memory Mirror Function, Memory Protection Unit
- 12-bit A/D, Programmable Gain Amplifier
- JPEG Codec, 2D Drawing Engine, WVGA (800x480) with 32-bit color
- Features to address functional safety requirements
- Industry-leading hardware acceleration for cryptography and HASH algorithms, true random number generator, 128 bit unique ID and more

The highly integrated 120 MHz S5 Series MCUs balance processing performance with large memory and an extensive array of built-in features.

**S5**

### KEY FEATURES

- Cortex-M4, 120 MHz, 2.7 V to 3.6 V, 117 µA/MHz
- 40-nm high-performance process
- Operating temperature range -40° C to 105° C
- Comprehensive and flexible connectivity including USBHS, Ethernet PTP, QSPI External Memory Bus, and more
- 2 MB Flash, 640 KB SRAM, Memory Mirror Function, Memory Protection Unit
- 12-bit A/D, Programmable Gain Amplifier
- JPEG Codec, 2D Drawing Engine, WVGA (800x480) with 32-bit color
- Features to address functional safety requirements
- Industry-leading, NIST-compliant security features: hardware acceleration for cryptography and HASH algorithms, true random number generator, secure key generation and storage, 128-bit unique ID, and more

High-efficiency 48 MHz S3 Series MCUs are low-power chips that integrate up to 1 MB of Flash and 192 KB of SRAM.

**S3**

### KEY FEATURES

- Cortex-M4, 48 MHz, 1.6 V to 5.5 V
- 130-nm low power process
- Operating temperature range -40° C to 105° C
- External Memory Bus
- 1 MB Flash, 192 KB SRAM, Memory Mirror Function, Memory Protection Unit
- 12-bit A/D, Programmable Gain Amplifier
- 28-channel 14-bit A/D
- Capacitive Touch Sensing Unit with Segment LCD Controller
- ECC and Parity Error Check in SRAM, ADC Diagnostics, CRC Calculator
- NIST-compliant security features: hardware acceleration for cryptography and HASH algorithms, true random number generator, secure key generation and storage, unique ID, and more
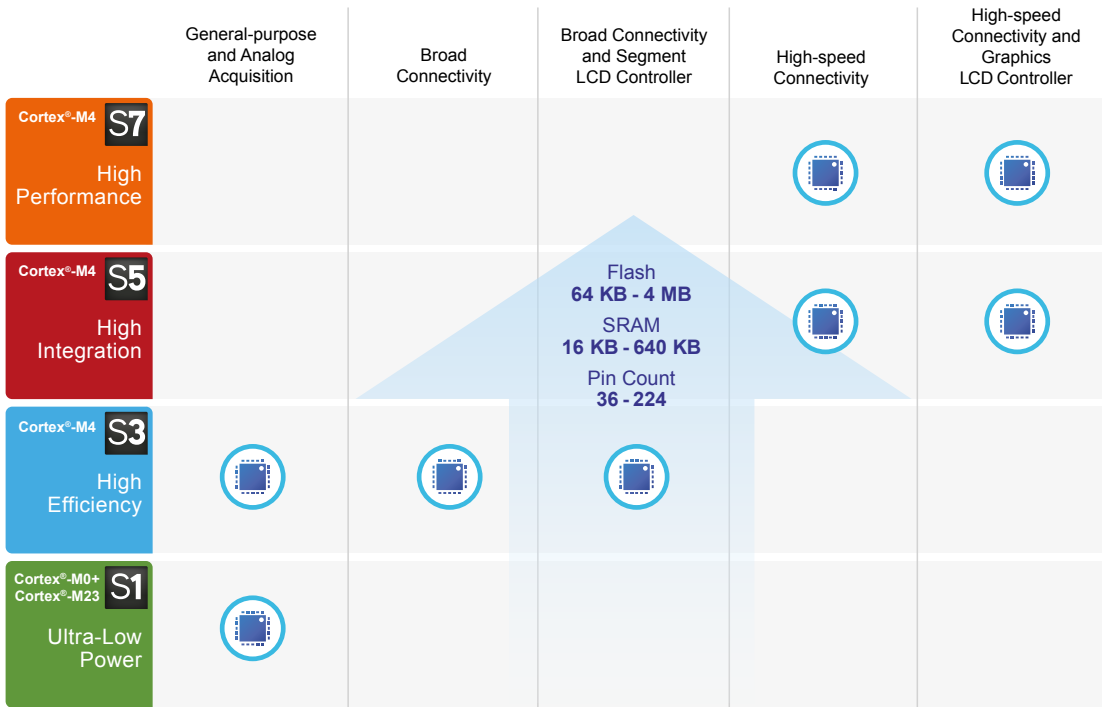
Ultra-low-power 32/48 MHz S1 Series MCUs operate down to 1.6 V and feature low-power operating modes and fast wake-up times.

**S1**

### KEY FEATURES

- Cortex-M0+, 32 MHz, 1.6 V to 5.5 V, 500 nA (Software Standby Mode), 130 µA/MHz
- Cortex-M23, 48 MHz, 1.6 V to 5.5 V
- Up to 16-bit SAR ADC
- 24-bit delta-sigma ADC
- 31-channel Capacitive Touch Sensing Unit
- USBFS, CAN
- Real-Time Clock
- SRAM Parity Error Check, ADC Diagnostics, CRC Calculator, Flash Area Protection
- NIST-compliant security features: hardware acceleration for cryptography, unique ID, and more
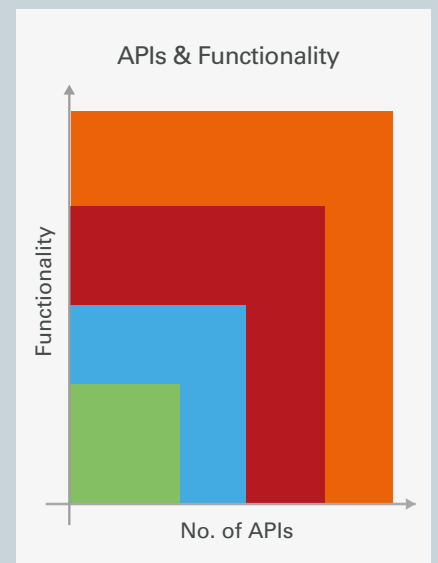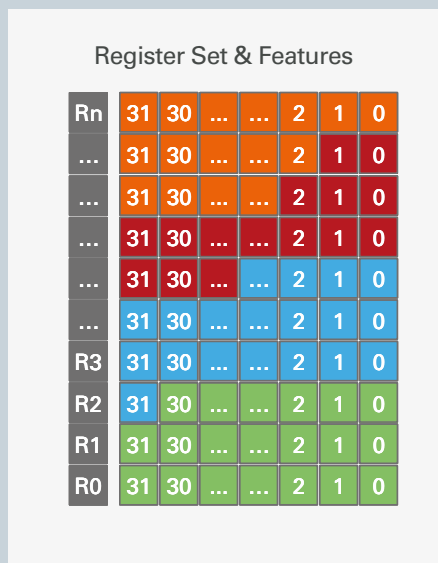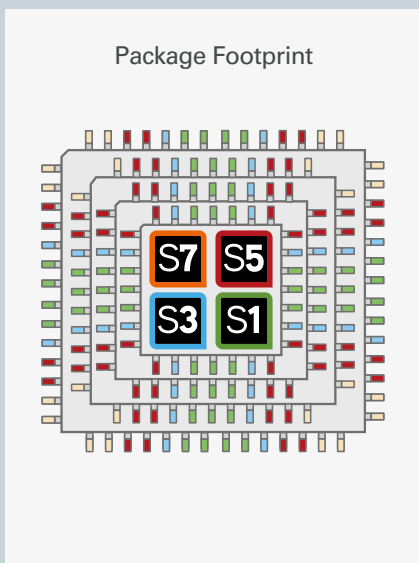
# Pin-Compatible and Scalable MCUs

| | General-purpose and Analog Acquisition | Broad Connectivity | Broad Connectivity and Segment LCD Controller | High-speed Connectivity | High-speed Connectivity and Graphics LCD Controller |
|---|---|---|---|---|---|
| **Cortex®-M4 S7** High Performance | | | | ● | ● |
| **Cortex®-M4 S5** High Integration | | | Flash **64 KB - 4 MB** SRAM **16 KB - 640 KB** Pin Count **36 - 224** | ● | ● |
| **Cortex®-M4 S3** High Efficiency | ● | ● | ● | | |
| **Cortex®-M0+ Cortex®-M23 S1** Ultra-Low Power | ● | | | | |

The capabilities provided by S7, S5, S3, and S1 Series MCUs readily handle a wide range of applications, from ultra-small mobile devices to calculation-intensive industrial systems, medical equipment, and more. The rigorously enforced compatibilities expand system design flexibility and help conserve development resources.

No matter the requirements of an IoT application, there is a Synergy MCU that can meet them.

Learn more at renesas.com/synergy/hardware

# Scalable MCUs Designed with Software in Mind.

## Package Footprint

S7  S5
S3  S1

## Register Set & Features

| Rn | 31 | 30 | ... | ... | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| ... | 31 | 30 | ... | ... | 2 | 1 | 0 |
| ... | 31 | 30 | ... | ... | 2 | 1 | 0 |
| ... | 31 | 30 | ... | ... | 2 | 1 | 0 |
| ... | 31 | 30 | ... | ... | 2 | 1 | 0 |
| ... | 31 | 30 | ... | ... | 2 | 1 | 0 |
| R3 | 31 | 30 | ... | ... | 2 | 1 | 0 |
| R2 | 31 | 30 | ... | ... | 2 | 1 | 0 |
| R1 | 31 | 30 | ... | ... | 2 | 1 | 0 |
| R0 | 31 | 30 | ... | ... | 2 | 1 | 0 |

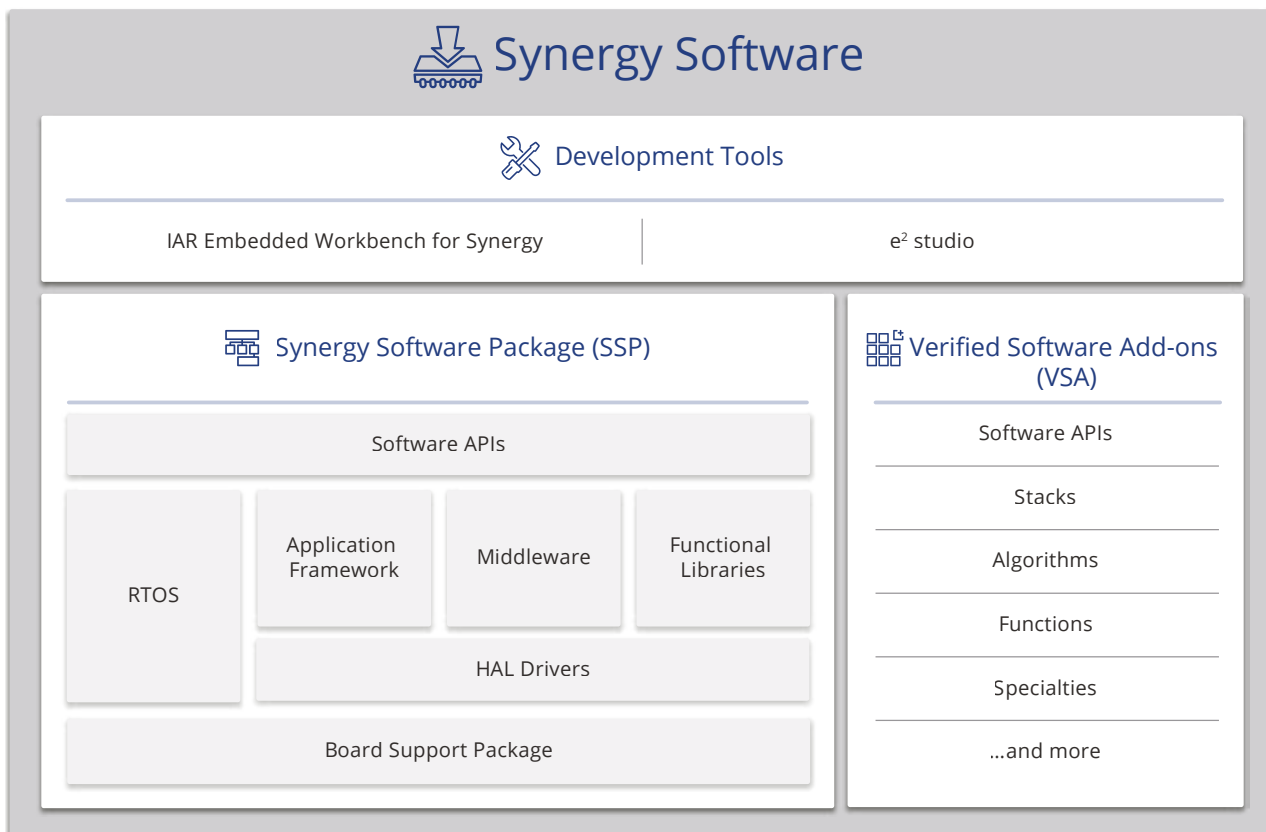## APIs & Functionality

Functionality

No. of APIs

Compatibilities are rigorously enforced for Synergy MCUs. This configuration discipline ensures the design flexibility needed to leverage engineering investments for diverse opportunities in local and global IoT markets.

Tested and Production Ready
# INTEGRATED SYNERGY PLATFORM SOFTWARE

Connected devices, especially for IoT, elevate the requirements for embedded systems software. Real-time operating systems (RTOS), network protocols, security, and power management are just a few examples. Synergy Software delivers solutions in three ways – your choice of professional Development Tools, the Synergy Software

Package (SSP), and Verified Software Add-ons. Full licensing, maintenance, support, and an unlimited number of seats of development tools and products that use the SSP are included. No royalties, no fees.

## Synergy Software

### Development Tools

| IAR Embedded Workbench for Synergy | e² studio |
|---|---|

### Synergy Software Package (SSP)

**Software APIs**

| RTOS | Application Framework | Middleware | Functional Libraries |
|---|---|---|---|

**HAL Drivers**

**Board Support Package**

### Verified Software Add-ons (VSA)

Software APIs

Stacks

Algorithms

Functions

Specialties

...and more

Learn more about Synergy Software, visit: renesas.com/synergy/software

# Synergy Software Package

Synergy Software Package (SSP) is a proven series of frameworks and standard APIs that tightly integrate a premium commercial RTOS, a suite of middleware, a variety of libraries, and low-level drivers to simplify complex functions you encounter while developing connected embedded systems.

A layered architecture enables you to write your application with the Application Frameworks using common APIs or by directly connecting to the MCU device driver level as needed. Renesas qualifies the SSP to operate per SSP datasheet specifications, and Renesas provides all SSP maintenance and support.

## Synergy Software Package (SSP)

### Application Programming Interface (API)

| ThreadX® RTOS | Application Framework | | Middleware | | | | Functional Libraries |
|---|---|---|---|---|---|---|---|

**ThreadX® RTOS**
- Fully Preemptive Scheduler
- Inter-process and Inter-thread Communication
- Memory Management
- Interrupt Management
- Execution Profiling
- Picokernel™ Architecture
- Event-Chaining™ Technology
- Preemption-Threshold™ Scheduling

**Application Framework**

| Audio | Wi-Fi |
|---|---|
| Console | BLE |
| JPEG | Cellular (NB-IOT, CAT1/3/M1) |
| Touch Panel | ADC |
| Capacitive Touch | Thread Monitor |
| Cryptographic | Power Profile |
| X-Ware Interface | External Interrupt |
| SPI, I2C, UART | Mass Storage (SDMMC, USB, QSPI, RAM) |

**Middleware**

**FileX™**
- FAT 12/16/32 Formats
- SDSC, SDHC, eMMC Support
- Simultaneous Media Support
- Fault tolerant, Journal-Based
- LevelX Flash Wear Leveling

**USBX™**
- Host Classes (Storage, CDC, HID, Hub)
- Host Stack
- Host Controller
- Device Classes (Storage, CDC, HID, UVC)
- Device Stack
- Device Controller
- Isochronous Transfer

**GUIX™**
- Run Time Library
- Image Processing
- Widget Library
- Event Processing
- Canvas Processing
- Rotation, Scaling
- Blend, Anti-alias
- SDSC, SDHC, eMMC Support

**NetX™ and NetX Duo™**

| FTP | SNTP |
|---|---|
| TFTP | NAT |
| Telnet | TCP |
| PPP | IPv4/v6 |
| SMTP | UDP |
| POP3 | ICMP |
| TLS | MQTT |
| DNS | ARP |
| DHCP | RARP |
| HTTP/1.1 | SNMP |
| HTTPS | BSD Socket Library |

**Functional Libraries**
- Encryption and Hashing Library
  - AES, RSA, ECC, SHA1/256, ARC4, 3TDES, MD5, TRNG
- CMSIS DSP Library
- Software Safety Library
- Signature Generation and Verification
- Wrapped Key Generation
- Key Installation
- Public Key Encryption
- Private Key Decryption

### Hardware Abstraction Layer (HAL) Drivers

| UART | SPI | ADC 12/14/16 | Code Flash | Data Flash | QSPI | SDHI | CRC |
|---|---|---|---|---|---|---|---|
| USBHS | I2C | Sigma Delta ADC | CAN | GPIO | RTC | JPEG Codec | PDC |
| USBFS | SSI | DAC 8 | Timer | Watchdog Timer | DMA Controller | AGT 16-BitTimer | GPT 32-BitTimer |
| Ethernet MAC Controller | Factory MCU Information | DAC 12 | Independent Watchdog Tmr | 2D Drawing Engine | Low Voltage Detection | Low Power Modes | Segment LCD Controller |
| Clock Management | Functional Safety | Data Tranfer Controller | Capacitive Touch Sensing Unit | Event Link Controller | Interrupt Control Unit | Security and Encryption | Graphics LCD Controller |
| Analog Comparators | OPAMP | | | | | | |

### Board Support Package (BSP)

# Software Quality Assurance

To ensure production readiness, Renesas developed the SSP according to the international standard ISO/IEC/IEEE 12207 that covers the entire Software Development Life Cycle. Every element of the SSP is defined by and tested to meet these requirements.

SSP quality is tracked and measured using combinations of unit, functional, integration, performance, regression, dynamic, and static analysis tests.

Developed and Optimized for the Synergy Platform
# RTOS AND MIDDLEWARE

## Optimized for size, performance, and ease of use on Synergy MCUs

The Synergy Platform integrates Express Logic's popular ThreadX® real-time operating system. This RTOS ensures reliable system operation, supports an API that allows portability across Synergy MCUs, and minimizes the length of system development cycles. ThreadX RTOS features an extremely fast, commercial multitasking real-time kernel with preemptive scheduling and a small memory footprint.

### Express Logic's ThreadX RTOS Features

- Small FLASH footprint
  - Less than 2 KB on Synergy processor families
- Small RAM requirements
  - Minimum of <1 KB for kernel RAM
- Fast Context Switch
  - 0.7 ms on Synergy S7G2 MCU Group
- Optimized for Synergy MCUs with stack bounds checking and Cortex®-M optimizations

- Intuitive API
- Multiple scheduling algorithms (Fully Preemptive, Round-Robin, Preemption-Threshold™)
- Real-time event trace
- Fully deterministic
- Certified by SGS-TUV Saar for use in safety-critical systems according to IEC-61508 SIL 4, IEC-62304 SW Safety Class C, ISO 26262 ASIL D and EN 50128

## TLS and MQTT for Secure, Efficient IoT Communication

SSP v1.3 and higher includes Transport Layer Security (TLS) that delivers security three ways: by establishing secret keys between the client and server, applying hashing algorithms to detect alteration or forgery of packet content, and authorizing remote host identity using digital certificates. TLS is used for sending confidential data such as personal and credit card information in a secure fashion.
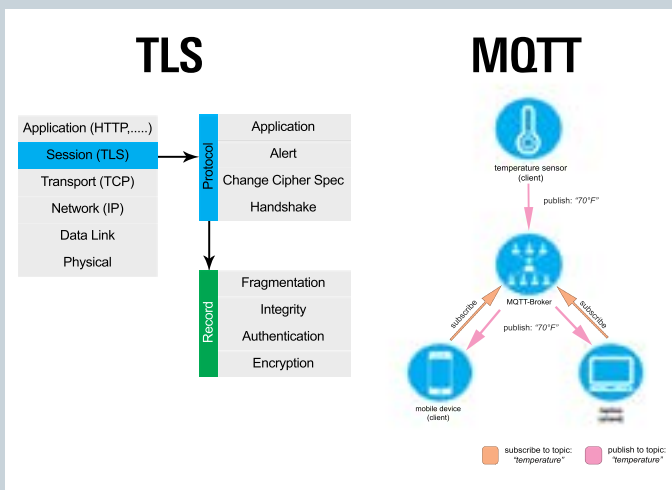


## Complete, Integrated IoT Connectivity Client

Quickly add secure device to cloud connectivity using SSP APIs

Supports secure connectivity with AWS, Azure, and Google Cloud platforms

**MQTT/HTTPS Client for Secure IoT**
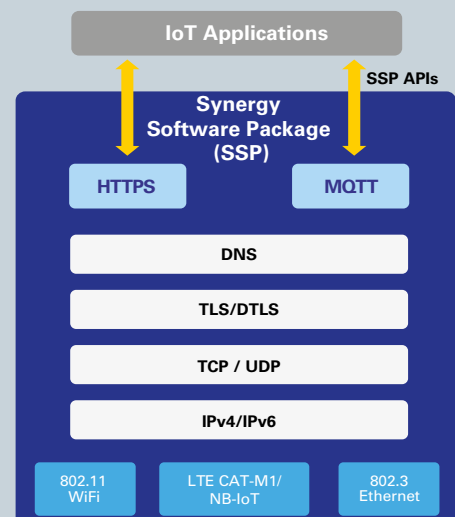
## Advanced Commercial-Grade Middleware and Network Stack Included

Synergy Software includes Express Logic's X-Ware™, a complete set of commercial-grade middleware products. The easy-to-use NetX™, NetX Secure, FileX®, USBX™, GUIX®, and TraceX® software products are all fully licensed, with no runtime royalties, and fully supported.

NetX Duo™, a streamlined TCP/IP stack, provides both IPv4 and IPv6 capabilities. Its unique Piconet™ architecture links into the final image only those services and protocols actually used by the application. NetX Duo achieves "Near Wire Speed" performance on the independent Iperf benchmark suite and has obtained IPv6 Ready Logo certification.

| | |
|---|---|
| **FileX®** | FAT compatible file system. Supports FAT12, FAT16, FAT32 and exFAT |
| **NetX™** | Embedded TCP/IP Network Stack |
| **NetX Secure** | Secure cloud connectivity protocols TLS, HTTPS, MQTT |
| **USBX™** | USB Host/Device Protocol Stack |
| **GUIX®** | Embedded GUI Development Framework |
| **TraceX®** | Real-Time, Graphical Event Trace/Analysis |
| **LevelX®** | Flash wear leveling support for internal and external memory |

### NetX Duo IPv4/IPv6 TCP/IP Networking

- Optimized IPv4/IPv6 Dual TCP/IP stack for embedded systems
- Small footprint, ThreadX-optimized performance
- "Near Wire Speed" on Iperf network throughput benchmark
- TCP, UDP, IP, ARP, RARP, IGMP, and ICMP core support
- TLS, HTTP/1.1, HTTPS, MQTT
- Network configuration protocols
- DHCP client/server (dynamic address allocation)
  - DHCPv6 (client only)
  - SNTP (network time protocol)
- Domain name services
  - DNS, mDNS, DNS-SD
  - DNSv6
  - NAT (private network extension)
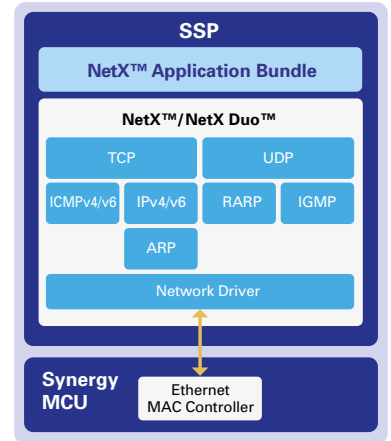


Streamlined TCP/IP stack in NetX Duo provides both IPv4 and IPv6 capabilities, easing the design of IoT products that utilize TCP/IP network communication.

## Conquer the Integration Gap with the Synergy Platform

A major benefit of the Synergy Software Package is that it eliminates the laborious R&D work associated with bridging the integration gap. This thoroughly engineered solution makes it unnecessary to write the critical code that unites stacks with I/O drivers, handles GUI frameworks with touch-screen drivers, and manages other system peripherals so IoT applications work predictably and reliably.
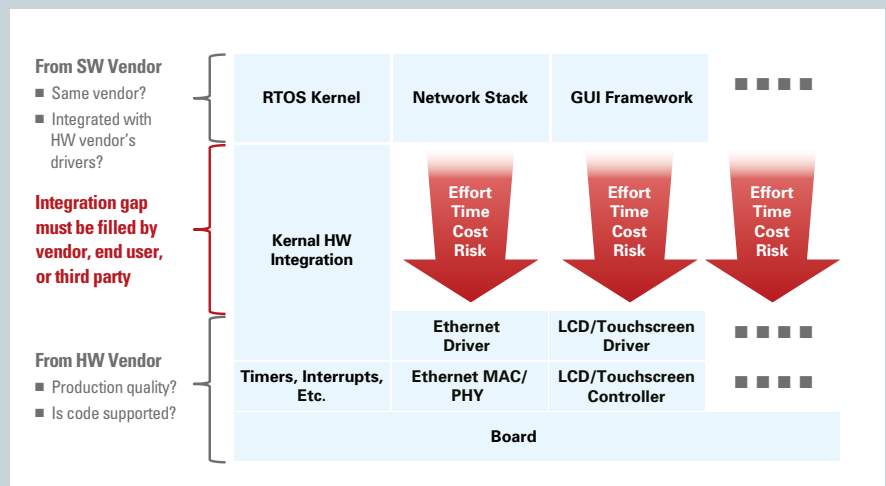
All included with the Synergy Platform

# SOFTWARE DEVELOPMENT TOOLS

Designed to accelerate time to market through rapid code development, Synergy Tools facilitate file management, software and MCU configuration, code generation, compilation, debugging, and intuitive graphic interface design.

All Synergy Tools, support, unlimited seats of development tools, and maintenance are included with the Synergy Platform in the price of a single Synergy MCU.

You can use any of these professional tools to develop software for your end-product.

- e$^2$ studio Integrated Development Environment (IDE) with choice of GCC or IAR C/C++ compilers and automatic code generation
- IAR Embedded Workbench® for Renesas Synergy™ IDE to generate fast performing, highly compact code
- TraceX® to visually monitor run-time performance
- GUIX Studio™ to enable drag-and-drop design of graphical user interfaces (GUI)

Learn more about Synergy Tools, visit: renesas.com/synergy/tools

# SYNERGY KITS

Select a Synergy Kit to evaluate the full Synergy Platform, access functionality of Synergy MCUs, and prototype rapidly.

Learn more about Synergy Kits, visit: renesas.com/synergy/kits
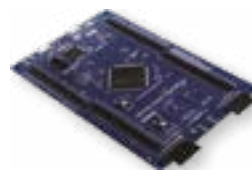
Target Board Kits          Starter Kit          Development Kits

## Powering an MCU

Renesas' digital and analog controllers, power modules and switching regulators provide a comprehensive set of solutions to power an MCU.
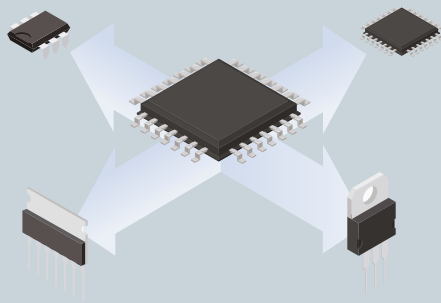
Learn more about Renesas power management ICs:
renesas.com/products/power-management

### Buck-Boost Converter
ISL9120, ISL91107, ISL91128
- Current Range: 400mA – 2.4A
- Low Iq ~ 20µA
- Input Voltage: 0.6V – 5.5V
- Output Voltage: 2.5V – 5.25V

### Buck Converters
ISL9103/A, ISL9107/A, ISL9307
- Current Range: 500mA – 1.5A
- Low Iq ~ 17µA
- Input Voltage: 2.7V – 6V
- Output Voltage: 0.8V - V$_{IN}$

### Boost Converters
ISL9111, ISL9113, ISL91133
- Current Range: 400mA – 2.3A
- Low Iq ~ 20µA
- Input Voltage: 0.6V – 5.4V
- Output Voltage: 2.5V – 5.25V

### Linear Regulators
ISL9007, ISL9021A, ISL9016
- Current Range: 150mA – 400mA
- Low Iq ~ 25µA
- Input Voltage: 1.5V – 6.5V
- Output Voltage: 0.9V – 3.3V

### Bi-Directional Buck-Boost Converter
ISL95338
- Current Range: <10A
- V$_{IN}$: 3.2V – 23.5V; V$_{OUT}$: 2.4V – 20V

### Battery Chargers
ISL6294, ISL9230, ISL9220
- Dual power source (USB & Wireless Charging + Power Path)
- Current Range: 300mA – 1.5A
- 30V Input Compliant

# THE SYNERGY PLATFORM AT-A-GLANCE

## Synergy Software Package (SSP)

- ThreadX® Real Time Operating System (RTOS)
- NetX™ and NetX Duo™ IPv4/IPv6 TCP/IP networking stack with protocols: DNS, AutoIP, DHCP, FTP HTTP/1.1, HTTPS, TLS, MQTT, SMTP, POP3, PPP, UDP, and more
- Phase-2 IPv6 Ready Logo certification
- USBX™ USB host/device/OTG stack
- GUIX™ graphical user interface framework with WYSIWYG GUIX™ Design Studio
- FileX® 12/16/32 FAT. exFAT-compatible file system
- LevelX® Flash Wear Leveling

- Standardized multi-layer API:
  - ThreadX®, NetX™, NetX Duo™, USBX™, GUIX™, FileX®
  - Functional Libraries including Security & Encryption, CMSIS DSP, and Captouch
  - Application Framework, Hardware Abstraction Layer (HAL), and Board Support Package (BSP)
- Rich Application Framework to encapsulate many common functions such as security services, audio playback, power management, network messaging, JPEG conversion, and more
- Security & Encryption Library for Symmetric and Asymmetric crypto functions, HASH algorithms, secure key generation, storage, and more

## Synergy Microcontrollers

| S7 Series High Performance | S5 Series High Integration | S3 Series High Efficiency | S1 Series Ultra Low Power |
|---|---|---|---|
| • 240 MHz ARM® Cortex®-M4 CPU w/FPU<br>• Up to 4 MB Code Flash<br>• Up to 640 KB SRAM<br>• Dual Ethernet MAC Controller w/PTP<br>• USBHS and USBFS<br>• CAN, SSI, QSPI, and SDHI<br>• Graphics LCD Controller w/2D Drawing Engine<br>• Capacitive Touch Sensing Unit<br>• TRNG, Symmetric and Asymmetric Crypto, HASH<br>• Integral Safety | • 120 MHz ARM® Cortex®-M4 CPU w/FPU<br>• Up to 2 MB Code Flash<br>• Up to 640 KB SRAM<br>• Ethernet MAC Controller w/PTP<br>• USBHS and USBFS<br>• CAN, SSI, QSPI, and SDHI<br>• Graphics LCD Controller w/2D Drawing Engine<br>• Capacitive Touch Sensing Unit<br>• TRNG, Symmetric and Asymmetric Crypto, HASH<br>• Integral Safety | • 48 MHz ARM® Cortex®-M4 CPU w/FPU<br>• Up to 1 MB Code Flash<br>• Up to 192 KB SRAM<br>• USBFS<br>• CAN, SSI, QSPI, and SDHI<br>• 14-bit A/D Converter and 12-bit D/A Converter<br>• OPAMP<br>• High-Speed and Low-Power Analog Comparators<br>• Capacitive Touch Sensing Unit<br>• TRNG, Crypto, HASH<br>• Integral Safety | • 32 MHz ARM® Cortex®-M0+ CPU<br>• 48 MHz ARM® Cortex®-M23 CPU<br>• Up to 256 KB Code Flash<br>• Up to 32 KB SRAM<br>• USBFS<br>• CAN<br>• Up to 16-bit SAR A/D Converter, 24-bit SD A/D Converter, 12-bit D/A Converter<br>• Low-Power Analog Comparator<br>• Capacitive Touch Sensing Unit<br>• TRNG and AES<br>• Integral Safety |

## Synergy Tools & Kits

**IAR Embedded Workbench for Renesas Synergy**
- IAR C/C++ compiler for ARM® C compiler
- C-SPY® debugger
- C-STAT® and C-RUN® code analytics tools
- Support for IAR I-jet™ with power consumption analysis

**e² studio, an Integrated Solution Development Environment (ISDE)**
- GNU ARM® C/C++ compiler (IAR ARM® compiler option)
- Smart Manual —Context-aware embedded documentation

**Common to IAR Embedded Workbench for Synergy and e² studio**
- Project Generator to generate start-up code
- Pin, Clock, and Interrupt Configurator to generate start-up code
- GUIX™ Studio — Desktop graphical user interface design tool

- Segger J-Link debugger
- RTOS-aware debugging via J-Link® JTAG and Single Wire Debug (SWD)
- TraceX® real time task monitoring for ThreadX®

**Kits**
- Starter Kits (SK) for low-cost introduction to using the entire Synergy Platform, with access to most Synergy MCU features and pins
- Development Kits (DK) for full project development. Modular access to all Synergy MCU features and pins
- Target Board Kits (TB) allow easy access to all MCU pins for prototyping

## Synergy Solutions

**Product Example Kits (PE)**
- Human Machine Interface with brilliant color TFT-LCD and wired/wireless connectivity
- Industrial data logger with precision analog and wireless

**Application Example Kits (AE)**
- Capacitive touch evaluation modules
- Cloud connectivity reference using either Ethernet, Wi-Fi or cellular connectivity

## Solution Gallery

- One stop hub to download tools, software, application projects, and more
- Get documentation, application notes, and working projects for all Synergy devices

**renesas.com/synergy**

# RENESAS

## BIG IDEAS FOR EVERY SPACE

## SALES OFFICES

Refer to "http://www.renesas.com/" for the latest and detailed information.

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