RZ/A1LU Group

Stream it! - RZ MJPEG Streaming Demonstration

Introduction

This application note describes how to configure the Stream it! - RZ kit (hardware) and install the tools to run the Oryx MJPEG Streaming demo supplied as part of the Stream it! - RZ kit.

The hardware needed to follow this application note includes:

- Windows™ 7/ 8/ 8.1/10 compatible PC
- Stream it! - RZ V2 kit including display
- USB to micro USB Cable
- Segger J-Link Lite Debugger

The software components that will be obtained while following this application note include:

- e² studio (Recommended latest version)
- GNU ARM NONE Embedded Compiler (Version 16.01)

> This document refers to many third party website resources. These websites are not controlled by Renesas Electronics, and we are therefore unable to offer support for these resources.

The following documents apply to the RZ/A1LU based Renesas Stream it! - RZ. Please refer to the latest versions of these documents.

Document Type	Description	Document Title	Available from
Hardware Manual	Provides technical details of the RZ/A1LU microcontroller.	RZ/A1LU Group User's Manual: Hardware	https://www.renesas.com/en-eu/products/microcontrollers-microprocessors/rz/rza/rza1lu.html

Target Device

RZ/A1LU Group

Glossary

ARM	Advanced RISC Machine
COM	Communication port
DHCP	Dynamic Host Configuration Protocol
FIQ	Fast Interrupt Request
FPS	Frames Per Second
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
IP	Internet Protocol
IPV4	Internet Protocol Version 4
IRQ	Interrupt Request
JTAG	Joint Test Action Group
JPEG	Joint Photographic Experts Group
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MJPEG	Motion JPEG
PC	Personal Computer
QSPI	Quad Serial Peripheral Interface
QVGA	Quarter VGA (resolution 320 x 240 pixels)
RAM	Random Access Memory
RISC	Reduced Instruction Set Computing
ROM	Read Only Memory
RTOS	Real Time Operating System
SPI	Serial Peripheral Interface
TCP/IP	Transmission Control Protocol / Internet Protocol
USB	Universal Serial Bus
VGA	Video Graphics Array (resolution 640 x 480 pixels)

Contents

1. Overview

This document aims to guide the user through opening, configuring and running the MJPEG Streaming demonstration for the Stream it! - RZ V2 product.

The figure below shows the final configuration of the Stream it! - RZ hardware setup.

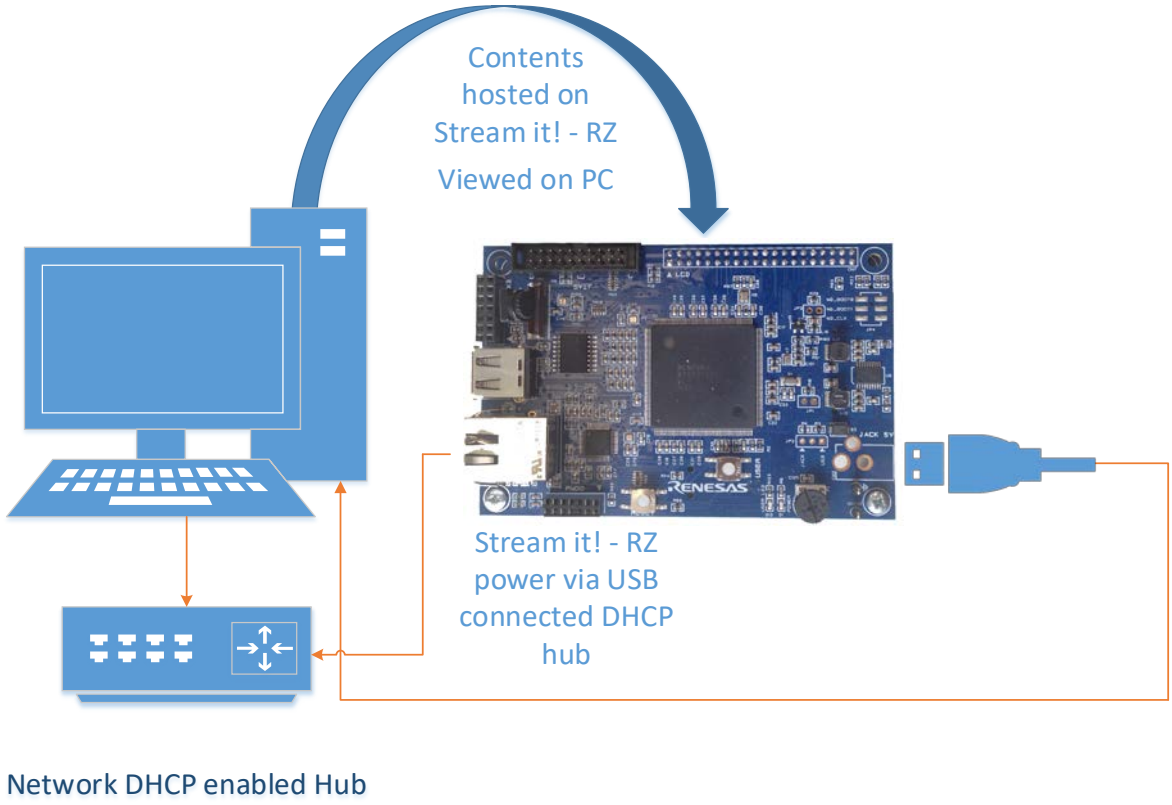


Figure 1 Hardware configuration of the Stream it! - RZ

Connections explained

- The PC is connected to a DHCP enabled wired network hub, to which the Stream it! - RZ is also connected.
- The Stream it! - RZ kit is assembled with the LCD screen connected to the connector fitted on the underside of the board near the top right hand side of the PCB (labelled ‘CN7’ and ‘LCD’).
- The Stream it! - RZ kit is powered via USB.

1.1 Licenses

This sample application includes several third party code applications, each of these includes a licence allowing various use cases for the provided code. A summary of the licences can be found below.

Component	Licence	Restrictions
Oryx	GNU GPL V2 or Later	Reciprocal disclosure requirement for all source code.
FreeRTOS	GNU GPL V2 (Modified with FreeRTOS Exception)	Modification allows use of FreeRTOS code in a product without disclosure of independent source code.

1.2 Oryx Streaming Media

Oryx Embedded SARL: http://www.oryx-embedded.com have provided this demonstration of the web streaming capabilities of the RZ/A1LU on the Stream it! - RZ product.

A network interface is started providing a simple web server interface that provides access to the web site hosted on the Stream it! - RZ.

1.3 FreeRTOS

Real Time Engineers Ltd: http://www.freertos.org/RTOS.html have provided the embedded operating system (OS) for this demonstration code.

2. Runtime Operation

This section details the Stream it! - RZ MJPEG streaming application. Specifically preparation for use, and how to interact with the demonstration application.

2.1 Preparing Demonstration for Use

This demonstration uses software and tools provided in the Stream it! - RZ kit please ensure that product DVD media (D015524_25) supplied in this kit is available.

2.1.1. Hardware Setup

- Connect your JLink Lite debugger to the connector (marked ‘JTAG’ and ‘CN1’) on the Stream it! - RZ board
- Connect the USB cable between your PC and the JLink debugger
- Connect an ethernet cable from your network hub, to the RJ45 socket (marked ‘CN6’) on the Stream it! - RZ board
- Connect a USB cable between your PC and the Stream it! - RZ board. If the Stream it! - RZ is connected via USB to a PC, then emulation of a serial (COM) port for debug is provided. Please refer to section (2.1.4) for instruction on how to configure this serial connection.
- Apply power to the USB port (marked ‘CN10’ - next to the SD card socket) or press the reset switch (located above the ‘A’ of the Renesas logo on the board and marked ‘RESET’) to reset the device.

2.1.2. Downloading the application

Please note that a previous application may be installed on the Stream it! - RZ hardware, so we must now install the application we wish to evaluate.

To update the application on the Stream it! - RZ board you must have installed the JLink debugger software.

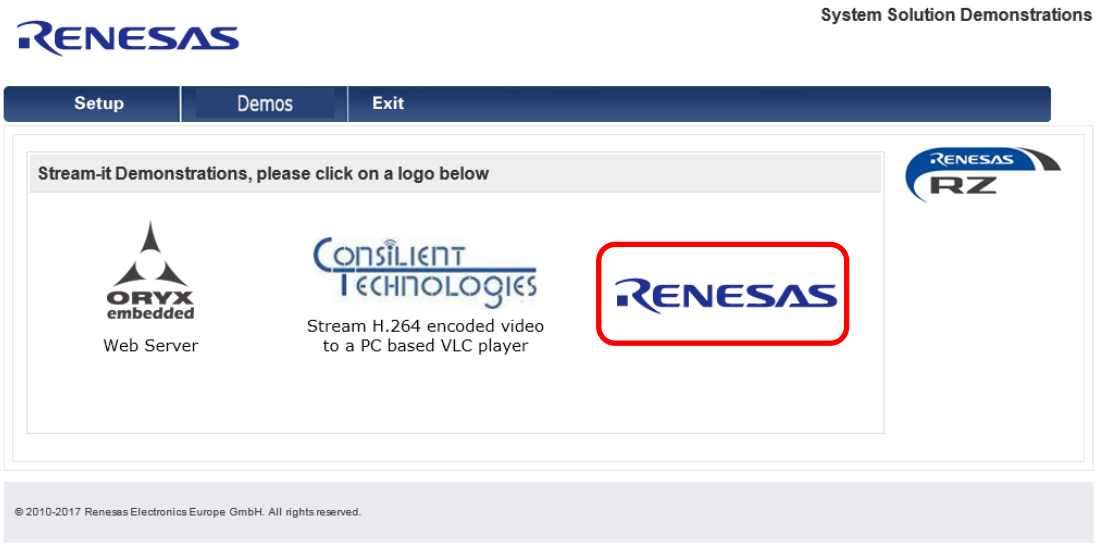
To use this batch file you must have the Segger Jlink drivers installed on your PC.

The Segger home page is www.segger.com and the version of the drivers that were used during development of this application and therefore are guaranteed to operate correctly is JLink_V6.12J

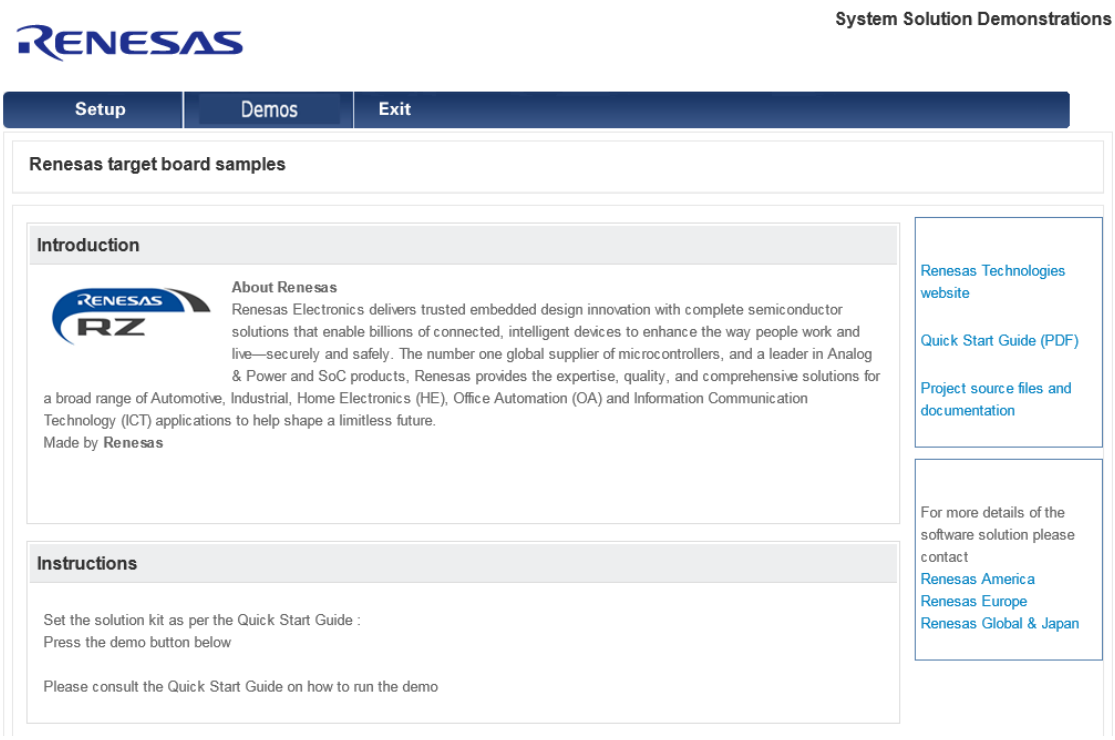
- Insert the product DVD media (D015524_25) supplied in this kit, or if the .ISO has been downloaded from the website, mount the image.

If the menu does not appear automatically in your browser, click on ‘setup.hta’.

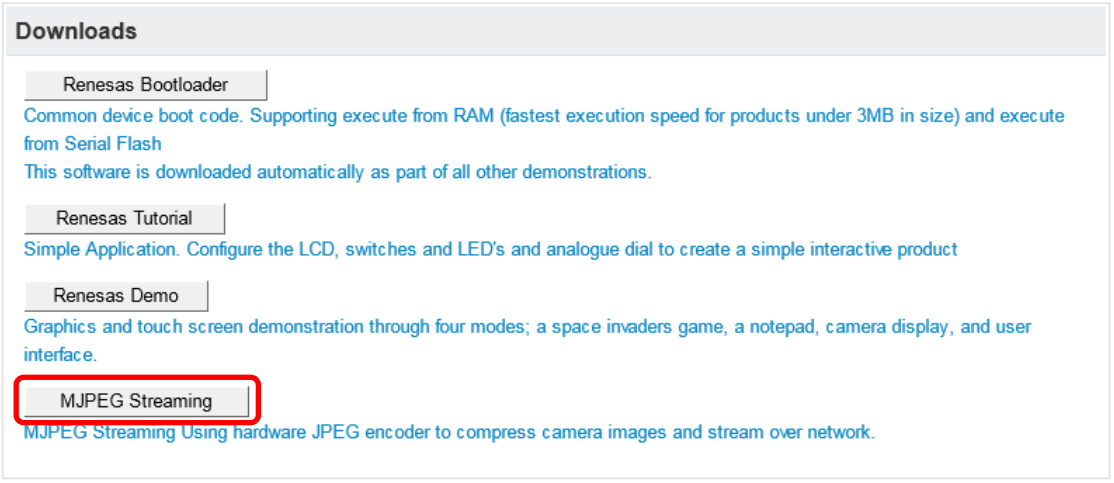
- Using the setup page (see above) click on ‘Demos’ in the menu bar



- Select the ‘Renesas’ demonstration and the details page will be displayed



- Scroll to the bottom of the page to see the downloads section



- Click on the ‘MJPEG Streaming’ download and this action shall invoke the device programmer batch file located in the media.
- This batch file will program your board with the binary file ‘StreamIt2_MJPEG_Streaming.bin’ located in the same folder.

  When programming is complete, the Stream it! - RZ board will restart and within a few seconds your application will be running.

2.1.3. Interaction with the application

Visually inspect the Stream it! - RZ board to confirm the following:

- The Green LED (D1, marked ‘POWER’) located near the potentiometer of the target board is illuminated
- The Red LED (D13, marked ‘USER LED’) located next to the green LED, will be flashing

- The serial console log (if connected see 2.1.4) displays a similar sequence to the one shown in section 2.1.7

2.1.4. Software Connections Debug Serial

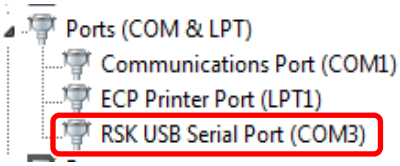
A debug console is provided via the power USB connector which is attached to this board.

When the board is powered by a PC then a virtual serial port is provided on the PC.

Using available Terminal Emulation software a connection can be made to this port allowing interaction with the Stream it! - RZ console.

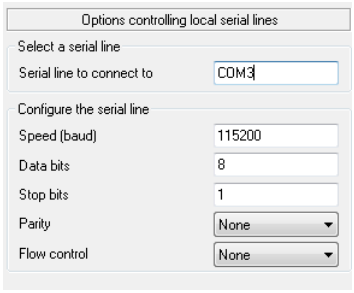
To find the COM port to use, in Windows™ go to the Device Manager dialog box (hold down the 'Windows' button and press break. Then select 'Device Manager' at the top left). Expand 'Ports (COM & LPT)' to find the COM port that the system has allocated for the virtual serial port.

It will be named 'RSK USB Serial Port' and in this case has been allocated COM3.



The connection settings should be as follows:

Baud Rate	115200
Data Rate	8-bit
Parity	None
Stop Bit	1
Flow Control	None

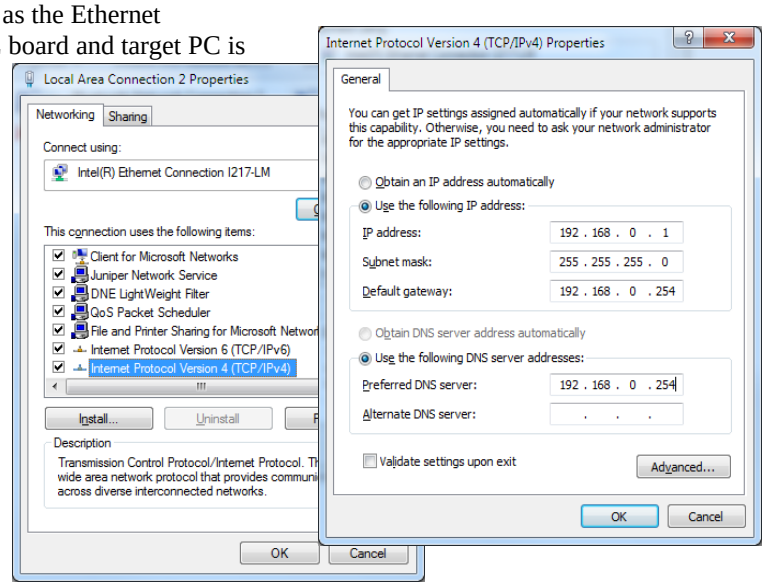


2.1.5. Software Connections Wired Ethernet DHCP Connection

- Simply connect your PC and Stream it! - RZ board, to the same DHCP using Ethernet cables
- The LCD display can remain connected to the Stream it! - RZ board, but it will not be used in this demonstration
- No additional software configuration is needed

2.1.6. Software Connections Wired Ethernet Fixed Ethernet Connection

- To specify a fixed IP in the demonstrations.
- An Ethernet hub can be used as long as the Ethernet connectivity between Stream it! - RZ board and target PC is specified.



Setting PC Fixed Ethernet address:

- Disconnect your PC from the network
- Open your network properties
- Select IPV4 properties.

  Make a note of the currently configured fixed IP settings. If you change them, you will need to return them to the original settings when you have finished.

- Set a unique IP address on the same domain as the Stream it! - RZ kit.

  The Stream it! - RZ board uses the following default IP address when DHCP is not available in a wired configuration (192.168.0.161) which is set in the code.

- Press OK and re-connect the PC to the Ethernet switch
- Reset the Stream it! - RZ kit

The IPV4 Address (192.168.0.161) will be used as the host address for the web server.

Note

Source code reference for default I.P. address (`\StreamIt2_MJPEG_Streaming\src\renesas\configuration\config.h line 53`).

2.1.7. Determining host address of Stream it! - RZ

- When DHCP is in use the IP address will be automatically assigned to the Stream it! - RZ kit and this address will be sent to the debug console log
- Connect a terminal to view the console output from the Stream it! - RZ kit (see 2.1.4)
- Reset the board and examine the console output using your terminal program it should look similar to this:-

```
************************************
*** CycloneTCP Web Streaming Demo ***
************************************
Copyright: 2010-2015 Oryx Embedded SARL
Website: http://www.oryx-embedded.com
Contact: info@oryx-embedded.com
TCP/IP Stack Version: 1.6.1
Compiled: Mar  6 2017 14:51:28
Target: Stream It! RZ Renesas Kit (RZ/A1L)

Detected OV7740 camera
```

```
Initialising EEPROM ...
Loading user settings...
Web Streaming Demo
cli_task starting
Initializing DHCP client...
End of NetworkSetup
Starting DHCP client...

DHCP configuration:
  Lease Start Time = 3s 406ms
  Lease Time = 86400s
  T1 = 43200s
  T2 = 75600s
  IPv4 Address = 192.168.2.110
  Subnet Mask = 255.255.255.0
  Default Gateway = 192.168.2.1
  DNS Server 1 = 192.168.0.1
  DNS Server 2 = 0.0.0.0
  MTU = 1500
```

- The IPV4 Address (192.168.2.110) has been assigned to the Stream it! - RZ
- You are now ready to interact with the sample application

2.2 Using the Demonstration

Now that your environment is configured and your Stream it! - RZ board is programmed with the code you can now evaluate the application.

With the application running and output logged to a console application, open a browser (Firefox or Chrome – Internet Explorer is not supported). Copy the IPv4 address from the console to the browser's address bar (192.168.2.110 from the console log above, but yours will likely show a different address).

The browser should then retrieve the web page from the Stream it! - RZ board and render the display as shown below:

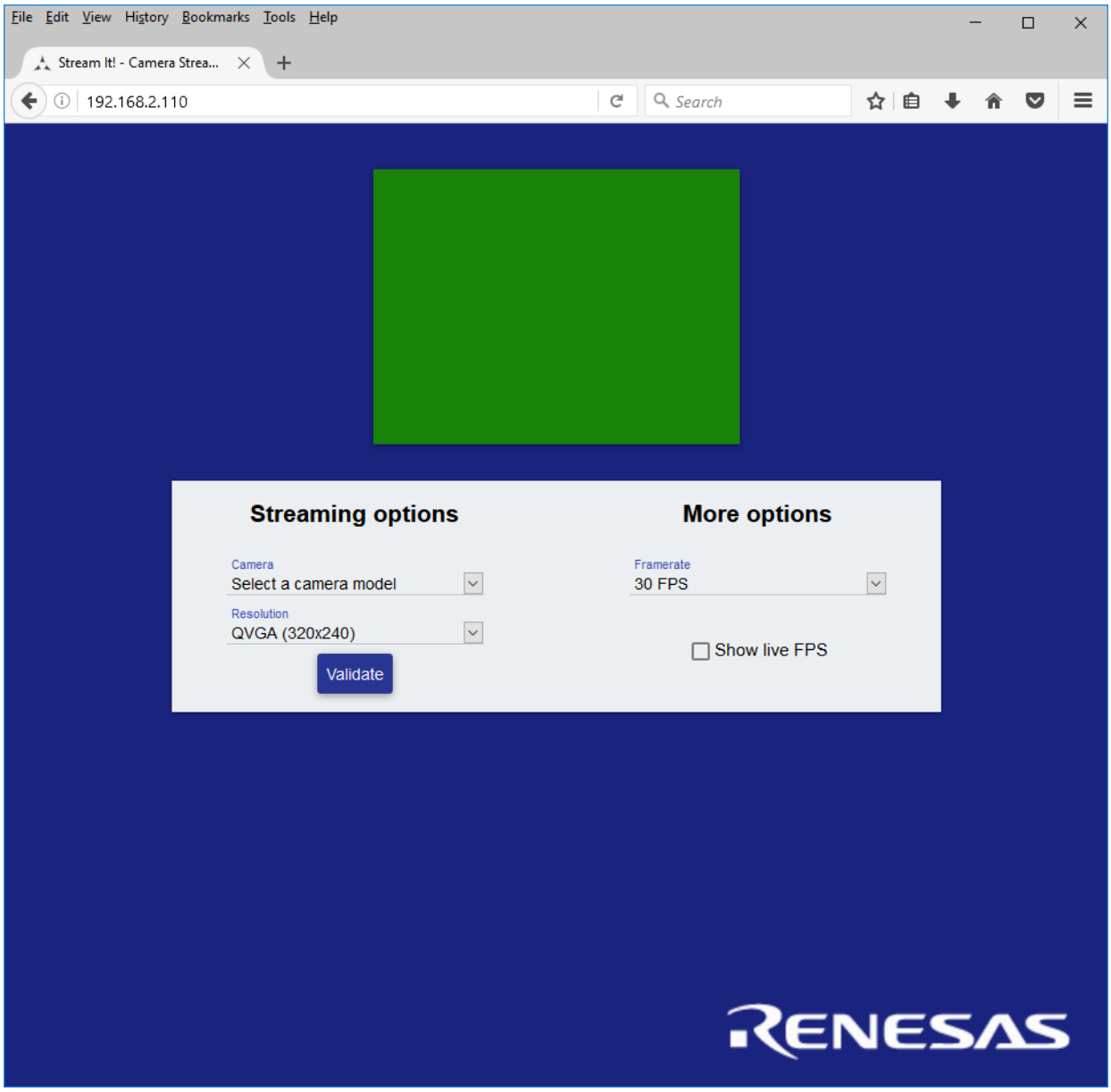


Figure 2 Initial web page

The user interface allows you to select the camera model, the resolution, the frame rate, and whether or not to display the number of frames per second.

Using the drop-downs, select 'Auto-detect' for Camera, 'VGA (640x480)' for Resolution, and '30 FPS' for the Framerate. Then click the 'Validate' button.

The browser should update and display a live image from the camera.

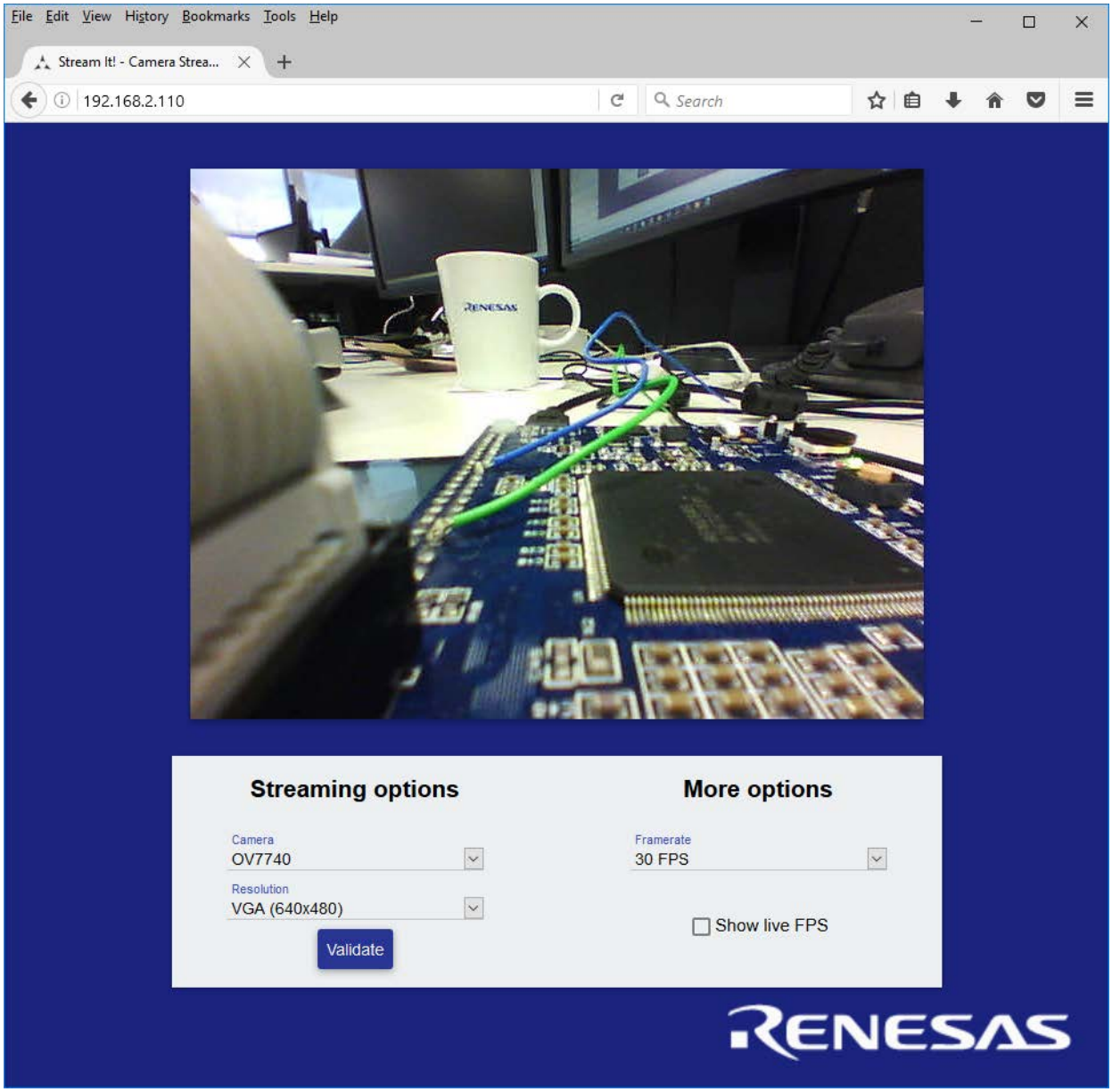


Figure 3 Web page streaming video

The board has automatically detected the OV7740 camera, and updated the ‘Camera’ selection control on the web page.

Now click the ‘Show live FPS’ checkbox. The top right-hand corner of the image will now be continually updated with the number of frames per second, and the data rate.

Figure 4 Image close up showing frames per second and data rate

3. Evaluation of Software

This section covers creating the demonstration software, specifically obtaining IDE required to build the software, importing the demo project, compiling the software, and downloading the software to the Stream it! - RZ target.

3.1 IDE Requirements e² studio

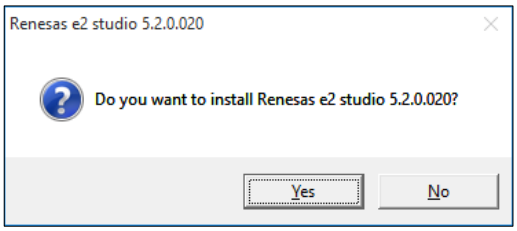
The evaluation source code supplied alongside this application note has been configured to use the Renesas IDE e² studio. The following instructions have been provide to help smooth the process of locating and configuring e² studio to build this project.

This section gives instructions on installing e² studio version 5.2. It is recommended to use the latest version of e² studio as available on the web site.

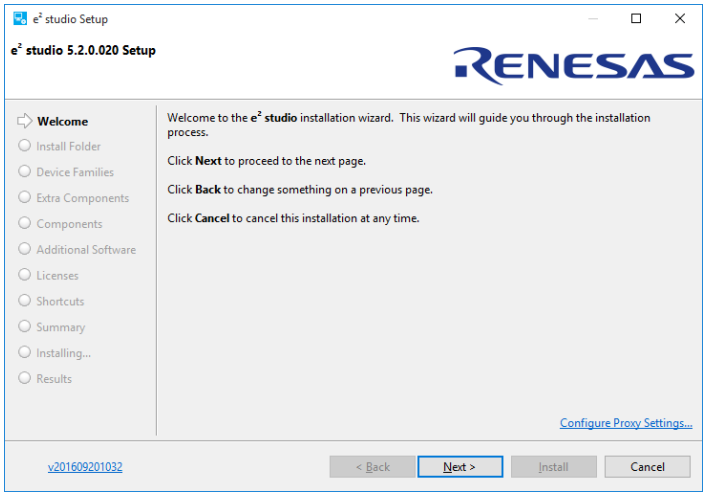
3.2 e² studio Installation

1. The latest e² studio installer can be acquired from the Renesas website at https://www.renesas.com/en-eu/products/software-tools/tools/ide/e2studio.html

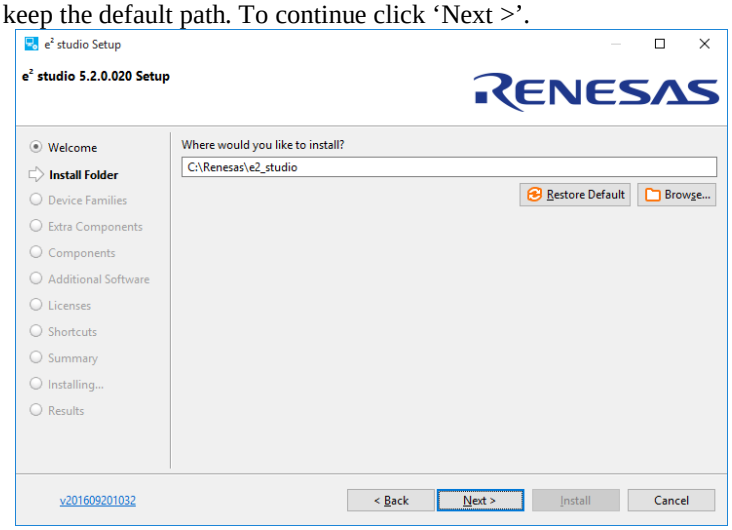
2. Once downloaded, double click on the application. A window will then pop-up, asking if you want to install e² studio (note the version number in the dialog may be different). Click 'Yes'.



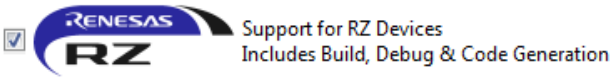
3. Once fully extracted, the e² studio installation wizard will guide you through the installation process. On the 'Welcome' tab click 'Next >'.



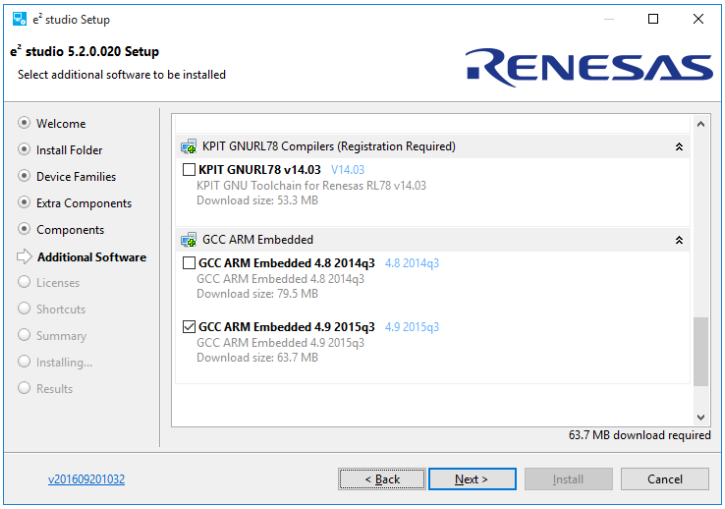
4. In the 'Install Folder' page, insert the path of a folder in which it is desired to be the root location for e² studio. It is suggested to keep the default path. To continue click 'Next >'.



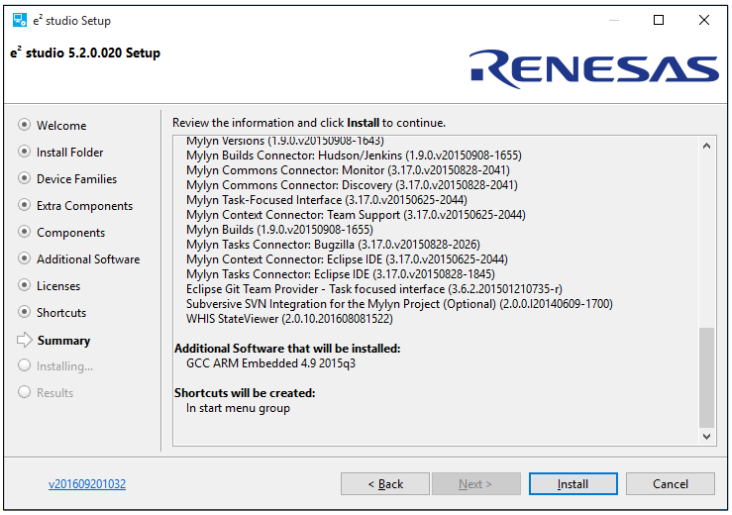
5. In the ‘Device Families’ page, ensure that the RZ family has been selected. It may also be desired to select support for other devices. Once selected, click ‘Next >’.



6. In the ‘Extra Components’ page you can select support needed for your development needs. To continue click ‘Next >’.
7. The ‘Components’ page will give the option to install optional components. It is recommended to ensure all are selected and to click ‘Next >’.
8. In the ‘Additional Software’ tab, ensure that ‘GCC ARM Embedded 4.9 2015q3’ is selected. Click ‘Next >’.



9. In the ‘Licenses’ page ensure to read and accept the Software Agreement to continue. Click ‘Install’.
10. The ‘Summary’ page will give an overview of the components of the installation. Click ‘Install’ to start the installation process.



11. Once the installation process has finished click ‘OK’.

To open e² studio please follow the instructions below:

1. Start e² studio
   Windows™ 7: Start Menu > All Programs > Renesas Electronics e2studio > e2 studio
   Windows™ 8 / 8.1: From Apps View, click ‘e² studio’ icon.
   Windows™ 10: Start Menu > All apps > Renesas Electronics e2studio > e2 studio
2. In the ‘Select a workspace’ dialog box, browse to a suitable location and enter a folder name to save your new workspace. Click ‘OK’ to continue.
3. On the ‘There are no new toolchains available for integration’ message box, click ‘OK’.

4. In the e² studio 'Welcome' screen, click the 'Go to the workbench' arrow icon, on the far right.
5. Code Generator Registration window will pop up to register code generator. Click 'OK'.
6. Once registered, another pop-up window will ask you to restart e² studio. Click 'OK'. e² studio will restart.

3.3 e² studio Update

To update e² studio both RZ support and the GNU ARM Embedded v4.9.3 compiler are to be installed. This is recommended to be done on e² studio version 4.3 or later.

To install the 'RZ support' please follow the instructions below:

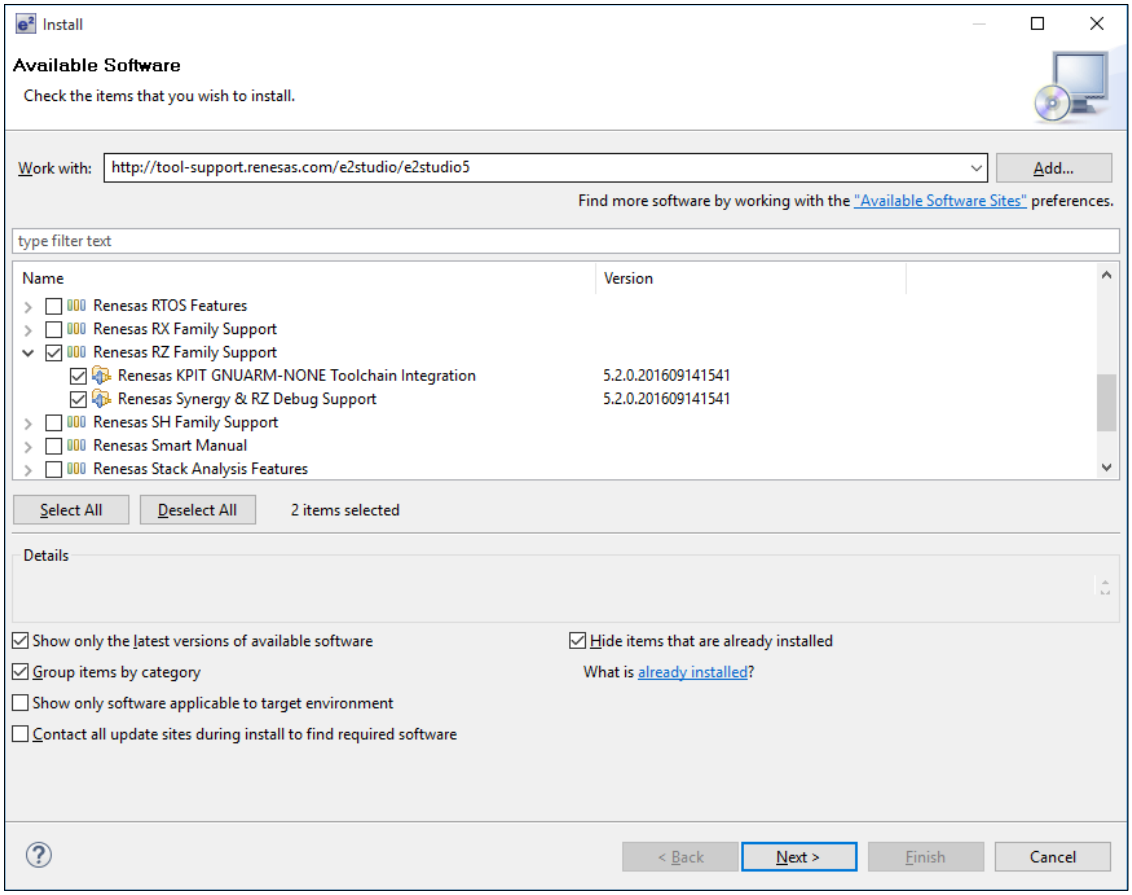
1. The RZ support can be installed through Renesas' tool support link. This can be achieved through

   Help -> Install New Software…

   Followed by inserting the following link in the 'Work with' box.

   http://tool-support.renesas.com/e2studio/e2studio5

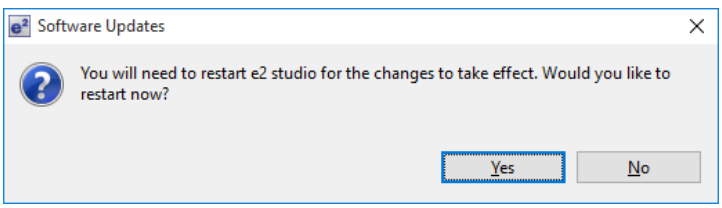
2. Select the 'Renesas RZ Family Support' and click 'Next >'.



   Installation details will then be shown. Click 'Next >'.

3. Read the 'License text' and select 'I accept the terms of the license agreement' to continue.

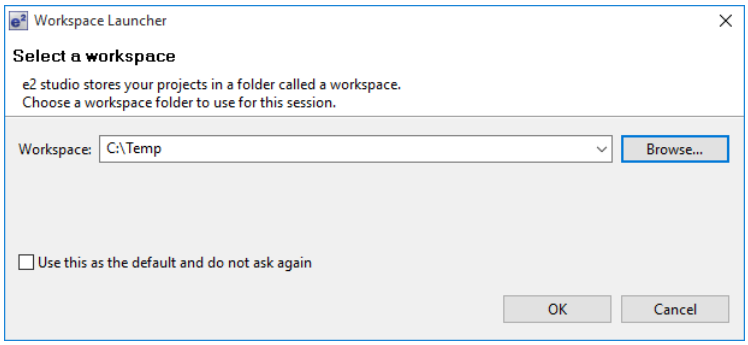
   A pop-up window will then ask you to restart e² studio. Click 'Yes'.



4. Once restarted the installation process is complete.

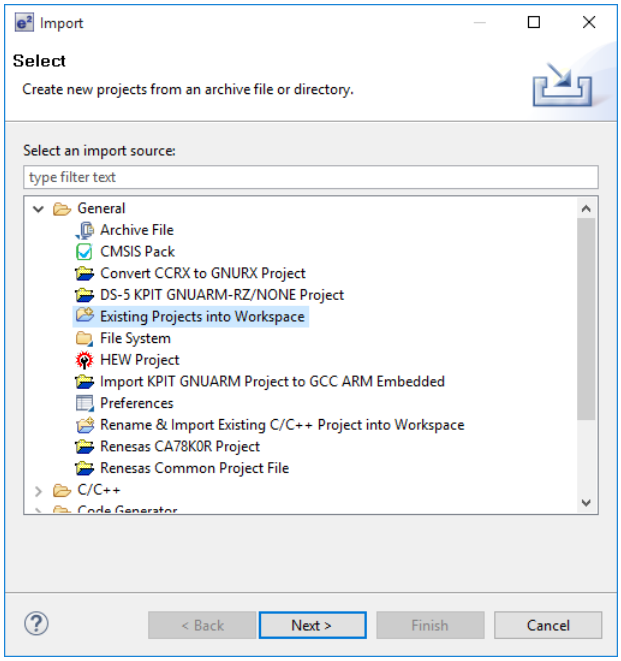
3.4 Importing the Project into e² studio

1. Start e² studio (skip this step if already open):
   Windows™ 7: Start Menu > All Programs > Renesas Electronics e2studio > e2 studio
   Windows™ 8 / 8.1: From Apps View, click 'e2 studio' icon.
   Windows™ 10: Start Menu > All apps > Renesas Electronics e2studio > e2 studio

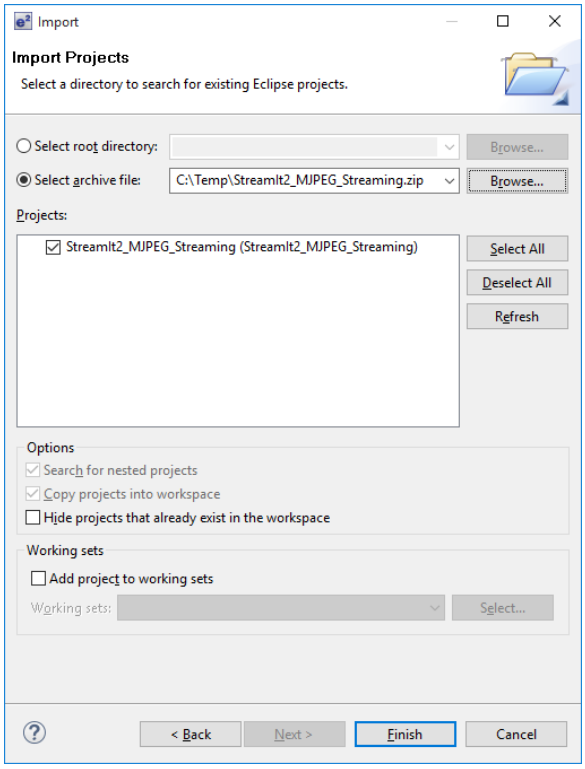


2. Select your desired e² studio workspace (C:\Temp in this case) and press 'OK'.

3. On the Welcome Splash Screen press 'Go to the e2 studio workbench'.
4. Right-click in the Project Explorer window, and select 'Import…'.

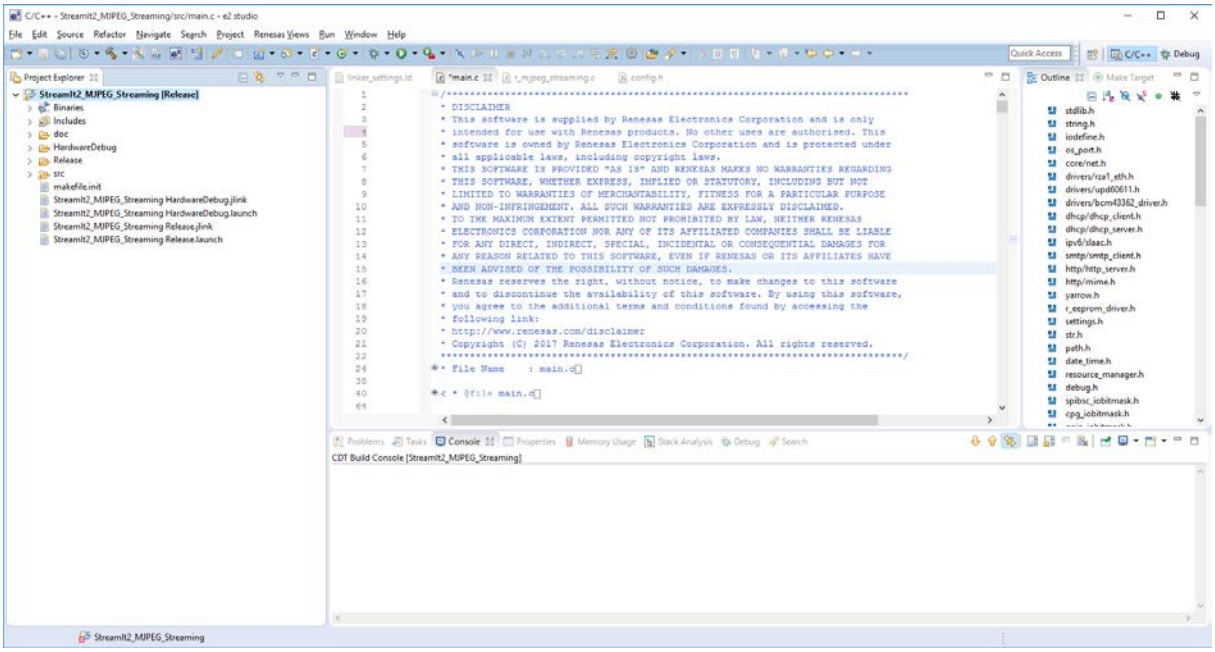


5. Under 'Select an import source', select 'General > Existing Projects into Workspace', and click 'Next'.



6. Select archive file then click the ‘Browse’ button, and locate zipped project location

7. Ensure the ‘Copy projects into workspace’ option is ticked and then click ‘Finish’.

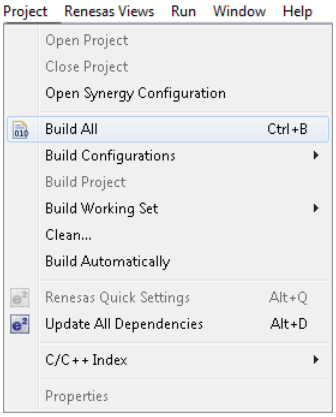


8. The opened project should look like the image (above).

3.5 Compiling the Software

The software compilation can be started using any 1 of 3 methods:

1. Push the Build button ()
2. Use the Project | Build-All option in the menu



3. Use the Build-All keyboard shortcut CTRL+B

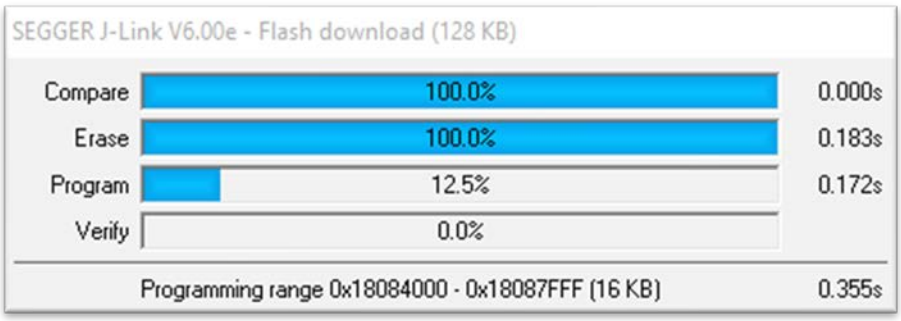
3.6 Running the Software

There are two different methods for running the project; from a batch file, or from e^2 studio. Firstly, the board needs to be connected up – see section (2.1.1).

3.6.1. Running From the Batch file

This method uses the Stream it! - RZ Boot Loader to run the application. It may be necessary to obtain this loader application to use this method. Copy the 'StreamIt2_MJPEG_streaming.bin' file into 'StreamIt2_QSPI_Loader\scripts' and rename the bin file to 'StreamIt2_User_App.bin'. Run the batch file 'Program_QSPI_Loader_Application.bat' that is in the project 'scripts' folder.

A window should pop up for the few seconds that it takes for the binary file to be copied to the flash memory on the Stream it! - RZ board.



Once the SPI flash has been reprogrammed the new code will be executed on device reset. The boot loader will determine if the user code needs to be relocated into RAM or executed in place from SPI as this is specified in the linker file. Details on the boot loader application can be found in the following document (QSPI Flash Boot Loader) found on the product website.

Unless the application is overwritten with another one, this application will now run automatically each time the board is powered on.

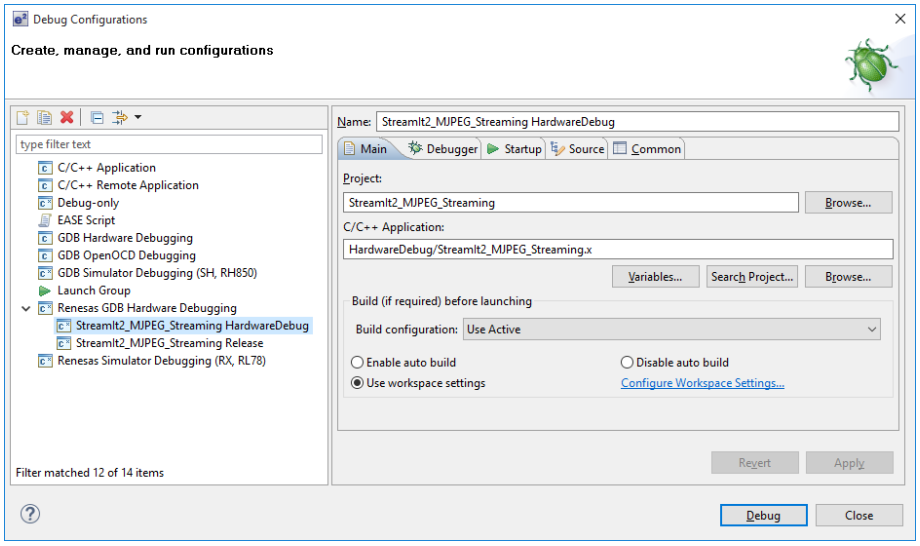
3.6.2. Running From e² studio

The provided e² studio workspace has two build configurations - 'HardwareDebug' and 'Release'.

Hardware Debug - This default build mode has all optimisation turned off, and provides full debug information. This is the best configuration to use whilst developing code as C code execution will be linear.

Release - This build mode has optimisation turned on, and provides little debug information. The C code execution may appear to be out of order, due to the way compiler optimises the code. This build configuration is intended for final ROM-programmable code.

1. Press the 'Debug' button () to open the 'Debug Configurations' dialog.



Select the Configuration you wish to use (HardwareDebug in this case). Note if the application (.x) file is not available or has errors, then the 'Debug' button on the bottom right will be disabled.

2. Press the 'Debug' button on the bottom right to start the download process.

```
start:
20040000    LDR pc, =reset_handler              /* Reset Vector                */
20040004    LDR pc, =undefined_handler
```

3. Once program download has complete the code execution will be at the entry point of your application which should look similar to the code segment above.

4. Pressing the resume button () will continue code execution. The code should stop again at the start of your main function. Pressing resume one more time will execute the rest of your code.

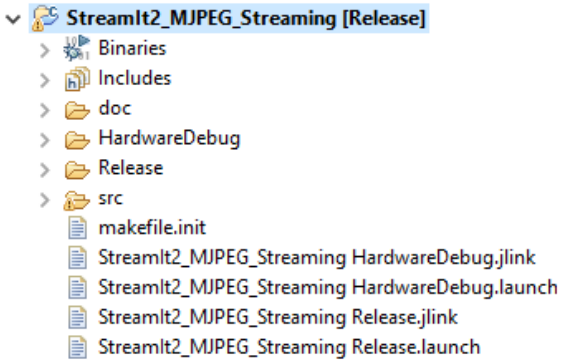
The code should now be running on your target device in RAM.

4. Project Details

This section details the sample project layout, components used and execution cycle.

4.1 Project Layout

The project layout as shown in e^2 studio is as follows:-



The following folders contain useful or user modifiable contents:

- doc Text file detailing simple download instructions and links to documentation
- src Source code for project. All user modifiable code is located in this sub folder

File `main.c` contains the start of the user level application (main function).
The debugger is configured to stop execution at the start of the main function.

4.2 Runtime Environment

The following resources are used in the application:

Resource	Device	Function/Description	Source Path
CEU	Capture Engine Unit	Captures images from the camera	src\renesas\peripherals\internal\r_ceu.c
JCU	JPEG Codec Unit	Convert images received from the camera to JPEGs	src\renesas\peripherals\internal\r_jcu.c
INTC_ID_RXI3	UART Ch3	Receive Interrupt used to provide serial console	src\renesas\application\cli.c
INTC_ID_OSTM0TINT	OS Timer Ch0	Provides system tick interrupt used by FreeRTOS	src\oryx\demo\freertos_tick_config.c
INTC_ID_ETHERI	Ethernet Ch0	Wired Ethernet interrupt handler, used by cyclone_tcp driver	src\oryx\cyclone_tcp\drivers\rza1_eth.c
I^{2}C Channel 1	I^{2}C Bus Interface	Used to send commands to configure the camera	src\renesas\peripherals\internal\riic_userdef.c src\renesas\peripherals\internal\r_riic_api.c src\renesas\peripherals\internal\r_riic_streamit.c

4.3 Startup Sequence

The following table gives a brief overview of the boot process for the device (executed before first call to main()):

File	Action	Details
src\renesas\compiler\asm\start.s	Program start	Creates initial vector table, calls reset vector.
src\renesas\compiler\asm\reset_handler.s	Reset code	Performs system reset, initialises arm stacks, memory manager etc. Calls peripheral_init_basic to initialise board. Final action to call Power_On_Reset() in resetprg.c
src\renesas\compiler\init\resetprg.c	'C' level code initialisation	Initialises any library code, enables irqs and fiqs. Calls 'C' level main()
src\main.c	Start application	Initialises rest of in-use board peripherals. Creates pre-kernel tasks. Starts the kernel.

The following FreeRTOS tasks created:-

Priority	Name	Short Description
1	Cli	Command line parser task
1	Connection Task	Manages network setup and configuration, then sleeps
3	Encode Task	Takes camera frames acquired by the CEU, and encodes them using the JCU
1	Framerate Task	Controls the rate at which the Encode Task is allowed to run
1	Blink Task	Performs LED control for USER LED
1	TCP/IP Stack (Tick) Task	Manages periodic TCP/IP operations
2	TCP/IP Stack (RX) Task	Manages incoming data packets
1	HTTP Connection Task	APP_HTTP_MAX_CONNECTIONS tasks, 1 task per potential connection (see below)
1	HTTP Listener Task	Manages new connections blocking too many simultaneous connections
4	Tmr Svc	FreeRTOS system timer handler
0	IDLE	FreeRTOS idle activity handler

Source code ref. (APP_HTTP_MAX_CONNECTIONS \StreamIt2_MJPEG_Streaming\src\renesas\configuration\config.h line 68).

The following diagram shows the task startup sequence and dependencies:

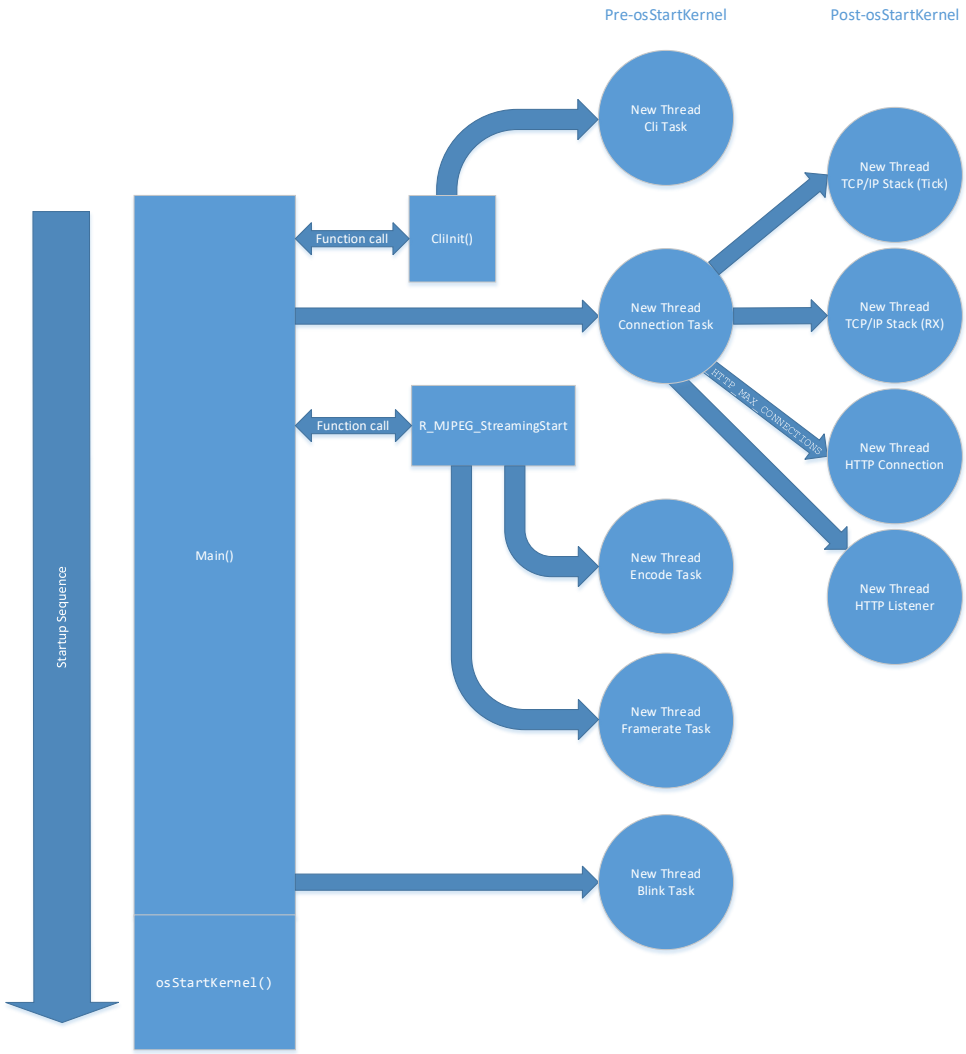
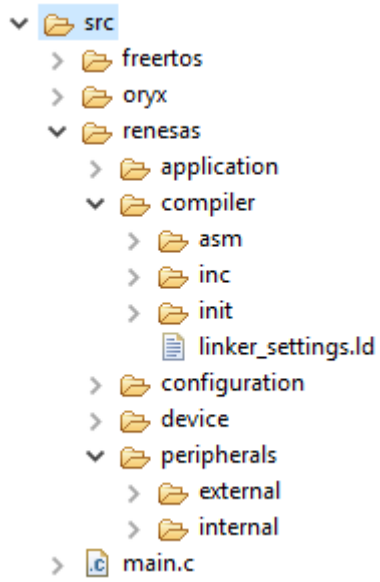


Figure 4-1 User Task creation workflow

5. High Level Overview of Source Tree Key Components

The application sample code is stored in the ‘src’ folder, the following provides a brief introduction into the layout of this folder.

The src (source) folder:



The layout of the src folder is as follows:

Name	Overview
renesas\application	Stores all the application specific files.
renesas\compiler	Stores any files specific to the startup procedure of the microcontroller The GNU linker (.ld) file is located in this folder
renesas\configuration	Application configuration files
renesas\peripherals	Stores the peripheral drivers required for this board. Internal folder stores the microcontroller peripheral drivers (e.g. adc, jcu, etc.) External folder stores the non-microcontroller peripheral drivers (e.g. sensors, camera, etc.)
freertos	Stores the FreeRTOS V9.0.0 embedded operating system (OS) source code. The OS configuration is controlled by the local file `\StreamIt2_MJPEG_Streaming\src\oryx\demo\freertosconfig.h`
oryx	Stores the Oryx Embedded HTTP server and demo code. The website (index.html, css and js scripts etc.) located in the subfolder `\StreamIt2_MJPEG_Streaming\src\oryx\resources\www`

6. Further Reading

Technical Support

For details on how to use e^2 studio, refer to the help file by opening e^2 studio, then selecting Help > Help Contents from the menu bar.

For information about the RZA1L series microcontrollers refer to the RZA1L Group Hardware Manual.

Technical Contact Details

***Please refer to the contact details listed in section 5 of the Stream it! - RZ* "Quick Start Guide" (r12qs0013eg0100-rza1lu.pdf).**

Renesas Electronics Website
https://www.renesas.eu/

Inquiries
https://www.renesas.eu/contact/

This product's homepage, where additional documentation and source code can be found, is located at:
https://www.renesas.com/en-eu/solutions/key-technology/human-interface/rz-stream-it.html

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	20th March 2017	All	Original release
1.10	16.Nov.2020	All	Application Note Software Update

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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