RSL10 Smart Shot Camera User Manual

Event−Triggered AI Imaging Platform, Bluetooth® Low Energy Enabled

SECO-RSL10-CAM-GEVB

Description

The RSL10 Smart Shot Camera (SECO−RSL10−CAM−GEVB) is a complete node−to−cloud platform that enables smart image capture for portable, low duty cycle IoT applications including asset monitoring and security. Based on the RSL10 SIP and ARX3A0 CMOS image sensor, the platform features multiple trigger modes including time, motion detection, and environmental sensor triggers (e.g. changes in temperature and humidity).

The RSL10 SIP serves as the processing hub of the camera, enabling Bluetooth Low Energy connectivity of captured image and sensor data to the provided mobile app (available on GooglePlay™, iOS®).

Using the app, developers can access a variety of features including cloud connectivity, remote configuration of sensors (thresholds and default settings), and change the image capture trigger modes. Connected to an Image Analytics/AI engine, located in the cloud, the app is capable of detecting and identifying objects using an AI cloud service. The mobile application returns the captured image, along with the list of identified objects and confidence levels.

The platform features the ARX3A0 Mono 65° DFOV IAS Module, a compact design form−factor used for developing compact cameras with 360 fps mono imaging based on the ARX3A0 CMOS image sensor. ARX3A0 offers high sensitivity at both visible and NIR wavelength, and has a super low power mode that consumes 3.2 mW when active. Additionally, ARX3A0 can be programmed to monitor specific zones of its field of view, automatically taking an image when the scene's contents change. Embedded on the platform hardware, the SPCV1100A from SunplusIT® provides multiple color processing features and JPEG image compression.

The impressive low−power operation of the RSL10 SIP and ARX3A0 is complemented by a dedicated NCP6925 Power Management IC (PMIC) (NCP6925) and additional smart power management modes implemented in hardware. Other devices enabling the efficient power management are the FAN54120 USB−compatible linear Li−Ion battery charger and the FAN49100 ultra−Low Iq buck−boost regulator. Thanks to these features, the RSL10 Smart Shot Camera supports an extended battery lifetime of more than one year.

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EVAL BOARD USER'S MANUAL



Figure 1. SECO−RSL10−CAM−GEVB

RELATED PARTS

- RSL10 SIP
- ARX3A0
- ARX3A0 Mono 65° DVOF IAS Module
- NCP6925
- FAN49100
- FAN54120
- LC709204F
- LE25U20AQG

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APPLICATIONS

- Asset Monitoring
- Security
- Smart Agriculture
- Criteria−based Monitoring

FEATURES

- Supports multiple image capture trigger modes
  - Periodic (1 second to 1 minute intervals)
  - Continuous video−like stream with less than 1 frame/s on BLE5.0 and above on compatible mobile devices
  - Proximity detection
  - Acceleration
  - Environment change
- Bluetooth Low Energy connectivity (Bluetooth 5) enabled by the RSL10 SIP
  - FOTA (Firmware Over The Air) updates
- Small form Factor (55 x 65 mm)
- Advanced 360 fps imaging provided by the ARX3A0 Mono 65° DFOV IAS Module
  - High sensitivity at both visible and NIR wavelength
  - Ultra low power (3.2 mW)
  - 1/10” sensor for super compact module
- Auto Exposure feature enabled during image processing
- RSL10 Smartshot Mobile App (GooglePlay) (IOS)
  - Cloud connectivity to Amazon Web Services™ (Amazon Rekognition™)
  - Image Analytics/AI Engine to detect and identify objects within an image
- Unprecedented ultra−low power consumption (Standby and Active Mode) for battery life >1 year
- Multiple powering options (USB or rechargeable Li−Ion batteries)

BENEFITS

- Portable
- Long battery life (> 1 year[1]) node−to−cloud near turnkey design for reduced development time
- Multiple trigger functions for various use cases

1. Depending on use mode

SYSTEM OVERVIEW

Figure 2 depictes the system architecture of the RSL10 Smart Shot Camera.

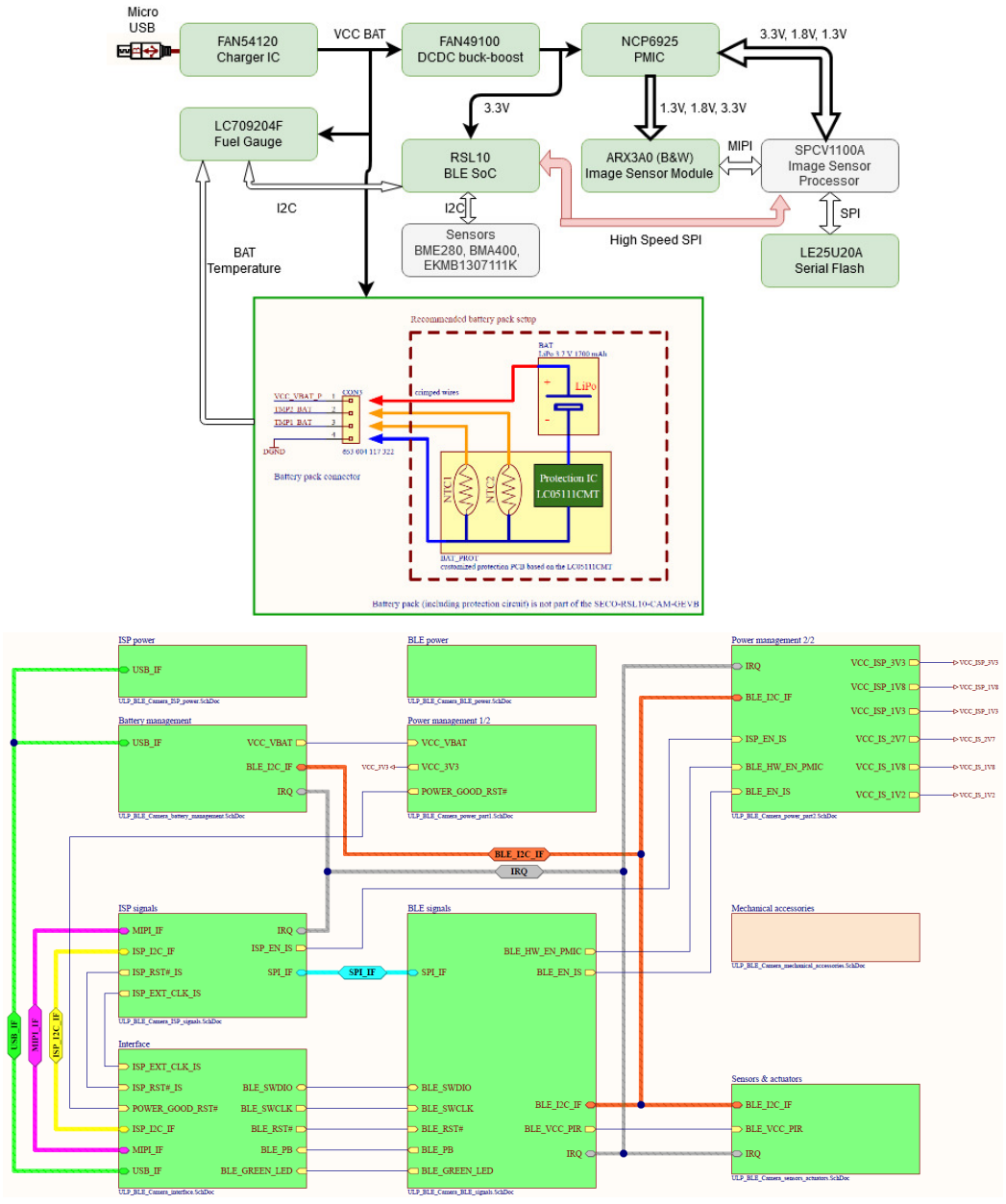


Figure 2. RSL10 Smart Shot Camera System Artchitecture

The platform consists of the following major blocks:

- RSL10 SIP Bluetooth Low Energy System in Package (SiP)
- ARX3A0 Mono 65° DVOF IAS Module
- SPCV1100A Image Sensor Processor from Sunplus IT
- Environmental Sensors from Bosch Sensortec– BMA400 (accelerometer), BME280 (humidity, temperature), EKMB1307111K (motion)
- Power Management – FAN54120 (battery charger), FAN49100 (buck/boost converter), NCP6925 (PMIC), LC709204F (Fuel Gauge)

The entire system is powered by a unique supply architecture that delivers optimized system performance and low power consumption. The board can be powered by a USB cable or Lithium Ion battery. A Li−Ion battery is not included with the camera platform, but can be added with battery protection circuitry as described below.

Whether a USB cable or Lithium Ion batter, the FAN54120 will identify and use the correct charging profile for operation. The output of the charger controller VCC_VBAT (Figure 2) delivers the supply voltage directly to the FAN49100 low power buck/boost converter (DC/DC) to maintain a 3.3 V output (VCC_3V3) delivery to the

RSL10, the NCP6925 and the sensors. Additionally, the FAN49100 can stabilize the supply voltage level in the event of a drop or if the input voltage range is within 2.5 to 5.5 V.

In case of the delivered board without battery, VCC_VBAT rail after FAN54120, entering FAN49100 always returns 4.2 V_{float} derived from battery charger controller.

VCC_3V3 rail out of the DCDC converter directly supplies environmental sensor, accelerometer, PIR sensor and the RSL10. All these elements features ultra−low power consumption and due to correct system operation, no additional power gating is needed.

For high−performance image processing, the system features the ARX3A0 Mono 65° DVOF IAS Module and the SPCV1100A Image Sensor Processor (ISP) from Sunplus IT. Interconnectivity between the ARX3A0 camera module and SPCV1100A ensures a high speed MIPI interface. Due to the short peak power delivery needed to process the image in SPCV1100A and overall system power consumption savings, supply voltage rails for proper operation of ISP and camera modules ensures ultra low power PMIC NCP6925, featuring highly efficient multi−rail power delivery with typical 300 nA current consumption when switched of programatically.

A high−speed SPI interface between the SPCV1100A and the RSL10 SIP is used transfer the captured and processed image over Bluetooth Low Energy. More information about this process, including the mobile app, is described in *ON Semiconductor RSL10 Smartshot Board Support Software Package*.

All components and their placement on the camera platform is shown in Figure 3.

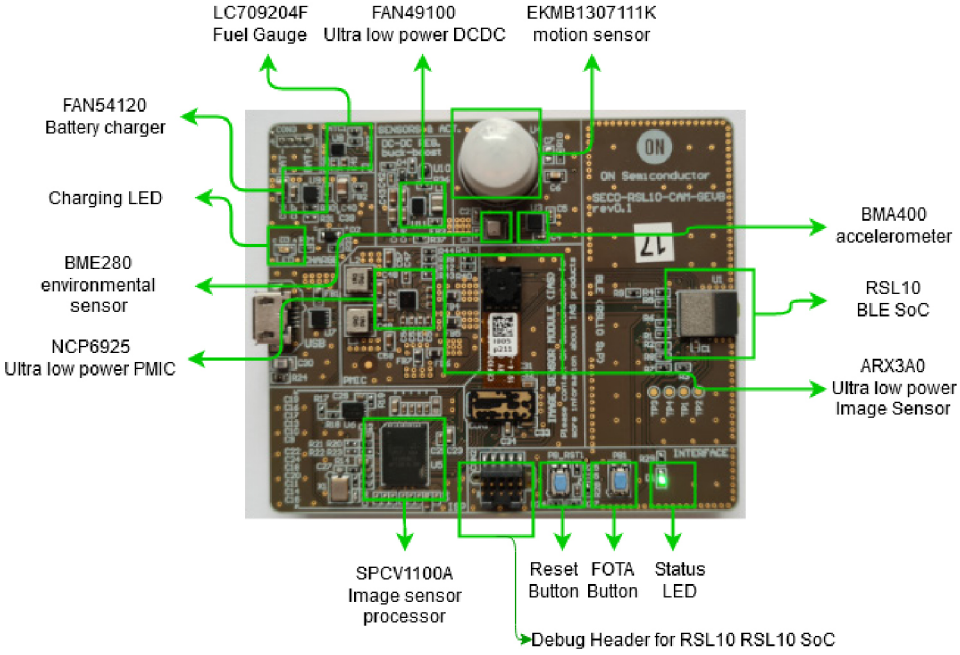


Figure 3. RSL10 Smartshot Camera Components

BLOCK DIAGRAM

Figures 4 and 5 depict the detailed block diagram for both power management part and signaling chain within the system.

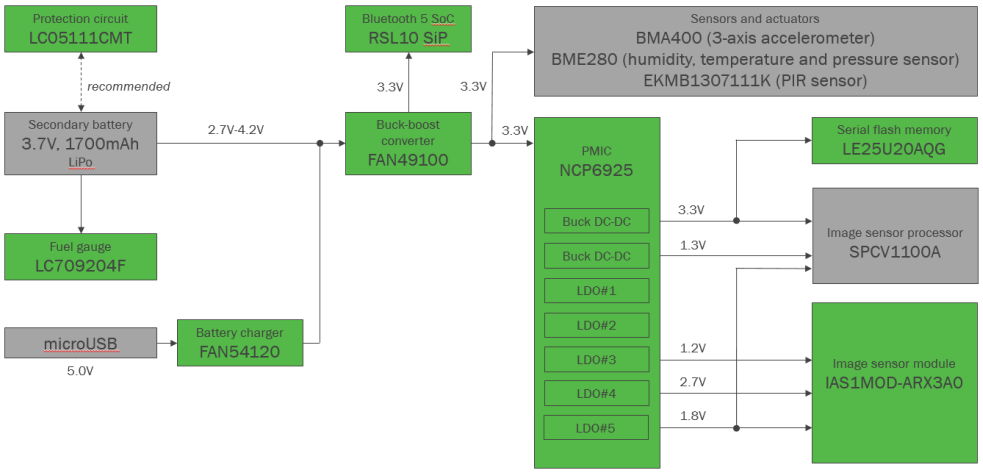


Figure 4. RSL10 Smart Shot Camera Block Diagram (Power Management)

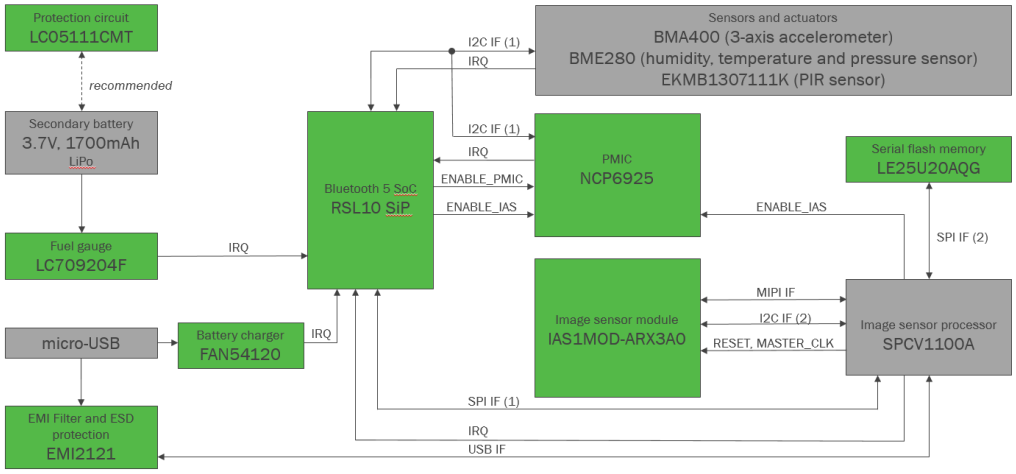


Figure 5. RSL10 Smart Shot Camera Block Diagram (Signals)

BATTERY AND USB SUPPLY MANAGEMENT

When the re−chargable battery is placed, the charging current is preset to I_{fast} = 400 mA (fast charging).

As discussed in the previous chapter, the board is delivered without a Li battery. In this configuration, the FAN54120 does not have to detect the battery and starting this system without a battery may be a problem. Given a valid USB input, the output of FAN54120 will be active (= V_{float}), even without a battery. Its STAT will be high, since it is not actively charging. It will support a load up to I_{fast} setting established. Any load larger than this will collapse the output. When output falls < V_{short}, default state is entered.

If load never exceeds I_{fast}, the output will be active and there is no need for a secondary battery. If load > I_{fast} and battery is not present to supplement load current, it will enter default state. Because STAT is high, it does not automatically mean the device is in default state. STAT high can also indicate I_{term} has been reached, which is the case when no battery has been installed (assumes load < I_{term}). With no battery and continuous load > I_{term}, STAT would be low. STAT will flip high when load < I_{term} for its de−bounce time (T_{chgend}).

Without a battery, safely dragging V_{out} down by V_{rch}, but not to V_{short} (enters fault state) is required to get STAT low. Since load can momentarily exceed I_{fast}, C_{out} needs to be designed to store enough charge to prevent V_{out} collapsing to V_{short}.

The proper selection of FAN54120's output capacitors and additional circuitry in respect to downstream FAN49100 must be arranged, in order to not colapse VCC_VBAT once the USB cable is connected and no battery is used.

The downstream FAN49100 normally has inrush current well in excess of 400 mA. Without a battery, it could crash the system. The FAN49100 ramps its output up in ~200 μs. There is typical 44 μF C_{out} (not bias derated). The current to charge that cap, with no load, would be close to 750 mA. If we reflect that current back to the 4.2 V input, its still around 690 mA. Obviously, the FAN54120 output is going to collapse.

There is a ~60 μs delay from rising EN until output starts ramping on FAN49100. The FAN54120 will not be fully started by that point. It's necessary to add a delay circuit on FAN49100 EN pin so that FAN49100 is enabled after the FAN54120 has started.

Figure 6 depicts the reliable way how to safely start the FAN54120 (delay circuit and proper sizing of output capacitors) with respect to downstream power management, if no Li battery is connected to the board.

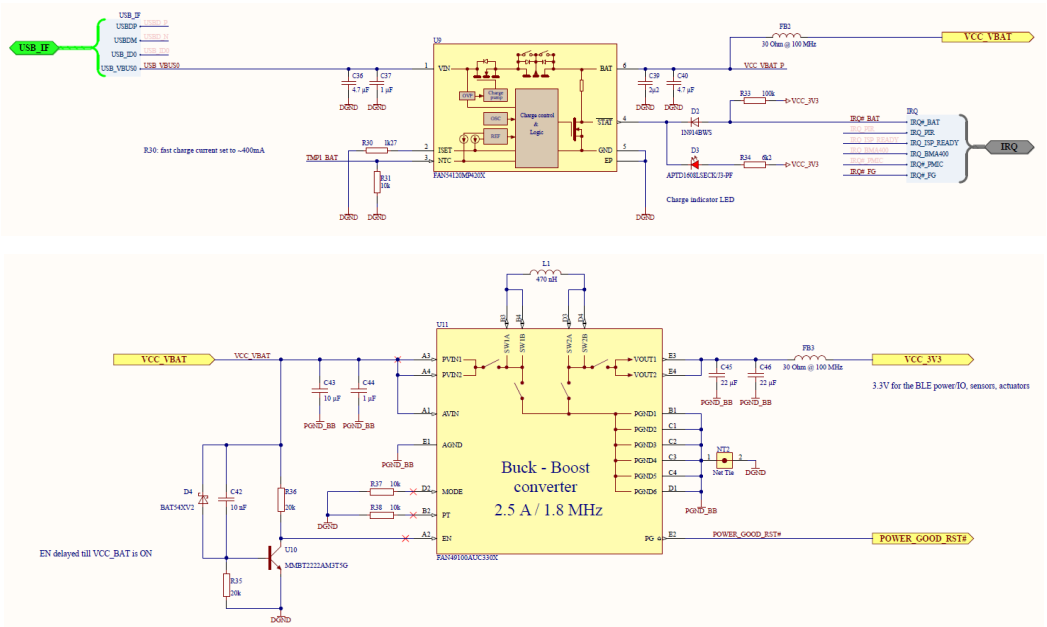


Figure 6. Charger Circuit with Respect to Downstream Power Management Ensures Proper Start−up when No Battery is Connected to the System

The consequence of above arrangement and delivery without battery is the following:

1. Once the USB is connected for the first time, the red LED D3 will blink once . This indicates that the device started properly. If the red LED D3 blinks continuously, this indicates that FAN54120 didn't start properly. If this occurs, unplug and re−connect the USB cable (Figure 7).

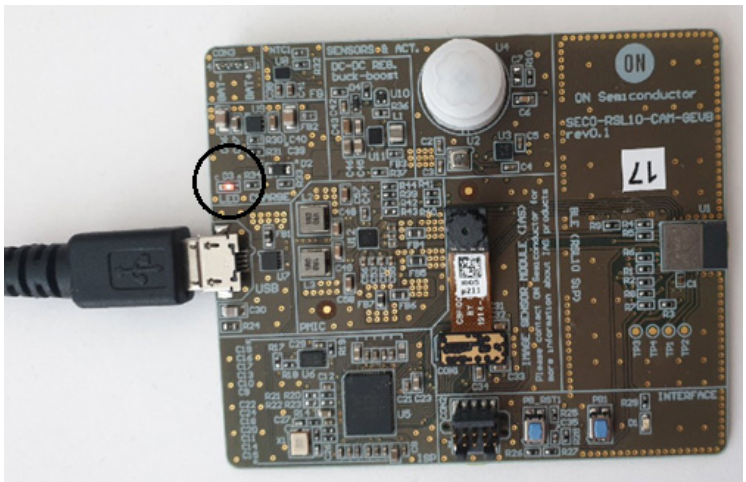


Figure 7. LED D3 Blinking Continously to Indicate Proper Start−up

2. FAN54120 requires for its operation the temperature sensing composed of NTC temperature sensor. As the battery isn't part of the delivery, for proper operation of the circuit, 10 kΩ resistor in place of R31 provides emulated function (Figure 8).

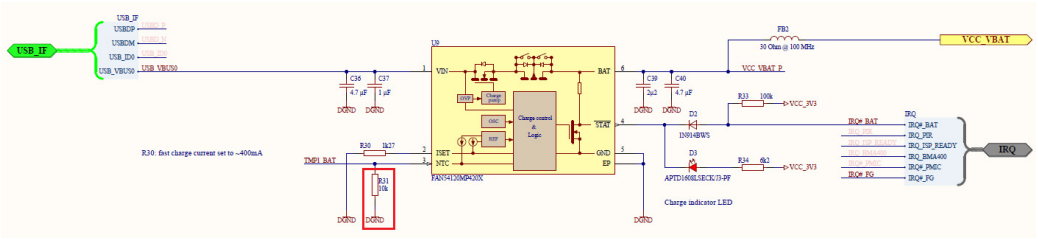


Figure 8. R31 = 10 kΩ Assembled by Default in Order to Emulate NTC Temperature Sensor, Normally Placed Close to the Battery

CONNECTING THE RECHARGEABLE BATTERY

For standalone operation, the RSL10 Smart Shot Camera can be adapted for Li / Li−Po battery connection. The high−level specification of the battery should follow these basic parameters:

- BAT type: Li or Li−Po
- BAT voltage = 3.7 V
- BAT floating voltage = 4.2 V
- Capacity = based on the use case (recommended 1700 mAh)

The charging current of the FAN54120 is fixed on the board to 400 mA (fast charge). The following description and tests relate to Li−Po battery type LP435656: 3.7 V 1700 mAh fitting into the PCB design dimensions.

In order to mount the battery on the bottom of the PCB, ON Semiconductor recommends additional battery protection circuitry mounted as close as possible to the battery. The whole design package, based on the LC05111C13MTTTG, is available at ON Semiconductor's webpage and not part of the delivery. Once the battery is connected, the application code can be developed with the LC709204FXE−01TBG fuel gauge IC, assembled on the SECO−RSL10−CAM−GEVB board.

These additional steps are required to properly connect the re−chargeable battery and its protection to the circuit:

1. Remove R31: the 10 kΩ resistor emulates the external NTC sensor. As the board is not delivered with a battery, this dummy resistive load must be connected towards FAN54120 (Figure 9).

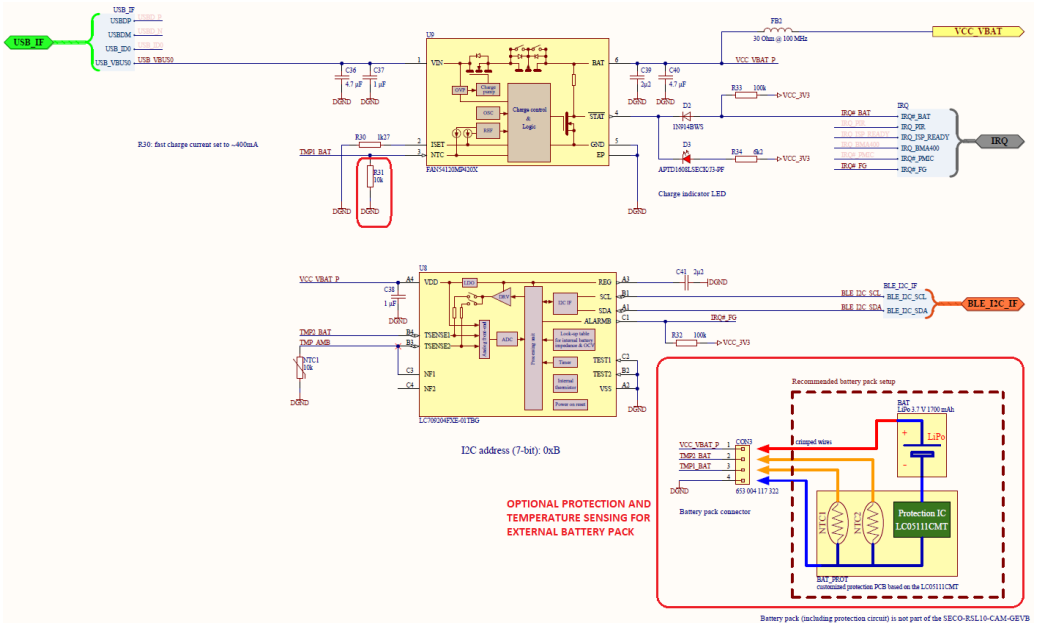


Figure 9. R31 = 10 kΩ to be Removed Once External Li Battery and it's Protection Circuit Connected

2. The protection circuit consists of two NTC temperature sensors that monitor battery temperature. NTC1 connects via TMP1_BAT header towards battery charger FAN54120, and NTC2 applies for fuel gauge LC709204. The connection of battery pack is shown in Figure 10.

To safely operate the RSL10 Smart Shot Camera with an external battery, the recommended protection circuit is shown in Figure 11 and Figure 12. The protection PCB is not part of the delivery but the complete manufacturing data, schematic and BOM is available online.

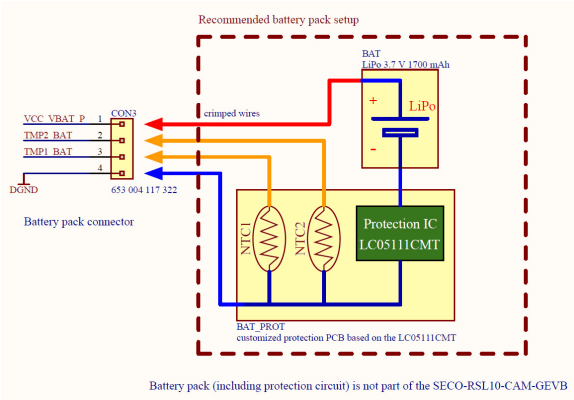


Figure 10. High−level Principal Schematic of Rechargable Battery Connection and Protection Circuitry Towards CON3

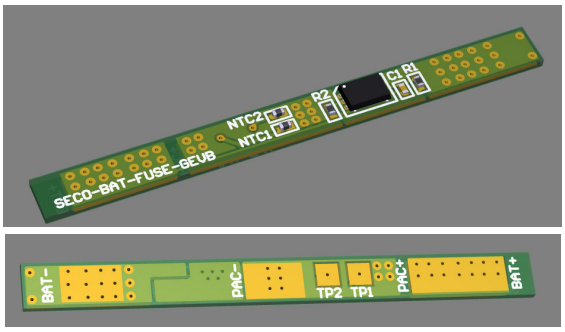


Figure 11. Top and Bottom Visualization of the Protection Circuit



Figure 12. Physical Implementation of the Battery and its Protection Circuit from Bottom Side of SECO−RSL10−CAM−GEVB

RSL10 SMART SHOT CAMERA DEVELOPMENT ENVIRONMENT

The RSL10 Smart Shot Camera is available with a complete software development environment and source code for the RSL10 SIP, including documentation explaining how the sensor data and image transfer services are defined and executed inside RSL10.

This chapter describes installation prerequisities and instructions, features and capabilities of the package, and how to modify the source code.

To easily access the core messaging structure of the Bluetooth Low Energy channel for sensors and images streaming, two documents has been created with detailed high level description:

Sensors Bluetooth Low Energy messaging document: *External Trigger Sensor Services V1.0.0*

Picture transfer Bluetooth Low Energy messaging document: *Picture Transfer Service V1.0.1*

Installation Prerequisites

1. Install 64−bit version of Java from https://www.java.com/en/download/
2. Install J−Link Version 6.32i or later from https://www.segger.com/downloads/jlink (select J−Link software and documentation pack)
3. Download and install “ON Semiconductor IDE Installer”
4. Download the *“RSL10 SDK Getting Started Guide”* and RSL10 CMSIS pack (baseline SDK) under *“RSL10 Software Package”* from the above site. Save this CMSIS pack in a folder, for example, C:\cmsis_packs
5. Download and install the RSL10 Smart Shot Camera CMSIS−Pack (*ONSemiconductor.RSL10−SmartShot_BSP.1.0.1+173* or higher) to discover and modify the RSL10 SoC source code with complete documentation attached in it.
6. ARM CMSIS pack 5.7.0 or higher (https://github.com/ARM−software/CMSIS_5/releases)
7. ARM CMSIS – FreeRTOS version 10.3.1 or higher for users exposed to design the code under FreeRTOS with RSL10 (https://github.com/ARM−software/CMSIS−FreeRTOS/releases)

IMPORTING THE CMSIS−PACKS

Once all packs are successfully imported, they can be viewed in the CMSIS pack manager perspective as shown below (Figure 13).

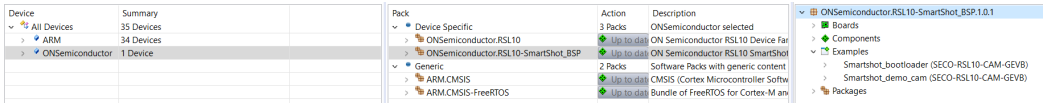


Figure 13. Imported CMSIS Packages from Prerequisites Including ONSemiconductor.RSL10−Smartshot_BSP (Board Support Package)

After installing the RSL10 Smart Shot CMSIS Pack, the display as *ONSemiconductor.RSL10−Smartshot_BSP*. The RSL10 Smart Shot CMSIS Pack consists of two sample codes that are bind to SECO−RSL10−CAM−GEVB platform. To have the source code and all related documentation visible, and right click on the selected sample code (Figure 14) to imports the project into the Project Explorer workspace.

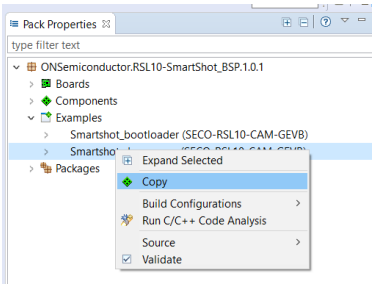


Figure 14. Right Click on the Sample Code Easily Access the Source Code and Complete Documentation

Once the above action is executed, user has access to source codes for RSL10 SoC attached this platform. It's split in two sample codes:

1. *SmartShot application software*: it provides the source code and documentation for actual Smartshot application running on RSL10 (Figure 15)

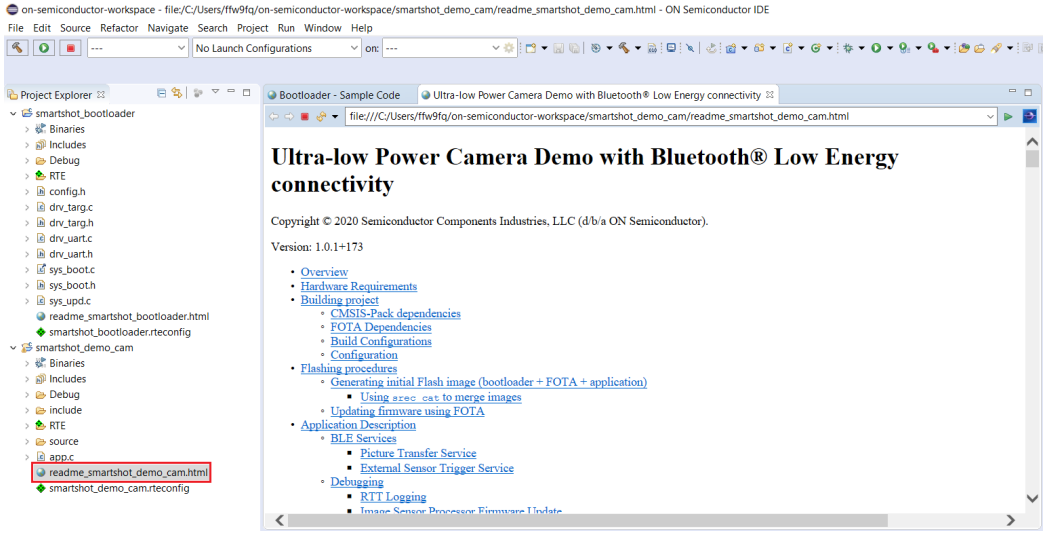


Figure 15. SmartShot Source Code and Documentation Inside CMSIS

2. *SmartShot bootloader sample code*: The SECO-RSL10-CAM-GEVB platform supports Firmware Over The Air (FOTA) updates for the RSL10.

Two methods are available for performing of FOTA updates on FOTA enabled devices:

- RSL10 FOTA Mobile Application (Android, iOS)
- FOTA.Console PC Tool with RSL10 USB Dongle

Both methods are described in *RSL10 Firmware Over−The−Air User's Guide* from RSL10 Documentation Package in section 4.4 and section 9.

The SECO−RSL10−CAM−GEVB board can be switched into FOTA mode by pressing and holding the on−board push button PB1 during normal operation. The switch to FOTA mode is indicated by a 1 second LED flash.

The FOTA images are bundled in *ONSemiconductor.RSL10-SmartShot_BSP.1.0.1+173* or higher SDK CMSIS package. Figures 16 and 17 show the sample code and documentation attached to that part.

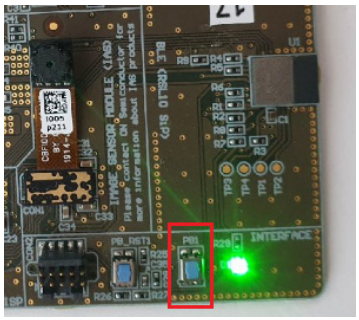


Figure 16. Switch to FOTA Mode by Hilding of PB1 Push Button

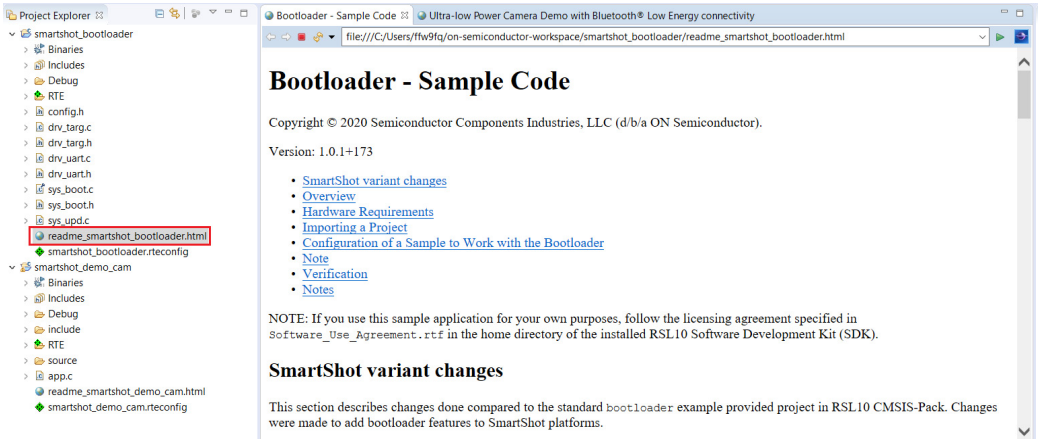


Figure 17. Bootloader Sample Code and Documentation Package

RSL10 SMARTSHOT MOBILE APP

The RSL10 Smart Shot Camera is supported by a mobile application available on Android and iOS . Using the app, developers can access a variety of features including cloud connectivity, remote configuration of sensors (thresholds and default settings), and change the image capture trigger modes. Connected to an Image Analytics/AI engine, the app is capable of detecting and identifying objects using an AI cloud service. The platform returns the captured image, along with the list of identified objects and confidence levels, on the app.

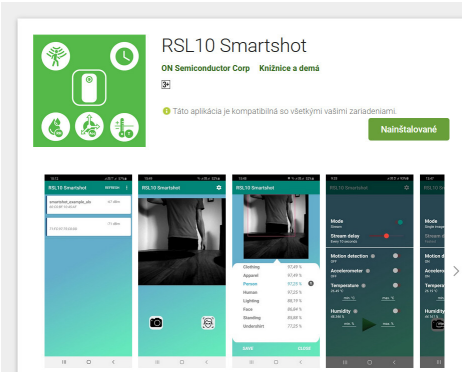


Figure 18. RSL10 Smartshot Mobile App

In the Current version of app let take a single image and enables recognition by the AWS Rekognition service, run stream of images and use the board like ”alarm system” by using sensors placed on the board.

By setting some of the triggers sensors (PIR sensor, accelerometer, temperature and humidity measure), the platform will take an image at a particular moment when some of the sensors detect change in state or value.

Installation

The RSL10 Smartshot app is available on Google Play and IoS. After successful installation, you can open the app. If opening the app for the first time, all permissions must be enabled, including *manually turning on GPS and Bluetooth functionalities*.

RSL10 Smartshot App Features

This section describes all functionalities of the RSL10 Smartshot set−up.

Discover Bluetooth Devices

Using the RSL10 Smartshot app, you can immediately starts to discover near Bluetooth devices. The app will only connect to the RSL10 Smartshot Camera which will be listed as ”smartshot−demo−cam” or similar (Figure 19).

NOTE: If the platform is not discoverable, select the *Refresh* button.

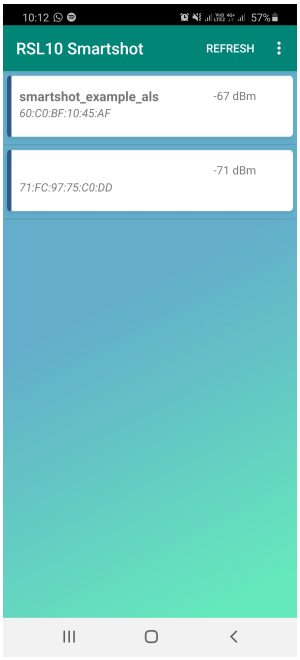


Figure 19. Discovery of the RSL10 Smart Shot Camera

Taking an Image

After successfully connecting to the platform, camera and recognition icons will appear.

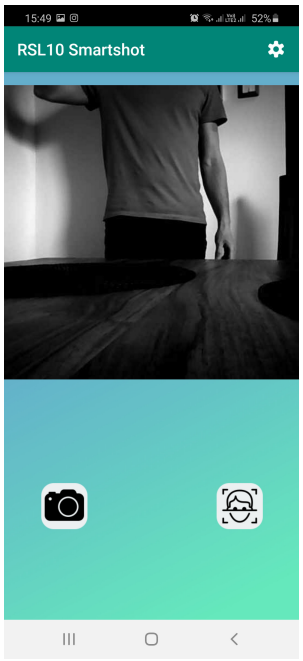


Figure 20. Taking the Picture

The most basic function is to capture a single image, which is done by selecting on the camera icon (left). Subsequently, the progress bar will be displayed to represent the progress of the receiving image. After receiving, the image is displayed on the screen. Next step may be to recognize this image by Amazon Rekognition.

Amazon Rekognition

You can provide your captured image to Amazon Rekognition, which will analyze the image and returns the labels of objects that were recognized on image.

To use this function, you will need to create an AWS account and have your smartphone connected to the internet. If you do not have an AWS account, you can register for one here.

To connect your AWS Account with the RSL10 Smartshot app, enter your *accessKey* and *secretKey* (Figure 21). After doing so, a screen with two rows will appear after click on the recognition icon, or you can find it in the option menu on the main (BLE discovery) screen.

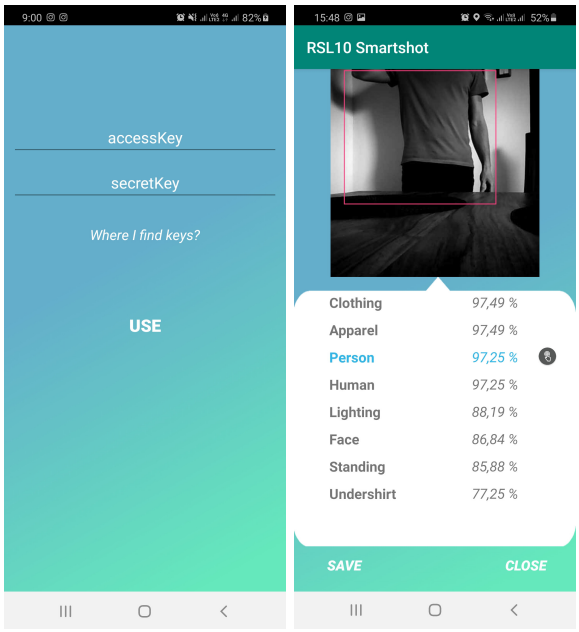


Figure 21. Amazon Rekognition

After analyzing the captured image, a list of detected objects is displayed. The blue label corresponds to a bounding box for a particular object within image (Figure 21). The accuracy of compliance is represented by percentage number next to every label.

The image can be saved for later analysis, or downloaded to your PC from your smartphone's storage. You can find the saved images in option menu on first (introductory) screen (Figure 22).

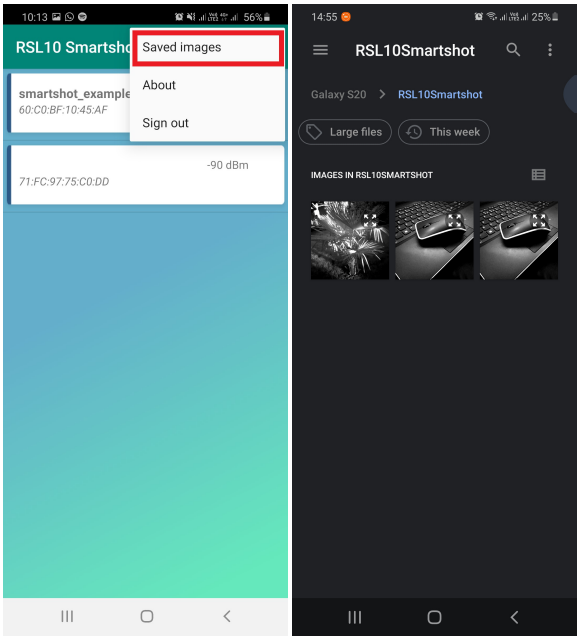


Figure 22. Saving Captured Images

NOTE: The RSL10 Smartshot app will only recognize images captured by RSL10 Smartshot platform.

Set Amazon Rekognition Permission

To use Amazon Rekognition services, you will need to confirm permissions in your AWS account.

1. Log into to your AWS account
2. Choose ”IAM” service in ”Security, Identity & Compliance”

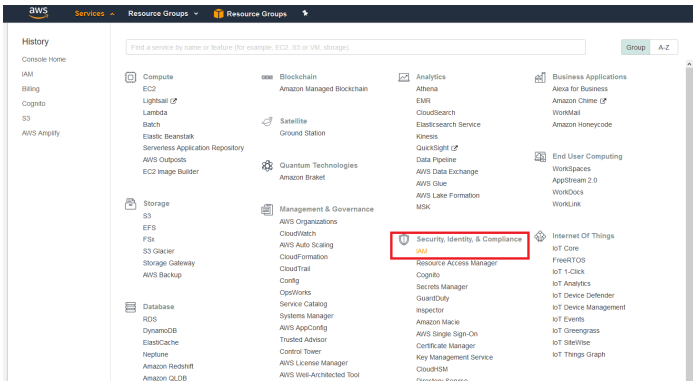


Figure 23.

3. In the left options menu, choose ”Access management” → ”Users” and add new user (Programmatic access → Next → Attach existing policies directly)

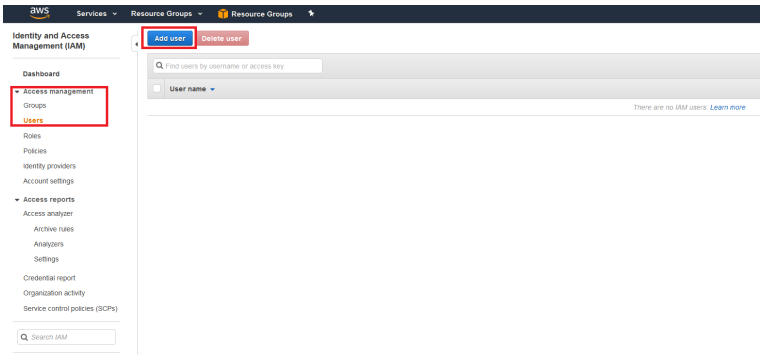


Figure 24.

4. Find “AmazonRekognitionReadOnlyAccess” and “AmazonRekognitionCustomLabelsFullAccess”, check the boxes and click on “Next: Review”

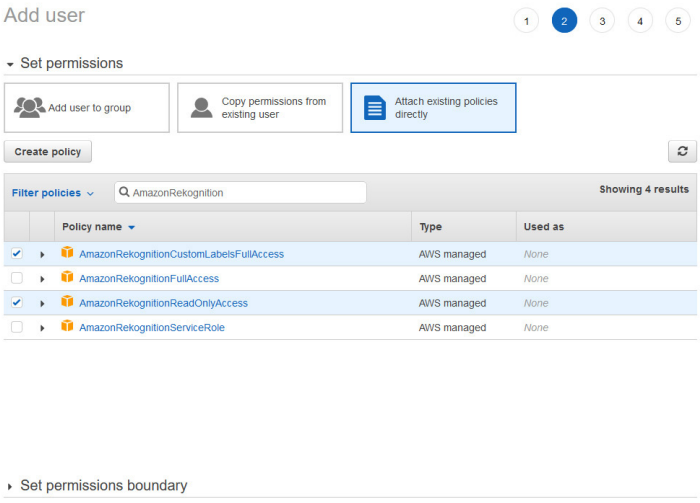


Figure 25.

5. Skip tags page and in review click on “Create user”
6. The last page shows the generated accessKey and secretKey. Copy SecretKey now and save it on safe place for later use, because you won’t be able to see it in future

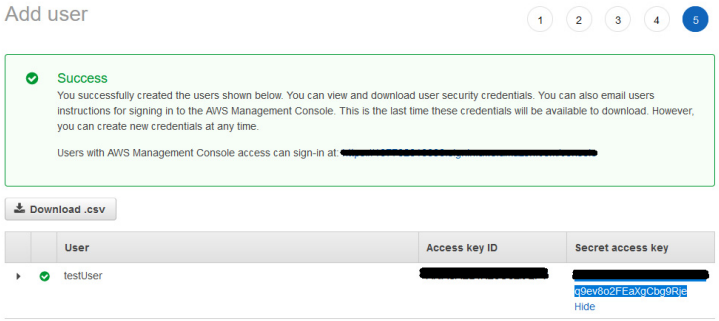


Figure 26.

7. Now users have accessKey and secretKey, so one can utilize them in the app.

Streaming Images

As well as using the platform to taking a single image, you can run a stream of images with different frame rates.

By tapping the icon in the upper right corner of the app, you’ll open the option menu where you can switch from ”Single image” mode to ”Stream” mode and set frame rate of stream (Figure 27).

The stream frame rate values listed under slider are different for each BLE version. Transmission time may be influenced by the size of the captured image and the Bluetooth Low Energy version used. The duration of sending an image in stream mode and available frame rates dependent on BLE version are listed in table below (Table 1). An average size image (15 kB) was used.

Table 1. IMAGE STREAM TIME INTERVAL DEPENDS ON THE BLE VERSION EMBEDDED IN THE PHONE

BLE Version	Sending a Single Image	Available Stream Frames (s)
4.0	~3.7 s	10, 15, 30, 60
5.0	~0.7 s	3, 10, 30, 60

After setting of the stream, you can hide an option menu and start the stream by play button.

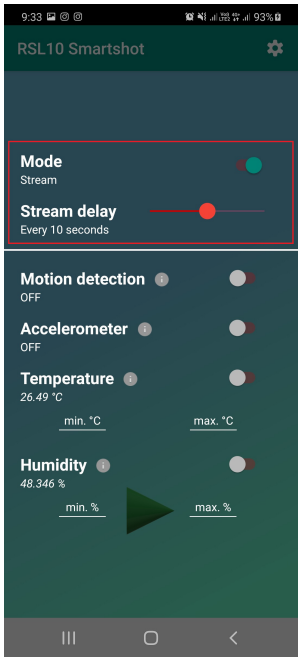


Figure 27. Image Streaming and Frame Rate Settings

Sensor Triggers

The RSL10 Smartshot platform allows the use of 4 sensors to set triggers, which will take a picture when change in value is detected. These functionalities can be

found after tapping on gear wheel icon in the upper right corner placed on main screen (same as for the stream settings). You can set one or multiple triggers depending on your preference, or expose all sensors at once to trigger the image capture based your defined threshold limits.

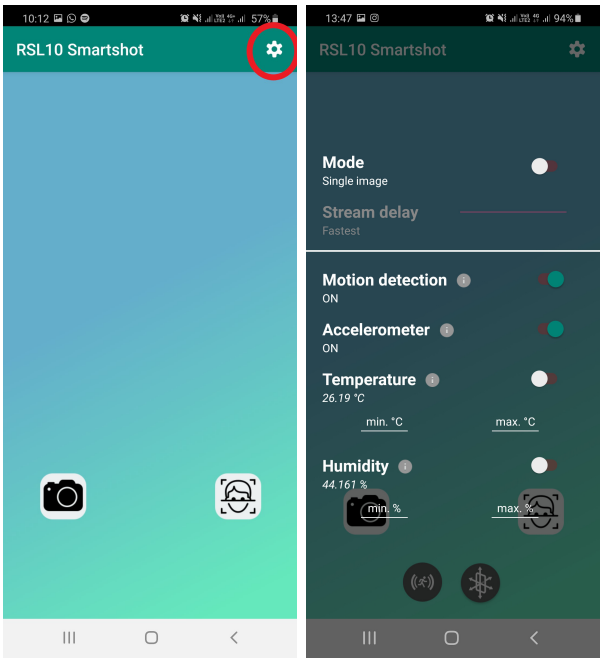


Figure 28. Image Streaming and Sensors Settings

The PIR sensor and accelerometer take a picture when the movement is detected, respectively acceleration. To set triggers for temperature and humidity, you have to enter a lower and upper limits for both values. If one of these limits are exceeded, the RSL10 Smartshot platform will take an image and notice for particular sensor will be displayed (Figure 29 – 32).

The use of sensors triggers is possible only in ”Single image” mode. The following sections describe the settings of each trigger. You can also find tips in the option menu by tap on information icons.

Motion Detection

By switching on “Motion detection” and hiding option menu, board starts to detect of motion by PIR sensor placed on RSL10 Smartshot platform. Board takes a picture and send captured data (image) to the app.



Figure 29. Motion Detection Trigger

The app will notify of a received image by the blinking motion icon. Minimal time between two detection is 5 seconds.

Acceleration Detection

By switching on “Accelerometer” and hiding the option menu, the platform starts to detect change of acceleration. The platform takes a picture and sends the captured data (image) to the app (Figure 30).



Figure 30. Accelerometer Detection Trigger

The app will confirm that an image has been received with the blinking of the accelerometer icon; the minimal time between detection is 5 seconds.

Temperature Detection

The function of the temperature trigger needs two limits or boundaries, lower and upper, which define monitored interval. The current temperature value is displayed below the temperature label. You can also enter temperature limits with a maximum of two decimal places.

After enter minimal and maximal values, switch on the button and hiding option menu, and the temperature trigger will become active (Figure 31).

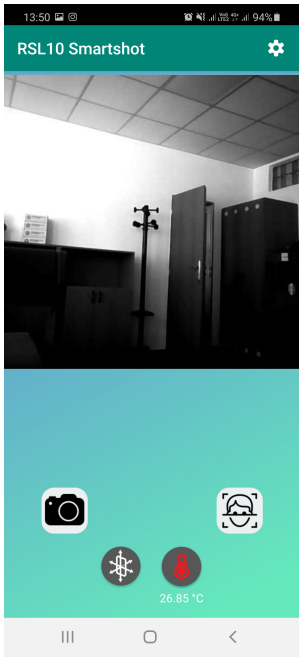


Figure 31. Temperature Thresholds Detection Trigger

If temperature crosses the lower limit, the RSL10 Smart Shot will take an image and display the temperature icon in blue. Likewise, the icon will be displayed in red if the upper limit has been exceeded. The minimum time between detection is 5 seconds.

In cases when value crosses the limit closely, the RSL10 Smartshot app may not notice crossing the same limit backward. For example, the upper limit is set to 25°C. If the temperature exceeds the limit over 25.1°, the RSL10 Smart Shot will take a picture. However, if the temperature crosses the upper limit backward by value 24.95°C, the RSL10 Smart Shot will not notice. This is caused by time between detections and taking a picture.

In the opposite case, when temperature is increasing/decreasing rapidly, there may be a large difference between the limit and the value that has exceeded the limit. For example, if the limit is set to 25°C and the detected value is 35°C, 35°C is recognized as the first value that crossed the limit.

Humidity Detection

The humidity trigger function needs two limits or boundaries, lower and upper, which define monitored interval. The current humidity value is displayed below the humidity label. You can set the humidity limits with a maximum three decimal places.

After entering the minimal and maximal values, switch on the button and hide the option menu to activate the humidity trigger active. The humidity trigger can be set between 0 to 100%.

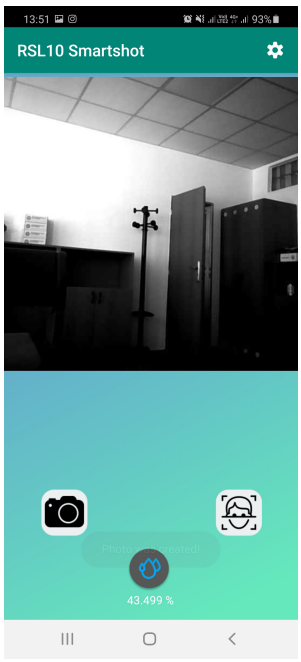


Figure 32. Humidity Detection Trigger

If humidity crosses the lower limit, the RSL10 Smart Shot Camera takes an image and displays the humidity icon in blue. Blue indicates that the lower limit has been crossed. If the upper limit has been exceeded, the humidity icon will be displayed in red.

Minimal time between two detections is 5 seconds.

In cases, when value crosses the limit closely, the RSL10 Smartshot app may not notice crossing the same limit backward. For example, if the upper limit is set to 40% and the humidity level crosses the limit by 40.08%, the RSL10 Smart Shot will take a picture. If humidity crosses the upper limit backward by value 39.97%, the RSL10 Smart Shot will not notice. This is caused by time between two detection and taking a picture.

In the opposite case, when humidity is increasing/decreasing rapidly, may be a large difference between the limit and the value that has exceeded the limit. For example, if the limit is set to 40% and the detected value is 65.4%, 65.4% is the first value that has crossed the limit.

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