Kneron Inc

Document Name: **Application Sample User Guide**

Application Sample User Guide
Kneron Inc
Engineering Design Document

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1 Introduction

The purpose of this document is to help user to bring up the Kneron sample code on development board. This sample code is application for Face Detection (FD) and Face Recognition (FR). You will need to programming the flash image to our EVB flash first. The flash image includes the SCPU/NCPU firmware and models for FD/FR. After flash programming, user can use Kneorn host_lib sample code command to demo the Face Detection and Face Recognition on Host.

2 Reference

KDP Flash Programming Guide,
KDP Host library software design

3 Acronyms, Abbreviations, Definitions

SPI – Serial Peripheral Interface
USB – Universal Serial Bus
UART – Universal Asynchronous Receiver-Transmitter

4   Reference Designs

Some reference designs are available in the SDK.

Please be noted that a standard flow should be followed
1.   Go to the reference design workspace
2.   Compile the whole workspace
3.   Run flash programming process. Ref: *KL520 Flash_Management.pdf*
4.   Boot from SPI
5.   Follow corresponding manual to enjoy the reference design
     Ref: *KL520 Host library software design.pdf*

4.1 Companion Reference Design

Companion reference design is composed of KL520 and a PC program run on a PC(host) with linux
installed. Host program submits trigger/commands and images to KL520 for process one by one, and
KL520 returns results back to host via USB cable. 2D/LW3D/DME/OTA functions are demonstrated with
Kneron Host Library examples.
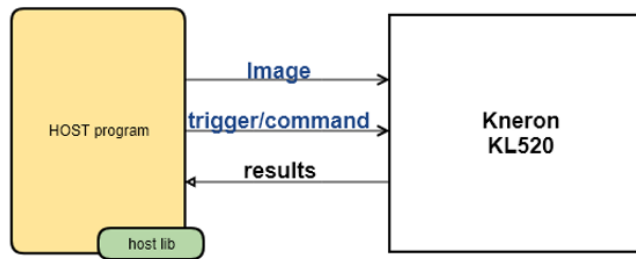
4.1.1 Build and Run Host Library Sample code

The host_lib sample code is designed for Linux. Please build the sample code under Linux. (Demo
environment: **Ubuntu 18.04** and **libusb** driver)

● **Requirement Packages**
Requirement package: gcc, g++, cmake and libusb-1.0-0-dev

```
sudo apt install gcc g++ cmake libusb-1.0-0-dev
```

● **Build Sample Code**
1.   Enter host_lib folder
2.   Modified image file location in the sample code. (file format is RGB565)
3.   Edit your g++ environment path in the build.sh
4.   Build host_lib sample code under Linux

```
chmod  +x build.sh
./build.sh
```

● **Run and verify FD/FR host sample code**
After compile the sample code, you can see the following output program.
(1) reguser: register user id
       ex: reguser 3 (register user id 3)
(2) veruser: user image inference

ex: ./veruser (return id=3 if the FD/FR inference successfully)
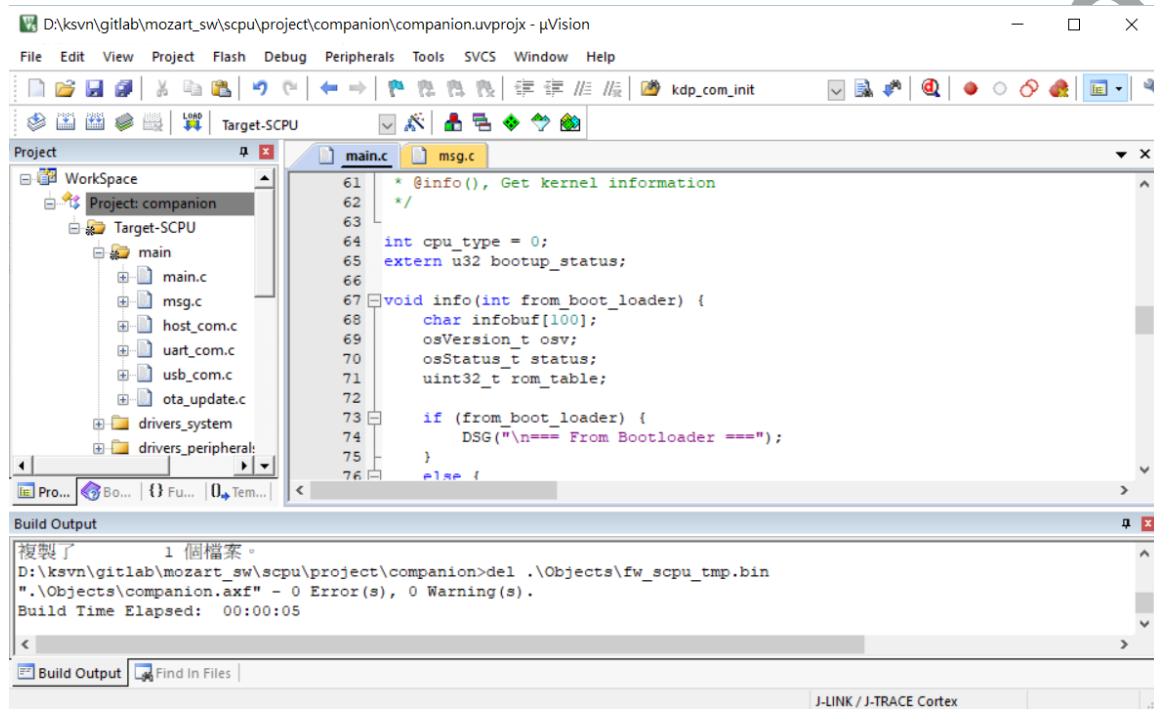(3) deluser: delete all user database

4.1.2 **Run Keil MDK to compile reference design**

Open workspace file ".\example_projects\companion\workspace.uvmpw".

User can edit and debug with Keil MDK development tool for further implementation
https://www2.keil.com/mdk5/docs.

4.1.3 **Flash Program for Compiled Bin File**

Image: *kl520_sdk/image/flash_fdfr_image_companion.bin*

Ref: *KL520 Flash_Management.pdf*

4.1.4 **Turn on KL520**

- All PFC connection must be removed. Both sensor and DVP FPC connector.
- Connect USB
- Power-on KL520
- Press PTN button
- Select "1" to boot from SPI

4.1.5 **Run FD/FR host_lib sample programs**

- Ref: **Run and verify FD/FR host sample code**, in section **4.1.1**

4.2 Host-Mode Reference Design

Host-Mode reference design demonstrated standalone usage which is composed of 2 camera MIPI sensor and one DVP display screen. A door entry simple system is demonstrated with Kneron LW3D algorithm. Face registration, face recognition and a simple database application are available.
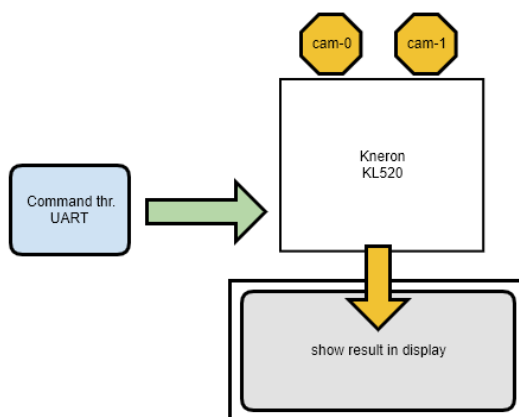
4.2.1 Run Keil MDK to compile reference design

Open workspace file ".\example_projects\host_mode\workspace.uvmpw".

User can edit and debug with Keil MDK development tool for further implementation https://www2.keil.com/mdk5/docs.

4.2.2 Flash Program for Compiled Bin File

Image: *kl520_sdk/image/flash_fdfr_image_host_mode.bin*

Ref: *KL520 Flash_Management.pdf*

4.2.3 Turn on KL520

- Connect both sensors and DVP display via FPC connector
- Remove USB cable if connected
- Power-on KL520
- Press PTN button
- Select "1" to boot from SPI

4.2.4 Host-Mode Reference Design Usage

Result shown in display http://eip.kneron.com:8080/redmine/issues/4255

Color rectangle frame description

GREEN rectangle	Everything is ok
	(Camera image matches with registered information)
YELLOW rectangle	LW3D fail
	(Camera image matches with registered information, but maybe NIR LED distance is too long > 70cm or < 30cm)

RED rectangle	Not registered user

Note: Valid NIR LED distance is around 30cm only.
RGB image format: RGB565
NIR image format: RAW8

Available commands:

=== Klp520 sample app console Test Kit (18) ===
(1) Combo: Prepare RGB/NIR Inference
(2) Combo: Close RGB/NIR/PANEL Display
(3) Switch camera source on display
(4) Start face recognition
(5) Stop face recognition
(6) Manual register user face
(7) Auto register user face
(8) Auto register 5 position face
(9) Abort registration record
(10) Add user face to database
(11) Delete user face from database
(12) Delete all user faces from database
(13) Stability recognition test
(14) Get system information
(15) Change draw FDR result mode
(16) open NIR led
(17) close NIR led
(18) Quit command >>

Note:
(1) After boot-up procedure, host mode application on kl520 will NOT open any cameras and display as default for saving power consumption.
(2) Perform command (1), (4), (5), (7), (8), (9), (10), (11), (12) and (13) will automatically open RGB + NIR cameras and display, refer to the command usage for the detailed information below.

4-2-4-1 Combo: Prepare RGB/NIR Inference (Console command 1)

[Description]

This console command is used to initialize/open RGB + NIR cameras, display and initialize user database.

[Usage]

If cameras and display driver aren't initialized/opened yet, type command 1 on your terminal emulator (ex: Tera Term).

[Except Result]

See the display preview from RGB camera source.

Note:
1. This command is mainly to verify the functionality of RGB camera, NIR camera and display sensor.
2. If you want to close RGB camera, NIR camera and display sensor, please refer to *4-2-4-2 Combo: Close RGB/NIR/PANEL (Console command 2)*.
3. If you want to see the display preview from NIR camera source, please refer to *4-2-4-3 Switch camera source which shows on display (Console command 3)*.
4. If you want to run user face recognition, please refer to *4-2-4-4 Start face recognition (Console command 4)*.

4-2-4-2 Combo: Close RGB/NIR/PANEL Display (Console command 2)

[Description]

This console command is used to stop/close RGB + NIR cameras and display sensors.

[Usage]

If RGB + NIR cameras and display driver are already initialized/opened, type command 2 on your terminal emulator (ex: Tera Term).

[Except Result]

Will NOT see the display preview from RGB or NIR camera.

4-2-4-3 Switch camera source on display (Console command 3)

[Description]

This console command is used to switch display preview from different camera sources.

[Usage]

If RGB + NIR cameras and display driver are already initialized/opened, type command 3 on your terminal emulator (ex: Tera Term).

[Except Result]

If you can see display preview from RGB camera, after you type command 3, then you can see display preview from NIR camera, and vice versa.

Note:
1. This command is mainly used to make sure if LW3D failure belongs to algorithm issue or device issue.
2. Known issue is that longer MIPI cable (30 cm) for NIR camera will get the fuzzy NIR capture image.

4-2-4-4 Start face recognition (Console command 4)

[Description]

This console command is used to start face recognition.

[Usage]

If RGB + NIR cameras and display driver are already initialized/opened, and you can see the display preview from RGB camera, type command 4 on your terminal emulator (ex: Tera Term).
If cameras and display driver aren't initialized/opened yet, type command 4 on your terminal emulator (ex: Tera Term), this command will also automatically initialize/open RGB + NIR cameras and display driver.

[Except Result]

After RGB + NIR cameras and display driver are already initialized/opened, you will see colorful rectangle bounding-box on your face on the display review during the face recognition. Colorful bounding-box can refer to *Color rectangle frame description* in *4.2.4 Host-Mode Reference Design Usage*.

Note:
1. For the better performance, recommend user to stay in indoor environment without backlight, and keep neutral facial expression which also as the same registration in database.
2. For the better performance, recommend user NOT stay in complete darkness or only with lightly light, keep your face can be clearly showed on the display preview.
3. For the better performance, stay distance in front of the display preview should be 30~70 cm.
4. If you want to stop user face recognition but RBG + NIR cameras and panel display will still work, please refer to *4-2-4-5 Stop face recognition (Console command 5)*.
5. If you want to stop user face recognition, also stop/close RGB + NIR cameras and panel display, please refer to *4-2-4-2 Combo: Close RGB/NIR/PANEL (Console command 2)*.

4-2-4-5 Stop face recognition (Console command 5)

[Description]

This command is used to stop face recognition.

[Usage]

If you already run *4-2-4-4 Start face recognition (Console command 4)*, type command 5 on your terminal emulator (ex: Tera Term).

[Except Result]

You will NOT see any bounding-box on your face on the display preview.

Note:
1. Even if RGB + NIR cameras and display driver aren't initialized/opened yet, type command 5 on your terminal emulator (ex: Tera Term), RGB + NIR cameras and display driver will be initialized/opened for ready to do user face recognition.
2. If you want to stop user face recognition, also stop/close RGB + NIR cameras and panel display, please refer to *4-2-4-2 Combo: Close RGB/NIR/PANEL (Console command 2)*.
3. If you want to run user face recognition again, please refer to *4-2-4-4 Start face recognition (Console command 4)*.

4-2-4-6 Manual Register user face (Console command 6)

[Description]

This command is used to register user face manually.

[Usage]

After run *4-2-4-1 Combo: Prepare RGB/NIR Inference (Console command 1)*, and you can see the display preview from RGB camera source, type command 6 on your terminal emulator (ex: Tera Term).

[Except Result]

After type *4-2-4-6 Register user face (Console command 6)*, you can see the following hint message on your terminal emulator (ex: Tera Term).

```
command >> 6
 try to register index 0, remaining fmap_cnt 5
 Assign UID=0, ready to capture image(5) to register, Y/N?
```

From console hint message, user can see how many images can be registered, and KL520 will automatically generate and assign UID.

User should type **"y"** or "Y" to capture an image to register or type **"n"** or "N" to finish the user face registration.

After you type **"y"** or "Y" to capture an image to register, if this step is successful, you can see the [registration] : -- OK! log message on your terminal emulator (ex: Tera Term) as below, and remaining capture images will minus one.

```
command >> 6
 try to register index 0, remaining fmap_cnt 5
 Assign UID=0, ready to capture image(5) to register, Y/N? y
[registration] : -- OK!

 try to register index 0, remaining fmap_cnt 4
 Assign UID=0, ready to capture image(4) to register, Y/N?
```

After you type **"y"** or "Y" to capture an image to register, if this step is failure, you can see the [registration] : -- ERROR!, err=0x101 log message on your terminal emulator (ex: Tera Term) as below. That means there is no any user on the display preview or user doesn't keep neutral facial expression or user face can't be clearly saw on the display preview.

```
try to register index 0, remaining fmap_cnt 4
 Assign UID=0, ready to capture image(4) to register, Y/N? y
[registration] : -- ERROR!, err=0x101
```

Note:
1. 1-5 image captures are accepted.
2. For the better registration, recommend user to stay in indoor environment without backlight.
3. For the better registration, recommend user NOT stay in complete darkness or only with lightly light, keep your face can be clearly showed on the display preview.
4. For the better registration, stay distance in front of the display preview should be 30~70 cm.
5. If you want to stop register user face manually, type **"n"** or "N" to finish the user face registration.
6. After finish the registration of user face, you need to run *4-2-4-11 Add user face (Console command 11)* to add this registration into database to be valid.
7. If you already run *4-2-4-4 Start face recognition (Console command 4)*, then you should run *4-2-4-5 Stop face recognition (Console command 5)* to stop user face recognition first.
8. Recommend user to register user face with different degrees (around 15 degree) each time.
9. If you want to abort this registration, please refer to *4-2-4-10 Abort register user face (Console command 10)*.

4-2-4-7 Auto-register user face (Console command 7)
[Description]
This command is used to register user face automatically by RGB image capture.

[Usage]
After run *4-2-4-1 Combo: Prepare RGB/NIR Inference (Console command 1)*, and you can see the display preview from RGB camera source, type command 7 on your terminal emulator (ex: Tera Term), and then you should move your face slowly with different degrees (around 15 degree).

[Except Result]
KL520 will automatically calculate the best pose to register as illustration below, and KL520 will automatically generate and assign UID.

```
command >> 7
 Start Auto Register for UID:0! (Move Your Face Slowly)
.................[inference 579] FD result : NO FACE
.. Done
 Registration confrim for id 0!
 check for best pose!
 best pose index 16 1 14 0 12!
```

If you don't stay in front of the cameras, you will see the following log messages to hint to move your face to be in front of the cameras.

```
[inference 579] FD result : NO FACE
```

Note:
1. For the better registration, recommend user to stay in indoor environment without backlight.
2. For the better registration, recommend user NOT stay in complete darkness or only with lightly light, keep your face can be clearly showed on the display preview.
3. After finish the registration of user face, you need to run *4-2-4-11 Add user face (Console command 11)* to add this registration into database to be valid.
4. If you already run *4-2-4-4 Start face recognition (Console command 4)*, then you should run *4-2-4-5 Stop face recognition (Console command 5)* to stop user face recognition first.
5. If you want to abort this registration, please refer to *4-2-4-10 Abort register user face (Console command 10)*.

4-2-4-8 Auto-register 5 face (Console command 9)

[Description]

This command is used to register user face automatically with 5 best face positions (central/left/right/up/down) by RGB image captures.

[Usage]

After run *4-2-4-1 Combo: Prepare RGB/NIR Inference (Console command 1)*, and you can see the display preview from RGB camera source, type command 8 on your terminal emulator (ex: Tera Term), and then you should move your face slowly with different 5 degrees(central/left/right/up/down).

[Except Result]

KL520 will automatically calculate the best 5 face positions and give the hint message on your terminal emulator (ex: Tera Term) to change your face degree as below, and KL520 will automatically generate and assign UID.

```
CENTER pose, please
LEFT pose, please
LEFT pose, please
LEFT pose, please
LEFT pose, please
LEFT pose, please
LEFT pose, please
LEFT pose, please
RIGHT pose, please
RIGHT pose, please
RIGHT pose, please
RIGHT pose, please
UP pose, please
UP pose, please
UP pose, please
UP pose, please
UP pose, please
DOWN pose, please
```

If you don't stay in front of the cameras, you will see the following log messages to hint to move your face to be in front of the cameras.

```
[inference 579] FD result : NO FACE
```

Note:
1. For the better registration, recommend user to stay in indoor environment without backlight.
2. For the better registration, recommend user NOT stay in complete darkness or only with lightly light, keep your face can be clearly showed on the display preview.
3. After finish the registration of user face, you need to run *4-2-4-11 Add user face (Console command 11)* to add this registration into database to be valid.
4. If you already run *4-2-4-4 Start face recognition (Console command 4)*, then you should run *4-2-4-5 Stop face recognition (Console command 5)* to stop user face recognition first.
5. If you want to abort this registration, please refer to *4-2-4-10 Abort register user face (Console command 10)*.
6. This is stricter registration than *4-2-4-7 Auto-register user face (Console command 7)* to avoid face recognition attach.

4-2-4-9 Abort register user face (Console command 9)

[Description]

This command is used to abort current registration record.

[Usage]

After succeed to run *4-2-4-6 Register user face (Console command 6)* or *4-2-4-7 Auto-register user face (Console command 7)* or *4-2-4-8 Auto-register 5 face (Console command 9)*, type command 9 on your terminal emulator (ex: Tera Term).

[Except Result]

After type *4-2-4-9 Abort register user face (Console command 9)*, you can see the following log message on your terminal emulator (ex: Tera Term) as below.

```
command >> 9
[cancel registration] -- OK!
```

Note:

1. Even if RGB + NIR cameras and display driver aren't initialized/opened yet, type command 9 on your terminal emulator (ex: Tera Term), RGB + NIR cameras and display driver will be initialized/opened for ready to do user face register.
2. This command will always get [cancel registration] -- OK! log message, because this command always abort current registration record, you can use *4-2-4-10 Add user face (Console command 10)* to verify if the current registration record is aborted.

4-2-4-10 Add user face (Console command 10)

[Description]

This command is used to add user face registration record from DDR to FLASH.

[Usage]

After succeed to run *4-2-4-6 Register user face (Console command 6)* or *4-2-4-7 Auto-register user face (Console command 7)* or *4-2-4-8 Auto-register 5 face (Console command 9)*, type command 10 on your terminal emulator (ex: Tera Term).

[Except Result]

After type *4-2-4-01 Add user face (Console command 11)*, you can see the following hint message on your terminal emulator (ex: Tera Term) as below if you have the current registration record.

```
command >> 10
[add_user] : UID:0, OK!
```

If you don't have the current registration record, then you will see the following error message.

```
command >> 10
[add_user] : UID:0, ERROR!, ret=204
```

Note:

1. Maximum user database stored in FLASH is 20.
2. KL520 will automatically generate and assign valid UID by sequential.

4-2-4-11 Delete user face (Console command 11)

[Description]

This command is used to delete specific user face which stored in FLASH.

[Usage]

If you succeed to run *4-2-4-10 Add user face (Console command 11)*, type command 11 on your terminal emulator (ex: Tera Term).

[Except Result]

If the specific user registration is actually stored in FLASH, and you type the correct user index on your terminal emulator (ex: Tera Term), then you can see the log messages as below.

```
command >> 11
 [del_user] Please enter 0 ~ 19 : 0
[delete user face] delete user face -- OK!
```

Otherwise, you will see the error message as below.

```
command >> 11
 [del_user] Please enter 0 ~ 19 : 2
[delete user face] delete user face -- ERROR, ret=206
```

And then you run *4-2-4-4 Start face recognition (Console command 4)*, you will only see RED bounding-box on your face.

4-2-4-12 Delete all user face (Console command 12)

[Description]

This command is used to delete all user faces which stored in FLASH.

[Usage]

Type command 13 on your terminal emulator (ex: Tera Term).

[Except Result]

After type *4-2-4-13 Delete all user face (Console command 12)*, you can see the console messages on your terminal emulator (ex: Tera Term) as below.

```
command >> 12
[delete user face] delete user face -- OK!
```

And then you run *4-2-4-4 Start face recognition (Console command 4)*, you will only see RED bounding-box on your face.

4-2-4-13 Stability face recognition test (Console command 13)

[Description]

This command is used to auto-run stability face recognition test for stress test overnight, kl520 system will open RGB + NIR cameras and run user face recognition for 3 seconds, and then stop user face recognition and close RGB + NIR cameras and display sensors, repeatedly auto-run above flow.

[Usage]

Type command 14 on your terminal emulator (ex: Tera Term).

[Except Result]

You will see kl520 system open RGB + NIR cameras and run user face recognition for 3 seconds, and then stop user face recognition and close RGB + NIR cameras and display sensors, repeatedly auto-run above flow and NEVER stop to run this stability recognition test until power off or reset the device.

4-2-4-14 Get system information (Console command 14)

[Description]

This command is used to print out the firmware version and sensor devices information.

[Usage]

Type command 14 on your terminal emulator (ex: Tera Term).

[Except Result]

After type *4-2-4-14 Get system information (Console command 14)*, you can see the console messages on your terminal emulator (ex: Tera Term) as below.

```
command >> 14
unique_id : 0x20b71003
boot loader version : 0x0
scpu firmware version : 0x90501
ncpu firmware version : 0x0
device name : sc132gs, id : 0x132
device name : gc2145, id : 0x2145
device name : nor flash, id : 0xef
device name : st7789v, id : 0x0
```

4-2-4-15 Change draw FDR result mode

[Description]

This command is used to change type of bounding-box during user face recognition.

There are three type of bounding-box"

(1) Only hint bounding-box

(2) Only user face recognition result bounding-box

(3) Hint + user face recognition result bounding-box

[Usage]

Type command 15 on your terminal emulator (ex: Tera Term).

[Except Result]

If you type 1 (Only hint boundingbox), then you can only see the hint bounding-box on four corners, and this hint bounding-box will show the difference color based on the result of user face recognition.

If you type 2 (Only fdfr result boundingbox), then you can only see the bounding-box on your face and without hint bounding-box on four corners, and this bounding-box will show the difference color based on the result of user face recognition.

If you type 3 (All boundingbox), then you can only see the bounding-box on your face and with hint bounding-box on four corners, and fdfr result bounding-box will show the difference color based on the result of user face recognition, and color of hint bounding-box will always be blue, this type of bounding-box is set as default.

```
command >> 15
 1(Only hint boundingbox)/2(Only fdfr result boundingbox)/3(All boundingbox). Please enter 1 ~ 3 :
```

4-2-4-16 Open NIR led (Console command 16)
[Description]
This command is used to open NIR led.

[Usage]
Type command 16 on your terminal emulator (ex: Tera Term).

[Except Result]
If you run *4-2-4-3 Switch camera source on display (Console command 3)* to show display preview from NIR camera source, you can see the lightness difference by run *4-2-4-16 Open NIR led (Console command 16)* and *4-2-4-17 Close NIR led (Console command 17)*.

4-2-4-17 Close NIR led (Console command 17)
[Description]
This command is used to close NIR led.

[Usage]
Type command 17 on your terminal emulator (ex: Tera Term).

[Except Result]
If you run *4-2-4-3 Switch camera source on display (Console command 3)* to show display preview from NIR camera source, you can see the lightness difference by run *4-2-4-16 Open NIR led (Console command 16)* and *4-2-4-17 Close NIR led (Console command 17)*.

4-2-4-18 Quit (Console command 18)
[Description]
This command is used to exit Kdp520 sample app console and shutdown whole system.

[Usage]
Type command 19 on your terminal emulator.

[Except Result]
You can see whole system is shutdown, and then whole system only RTC is active, you should press PTN button to wakeup system again.