USER GUIDE

Display Evaluation Kit
K_Beaglebone

for
4.0", 4.7", 4.9" and 10.7" displays
on Epson and Drivers-only platform

Valid for Evaluation Kit Part No.:
303003, 303005, 303007, 303011

Revision 1

February 15th 2018

Revision Status	Date	Author	Reason of Modification
1	15-Feb-2018	RP	Initial Version

Contents

1 About Plastic Logic's Display Evaluation Kit

Plastic Logic's Display Evaluation Kit (PLDEK, referred to as the "kit") has been designed to be used for a range of activities including:

1. Evaluating Plastic Logic's display technology.
2. Evaluating the appearance of customer and 3rd party content on Plastic Logic displays.
3. Building expertise with Plastic Logic Display systems prior to designing products or systems that incorporate our displays.
4. Application development.

2 About this document

This document is a user guide for the **Display Evaluation Kit**. It is only to be used for kits containing a BeagleBone and Falcon board. It is intended to give sufficient information to:

1. Safely unpack and power up the kit.
2. Start displaying images in png format.
3. Understand how to start using the Plastic Logic Software Development Kit (SDK).

3 Glossary of terms / abbreviations

COF	Chip On Flex. A packaging technology used by Plastic Logic for packaging source and gate driver chips.
Electrophoretic Display	An electrophoretic display typically consists of a layer of small capsules of fluid which also contains electrically charged dye particles. When an electric field is applied to the capsules, the dye particles will tend to move in a direction determined by the sign of the charge.
Display Controller	This part of the display system converts a target image which is due to be displayed into a sequence of sub-frames.
EPDC	Electrophoretic Display Controller
FPC	Flexible Printed Board
PLDEK	Plastic Logic Display Evaluation Kit
SDK	Software Development Kit
HVPMIC	High Voltage Power Management Integrated Circuit

4 Safety Instructions

Warning:

- **To avoid risk of electric shock or damage to the display, disconnect the display module from its power source before handling it.**
- **Do not touch the connections or circuits whilst the display is in operation.**

Caution:

- **Follow ESD handling procedures to avoid circuit damage. Use a grounded wrist strap.**
- **Do not press on the display panel or its edges as damage can result.**

Important Notice

The Plastic Logic Display Evaluation Kit ("the kit") is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by Plastic Logic to be a finished end-product fit for general consumer use. Persons handling the kit must have electronics training and observe good engineering practice standards. As such, the kit being provided is not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. The kit does not fall within the scope of the European directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

5 Supported Display Types

The PLDEK based on the Beaglebone Black Evaluation Kits support the following displays:

Evaluation Kits based on:	Display Type	Size & Resolution	Required Connector/Power Board
Falcon	S047_T2.1	4,7" 800x450px 196ppi	Hermes 4.0 (B_HM4)
	D107_T3.1	10.7" 1280x960px 150ppi	Hermes 3.0 (B_HM3)
Ruddock	S040_T1.1	4.0"400x240px	Hummingbird Z6 (C_HBZ6)
	S049_T1.1	4.9"720x120px	Hummingbird Z7 (C_HBZ7)

6 Supported Operating Systems

Windows 7 and Windows XP are the supported operating systems to control the kit remotely via SSH, FTP or a serial connection. All described procedures are based on a Windows 7 system.

7 Evaluation Kits for 4.7" and 10.7" displays

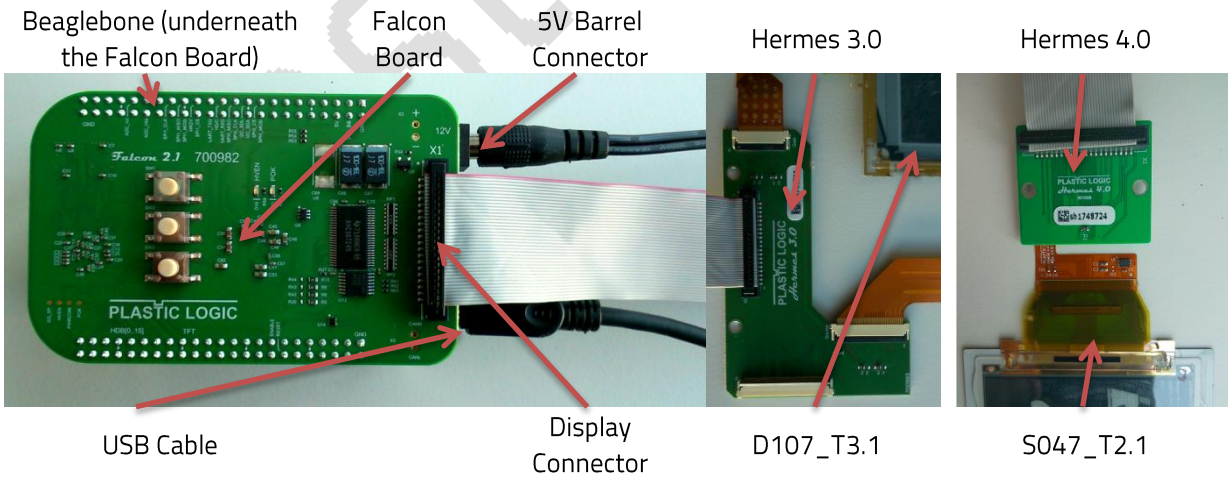
7.1 Getting Started

This Quick Start Guilde is a subset of the User Guide available on the PLDEK SD-Card.
Prior to unpacking the kit the user is required to take appropriate ESD and safety precautions!

7.2 Unpacking the Kit

The kit is shipped with the items listed in the table below. Ensure that the items listed have been included in your kit. Remove the kit from the anti-static bags and perform a visual inspection.

No.	Item	Description
1	Board 1	BeagleBone Evaluation Board
2	Board 2	Falcon Board
3	Board 3	Hermes 3.0 or Hermes 4.0 (depending on display type)
4	Flat Cable	Cable to connect the Display Adapter Board to the Falcon Board
5	Micro - SD Card	Contains operating system, slideshow images, display specific waveforms. The Micro-SD card is mounted in the socket of the Beaglebone.
6	Power supply	5.0V/2A power supply with regional adapters
7	USB cable	To connect the kit via the mini USB port with a PC
8	Flat cable	Cable to connect the Falcon board with the Hermes board



7.3 Connecting the Display with the Kit

Plug the display into the display connector of the Hermes connector board first. It is important to connect the display before powering up the kit to avoid damages of any parts!
Attention: Do not connect or disconnect a display during the kit is powered up!

8 Evaluation Kits for 4.0" and 4.9"displays

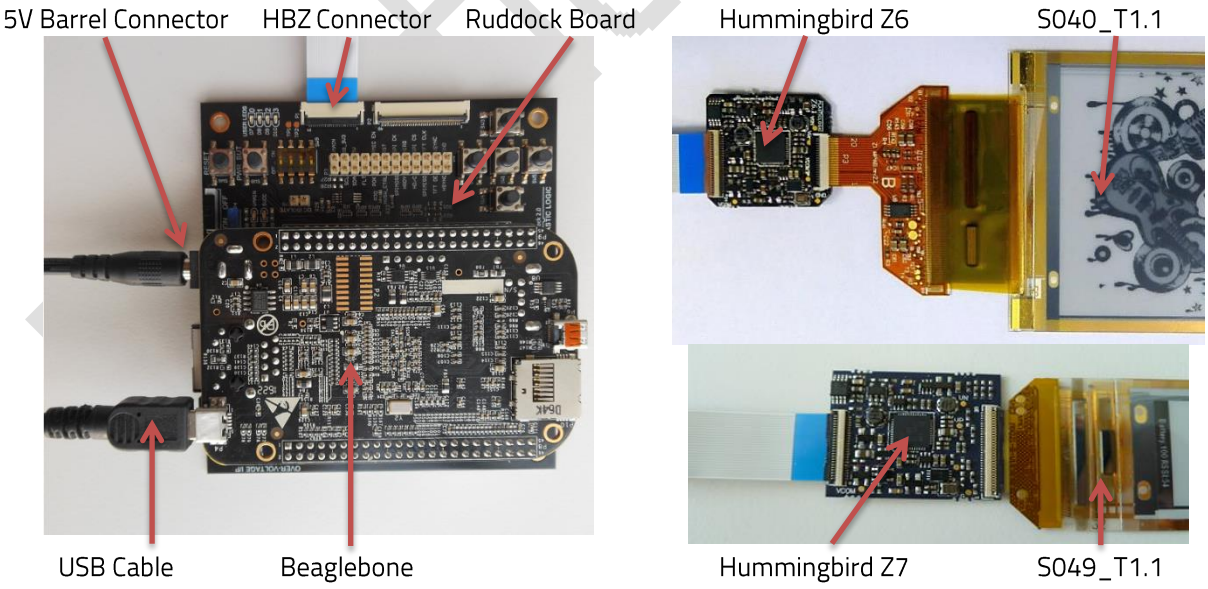
8.1 Getting Started

This Quick Start Guilde is a subset of the User Guide available on the PLDEK SD-Card.
Prior to unpacking the kit the user is required to take appropriate ESD and safety precautions!

8.2 Unpacking the Kit

The kit is shipped with the items listed in the table below. Ensure that the items listed have been included in your kit. Remove the kit from the anti-static bags and perform a visual inspection.

No.	Item	Description
1	Board 1	BeagleBone Evaluation Board
2	Board 2	Ruddock Board
3	Board 3	Hummingbird Z6 or Z7 (depending on display) Power Board
4	Flat Cable	Cable to connect the Display Adapter Board to the Ruddock Board
5	Micro - SD Card	Contains operating system, slideshow images, display specific waveforms.
6	Power supply	5.0V/2A power supply with regional adapters
7	USB cable	To connect the kit via the mini USB port with a PC



8.3 Connecting the Display with the Kit

Plug the display into the display connector of the Hummingbird board first. Then connect the Hummingbird with the Ruddock 2 Board through the 24pin flat flexi cable. Connect the Beaglebone to the Ruddock Board. It is important to connect the display before powering up the kit to avoid damages of any parts!
Attention: Do not connect or disconnect a display during the kit is powered up!

9 System Boot and Image Display

After the display is plugged in use the power supply (DC 5V/2A) to power up the kit. The image slideshow will start after a couple of seconds. Do not run the kit powered from USB only! This will cause errors and malfunction. Though the system boots the display is not going to operate correctly.

10 Starting the EPD

Once after startup or after significant changes to the configuration, it is needed to start the EPDC.

Use epdc-app –start_epdc [nvm-content] [clear screen]. The Parameters are optional. Set the clear screen option to 1 to clear the screen on epdc init.

11 Stopping and Starting the Slideshow

To start the slideshow use the command *slideshow-start.sh*. The slideshow will show the png-images in the images folder */boot/uboot/[DisplayType*]/img*.

The command *slideshow-stop.sh* stops the slideshow.

To enable the slideshow at startup use the command *slideshow-enable.sh*

To disable the slideshow at startup use the command *slideshow-disable.sh*

The slideshow scripts are located on the SD-Card (/boot/uboot/)epdc/bin.

12 Setting Waveform and VCOM

The Waveform and the VCOM are set in the config file epdc.config on the */boot/uboot/[DisplayType*]*

13 References

[1] www.chiark.greenend.org.uk/~sgtatham/putty/download.html

[2] http://beagleboard.org/Products/BeagleBone

*) See the available display types either on the SD-Card (Display data is stored in folders with the display type name) or in the table in section 4

14 Controlling the Kit from a PC

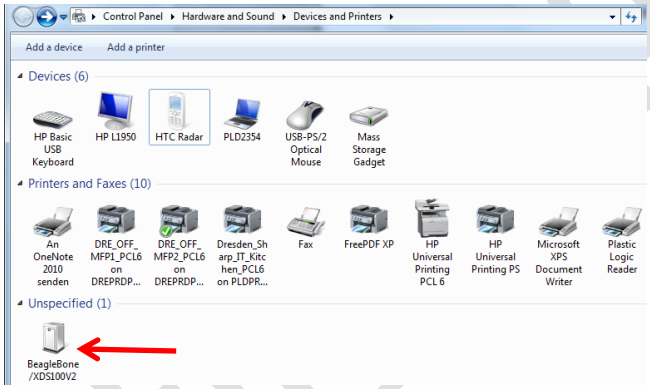
14.1 Connecting the Kit to a PC via USB

To control the kit remotely it is required to set up a connection. It is recommended to use a serial connection over USB. Plug in the included USB cable into the PC first. Plug in the cable into the kit afterwards.

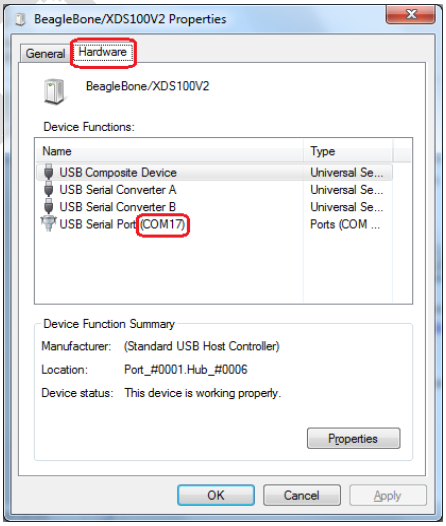
If the connection fails by some reason it is important to remove the mini USB cable from the kit and reconnect it.

Execute the following steps to establish the connection:

- Click on the Windows "Start" button and select "Devices and Printers".
- Double-Click "BeagleBone…".

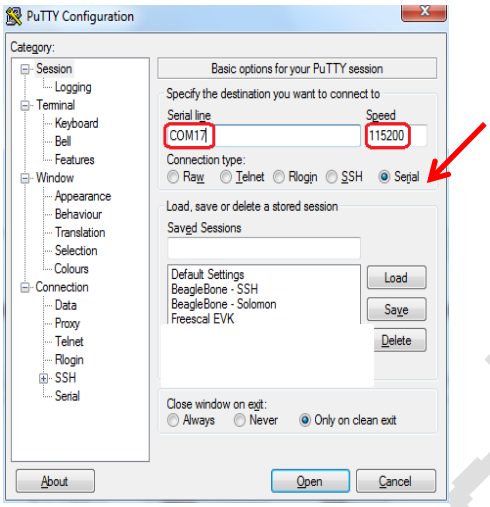


- Click the "Hardware" tab.
- Find out the COM port of the USB Serial Port.



- Use "PuTTY" to connect the PC to the kit. This is a free SSH implementation for Windows which also supports serial connections. It can be downloaded from: www.chiark.greenend.org.uk/~sgtatham/putty/download.html.

- Choose connection type “Serial” and configure the COM port and the speed (115200).

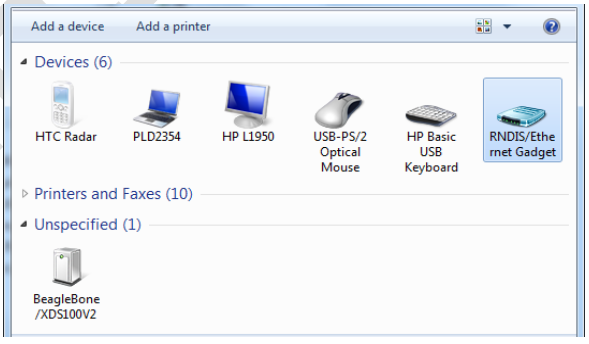


- Click “Open” and a terminal window will appear.
- Press “ENTER” and the Debian Linux login screen appears.
- Log in using the following credentials: login “root”, password “”.
- Now you are successfully logged-in and can use the shell.

15 Transferring Files

15.1 Ethernet via USB

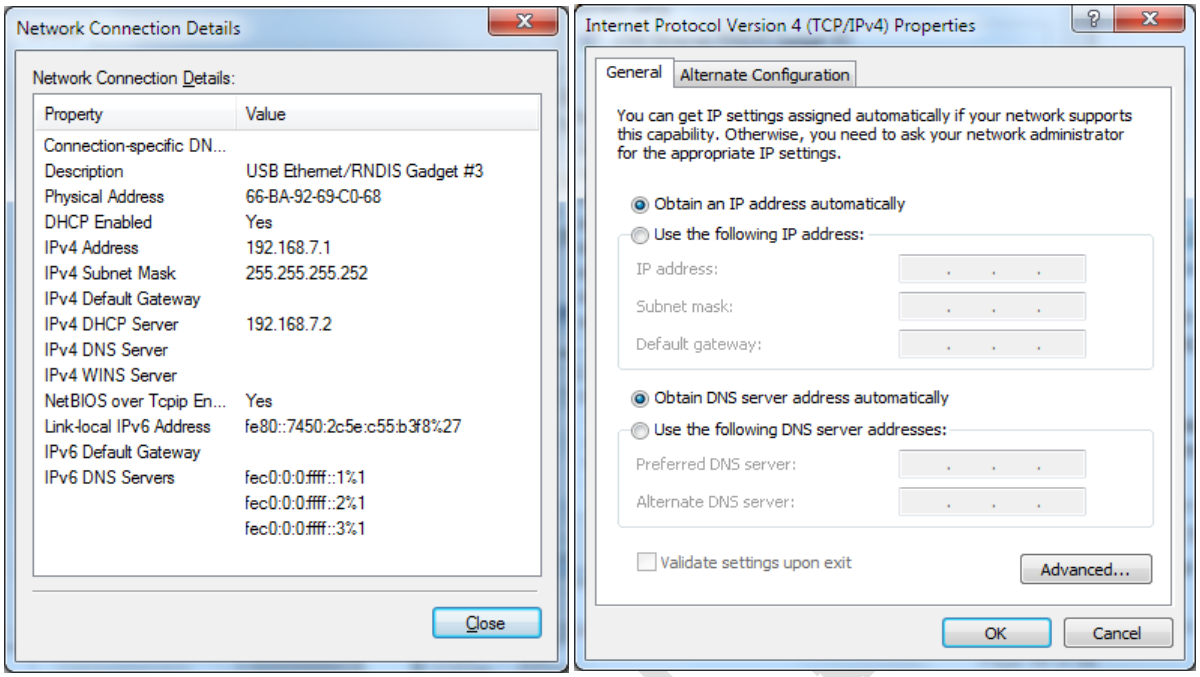
If the system is powered up and the slideshow is running connect the kit with the provided mini USB cable to your PC. Ethernet over USB will be enabled automatically on the kit after plugging in the USB cable. A USB Ethernet/RNDIS gadget will be installed on the PC automatically. This device can be found in the “Devices and Printers” dialog.



Now your Ethernet connection is enabled. The kit runs a DHCP server so that it is not required to change the network settings of the RNDIS/Ethernet Gadget on the PC. The kit uses the IP address *192.168.7.2* and the PC uses the IP address *192.168.7.1*.

Check the “Network and Sharing Center” to verify the network settings on the PC. Use “Change adapter settings” to list all available network connections. Open the local area connection which belongs to the USB Ethernet/RNDIS Gadget. Open “Details” to check the IP address which is actually used. Close the dialog and

open “Properties” and then open the “Internet Protocol Version 4” properties. This should have “Obtain an IP address automatically” selected.



With the Ethernet connection enabled the kit can be accessed via FTP and SSH. The FTP connection does not require a user or a password. The SSH connection uses the same credentials as the serial connection (login “root”, password “”).

15.2 Further Information

The “C_FN2” Evaluation kit is to be used to drive a wide variety of Plasticlogic displays. For detailed information on this components, please refer to their respective documentation.

Please remove the Micro-SD card from the switched off kit and insert it into a PC. Please check the folders “Source” and “Documentation” for further information.

The SD-Card content and source code can be found on github. Make sure to use the same version of both repositories.

15.2.1Change the display type

To change the display type, remove the SD-Card from the Beaglebones SD-Card slot and open the file config.txt with a text editor. Edit the line “display type [old Display Type]” to “display type [new Display Type]” and restart the application (epdc-app –start_epdc).

16 SD-Card Content

The PLDEK is preinstalled on the shipped SD-Card and runs out of the box. Since the PLDEK is installed on a standard BeagleBone image, there are a lot of files on the SD-Card which are not directly related to the PLDEK content. Furthermore the PLDEK-SD-Card is shared between the microcontroller platform and the

BeagleBone Platform, so some files on the SD-Card are necessary for the BeagleBone and not for the microcontroller, for not the BeagleBone and for the microcontroller or both.

Related files and folders are

- Display type folders like D107_T3.1 or S040_T1.1 with
  - bin:
  - display: contains display specific data like the waveform file and the vcom file (used not on the Beaglebone PLDEK)
  - Img: Contains slideshow images
  - epdc.config – file: Contains a wide range of basic and advanced settings.
- The epdc folder. This folder contains
  - bin: slideshow scripts, a setup and an autostart script
  - documentation: Documentation for the PLDEK and its components like user guide, technical explanations, schematics and the source code for the epdc-app.
- config.txt: Sets the display type only (for BeagleBone. This file also configures the microcontroller code)
- Note: In case one BeagleBone SD-Card is intedned to be used both on Ruddock and Falcon Board, the setup-environment.sh script must be changed to cover the hardware differences.
- Since the Ruddock Board uses SPI and the Falcon board uses the Epson Parallel Interface the SPIDEV0 device tree overlay must be loaded for Ruddock and must not be loaded for Falcon.

```
#!/bin/bash
set -e
#comment out for use with Falcon
echo BB-PL-SPIDEV0 > /sys/devices/bone_capemgr.*/slots
echo BB-PL-SPIDEV1 > /sys/devices/bone_capemgr.*/slots
export PATH=/boot/uboot/epdc/bin:$PATH
sleep 3
epdc-app -start_epdc 0 1
sleep 3
slideshow-start.sh
exit 0
```

The setup-environment.sh script

So the change of the config.txt file may require the setup-environment.sh script to be changed, too. This script is always called during startup from /etc/rc.local .

The epdc.config file contains detailed setup data for the display. In most cases no adjustment is necessary.

```
[version]
name = CONFIG_S040_T1.1

[display]
nvm = MICROCHIP_24AA256
nvm_format = S040
controller = S1D13541
temp_mode = MANUAL
```

```
instruction_code_file = "/boot/uboot/S040_T1.1/bin/Ecode.bin"
default_vcom = 4000
default_temp = 23
default_waveform = "/boot/uboot/S040_T1.1/display/waveform.bin"

[general]
driver_board = RUDDOCK
control_system = BEAGLEBONE_BLACK
spi_port = 1
epdc_spi_port = 1
nvm_spi_port = 1
DISPLAY_SCRAMBLE_CONFIG = 0

[vcom]
dac_x1      = 127 ; /* first DAC register value (25% of full scale) */
dac_y1      = 4172      ;   /* corresponding first voltage in mV */
dac_x2      = 382 ;   /* second DAC register value (75% of full scale) */
dac_y2      = 12490     ;   /* corresponding second voltage in mV */
vgpos_mv    = 25080     ;   /* VGPOS in mV */
vgneg_mv    =-32300     ;   /* VGNEG in mV */
swing_ideal = 56886

[hv_hardware]
hv_config_vgl = -32300
hv_config_vgh =  25080
hv_config_vsh =  15000
vcom_driver = NULL
vcom_config = TPS65185
hv_driver = GPIO
hv_config = TPS65185
hv_timing = TPS65185
vcom_switch = GPIO
TOFFSET_VGL_ON    =     8
TOFFSET_VSL_ON    =     2
TOFFSET_VSH_ON    =     11
TOFFSET_VGH_ON    =     3
TOFFSET_VGH_OFF   =     0
TOFFSET_VSH_OFF   =     0
TOFFSET_VSL_OFF   =     0
TOFFSET_VGL_OFF   =     0
```

The epdc.config for S040_T1.1

17 Software Overview

The epdc-app is a command line tool to interface with the Epson S1D135xx EPD-Controller on the Falcon or Ruddock Board and preinstalled on the SD-Card. It can be found on the rootfs in the folder /usr/bin/epdc-app. If the software is recompiled, it's necessary to replace the binary.

The source code is located on the SD-Card in the epdc/documentation folder (epdc-app.zip).

17.1 Steps to set up a customized slideshow

First of all check which display type is used. The commands may differ from display type to display type. In this example display type D107_T3.1 is used. It is also assumed that the SD-Card is mounted on a Windows PC on Disk E:\.

- Connect up the kit and make sure the Plasticlogic slideshow will run on boot.
- Power down the kit, remove the SD-Card from the slot of the Beaglebone and plug the SD-Card to a PC (use an adapter if your PC does not have a SD-Card slot).
- Browse to the folder E:\ D107_T3.1\img
- Copy the desired image files in the folder. Images should fit the display resolution, so for D107_T3.1 1280x960px. Refer to the display data sheet for the resolution of other display types.
- Remove the Plasticlogic images, if needed.
- Plug the SD-Card to the Beaglebone and power up the kit.
- Enjoy the slideshow

17.2 EPDC-Scripts

The slideshow and the enabler and disabler are simple shell scripts

17.2.1 $ slideshow_start.sh

```
#!/bin/sh

set -e

# do not run the slideshow if it is disabled
if [ -e /var/tmp/slideshow-disabled ]; then
    echo "Slideshow disabled"
    exit 1
fi

# remove the file which is used to stop the slideshow
rm -f /var/tmp/slideshow-stop

# persist cached changes of file system
sync

# run the slideshow
while true; do
      for f in /var/tmp/slideshow/*.png; do
            if [ -e /var/tmp/slideshow-stop ]
            then
```

```
                    echo "Stopping slideshow"
                    exit 1
                fi
                epdc-app -update_image $f > /dev/null
                sleep 3
        done
done
exit 0
```

17.2.2 $ slideshow-stop.sh

```
#!/bin/sh

touch /var/tmp/slideshow-stop
sync
```

17.2.3 $ slideshow-select [display-type]

```
#!/bin/sh

set -e

IMG_ROOT=/boot/uboot

display_type="$1"

[ -z "display_type" ] && {
    echo "Error: no directory specified"
    exit 1
}

dir="$IMG_ROOT/$display_type/img"

[ -d "$dir" ] || {
    echo "Invalid directory: $dir"
    exit 1
}

echo "Slideshow directory: $dir"

rm -f /var/tmp/slideshow
ln -s "$dir" /var/tmp/slideshow
sync

exit 0
```

17.2.4 $ slideshow-enable.sh

```
#!/bin/sh

rm -f /var/tmp/slideshow-disabled
sync
```

17.2.5 $ slideshow-disable.sh

```
#!/bin/sh

touch /var/tmp/slideshow-disabled
sync
```

17.2.6 $ setup-environment.sh

```
#!/bin/bash
set -e
#comment out for use with Falcon
#echo BB-PL-SPIDEV0 > /sys/devices/bone_capemgr.*/slots
echo BB-PL-SPIDEV1 > /sys/devices/bone_capemgr.*/slots
export PATH=/boot/uboot/epdc/bin:$PATH
sleep 3
epdc-app -start_epdc 0 1
sleep 3
slideshow-start.sh
exit 0
```

17.3 Troubleshooting

If the PLDEK is not showing the slideshow on startup, there are a set of steps to sort out what went wrong:

- Check if the Beaglebone is powered correctly. Is the heartbeat LED blinking?
- Check if all connections are properly set up and that the SD-Card is fitted to the SD-Card-Slot
- Check if you can access the Beaglebone's command line.
    - SSH to the Beaglebone (i.e. using PuTTY):
        - Use the USB-Cable and connect to 192.168.7.2:22 or
        - Use the UART-Port to connect to the serial console
- Check if the Beaglebone booted correctly
    - `$ dmesg` will show all messages during the boot process. Check for errors on module load and if the device tree overlays applied correctly
- Check if the process epdc-app is running `$ps aux | grep epdc-app`
    - If it is running, kill the process and restart the epdc-app.
    - If not, just restart the epdc-app `$epdc-app -start_epdc 1 1`
    - In case of errors please contact techsupport@plasticlogic.com and specify what was tried and where it failed with which error.
- Check if the slideshow is running correctly:
    - Check if the slideshow starts and if it stops check the image which did not show up correctly.
- Check if the autostart- and slideshow-scripts are in place and enabled.
    - **Note: Unfortunately the SD-Card might be damaged if the Beaglebone is not powered down correctly. That can lead to booting problems.**
    - `$ ls /var/lib/systemd/system/ | grep slideshow`
    - `$ ls /boot/uboot/epdc/bin/ | grep slideshow`
- If nothing seems to work or in case of any other trouble with the kit, please contact **techsupport@plasticlogic.com**

17.4 Epdc-app help

```
epdc-app software help:

Usage:          epdc-app [operation] [parameter] --> executes an operation
                epdc-app [operation] --help   --> prints detailed help
                epdc-app [operation] --help -all --> prints complete help at once
Available Operations:
                -start_epdc: initializes the EPD controller
                -stop_epdc: de-initializes the EPD controller
                -set_vcom: sets com voltage
                -set_waveform: sets the waveform
                -set_temperature: sets the temperature
                -update_image: updates the display
                -slideshow: shows a slidshow of .png images
                -send_cmd: sends a command of EPD controller
                -write_reg: writes to a register of EPD controller
                -read_reg: reads from a register of EPD controller
                -info: displays general display informations
                -switch_hv: switches hv on/off based on parameter
                -version: displays version info
                --help: prints this help message

Detailed Operation Description:

         -start_epdc: initializes the EPD controller
                Activates and initializes the EPD controller.
                Usage: epdc-app -start_epdc [<nvm_flag> [ <clear_flag> ]]]
                <nvm_flag>     if 0 = override of waveform and vcom enabled (default).
                               if 1 = override disabled, use settings from NV memory.
                <clear_flag>   if 0 = display will not be cleared. (default)
                               if 1 = display will be cleared with default clear operation.
        -stop_epdc: de-initializes the EPD controller
                De-initializes the EPD controller.
                Usage: epdc-app -stop_epdc
        -set_vcom: sets com voltage
                Sets the Vcom voltage.
                Usage: epdc-app -set_vcom <voltage>
                <voltage>:com voltage in volts.
        -set_waveform: sets the waveform
                Sets the waveform used for later update operations.
                Usage: epdc-app -set_waveform <waveform> <temp>
                       <waveform> :path to the waveform file.
                       <temp> :Temperature in degree celsius.
        -set_temperature: sets the temperature
                Sets the temperature.
                Usage: epdc-app -set_temperature <temp>
                       <temp> :Temperature in degree celsius.
        -update_image: updates the display
                Updates the display with a given image.
                Usage: epdc-app -update_image <image>
                       <image> :      path to the image file.
                       <wfID>         :       id of the used waveform id.
                       <updateMode>   :       id of the used update mode.
                       <updateCount>   :      count of image updates to execute.
                       <waitTime>     :       time to wait after each image update [ms].
                       <vcomSwitchEnable>:    automatic vcom switch enable: 0=disable/1=enable.
        -slideshow: shows a slidshow of .png images
                Updates the display with a slideshow of a given path.
                Usage: epdc-app -slideshow <image path>
                       <image path>   :       path to the image files.
                       <wfID>         :       id of the used waveform id.
                       <waitTime>     :       time to wait after each image update [us].
        -send_cmd: sends a command of EPD controller
                Sends a command with specified arguments to the EPD controller.
```

```
        Usage: epdc-app -send_cmd <cmd> <datacount> <data> [bitmask]
               <cmd> :  specifies the cmd to be executed.
               <datacount>    optional paraetmer, specifies the amount of data portions
                              to be written.
               <data>         optional parameter, arguments to be send. Data portions
                              must beseparated by commata (',').
-write_reg: writes to a register of EPD controller
       Writes to a specified register of the EPD controller.
       Usage: epdc-app -write_reg <reg_addr> <datacount> <data> [bitmask]
               <reg_addr>     :specifies the address of the register where the data is
                              written.
               <datacount>    :specifies the amount of data portions to be written.
               <data>         :The data to be written. Data portions must be separated
                              by commata (',').
                              Data should be given as one string without any spaces.
               <bitmask>      :optional parameter, which can mask out bits from write
                              operation.
 -read_reg: reads from a register of EPD controller
       Reads from a specified register of the EPD controller and prints the values to
       the shell.
       Usage: epdc-app -read_reg <reg_addr> <datacount>
               <reg_addr>     :specifies the address of the register to be read.
               <datacount>    :specifies the amount of data portions to be read.
 -info: displays general display informations
       Displays general display informations.
       Usage: epdc-app –info

-switch_hv: switches hv on/off based on parameter
       Switches HV on/off based on parameter.
       Usage: epdc-app -hv <state>
               <state>         : 0 = off; 1= on.
```