



StarFive
赛昉科技

JH7110 HDMI Developing Guide

VisionFive 2

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Legal Statements

Important legal notice before reading this documentation.

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Preface

About this guide and technical support information.

About this document

This document mainly provides the SDK developers with the programming basics and debugging know-how for the HDMI of the StarFive next generation SoC platform - JH7110.

Audience

This document mainly serves the HDMI relevant driver developers. If you are developing other modules, place a request to your sales or support consultant for our complete documentation set on JH7110.






Revision History

Table 0-1 Revision History

Version	Released	Revision
1.0		First official release.

Notes and notices

The following notes and notices might appear in this guide:

-  **Tip:**
Suggests how to apply the information in a topic or step.
-  **Note:**
Explains a special case or expands on an important point.
-  **Important:**
Points out critical information concerning a topic or step.
-  **CAUTION:**
Indicates that an action or step can cause loss of data, security problems, or performance issues.
-  **Warning:**
Indicates that an action or step can result in physical harm or cause damage to hardware.

1. Introduction

The display subsystem, named as dom_vout_top in the JH7110 system, includes front-end video data capture, display controller and display interface, such as RGB IF, HDMI and MIPI.

In the display subsystem, *High Definition Multimedia Interface (HDMI)* is used to transmit high quality video and audio data, with the transmission speed up to 5 Gbps. Before HDMI data transmission, no analog/digital data transformation is required, its simplicity ensures the highest quality signal transmission especially for high definition movies and musics.

See [Block Diagram \(on page 7\)](#) for more information.

1.1. Function Introduction

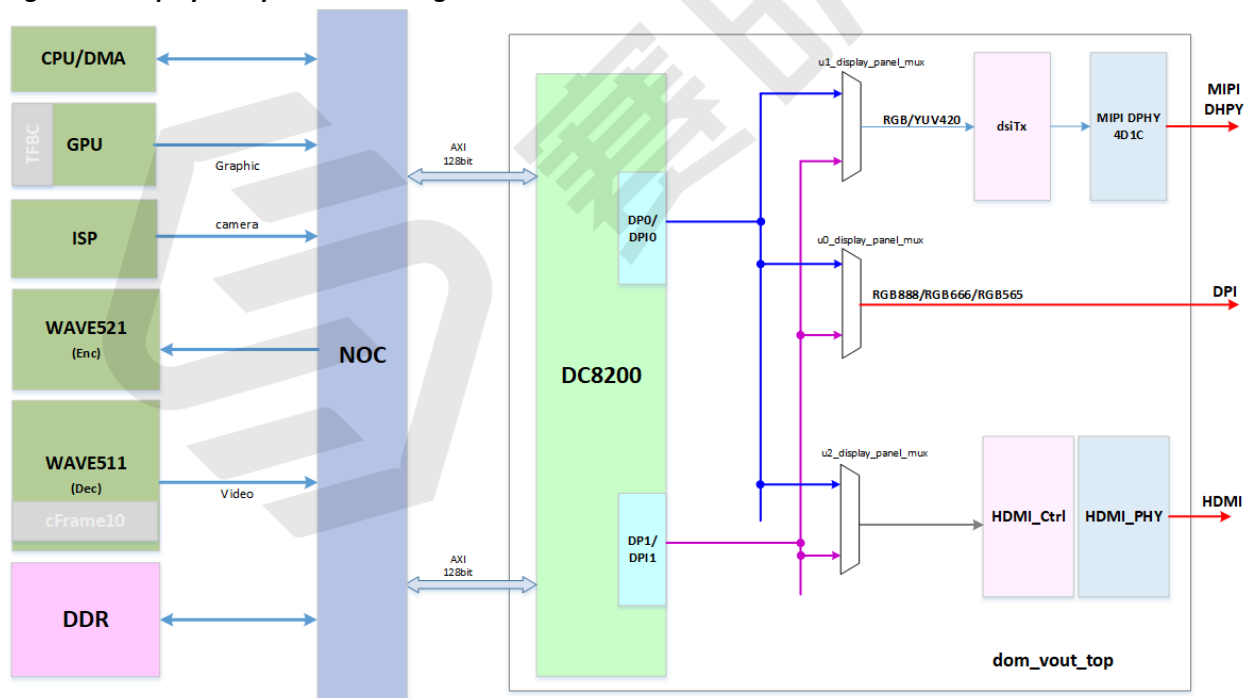
The JH7110 SoC Platform supports the following features and specifications on the HDMI2.0 interface.

- Support 4K, 1080p, 720p, 480p and other common resolutions.
- Support YUV444, YUV420, RGB444 and other common formats.
- Support 8-bit color width.
- Support BIST mode.
- Standard I2C communication.

1.2. Block Diagram

The block diagram of the display subsystem is displayed in following diagram.

Figure 1-1 Display Subsystem Block Diagram



Data Mapping

The DSI transmitter's pixel data could be from panel 0 or panel 1 interface of DC8200, and could be selected from DP or DPI interface. The RGB PAD and HDMI have similar mechanism.

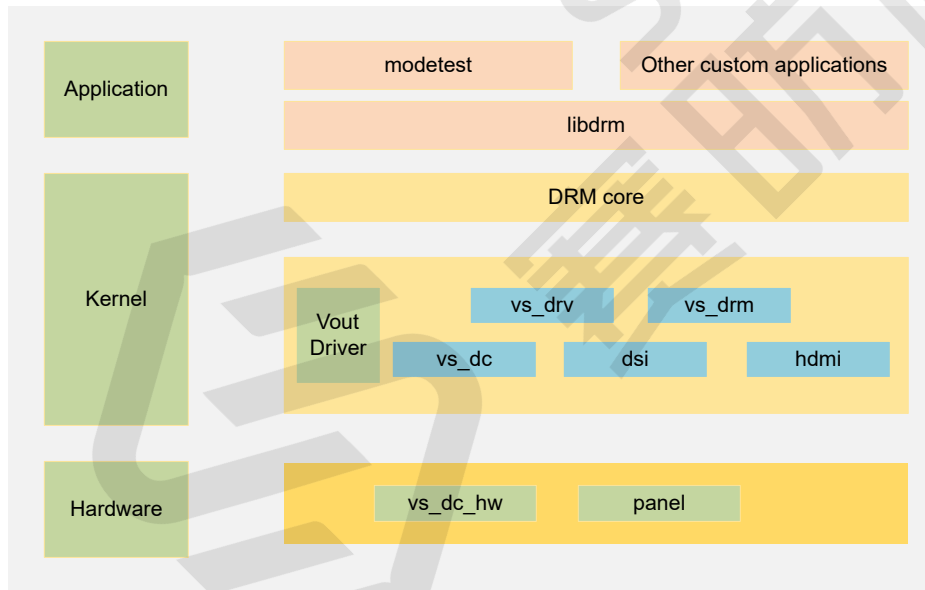
Table 1-1 Display Subsystem Data Mapping

Destination	Supported Data Mapping	Comment
DPI to PAD	<ul style="list-style-type: none"> • DP0/DP1 or DPI0/1 is used, default DPI is used. • RGB24, RGB666 (CFG1), RGB565 (CFG1) when DPI is used. 	For flexibility
DSI Tx Data from DC8200	<ul style="list-style-type: none"> • Both DPI and DP are supported. • YUV420 8-bit only (CFG3). • YUV422 8-bit only (CFG1). 	Default DPI
HDMI Data from DC8200	<ul style="list-style-type: none"> • Both DP0 and DP1 are used for RGB and YUV. • YUV444 and YUV422 8-bit/10-bit (CFG1). • YUV420 8-bit/10-bit (CFG3). 	DP by default, and DPI for back-up

1.3. Video Output Driver Framework

The following figure shows the framework of the video output driver and the display controller.

Figure 1-2 Driver Framework



The video output driver framework has the following 3 layers.

- **Application** layer consists of application code and test code and communicate with kernel layer through **libdrm**.
- **Kernel** layer consists of **DRM core** and **Vout driver**. **DRM core** receives commands from **libdrm** and transfer to **Vout driver**.
- **Hardware** layer is connected with **Vout driver**, and it operates the hardware directly.

1.4. Source Code Structure

The following code block shows the source code structure of the HDMI driver.


```

linux-5.15.0
├── drivers
│   ├── gpu
│   │   ├── drm
│   │   │   ├── verisilicon
│   │   │   ├── inno_hdmi.c
│   │   │   └── inno_hdmi.h

```

1.5. Device Tree Overview

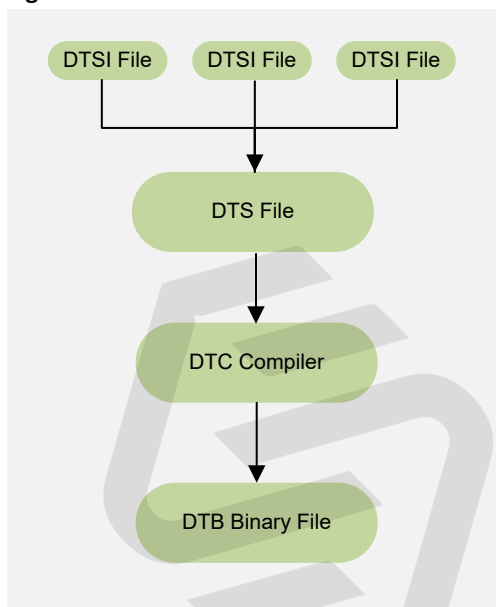
Since Linux 3.x, device tree is introduced as a data structure and language to describe hardware configuration. It is a system-readable description of hardware settings so that the operating system doesn't have to hard code details of the machine.

A device tree is primarily represented in the following forms.

- *Device Tree Compiler (DTC)*: The tool used to compile device tree into system-readable binaries.
- *Device Tree Source (DTS)*: The human-readable device tree description file. You can locate the target parameters and modify hardware configuration in this file.
- *Device Tree Source Information (DTSI)*: The human-readable header file which you can include in device tree description. You can locate the target parameters and modify hardware configuration in this file.
- *Device Tree Blob (DTB)*: The system-readable device tree binary blob files which is burned in system for execution.

The following diagram shows the relationship (workflow) of the above forms.

Figure 1-3 Device Tree Workflow



1.6. Device Tree Source Code

Overview Structure

The device tree source code of JH7110 is listed as follows:

```

linux
├── arch
│   ├── riscv
│   │   ├── boot
│   │   │   ├── dts
│   │   │   │   └── starfive
│   │   │   └── codecs

```


2. Configuration

2.1. Device Tree Configuration

A DTS/DTSI file is used to store all the device tree configuration.

The device tree of HDMI is stored in the following path:

```
linux-5.10/arch/riscv/boot/dts/starfive/
```

The following code block shows the DTS file structure for HDMI.

```
linux-5.15.0
├── arch
│   └── riscv
│       ├── boot
│       ├── dts
│       └── starfive
│           ├── jh7110-common.dtsi
│           └── jh7110.dtsi
```

The following is an example of the HDMI configuration in the file `jh7110.dts`.

```
hdmi: hdmi@29590000 {
    compatible = "starfive,jh7100-hdmi","inno,hdmi";
    reg = <0x0 0x29590000 0x0 0x4000>;
    interrupts = <99>;
    status = "disabled";
    clocks = <&clkvout JH7110_U0_HDMI_TX_CLK_SYS>,
    <&clkvout JH7110_U0_HDMI_TX_CLK_MCLK>,
    <&clkvout JH7110_U0_HDMI_TX_CLK_BCLK>,
    <&hdmitx0_pixelclk>;
    clock-names = "sysclk", "mclk", "bclk", "pclk";
    resets = <&rstgen RSTN_U0_HDMI_TX_HDMI>;
    reset-names = "hdmi_tx";
};
```

The following list provides explanations for the parameters included in the above code block.

- **compatible:** Compatibility information, used to associate the driver and its target device.
- **reg:** Register base address "0x29590000" and range "0x4000".
- **interrupts:** Hardware interrupt ID.
- **status:** The work status of the HDMI module. To enable the module, set this bit as "okay" or to disable the module, set this bit as "disabled".
- **clocks:** The clocks used by the HDMI module.
- **clock-names:** The names of the above clocks.
- **resets:** The reset signals used by the HDMI module.
- **reset-names:** The names of the above reset signals.

The following is an example of the HDMI configuration in the file `jh7110-common.dtsi`.

```
&hdmi {
    status = "okay";
    pinctrl-names = "default";
    pinctrl-0 = <&inno_hdmi_pins>;

    hdmi_in: port {
        #address-cells = <1>;
        #size-cells = <0>;
        hdmi_in_lcdc: endpoint@0 {
            reg = <0>;
        };
    };
};
```

| 2 - Configuration

```
remote-endpoint = <&dc_out_dp11>;
};
};
};
```

In the above code block, the parameters of **pinctrl-names** and **pinctrl-0** are used to configure the HDMI IOMUX pin configuration settings.

2.2. Driver Configuration

The following code block shows the driver configuration.

```
CONFIG_DRM_VERISILICON=y
CONFIG_STARFIVE_INNO_HDMI=y
```

2.3. Kernel Menu Configuration

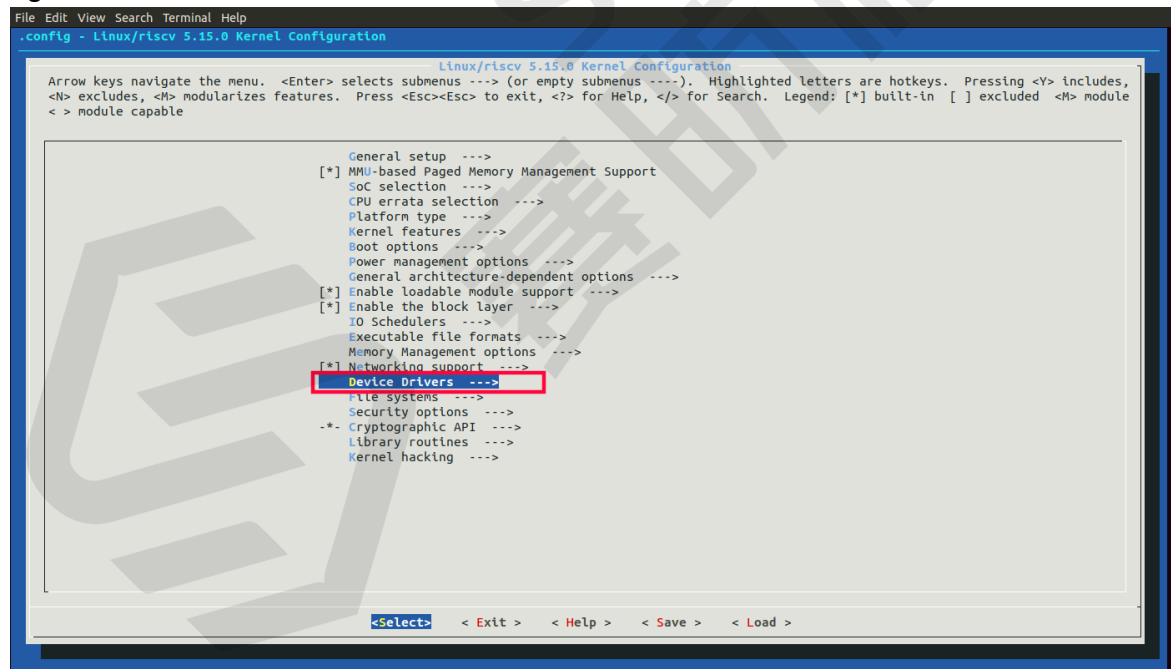
Follow the steps below to enable the kernel configuration for HDMI.

1. Under the root directory of `freelight-u-sdk`, type the following command to enter the kernel menu configuration GUI.

```
make linux-menuconfig
```

2. Enter the **Device Drivers** menu.

Figure 2-1 Device Drivers



3. Enter the **Graphics support** menu.

Figure 2-2 Graphics Support

```

.config - Linux/riscv 5.15.0 Kernel Configuration
> Device Drivers
Device Drivers
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu --->). Highlighted letters are hotkeys. Pressing <Y> includes, <N>
excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ] excluded <M> module <C> module
capable

^^(~)
<> RapidIO support ----
<> generic Driver Options ---->
Bus devices ---->
<> Connector - unified userspace <=> kernel-space linker ----
Firmware Drivers ---->
<> GNSS receiver support ----
<> Memory Technology Device (MTD) support ----
-[*] Device Tree and Open Firmware support ---->
<> Parallel port support ----
[*] Block devices ---->
  NtME Support ---->
  Misc devices ---->
  SCSI device support ---->
<M> Serial ATA and Parallel ATA drivers (libata) ---->
[ ] Multiple devices driver support (RAID and LVM) ----
<> Fusion MPT device support ---->
  IEEE 1394 (FireWire) support ---->
[*] Network device support ---->
  Input device support ---->
  Character devices ---->
  I2C support ---->
<> I3C support ---->
[*] SPI support ---->
<> SPMI support ---->
<> HSI support ---->
<> PPS support ---->
  PTP clock support ---->
[*] Pin controllers ---->
-[*] GPIO support ---->
<> Dallas's 1-wire support ---->
[*] Board level reset or power off ---->
  Power supply class support ---->
<M> Hardware Monitoring support ---->
  Thermal drivers ---->
[*] Watchdog Timer Support ---->
<> Sonics Silicon Backplane support ---->
<> Broadcom specific AMBA ---->
  Multifunction device drivers ---->
[*] Voltage and Current Regulator Support ---->
<> Remote Controller support ---->
[ ] HMI/CEC drivers ---->
<M> Multimedia support ---->
  Graphics support ---->
    sound card support ---->
    HID support ---->
  +(+>
  <select> < Exit > < Help > < Save > < Load >

```

4. In the Graphics support menu, select the **DRM Support** option to enable video output.

Figure 2-3 DRM Support

```

.config - Linux/riscv 5.15.0 Kernel Configuration
> Device Drivers > Graphics support
Graphics support
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu --->). Highlighted letters are hotkeys. Pressing <Y> includes, <N>
excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ] excluded <M> module <C> module
capable

[*] VGA Arbitration
(16) Maximum number of GPUs
-[*] Direct Rendering Manager (XFree86 4.1.0 and higher DRI support) ---->
  RM devices ---->
    <> ATI Radeon
    <> AMD GPU
    <> Nouveau (NVIDIA) cards
    <> virtual GEM provider
    <> Virtual KMS (EXPERIMENTAL)
    <> DisplayLink
    <> AST server chips
    <> Mxrox G260
    <> R-Car Gen3 and RZ/G2 DU HDMI Encoder Support
    <> R-Car DU LVDS Encoder Support
    <> XL virtual GPU
  Display Panels ---->
    Display Interface Bridges ---->
    <> ETNAVIV (DRM support for Vivante GPU IP cores)
    <> .iMX (e)ILCDIF LCD controller
    <> ARC PDU
    <> DRM Support for bochs disp1 vga interface (qemu stdvga)
    <> Cirrus driver for QEMU emulated device
    <> MI20320 driver for USB projectors
    <> Simple framebuffer driver
    <> DRM support for HX8357D display panels
    <> DRM support for IL19225 display panels
    <> DRM support for IL19341 display panels
    <> DRM support for IL19486 display panels
    <> DRM support for MI0283QT
    <> DRM support for Pervasive Displays RePaper panels (V231)
    <> DRM support for Sitronix ST7586 display panels
    <> DRM support for Sitronix ST7715R/ST7735R display panels
    <> UD USB Dtsplay
  [*] HDMI support <M> Verisilicon
    [ ] Display content output to debugfs file
    [ ] Verisilicon specific driver for Synopsys DW MIPI DSI
    [ ] MM support for Verisilicon display controller
    [ ] EC support for Verisilicon display controller
  [*] HDMI2.0
  [*] Starfive MIPI DSI Select
  <> DV7513 encoder
  -[*] Imagination PowerVR GPU
  [*] DRM support for PowerVR GPU
  [*] Enable legacy drivers (DANGEROUS) ---->
  Frame buffer Devices ---->
  Backlight & LCD device support ---->
  Console display driver support ---->
  [ ] Bootup logo ----
  <select> < Exit > < Help > < Save > < Load >

```

5. In the Graphics support menu, select the **HDMI2.0** option.

Figure 2-4 HDMI2.0

```

conf: Linux/rtscv 5.15.0 Kernel Configuration
> Device Drivers > Graphics support
Graphics support
Arrow keys navigate the menu. <Enter> selects submenus --- (or empty submenu ---). Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes
features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ] excluded <M> module <> module capable

[*] VGA Arbitration
(16) Maximum number of GPUs
--> Direct Rendering Manager (XFree86 4.1.0 and higher DRI support) --->
  ARM devices --->
    <> ATI Radeon
    <> AMD GPU
    <> Nouveau (NVIDIA) cards
    <> Virtual GEM provider
    <> Virtual KMS (EXPERIMENTAL)
    <> DisplayLink
    <> STI server chips
    <> Matrox G200
    <> R-Car Gen3 and RZ/G2 DU HDMI Encoder Support
    <> R-Car DU LVDS Encoder Support
    <> iXL virtual GPU
  Display Panels --->
    Display Interface Bridges --->
    <> TMNAVIV (DRM support for Vivante GPU IP cores)
    <> .MX (e)LCDIF LCD controller
    <> ARC PGU
    <> ARM support for bochs dispi vga interface (qemu stdvga)
    <> cirrus driver for QEMU emulated device
    <> GM12U320 driver for USB projectors
    <> simple framebuffer driver
    <> ARM support for HX83570 display panels
    <> ARM support for ILI9225 display panels
    <> ARM support for ILI9341 display panels
    <> ARM support for ILI9486 display panels
    <> ARM support for MIO2830T
    <> ARM support for Pervasive Displays RePaper panels (V231)
    <> ARM support for Sitronix S77586 display panels
    <> ARM support for Sitronix S7715R/S7735R display panels
    <> iUD USB Display
  <M> ARM Support for Verisilicon
    [ ] Display content output to debugfs file
    [ ] Verisilicon specific driver for Synopsys DW MIPI DSI
    [ ] MMIO support for Verisilicon display controller
    [ ] IEC support for Verisilicon display controller
  [*] HDMI2.0
  [*] Starfive MIPI DSI Select
  <> iDV7513 encoder
  -* Imagination PowerVR GPU
  [*] ARM support for PowerVR GPU
  [*] enable Legacy drivers (DANGEROUS) --->
    Frame buffer Devices --->
    Backlight & LCD device support --->
    Console display driver support --->
  [ ] Bootup logo ----

<Select> < Exit > < Help > < Save > < Load >

```

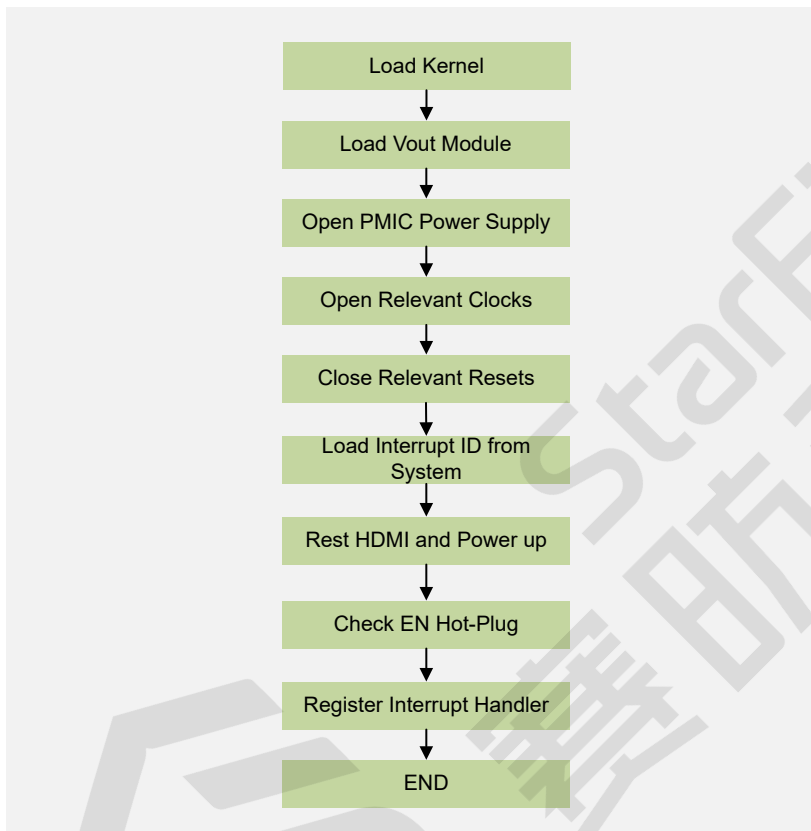
6. Save your change before you exit the kernel configuration dialog.

3. Work Process

3.1. Initialization Process

The following diagram shows the HDMI initialization process for JH7110.

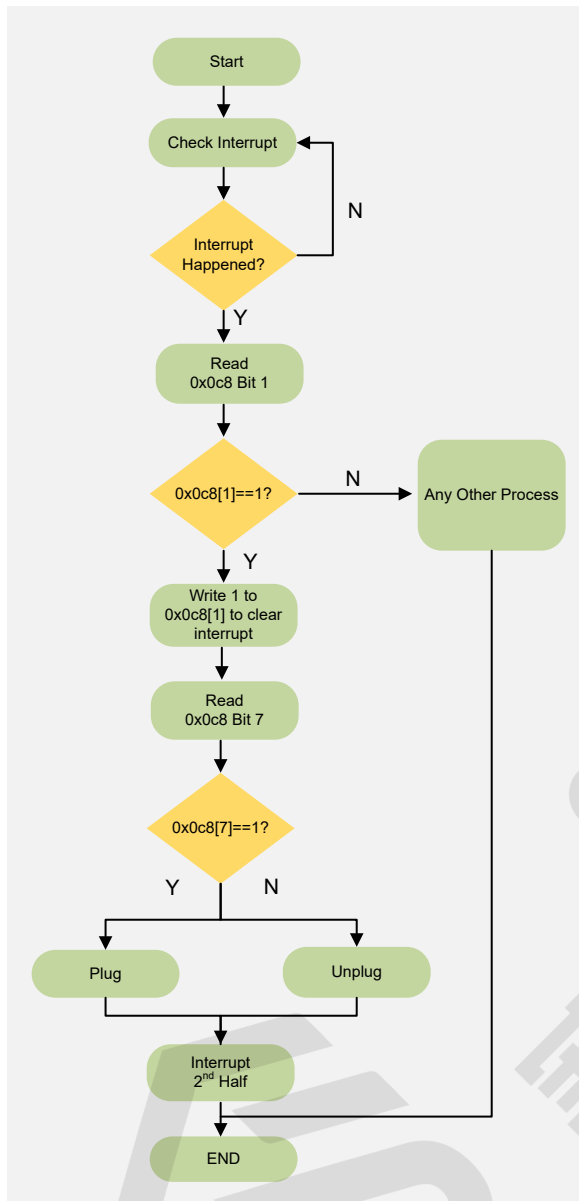
Figure 3-1 Initialization Process



3.2. Plug and Unplug Process

The following diagram shows the HDMI plug and unplug procedure.

Figure 3-2 Plug and Unplug Process



4. Debug HDMI

4.1. Test Case Configuration

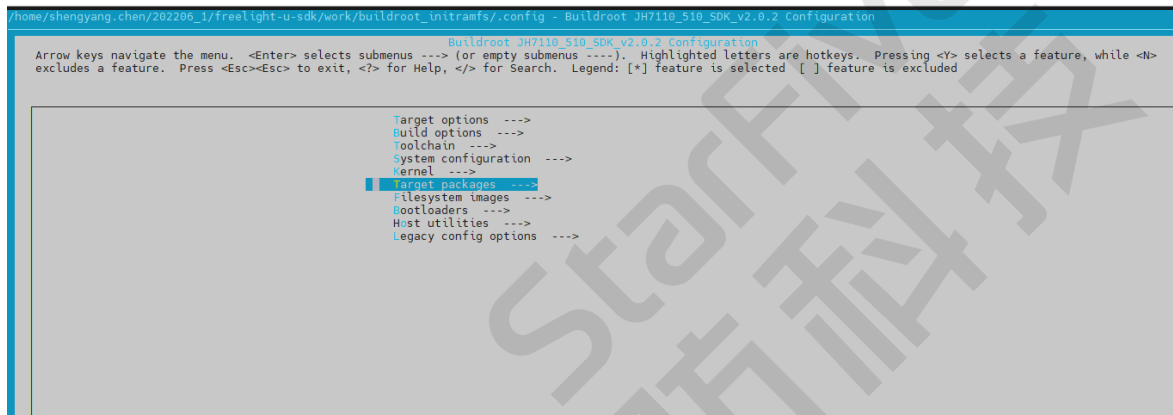
Follow the steps below to enable the kernel configuration for HDMI.

1. Under the root directory of `freelight-u-sdk`, type the following command to enter the kernel menu configuration GUI.

```
make linux-menuconfig
```

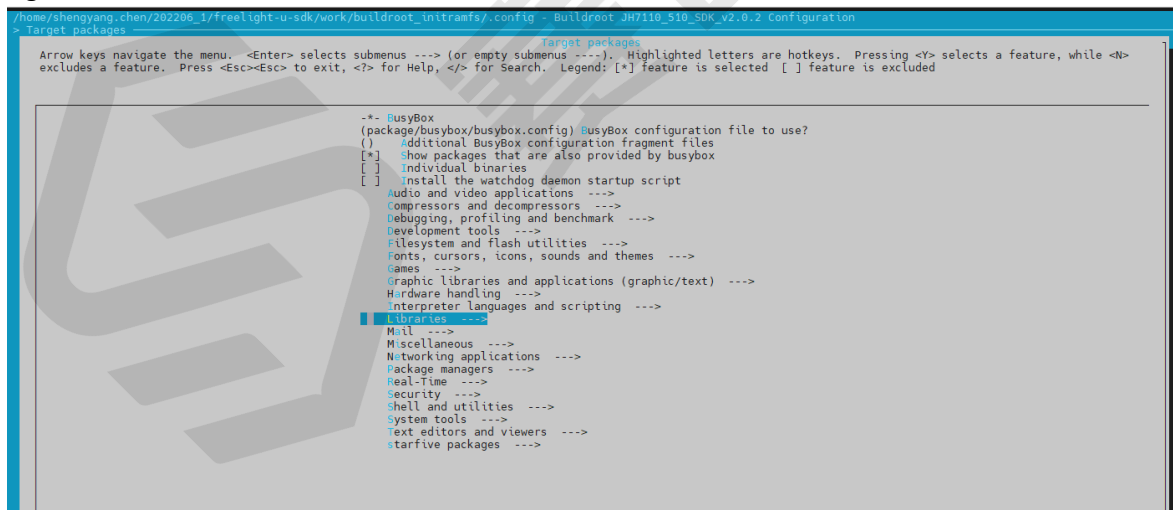
2. Enter the **Target packages** menu.

Figure 4-1 Target Packages



3. Enter the **Libraries** menu.

Figure 4-2 Libraries



4. Enter the **Graphics** menu.

Figure 4-3 Graphics

```

/home/shengyang.chen/202206_1/freelight-u-sdk/work/buildroot_intrafrms/.config - Buildroot JH7110_510_SDK_v2.0.2 Configuration
> Target packages > Libraries
Libraries
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N>
excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature is excluded

Audio/Sound --->
Compression and decompression --->
Crypto --->
Database --->
Filesystem --->
Graphics --->
Hardware handling --->
Javascript --->
JSON/XML --->
Logging --->
Multimedia --->
Networking --->
Other --->
Security --->
Text and terminal handling --->

```

5. Enter the **libdrm** menu.

Figure 4-4 libdrm

```

/home/shengyang.chen/202206_1/freelight-u-sdk/work/buildroot_intrafrms/.config - Buildroot JH7110_510_SDK_v2.0.2 Configuration
> Target packages > Libraries > Graphics
Graphics
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N>
excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature is excluded

[ ] assimp
*** at-spi2-atk depends on X.org ***
*** at-spi2-core depends on X.org ***
[ ] atk
[ ] atkmm
[ ] bullet
[*] cairo
[ ] postscript support
[ ] pdf support
-* png support
[ ] script support
[ ] svg support
[ ] tee support
[ ] xml support
[ ] cairomm
*** chipmunk needs an OpenGL backend ***
[ ] exeml
[ ] exiv2
-* fontconfig
-* freetype
[ ] gd ---
[ ] gdk-pixbuf
[ ] giflib
*** granite needs libgtk3 and a toolchain w/ wchar, threads ***
[ ] graphite2
*** gtkmm3 needs libgtk3 and a toolchain w/ C++, wchar, threads, gcc >= 4.9 ***
-* harfbuzz
[ ] js
[ ] imlib2
*** irrlicht needs X11 and an OpenGL provider ***
[ ] asper
[ ] libg2dec
-* jpeg support
  jpeg variant (jpeg) --->
[ ] lms++
[ ] cms2
[ ] lensfun
[ ] leptontica
[ ] libart
[ ] libdmtx
[*] libdrm ---
[ ] libepoxy
[ ] libexif
*** libfm needs X.org and a toolchain w/ wchar, threads, C++, gcc >= 4.8 ***
[ ] libfm-extra
*** libfreelut depends on X.org and needs an OpenGL backend ***
[ ] libfreetype
[ ] libgexif
*** libglew depends on X.org and needs an OpenGL backend ***
*** libglfw depends on X.org and needs an OpenGL backend ***
*** libglu needs an OpenGL backend ***
[ ] libgta
[ ] libgtk3
[ ] libmediaart
[ ] libmng
-* libpng
[ ] libqrencode

```

6. Select the **Install test programs** option, or you may select ALL options under this menu.

Figure 4-5 Install Test Programs

```

/home/shengyang.chen/202206_1/freelight-u-sdk/work/buildroot_intrafrms/.config - Buildroot JH7110_510_SDK_v2.0.2 Configuration
> Target packages > Libraries > Graphics > libdrm
libdrm
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N>
excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature is excluded

-- libdrm
[ ] radeon
[ ] amdppu
[ ] nouveau
[ ] etnaviv (experimental)
[*] Install test programs

```

Result: After you have completed all the above configuration, you can use the `modetest` tool in kernel for testing.

7. Save your change before you exit the kernel configuration dialog.

4.2. Debug Display

Follow the steps below to debug the display functions for your JH7110.

1. Follow the steps in [Test Case Configuration \(on page 17\)](#) to configure the test environment.



Note:

Make sure you have configured **libdrm** and **modetest** before compiling and burning an image.

2. After you have completed the kernel start-up, use the following command to verify the display functions and connection status.

```
modetest -M starfive
```

The following legends and tables display an example output and descriptions.

- Debug output 1:

Figure 4-6 Debug Display 1

```
# modetest -M starfive
Encoders:
id      crtc    type    possible crtcs    possible clones
115     0         TMDS   0x00000001        0x00000001
117     0         DSI    0x00000002        0x00000002

Connectors:
id      encoder  status  name             size (mm)    modes    encoders
116     0         connected HDMI-A-1       0x0         10       115

modes:
index name refresh (Hz) hdisp hss hse htot vdisp vss vse vtot
#0 1920x1080 60.00 1920 2008 2052 2200 1080 1084 1089 1125 148500 flags: phsync, pvsync; type: driver
#1 1920x1080 59.94 1920 2008 2052 2200 1080 1084 1089 1125 148352 flags: phsync, pvsync; type: driver
#2 1920x1080 50.00 1920 2448 2492 2640 1080 1084 1089 1125 148500 flags: phsync, pvsync; type: driver
#3 1280x720 60.00 1280 1390 1430 1650 720 725 730 750 74250 flags: phsync, pvsync; type: driver
#4 1280x720 59.94 1280 1390 1430 1650 720 725 730 750 74176 flags: phsync, pvsync; type: driver
#5 1280x720 50.00 1280 1720 1760 1980 720 725 730 750 74250 flags: phsync, pvsync; type: driver
#6 1280x720 48.00 1280 2240 2280 2500 720 725 730 750 90000 flags: phsync, pvsync; type: driver
#7 1280x720 47.95 1280 2240 2280 2500 720 725 730 750 89910 flags: phsync, pvsync; type: driver
#8 640x480 60.00 640 656 752 800 480 490 492 525 25200 flags: nhsync, nvsync; type: driver
#9 640x480 59.94 640 656 752 800 480 490 492 525 25175 flags: nhsync, nvsync; type: driver

props:
1 EDID:
  flags: immutable blob
  blobs:
  value:
    00ffffffffffff004a8b201980102019
    001e010380000078ecee91a3544c9926
    0f5054230800d1c0b300950081006140
    4540814081c0023a801871382d40582c
    250058c31000001e000000fc00000a20
    20202020202020202020000000ff0000
    0a2020202020202020202020000000fd
    00383f545413000a202020202001a3
    020332f24f04051013141f6c6c6c276c
    6c6c4b4ce200d5e305c00023097f0783
    01000067030c001000383ce606050169
    694f023a801871382d40582c250058c3
    1000001e011d8018711c1620582c2500
    58c31000009e00000000000000000000
    00000000000000000000000000000000
    0000000000000000000000000000007a

2 DPMS:
  flags: enum
  enums: On=0 Standby=1 Suspend=2 Off=3
  value: 0

5 link-status:
  flags: enum
  enums: Good=0 Bad=1
  value: 0

6 non-desktop:
  flags: immutable range
  values: 0 1
```

Table 4-1 Debug Display 1

Legend	Label	Description
①	possible crtcs	Available <i>Cathode Ray Tube Controller (CRTC)</i> devices
②	status	Whether the display connector is connected or not
③	name	The name (type) of the display connector

Legend	Label	Description
④	encoders	The connected encoders
⑤	modes	The supported display modes
⑥	value	The <i>Extended Display Identification Data (EDID)</i> of the screen

◦ Debug output 2:



Figure 4-7 Debug Display 2

```

CRTCs:
id ① fb      pos      size
31 0      (0,0)   (0x0)
#0 nan 0 0 0 0 0 0 0 0 0 0 flags: ; type:
props:
  24 VRR_ENABLED:
      flags: range
      values: 0 1
      value: 0
  28 GAMMA_LUT:
      flags: blob
      blobs:

      value:
  29 GAMMA_LUT_SIZE:
      flags: immutable range
      values: 0 4294967295
      value: 300
  32 BG_COLOR:
      flags: range
      values: 0 4294967295
      value: 0
  33 SYNC_ENABLED:
      flags: range
      values: 0 1
      value: 0
  34 DITHER_ENABLED:
      flags: range
      values: 0 1
      value: 0
id ② fb      pos      size
35 0      (0,0)   (0x0)
#0 nan 0 0 0 0 0 0 0 0 0 0 flags: ; type:
props:
  24 VRR_ENABLED:
      flags: range
      values: 0 1
      value: 0
  28 GAMMA_LUT:
      flags: blob
      blobs:

      value:
  29 GAMMA_LUT_SIZE:
      flags: immutable range
      values: 0 4294967295
      value: 300
  36 BG_COLOR:
      flags: range
      values: 0 4294967295
      value: 0
  37 SYNC_ENABLED:
      flags: range
      values: 0 1
      value: 0
  38 DITHER_ENABLED:
      flags: range
      values: 0 1
      value: 0

Planes:

```

Table 4-2 Debug Display 2

Legend	Label	Description
①	id	The CRTC 0x00000001 mentioned in row ① of table Table 4-1 : Debug Display 1 (on page 19) , which means the CRTC is available for use.

Legend	Label	Description
②	id	The CRTC 0x00000002 mentioned in row ① of table Table 4-1 : Debug Display 1 (on page 19) , which means the CRTC is available for use.



Note:

If the displayed CRTC is 0x00000003, both of the CRTCs are available for use.

◦ Debug output 3:

Figure 4-8 Debug Display 3

```

Planes:
id 39 ① crtc fb CRTC x,y x,y gamma size possible crtcs ①
0 0 0,0 0,0 0 0 0x00000001
Formats: XR12 XB12 RX12 BX12 AR12 AB12 RA12 BA12 XR15 XB15 RX15 BX15 AR15 AB15 RA15 BA15 RG16 BG16 XR24 XB24 RX24 BX24 AR24 AB24 RA24
UYVY YUYV YV12 YU12 NV12 NV21 NV16 NV61 P010
props:
  8 type:
    flags: immutable enum
    enums: Overlay=0 Primary=1 Cursor=2
    value: 1
  30 IN_FORMATS:
    flags: immutable blob
    blobs:
      value:
        01000000000000002900000018000000
        08000000c00000005852313258423132
        52583132425831324152313241423132
        52413132424131325852313558423135
        52583135425831354152313541423135
        52413135424131355247313642473136
        58523234584232345258323442583234
        41523234414232345241323442413234
        41523330414233305241333042413330
        59555955956595535395659553539
        59563132595531324e5631324e563231
        4e5631364e5636315030313000000000
        00000000000000000000000000000000
        00000000000000000000000000000000
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        00000000000000000000000000000000
        00000000000000000000000000000000
        in_formats blob decoded:
    41 DEGAMMA_MODE:
      flags: enum
      enums: disabled=0 preset degamma for BT709=1 preset degamma for BT2020=2
      value: 0
    42 rotation:
      flags: bitmask
      values: rotate=0=0x1 rotate=90=0x2 rotate=180=0x4 rotate=270=0x8 reflect-x=0x10 reflect-y=0x20
      value: 1
    43 pixel blend mode:
      flags: enum
      enums: None=2 Pre-multiplied=0 Coverage=1
      value: 0
    44 alpha:
      flags: range
      values: 0 65535
      value: 65535
    45 COLOR_ENCODING:
      flags: enum
      enums: ITU-R BT.709 YCbCr=1 ITU-R BT.2020 YCbCr=2
      value: 0
    
```

Table 4-3 Debug Display 3

Legend	Description
①	The CRTC and its connected plane

4.3. Test Example

For HDMI Output

The following command shows an example for testing the HDMI output.

```
modetest -M starfive -D 0 -a -s 116@31:1920x1080 -P 39@31:1920x1080@RG16 -Ftiles
```

The following list provides explanations for the parameters in the above example command.

- **116@31:1920x1080** - <Connector ID>@<CRTC ID>: <Resolution>
- **39@31:1920x1080@RG16** - <Plane ID>@<CRTC ID>: <Resolution>@<Format>

Output Result

The following photo shows the output generated from the above example command.

Figure 4-9 Test Example

