Intel® Atom™ Processor E3800 Product Family and Intel® Celeron® Processor N2807/N2930/J1900

User Guide for Yocto Project* Board Support Package (BSP) Graphics Driver

July 2014

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Contents

Figures

Tables

Revision History

Date	Revision	Description
July 2014	001	Initial release.

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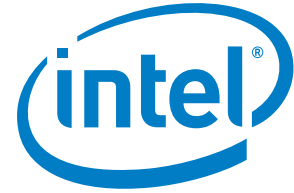
1 Introduction

This document describes features of the Intel Linux* graphics driver and how to verify it on Intel's Bay Trail-based platform with Yocto Project*. This document also contains the results of Intel's smoke test on the graphics driver with Yocto Project* on the same platform.

Intel recommends that you read this document together with the *Yocto Project* Setup Getting Started Guide* (Document Number: 330696) and the *Building Intel® Atom™ E3800 Processor Development Kit Yocto Project* Board Support Package (BSP) User Guide* (Document Number: 330693).

1.1 Intel® Atom™ Processor E38xx/Intel® Celeron® N2xx (formerly Bay Trail)

The Intel® Atom™ processor E3800 product family is the first system-on-chip (SoC) designed for intelligent systems that delivers outstanding computing, graphical, and media performance while operating in an extended range of thermal conditions. These SoCs are based on the Silvermont micro architecture and utilize Intel's industry-leading 22nm process technology with 3-D Tri-Gate transistors, which deliver significant improvements in computational performance and energy efficiency. For more information, see http://www.intel.com/content/www/us/en/intelligent-systems/baytrail/atom-processor-e3800-family-overview.html.

1.2 Yocto Project*

The Yocto Project* is an open-source project that provides templates, tools, and methods to help users create custom Linux*-based systems for an embedded product. For more information, see http://www.yoctoproject.org/.

1.3 Intel Linux* Graphics

The open-source graphic driver from Intel Open Source Technology Center is used on Linux* and Linux*-based operating systems. This driver includes the kernel's i915 DRM driver and its user space components for Linux*. For more information, see https://01.org/linuxgraphics/.

1.4   Terminology

Table 1.   Terminology

Term	Description
BSP	Board Support Package
CDCLK	Core Display Clock
CRT	Cathode Ray Tube
dclk	dot clock
DMT	Display Monitor Timing
DP	Display Port
DRI	Direct Rendering Infrastructure
DRM	Direct Rendering Manager
eDP	embedded Display Port
GLX	OpenGL Extension to the X Windows* System
HMDI	High-Definition Multimedia Interface

1.5   Reference Documents

Table 2.   Reference Documents

Document	Document No./Location
Yocto Project Setup Getting Started Guide*	330696
Building Intel® Atom™ E3800 Processor Development Kit Yocto Project Board Support Package (BSP) User Guide*	330693

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2 Intel Linux* Graphics Feature for Yocto Project*

This section describes features supported with the Linux* graphics driver from Intel on Yocto Project* for the Intel Bay Trail-based platform.

2.1 Supported Display Types

Table 3. Supported Display Types

Display Type	Supported	Supported Version	Verified on Yocto Project*	Notes
Analog (CRT)	Yes	N/A	Yes	
HDMI	Yes	Up to v1.4 (partially)	Yes	• Stereo 3D is supported. • Ultra High Definition on HDMI is not available on Intel Bay Trail. (See Note 1.)
Display Port (DP)	Yes	Up to v1.2	Yes	
Embedded Display Port (eDP)	Yes	Up to v1.3	Yes	Panel Self Refresh (PSR) is supported.
Thunderbolt	No		N/A	
Intel® Wireless Display (Intel® WiDi)	No		N/A	

NOTE:
1. Maximum dot clock (pixel clock) for HDMI on Bay Trail is limited to 165 MHz. Refer to VESA* Display Monitor Timing for dot clock specifications for each of the timings at http://www.vesa.org/vesa-standards/standards-summaries/.

Intel® Atom™ Processor E3800 Product Family and
Intel® Celeron® Processor N2807/N2930/J1900
July 2014   User Guide for Yocto Project* Board Support Package (BSP) Graphics Driver
Document Number: 330810-001US   7

2.2 Display Timing

Display timing is the timing/resolution used to set up the display, which consists of width, height, and vertical refresh rate.

2.2.1 Maximum Resolution/Timings Capability

For Intel Bay Trail, high resolution timing is supported on an Analog (CRT) and Display Port, but not on HDMI.

Absolute maximum dot clock (pixel clock) for each display type is listed below.

Table 4. Absolute Maximum Dot Clock (Pixel Clock) by Display Type

Display Type	Maximum Pixel Clock (dclk)
Analog (CRT)	355 MHz
Display Port (DP/eDP)	355 MHz
HDMI	165 MHz

- The actual maximum dot clock for Analog and Display Port (DP/eDP) is usually limited by the CPU's Core Display Clock (CDCLK). Maximum supported dot clock for Bay Trail is 90% of its CDCLK or lower, depending on the usage scenario.

  Different SKUs of Bay Trail have different CDCLK speeds. For example, a Bay Trail platform with a core that has its CDCLK running at 333 MHZ has a maximum dot clock (dclk) at 90% * 333 MHz = 299MHz. So, the maximum timings from VESA DMT supported by that particular Bay Trail SKU are:

  - 2560x1600@60 Hz (Reduced Blanking) with dclk at 268.5 MHz or
  - 1920x1440@75 Hz with dclk at 297.000 MHz

- For more details about Maximum Timings dot clock (dclk), refer to the *Intel Open Source HD Graphic Programmers' Reference Manual (PRM)* for Bay Trail under the section "Display Pixel Rate Limitations" at https://01.org/linuxgraphics/sites/default/files/documentation/intel_os_gfx_prm_vol10_-_display.pdf.

- For more information regarding display timing and dot clock (dclk), refer to VESA Display Monitor Timing (DMT) at http://www.vesa.org/vesa-standards/standards-summaries/.
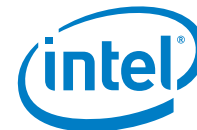
2.3 Multiple Displays

Bay Trail integrated graphic currently supports two displays.

Table 5. Supported Display Modes

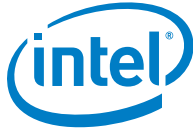| Mode	Driver Support	Verified in Yocto Project*	Notes
Dual Display Support			
Clone	Yes	Yes	
Extended	Yes	Yes	
Multi-Monitor Support (with PCIe*)	Yes	No	This usage model is not verified with Yocto Project*. This feature may be hindered by Hardware/Firmware configuration.
Three Independent Displays	No	No	Not supported on Bay Trail

2.4 Display Hotplug

Display Hotplug is a functionality that allows a user to connect and activate a display automatically during runtime.

Table 6. Display Hotplug Support

Display Type	Hotplug Support	Verified on Yocto Project*	Notes
VGA	Partially supported.	Yes	Monitor must be connected during boot up with Yocto Project*.
HDMI	Partially supported.	Yes	Monitor has to be connected during boot up with Yocto Project*.
Display Port (DP)	Partially supported.	Yes	Monitor has to be connected during boot up with Yocto Project*.
Embedded Display Port (eDP)	Not applicable.	N/A	Hotplug is not a valid usage model for eDP.

2.5 Power Management

The i915 graphic driver supports a power management feature for a Bay Trail display on Yocto Project*.

Table 7. Power Management Feature for a Bay Trail Display on Yocto Project*

Power Mode	Supported	Verified on Yocto Project*	Notes
Suspend	Yes	Yes	
Hibernate	Yes	No	System limitations exist on Intel's test subject.
Restart	Yes	Yes	
Shutdown	Yes	Yes	

2.6 Rendering

The i915 driver supports 2D, 3D, and video rendering on the Bay Trail platform.

Table 8. Supported Rendering Types on the Bay Trail Platform

Rendering Type	Hardware Acceleration	Verified on Yocto Project*	Notes
2D Rendering	Yes	Yes	
3D: OpenGL ES 2.0, OpenGL ES 3.0, Open GL 3.0 and partial OpenGL 4.x.	Yes	Partially yes	Necessary libraries need to be installed correctly. Refer to https://01.org/linuxgraphics/downloads
Hardware Video decode supported: h.264 AVC, h.264 MVC, h.264 SVC, JPEG & MJPEG, MPEG2.	Yes	Partially yes	Necessary libraries need to be installed correctly. Refer to https://01.org/linuxgraphics/downloads

2.7 Miscellaneous Features

Table 9. Miscellaneous Features

| Feature	Support on Yocto Project*
xrandr (mode setting and configuration)	Yes
Kernel mode setting	Yes
Switchable graphics (Mux and Muxless solution)	No

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3 Graphics Component Installation and Verification

This section describes the process of installing and verifying the graphics component.

3.1 Video Component Requirements

Below are the video components required and the respective download links for video playback for your reference.

Table 10. Video Component Requirements and Download Links

Package Requirements	Version	Download link
Libva	1.2.1	http://www.freedesktop.org/software/vaapi/releases/libva/libva-1.2.1.tar.bz2
Vaapi intel-driver	1.2.1	http://www.freedesktop.org/software/vaapi/releases/libva-intel-driver/libva-intel-driver-1.2.1.tar.bz2
libdrm	2.4.0	http://dri.freedesktop.org/libdrm/
Xf86-video-intel (2D)	2.99.910	http://xorg.freedesktop.org/archive/individual/driver/xf86-video-intel-2.99.910.tar.gz
X.Org X server	1.15.0	http://ftp.x.org/pub/individual/xserver/xorg-server-1.15.0.tar.bz2
orc	0.4.18	http://code.entropywave.com/download/orc/
yasm	1.2.0	http://www.linuxfromscratch.org/blfs/view/cvs/general/yasm.html
mplayer-vaapi	4.8.2	git://gitorious.org/vaapi/mplayer.git
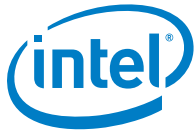
3.1.1 Video Components Dependencies

The stack diagram in Figure 1 describes the dependencies of video components with Intel Graphics.

Figure 1. Video Component Dependencies
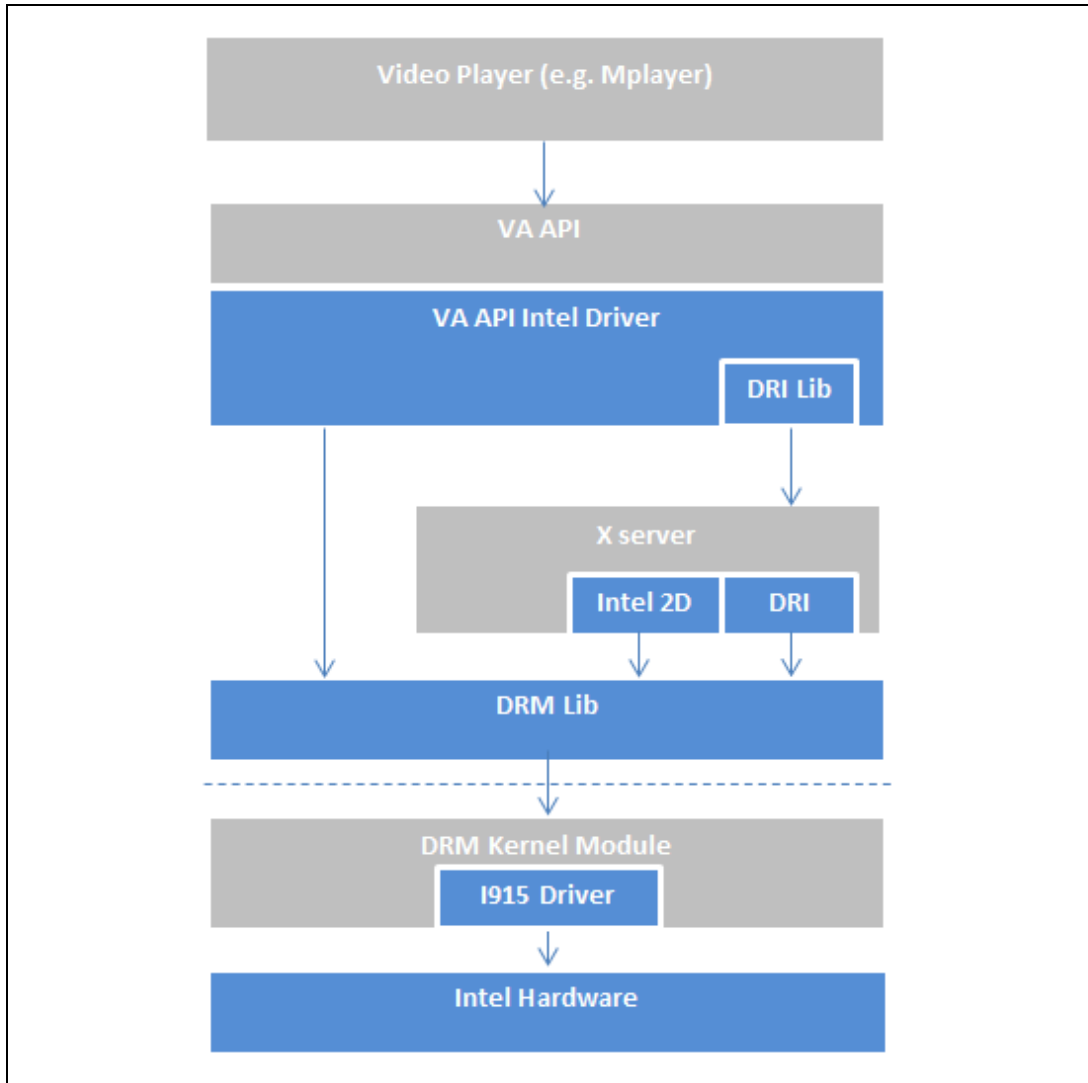
3.2 Configuring and Verifying the Video Component

This section provides information for configuring and verifying the video components.

Note: The following steps to install these components must be executed on a Yocto Project* image created with the SDK that contains all the required packages for the compilation process. The SDK-enabled image can be created by issuing the `bitbake core-image-sato-sdk` command.

Configure the components required to decode a video using MPlayer by preforming the following steps.

1. Libva version 1.2.1.

   a. Download Libva version 1.2.1 from the link provided in the previous section.

   b. Extract and install Libva version 1.2.1.

   ```
   tar -xvf libva-1.2.1.tar.bz2
   cd ../libva-intel-driver
   ./configure --prefix=/usr
   make
   make install
   ```

2. Vaapi intel-driver version 1.2.0

   a. Download Vaapi intel-driver version 1.2.0 from the link provided in the previous section.

   b. Extract and install Vaapi intel-driver.

   ```
   cd ../libva-intel-driver
   ./configure --prefix=/usr
   make
   make install
   ```

3. orc-0.4.18

   a. Download orc-0.4.18 from the link provided in the previous section.

   b. Extract and install orc-0.4.18.

   ```
   tar -xvf orc-0.4.18.tar.gz
   cd orc-0.4.18
   ./configure --prefix=/usr
   make
   ```

4. yasm-1.2.0

   a. Download yasm-1.2.0 from the link provided in the previous section.

   b. Extract and install yasm-1.2.0.

   ```
   tar –xvf yasm–1.2.0.tar.gz
   cd yasm-1.2.0
   ./configure --prefix=/usr
   make
   make install
   ```

5. mplayer

   a. Check out a copy of the source code of Mplayer-vaapi from the link below:
      git://gitorious.org/vaapi/mplayer.git

   b. Extract mplayer

   ```
   git clone git://gitorious.org/vaapi/mplayer.git
   git checkout hwaccel-vaapi
   ```

   c. Configure, compile and install the mplayer-vaapi using the following commands.

   ```
   ./configure  --enable-vaapi  --disable-vdpau
   ```
   (it automatically clones the ffmpeg objects first)
   ```
   make
   make install
   ```

6. Verify the video components using the following commands.

   a. `vainfo`

The `vainfo` command provides the following information:

```
output of vainfo
vainfo: VA-API version: 0.34 (libva 1.2.1)
vainfo: Driver version: Intel i965 driver - 1.2.1
vainfo: Supported profile and entrypoints
    VAProfileNone               : VAEntrypointVideoProc
    VAProfileMPEG2Simple         : VAEntrypointVLD
    VAProfileMPEG2Simple         : VAEntrypointEncSlice
    VAProfileMPEG2Main           : VAEntrypointVLD
    VAProfileMPEG2Main           : VAEntrypointEncSlice
    VAProfileH264Baseline        : VAEntrypointVLD
    VAProfileH264Baseline        : VAEntrypointEncSlice
    VAProfileH264Main            : VAEntrypointVLD
    VAProfileH264Main            : VAEntrypointEncSlice
    VAProfileH264High            : VAEntrypointVLD
    VAProfileH264High            : VAEntrypointEncSlice
    VAProfileVC1Simple           : VAEntrypointVLD
    VAProfileVC1Main             : VAEntrypointVLD
    VAProfileVC1Advanced         : VAEntrypointVLD
    VAProfileJPEGBaseline        : VAEntrypointVLD
```

b. `mplayer-vaapi`

To play video using the mplayer-vaapi, run the following command.

```
mplayer -vo vaapi -va vaapi <video_filename>
```

You should see the following output while video is playing on the screen:

```
MPlayer SVN-r35107-4.8.2 (C) 2000-2012 MPlayer Team
Playing /dsjamwax/media_tmp/helloMoscow.mpg.
libavformat version 54.25.104 (internal)
TS file format detected.
VIDEO H264(pid=481) AUDIO MPA(pid=482) NO SUBS (yet)!  PROGRAM N. 1
FPS seems to be: 25.000000
Load subtitles in /dsjamwax/media_tmp/
libva info: VA-API version 0.34.0
libva info: va_getDriverName() returns 0
libva info: Trying to open /usr/lib/dri/i965_drv_video.so
libva info: Found init function __vaDriverInit_0_34
libva info: va_openDriver() returns 0
=========================================================
Opening video decoder: [ffmpeg] FFmpeg's libavcodec codec family
libavcodec version 54.53.100 (internal)
Selected video codec: [ffh264] vfm: ffmpeg (FFmpeg H.264)
=========================================================
```
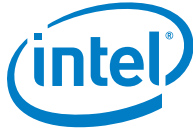
```
============================================================
Requested audio codec family [mpg123] (afm=mpg123) not available.

Enable it at compilation.

Opening audio decoder: [ffmpeg] FFmpeg/libavcodec audio decoders

AUDIO: 48000 Hz, 2 ch, floatle, 224.0 kbit/7.29% (ratio: 28000->384000)

Selected audio codec: [ffmp2float] afm: ffmpeg (FFmpeg MPEG layer-1 and layer-2
audio)

============================================================
[AO OSS] audio_setup: Can't open audio device /dev/dsp: No such file or directory

AO: [pulse] Init failed: Connection refused

[AO SDL] Samplerate: 48000Hz Channels: Stereo Format floatle

[AO SDL] Unsupported audio format: 0x1d.

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/confmisc.c:768:(parse_card) cannot find card '0

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/conf.c:4248:(_snd_config_evaluate) function snd

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/confmisc.c:392:(snd_func_concat) error evaluati

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/conf.c:4248:(_snd_config_evaluate) function snd

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/confmisc.c:1251:(snd_func_refer) error evaluati

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/conf.c:4248:(_snd_config_evaluate) function snd

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/conf.c:4727:(snd_config_expand) Evaluate error:

ALSA lib /home/ubuntu/Desktop/daisy/poky/build/tmp/work/core2-32-poky-linux/alsa-
lib/1.0.27.2-r0/alsa-lib-1.0.27.2/src/pcm/pcm.c:2239:(snd_pcm_open_noupdate)
Unknown

[AO SDL] Unable to open audio: No available audio device

DVB card number must be between 1 and 4

AO: [null] 48000Hz 2ch floatle (4 bytes per sample)

Starting playback...

Unsupported PixelFormat 61

[VD_FFMPEG] Trying pixfmt=1.

Movie-Aspect is 1.25:1 - prescaling to correct movie aspect.

VO: [vaapi] 720x576 => 720x576 H.264 VA-API Acceleration

[vo_vaapi] Using 1:1 VA surface mapping

[VD_FFMPEG] XVMC-accelerated MPEG-2.

A:  32.6 V:  32.6 A-V:  0.000 ct: -0.039 763/763  1%  4%  1.6% 0 0

TS_PARSE: COULDN'T SYNC

A:  32.7 V:  32.7 A-V: -0.002 ct: -0.040 767/767  1%  4%  1.6% 0 0

Exiting... (End of file)
```

3.3 Verifying the OpenGL Graphic Component

Figure 2 illustrates the components related to 3D rendering on Yocto Project* BSP:

Figure 2. Stack Showing the Components Related to 3D Rendering on Yocto Project* BSP
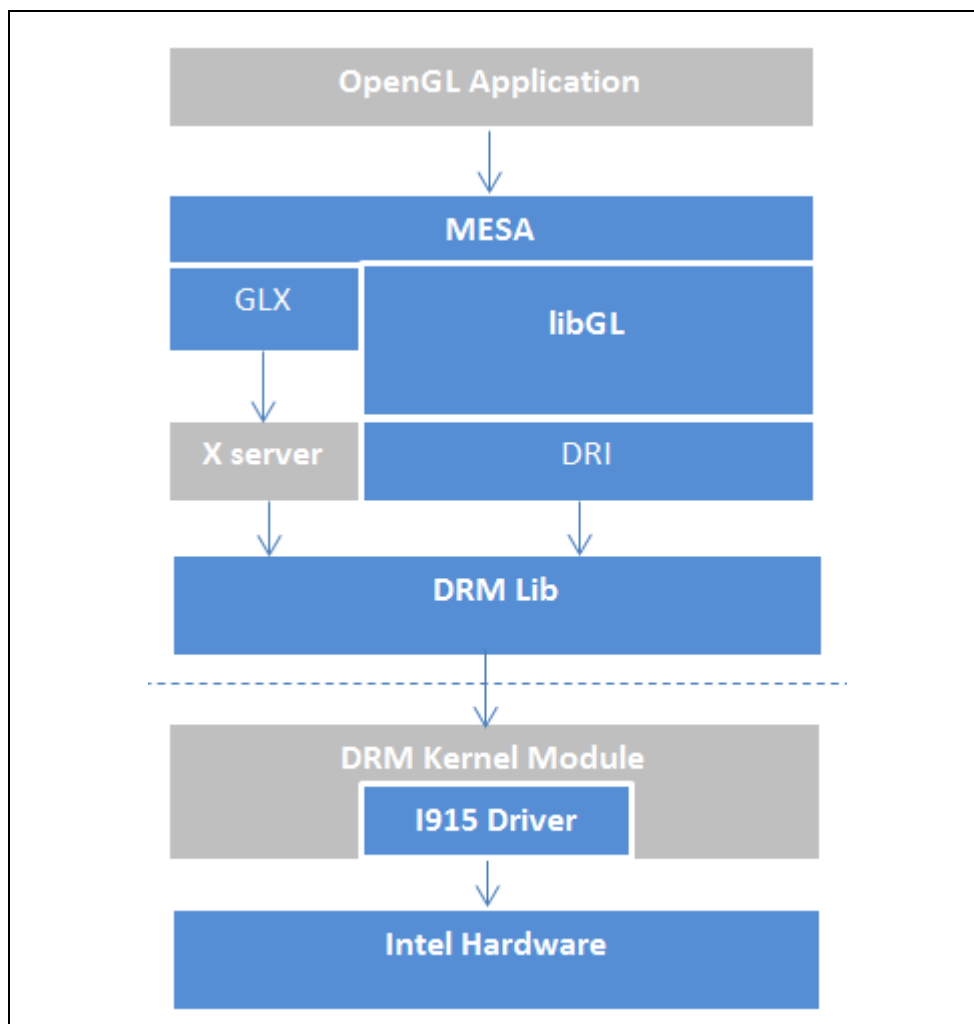
Yocto Project* BSP uses open-source MESA OpenGL stack. By default, OpenGL capabilities are available on Yocto Project* BSP. However, to add the testing tools, such as `glxgears` and `glxinfo`, for OpenGL to the Yocto Project* image, the user must modify the conf/local.conf file with following parameters:

```
EXTRA_IMAGE_FEATURES = "debug-tweaks tools-testapps"
```

Use the following procedure to verify that your Yocto Project* system has OpenGL installed correctly and that it is accelerated by the hardware.

1. Run `glxinfo` on the terminal and search for "direct rendering: Yes" on the output and "OpenGL renderer string:" is "Bay Trail" for the Intel Bay Trail-based platform. If both strings are displayed, it is confirmation that OpenGL is hardware accelerated by the graphic engine.

2. Run `glxgears` to see OpenGL running correctly. It should display an application with three gears rotating on your screen.

## 3.4   Verifying Display Mode Setting

It is likely that your display is already working correctly on your first boot up. This section describes optional steps to verify that the display driver is working properly.

To verify the display mode setting capabilities, run any of the following `XRandR` commands at the terminal (console).

Table 11. Commands To Verify Display Mode Setting Capabilities

Mode	Commands	Output
List all supported timings (resolution)	`xrandr -q`	The output lists all supported timing depending on display capability.
Single display	`xrandr --output HDMI2 -mode 800x600 -rate 60`	Change the resolution of HDMI display to 800x600 at 60Hz vertical refresh rate.
Clone display	`xrandr --output VGA1 --mode 1280x1024 -same-as HDMI1`	Set a clone display with Analog (VGA) and HDMI with a resolution of 1280x1024.
Extended display	`xrandr --output VGA1 --mode 1280x1024 --right-of HDMI1`	Set an extended display with Analog on the right of HDMI with the resolution of 1280x1024.

See to http://www.x.org/wiki/Projects/XRandR/ for more information about `xrandr`.
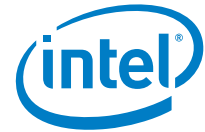
4 Test Results

This section contains the smoke test results.

4.1 Timing Verifications

This is the list of timings that Intel has verified on Yocto Project*.

Note: Other timings can run correctly if your display supports those timings.

Table 12. List of Timings Verified on Yocto Project*

Display	Timings Verified on Yocto Project*	Result
Analog (CRT)	1280x1024@60Hz 1280x1024@75Hz 1152x864@75Hz 1024x768@75.1Hz 832x624@74.6Hz 800x600@72.2Hz 640x480@72.8Hz 720x400@70.1	Pass
HDMI	1920x1080@60Hz 1600x1200@60Hz 1680x1050@59.9Hz 720x576@50Hz 720x480@60Hz 640x480@60Hz	Pass
Display Port (DP)	1920x1200@60Hz 1920x1080@60Hz 1600x1200@65Hz 800x600@60.3Hz 640x480@60Hz 720x400@70.1Hz	Pass
Embedded Display Port (eDP)	1600x900@60Hz 800x600@60.3Hz 800x600@56.2Hz 640x480@59.9Hz	Pass

4.2 Smoke Test Results
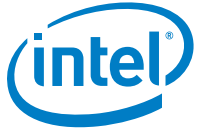
Table 13. Smoke Test Results

Smoke Test Cases	Results
Analog Display	Passed
HDMI	Passed
Display Port	Passed
Embedded Display Port	Passed
Dual Display	Passed
Clone Mode	Passed
Extended Mode	Passed
3D Rendering	Passed
Open GL Rendering String	Passed
Glxgears Running	Passed
Video PlayBack (verifed with the mp4, png, avi files)	Passed
Hotplug VGA	Partially Passed
HotPlug HDMI	Partially Passed
HotPlug DP	Partially Passed
Restart/shutdown/standby	Passed

5   Known Issues

1. Displays must be present during boot time for Hotplug.

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