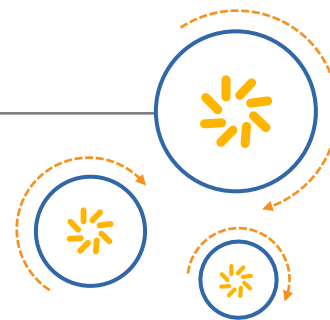




Qualcomm Technologies, Inc.



# DragonBoard™ 410c based on Qualcomm® Snapdragon™ 410E processor

## DSI Display Porting Guide

September 2016

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## Revision history

Revision	Date	Description
D	September 2016	Updated to 'E' part.
C	June 16, 2015	Miscellaneous updates.
B	May 22, 2015	Updated Revision history and © date.
A	April 22, 2015	Initial release.

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# 1 Introduction

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## 1.1 Purpose

This document describes how to port the Linux Android display driver for MIPI DSI display panel onto Qualcomm® Snapdragon™ 410E processor using DragonBoard 410c development board. DragonBoard™ 410c has MIPI DSI interface exposed through the high speed Expansion Connector on the board.

## 1.2 Conventions

Function declarations, function names, type declarations, and code samples appear in a different font, e.g., `#include`.

Code variables appear in angle brackets, e.g., `<number>`.

Commands to be entered appear in a different font, e.g., `copy a:*. * b:`.

Button and key names appear in bold font, e.g., click **Save** or press **Enter**.

If you are viewing this document using a color monitor, or if you print this document to a color printer, **red boldface** indicates code that is to be **added**, and ~~blue strikethrough~~ indicates code that is to be **replaced** or **removed**.

## 1.3 Acronyms

Acronym	Definition
CLK	Click
CMD	Command
DCS	Digital Cellular System
D-PHY	Display Serial Interface Physical Layer
DSI	Display Serial Interface
DTS	Digital Test Sequence
GCDB	Global Component Database
GPIO	General Purpose Input/Output
HS	High Speed
HW	Hardware
IC	Integrated Circuit
LCD	Liquid Crystal Display
LK	Little Kernel
MDP	Mobile Display Processor

Acronym	Definition
MDSS	Multimedia Display Sub-System
MIPI	Mobile Industry Processor Interface
OEM	Original Equipment Manufacturer
PHY	Physical Layer
PMIC	Power Management Integrated Circuit
PWM	Pulse Width Modulation
TE	Terminal Emulator
XML	eXtensible Markup Language

## 1.4 Additional information

For additional information, go to <http://www.96boards.org/db410c-getting-started/> .

## 2 Display Driver Porting Procedures

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This chapter describes how to port the DSI driver into the Little Kernel (LK) and the Android kernel.

Section 2.1 provides information on where to download the display driver. Section 2.2 describes how a DTSI and panel file can be manually generated per the XML input parameters from the display vendor. Section 2.3 to Section 2.7 provides instructions for porting the display driver.

**NOTE:** See the display vendor's specification for driver IC, bridge IC, etc., details before porting.

### 2.1 Download the display component driver

1. The reference panel driver can be found on the Codeaurora website. Here are the Codeaurora links

<https://www.codeaurora.org/cgit/external/thundersoft/ihvjointlab/gcdb-kernel/tree/display/> — Kernel Space support

<https://www.codeaurora.org/cgit/external/thundersoft/ihvjointlab/gcdb-user-space/tree/display/> — User Space support

Download the relevant Kernel/User Space driver code patches and apply them in relevant repositories, e.g:

In Kernel space:

```
cd $ANDROID_BUILD_TOP/kernel
patch -p1 < 0001-ARM-dts-msm-support-truly-hx8379_a-devicetree.patch
```

In LK Bootloader:

```
cd $ANDROID_BUILD_TOP/ bootable/bootloader/lk
patch -p1 < 0001-bootloader-lk-add-lcd-truly-hx8379_a.patch
```

**NOTE:** These are the reference patches. These may not apply directly on all the release code bases at all time. The user will have to resolve the conflicts (see Section 2.6).

2. Obtain the following information in preparation for DSI bringup:
  - Display specification, including parameters.
  - Display power-on sequence and signal duration for GPIO pins, e.g., RESET/IOVDD.
  - DSI initial command sequence and duration information.
  - bitclk, to reach the fps target number.

## 2.2 Generate DTSI file for kernel and LK

The Global Component Database (GCDB) supported on APQ8016E chipsets allows the panel DTSI and LK panel header file to be generated according to the XML input parameters from the panel vendors.

1. Update the device tree parameters. The GCDB source is located in the `device/qcom/common/display/tools` folder; the device tree parameters detail description is present at `kernel\Documentation\devicetree\bindings\fb\mdss-dsi-panel.txt`.

2. Use the GCDB translate command to generate the DTSI and LK panel header files:

```
perl parser.pl <source xml file OEM edit> panel
```

For example:

```
#perl parser.pl panel_<vendor>_720p_video.xml panel
```

It generates `dsi-panel-<vendor>-720p-video.dtsi` and `panel_<vendor>_720p_video.h` files.

### 2.2.1 Bring up LK

**NOTE:** It is recommended to first bring up the panel in kernel.

1. Update Android Kernel by copying the panel driver DTSI file to the `kernel/arch/arm64/boot/dts/qcom` folder.
2. Update LK by copying the panel driver header file to the `bootable/bootloader/lk/dev/gcdb/display/include/` folder.
3. Bring up the panel in the Android Kernel.
4. Disable the LK display and the continuous splash display.
  - a. To disable the continuous splash display, change `DISPLAY_SPLASH_SCREEN` to **0** at `bootable/bootloader/lk/target/msm8916/rules.mk`. Then continue to bring up in LK.
  - b. Update the `target_cont_splash_screen` function at `bootable/bootloader/lk/target/msm8916/init.c`.

For example:

```
static uint8_t splash_override;
/* Returns 1 if target supports continuous splash screen. */
int target_cont_splash_screen()
{
    uint8_t splash_screen = 0;
    if(!splash_override) {
        switch(board_hardware_id())
        {
            case HW_PLATFORM_MTP:
            case HW_PLATFORM_QRD:
                dprintf(SPEW, "Target_cont_splash=1\n");
        }
    }
}
```

```

        splash_screen = 1; // Change to "0" to disable continous
                           splash screen
        break;
        default:
        dprintf(SPEW, "Target_cont_splash=0\n");
        splash_screen = 0;
    }
}
return splash_screen;
}

```

5. Disable the continuous splash screen at **msm8xxx-cdp.dts** file.

```

&dsi_<vendor>_720p_video{
//      qcom,cont-splash-enabled; // Disable continous splash screen
      }003B
};

```

## 2.2.2 Input LCD panel parameters in .xml file

Update the .xml file with the panel parameters from the LCD vendor. In the following example, red font indicates the panel parameters to be updated.

```

<!-- Panel configuration -->
<PanelType>0</PanelType> // 0 stands for video mode panel, 1 stands for
command mode panel
<PanelFrameRate>60</PanelFrameRate>

<!-- Panel Resolution -->
<PanelWidth>720</PanelWidth>
<PanelHeight>1280</PanelHeight>
<HFrontPorch>140</HFrontPorch>
<HBackPorch>164</HBackPorch>
<HPulseWidth>8</HPulseWidth>
<HSyncSkew>0</HSyncSkew>
<VBackPorch>4</VBackPorch>
<VFrontPorch>8</VFrontPorch>
<VPulseWidth>4</VPulseWidth>

<!-- Panel Color Information -->
<ColorFormat>24</ColorFormat> // 24bpp

<!-- Panel Command information -->
<OnCommand>"0x29, 0x01, 0x00, 0x00, 0x00, 0x00, 0x02, 0xFF, 0xEE,
0x29, 0x01, 0x00, 0x00, 0x00, 0x00, 0x02, 0xFB, 0x01,
... ..

```



```

        0x29, 0x01, 0x00, 0x00, 0x78, 0x00, 0x02, 0x29, 0x00"
</OnCommand> // add your panel on commands from LCD vendor

<OffCommand>"0x05, 0x01, 0x00, 0x00, 0x32, 0x00, 0x02, 0x28, 0x00,
... ..
0x05, 0x01, 0x00, 0x00, 0x78, 0x00, 0x02, 0x10, 0x00"
</OffCommand> // add your panel off commands from LCD vendor

<OnCommandState>0</OnCommandState> // 0 stands for lp mode
<OffCommandState>1</OffCommandState> // 1 stands for hs mode

<!-- Video mode panel information -->
<HSyncPulse>1</HSyncPulse>
<BLLPEOFPowerMode>1</BLLPEOFPowerMode>
<BLLPPowerMode>1</BLLPPowerMode>
<TrafficMode>2</TrafficMode>

<!-- Panel Reset Sequence -->
<ResetSequence>
    <PinState1>1</PinState1>
    <PulseWidth1>20</PulseWidth1>
    <PinState2>0</PinState2>
    <PulseWidth2>2</PulseWidth2>
    <PinState3>1</PinState3>
    <PulseWidth3>20</PulseWidth3>
</ResetSequence>

```

## 2.2.3 Calculate DSI PHY timings register

The D-PHY auto calculation spreadsheet (click the paperclip icon on the left of the PDF screen to open the file) is used to calculate the DSI PHY timing settings; this spreadsheet is intended for the MSM8x16 chipset, which uses the DSI6G DSI host design.

1. On the **DSI and MDP registers** worksheet, enter the panel resolution, porch values, fps, color depth, and lane numbers into the fields shown.

**Enter requirements (Enter values in blue)**

frame rate	60 frame per sec	
lane config	4 lanes	
pixel format BPP	3 bytes/pixel	
Display Width	1080 pixels	(including reqd. border fill)
Display Height	1920 lines	(including reqd. border fill)
Active Width	1080 pixels	(active image region)
Active Height	1920 lines	(active image region)
Hsync Pulse Width	32 pclk	ok
Hori. Back Porch	60 pclk	ok
Hori. Back Porch + hsync pulse width	92 pclk	
Hori. Front Porch	48 pclk	ok
Vsync Pulse Width	5 lines	
Vert. Back Porch	6 lines	
Vert. Back Porch + Vsync pulse width	11 lines	
Vert. Front Porch	3 lines	
Escclk source (mxo = 27MHz or pxo = 24MHz)	19.2 MHz	
MMSS_CC ESCCLK PREDIV	1	

change those panel related parameters in spreadsheet

**MDP REGISTER PROGRAMMING**

Hsync period	1220 dclks/line
Vsync period	1934 lines/frame
Dot clock overhead (blanking %)	1.14

QTL Title Page Rev. History User Instructions DSI and MDP registers DSI PHY timing setting

2. The DSI-related clock rate is calculated using the **DSI PHY timing setting** worksheet. An invalid value appears in the **Check for T\_CLK\_ZERO** field. Press **CTRL+J** and **CTRL+K** to recalculate T\_CLK\_ZERO to a valid value.

**1. PHY Timing parameters calculated from bitclk calculated in "dsi and mdp registers" and escclk source set in "dsi and mdp registers"**  
**(User may overwrite the values in blue)**

Full Rate Bitclk	850.00 Mbps					
escclk	19.2 MHz					
UI	1.176470588 ns					
Tlpx	52.08333333 ns					
Treot	20 ns					
<b>MIPI PHY v1.1 requirement</b>						
	min (ns)	max (ns)	min	max	Recommended register settings (dec)	program value (hardwired to PHY inputs)
T_CLK_PREPARE	38	95	31	79	36	36
T_CLK_ZERO	255.2941176		215	255	218	218
T_CLK_TRAIL	60	99.11764706	49	83	52	52
T_HS_PREPARE	44.70588235	92.05882353	36	77	40	40
T_HS_ZERO	105		88	255	104	104
T_HS_TRAIL	64.70588235	99.11764706	53	83	56	56
T_HS_RQST					42	42
T_HS_EXIT	100		83	255	100	100
T_TA_GO	208.3333333	208.3333333			208.3333333	3
T_TA_SURE	52.08333333	104.1666667			52.08333333	0
T_TA_GET	260.4166667	260.4166667			260.4166667	4
TEOT of data lane		119.1176471				78.23529412
TEOT of clock lane						73.52941176
T_CLK_POST	121.1764706		-4	63	3	3
T_CLK_PRE	9.411764706		38	63	41	41
overhead in data transmission						1070.588235

clock related information

Check for T\_CLK\_ZERO **VALID** CTRL+J then become valid

The panel requires PHY value setup for bitclk in the DSI PHY register.

## 2. DSI PHY registers

PHY Registers (address)	value in hex
DSIPHY_TIMING_CTRL_0 (0xC40)	DA
DSIPHY_TIMING_CTRL_1 (0xC44)	34
DSIPHY_TIMING_CTRL_2 (0xC48)	24
DSIPHY_TIMING_CTRL_3 (0xC4C)	0
DSIPHY_TIMING_CTRL_4 (0xC50)	64
DSIPHY_TIMING_CTRL_5 (0xC54)	68
DSIPHY_TIMING_CTRL_6 (0xC58)	28
DSIPHY_TIMING_CTRL_7 (0xC5C)	38
DSIPHY_TIMING_CTRL_8 (0xC60)	2A
DSIPHY_TIMING_CTRL_9 (0xC64)	3
DSIPHY_TIMING_CTRL_10 (0xC68)	4

- Input the panel timings value in the .xml file.

```
<!-- Panel Timing -->
<PanelTimings>"0xDA, 0x34, 0x24, 0x00, 0x64, 0x68,
               0x28, 0x38, 0x2A, 0x03, 0x04, 0x00"</PanelTimings>
<TClkPost>0x03</TClkPost>
<TClkPre>0x41</TClkPre>
```

**NOTE:** DSIPHY\_TIMING\_CTRL\_3 is 0x00. DSIPHY\_TIMING\_CTRL\_11 is used for the DSI secondary display; it is not necessary to modify it if there is no DSI secondary panel.

### 2.2.3.1 Set DSI clock to HS mode

Certain panels must be set to `force_clk_lane_hs` to send commands in HS mode.

At `kernel/drivers/video/msm/mdss/mdss_dsi.c` file, on `mdss_dsi_onfunction`.

For example,

```
mipi->force_clk_lane_hs= 1;
if(mipi->force_clk_lane_hs)
{
    u32tmp;
    tmp= MIPI_INP((ctrl_pdata->ctrl_base) + 0xac);
    tmp|= (1<<28);
    MIPI_OUTP((ctrl_pdata->ctrl_base) + 0xac, tmp);
    wmb();
}
```

## 2.3 Input backlight control parameters

Three methods used to control backlight are:

- “`bl_ctrl_pwm`” = Backlight controlled by PWM GPIO
- “`bl_ctrl_wled`” = Backlight controlled by WLED

- “bl\_ctrl\_dcs” = Backlight control by DCS commands

If WLED is used to control the backlight, input the backlight parameters in the .xml file:

```
<!-- Backlight -->
<BLInterfaceType>1</BLInterfaceType>
<BLMinLevel>1</BLMinLevel>
<BLMaxLevel>4095</BLMaxLevel>
<BLStep>100</BLStep>
<BLPMICModel>"PMIC_8xxx"</BLPMICModel>
<BLPMICControlType>1</BLPMICControlType> // 1 stands for Backlight
controlled by WLED.
```

The DCS backlight control is selected at the panel side. The backlight control is highly related to hardware configuration/schematics. If the backlight uses a third-party backlight driver IC, or the schematics is changed from the QTI reference schematics, modify the software to add backlight control routines. The default backlight entry function is used in mdss\_fb.c (do not modify).

## 2.4 Set up DSI panel-related GPIO pins

1. Input GPIO pins parameter in **platform-8xxx.xml** file.

The information about setting up DSI panel-related GPIO reset pins can be found at arch/arm/boot/dts/qcom/msm8xxx-mdss.dts. The GPIO parameters are entered in the .xml file at device/qcom/common/display/tools/platform-8xxx.xml.

For example,

```
<PlatformId>"msm8xxx"</PlatformId>
<!-- GPIO configuration -->
<ResetGPIO>
    <PinSource>"msmgpio"</PinSource>
    <PinId>25</PinId>
    <PinStrength>3</PinStrength>
    <PinDirection>1</PinDirection>
    <PinPull>0</PinPull>
    <PinState>1</PinState>
</ResetGPIO>

<EnableGPIO>
    <PinSource>"msmgpio"</PinSource>
    <PinId>32</PinId>
    <PinStrength>3</PinStrength>
    <PinDirection>1</PinDirection>
    <PinPull>0</PinPull>
    <PinState>1</PinState>
```

For the TE GPIO and backlight GPIO using DCS backlight control, see the platform MDSS DSI parameters description at `kernel/Documentation/devicetree/bindings/fb/mdss-dsi-ctrl.txt`.

For pin definitions, see the parameter details at `/arch/arm/boot/dts/qcom/msm8xxx-pinctrl.dtsi`.

Any LCD module-specific reset sequences beyond QTI's default release software should be handled by the QEM. In general, the default release software should cover most use cases.

## 2.5 Add the panel device tree to the platform DTS file

Modify the `msm8xxx-qrd.dts` at `arch/arm/boot/dts/qcom/` by adding the panel device tree.

For example,

```
/include/ "dsi-panel-<vendor>-720p-video.dtsi"

&mdss_mdp {
    qcom,mdss-pref-prim-intf = "dsi";
};

&mdss_pinmux {
    qcom,num-grp-pins = <3>;
    qcom,pins = <&gp 32>, <&gp 25>, <&gp 97>;
};

&mdss_dsi0 {
    qcom,dsi-pref-prim-pan = <&dsi_<vendor>_720p_video>;
    pinctrl-names = "default", "sleep";
    pinctrl-0 = <&mdss_dsi_active>;
    pinctrl-1 = <&mdss_dsi_suspend>;
};
```

## 2.6 Add panel driver header file and detect panel ID in LK

1. Add the panel header file to `bootable/bootloader/lk/target/msm8xxx/oem_panel.c`.

For example,

```
#include "include/panel_toshiba_720p_video.h"
#include "include/panel_nt35590_720p_video.h"
#include "include/panel_nt35590_720p_cmd.h"
#include "include/panel_hx8394a_720p_video.h"
+#include "include/panel_nt35521_720p_video.h"
```

2. Add the `<vendor>_<resolution>_VIDEO_PANEL` parameter to the enum.

```
enum {
```

```

TOSHIBA_720P_VIDEO_PANEL,
NT35590_720P_CMD_PANEL,
NT35590_720P_VIDEO_PANEL,
HX8394A_720P_VIDEO_PANEL,
+NT35521_720P_VIDEO_PANEL,
UNKNOWN_PANEL
};

```

3. Add the <vendor>\_<resolution>\_VIDEO\_PANEL parameter to the panel\_list\_supp\_panels struct.

```

static struct panel_list supp_panels[] = {
{"toshiba_720p_video", TOSHIBA_720P_VIDEO_PANEL},
{"nt35590_720p_cmd", NT35590_720P_CMD_PANEL},
{"nt35590_720p_video", NT35590_720P_VIDEO_PANEL},
{"hx8394a_720p_video", HX8394A_720P_VIDEO_PANEL},
+{"nt35521_720p_video", NT35521_720P_VIDEO_PANEL},
};

```

4. Add the <vendor>\_<resolution>\_VIDEO\_PANEL case to the init\_panel\_data function.

```

static void init_panel_data(struct panel_struct *panelstruct,
                          struct msm_panel_info *pinfo,
                          struct mdss_dsi_phy_ctrl *phy_db)
{
    switch (panel_id) {
+case NT35521_720P_VIDEO_PANEL:
+    panelstruct->paneldata      = &nt35521_720p_video_panel_data;
+    panelstruct->panelres       = &nt35521_720p_video_panel_res;
+    panelstruct->color          = &nt35521_720p_video_color;
+    panelstruct->videopanel     = &nt35521_720p_video_video_panel;
+    panelstruct->commandpanel   = &nt35521_720p_video_command_panel;
+    panelstruct->state          = &nt35521_720p_video_state;
+    panelstruct->laneconfig     = &nt35521_720p_video_lane_config;
+    panelstruct->paneltiminginfo
                                = &nt35521_720p_video_timing_info;
+    panelstruct->panelresetseq
                                = &nt35521_720p_video_panel_reset_seq;
+    panelstruct->backlightinfo  = &nt35521_720p_video_backlight;
+    pinfo->mipi.panel_cmds
                                = nt35521_720p_video_on_command;
+    pinfo->mipi.num_of_panel_cmds
                                = NT35521_720P_VIDEO_ON_COMMAND;
+    memcpy(phy_db->timing,
            nt35521_720p_video_timings, TIMING_SIZE);
    }
}

```

```
break;
```

5. Select the panel ID according to `hw_id` in the `oem_panel_select` function.

```
enum target_subtype {
    HW_PLATFORM_SUBTYPE_SKUAA = 0,
    HW_PLATFORM_SUBTYPE_SKUF = 1,
    HW_PLATFORM_SUBTYPE_SKUAB = 2,
    HW_PLATFORM_SUBTYPE_SKUG = 3,
    +HW_PLATFORM_SUBTYPE_720P = 5,
};

switch (hw_id) {

    case HW_PLATFORM_MTP:
    case HW_PLATFORM_QRD:
        if (hw_subtype == HW_PLATFORM_SUBTYPE_720P)
            + panel_id = NT35521_720P_VIDEO_PANEL;
        else
            panel_id = nt35590_panel_id;
        break;
    default:
        dprintf(CRITICAL, "Display not enabled for %d HW type\n"
                , hw_id);

        return false;
}
```

## 2.7 Rebuild images, flash, and debug through adb

1. Rebuild the software.
2. Flash the `emmc_appsboot.mbn` and `boot.img` files onto the device.
3. Verify that the panel is lighted. If not, check the panel initialization commands, reset sequence, and measure the signal for DSI clock lane and data lane, etc.
4. If there is no DSI Clock output, check the DSI-related clocks using adb commands.
  - a. `adb root`
  - b. `adb remount`
  - c. `adb shell`
  - d. `#mount -t debugfs none /sys/kernel/debug`
  - e. `#cd /sys/kernel/debug/clock/dsi1_byte_clk`
  - f. `#cat measure`

## EXHIBIT 1

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