

# SC668S Series Display Driver Development Guide

**Smart Module Series**

Version: 1.0

Date: 2023-04-23

Version: Released



At Quectel, our aim is to provide timely and comprehensive services to our customers. If you require any assistance, please contact our headquarters:

**Quectel Wireless Solutions Co., Ltd.**

Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China

Tel: +86 21 5108 6236

Email: [info@quectel.com](mailto:info@quectel.com)

**Or our local offices. For more information, please visit:**

<http://www.quectel.com/support/sales.htm>.

**For technical support, or to report documentation errors, please visit:**

<http://www.quectel.com/support/technical.htm>.

Or email us at: [support@quectel.com](mailto:support@quectel.com).

## Legal Notices

We offer information as a service to you. The provided information is based on your requirements and we make every effort to ensure its quality. You agree that you are responsible for using independent analysis and evaluation in designing intended products, and we provide reference designs for illustrative purposes only. Before using any hardware, software or service guided by this document, please read this notice carefully. Even though we employ commercially reasonable efforts to provide the best possible experience, you hereby acknowledge and agree that this document and related services hereunder are provided to you on an “as available” basis. We may revise or restate this document from time to time at our sole discretion without any prior notice to you.

## Use and Disclosure Restrictions

### License Agreements

Documents and information provided by us shall be kept confidential, unless specific permission is granted. They shall not be accessed or used for any purpose except as expressly provided herein.

### Copyright

Our and third-party products hereunder may contain copyrighted material. Such copyrighted material shall not be copied, reproduced, distributed, merged, published, translated, or modified without prior written consent. We and the third party have exclusive rights over copyrighted material. No license shall be granted or conveyed under any patents, copyrights, trademarks, or service mark rights. To avoid ambiguities, purchasing in any form cannot be deemed as granting a license other than the normal non-exclusive, royalty-free license to use the material. We reserve the right to take legal action for noncompliance with abovementioned requirements, unauthorized use, or other illegal or malicious use of the material.

## Trademarks

Except as otherwise set forth herein, nothing in this document shall be construed as conferring any rights to use any trademark, trade name or name, abbreviation, or counterfeit product thereof owned by Quectel or any third party in advertising, publicity, or other aspects.

## Third-Party Rights

This document may refer to hardware, software and/or documentation owned by one or more third parties (“third-party materials”). Use of such third-party materials shall be governed by all restrictions and obligations applicable thereto.

We make no warranty or representation, either express or implied, regarding the third-party materials, including but not limited to any implied or statutory, warranties of merchantability or fitness for a particular purpose, quiet enjoyment, system integration, information accuracy, and non-infringement of any third-party intellectual property rights with regard to the licensed technology or use thereof. Nothing herein constitutes a representation or warranty by us to either develop, enhance, modify, distribute, market, sell, offer for sale, or otherwise maintain production of any our products or any other hardware, software, device, tool, information, or product. We moreover disclaim any and all warranties arising from the course of dealing or usage of trade.

## Privacy Policy

To implement module functionality, certain device data are uploaded to Quectel’s or third-party’s servers, including carriers, chipset suppliers or customer-designated servers. Quectel, strictly abiding by the relevant laws and regulations, shall retain, use, disclose or otherwise process relevant data for the purpose of performing the service only or as permitted by applicable laws. Before data interaction with third parties, please be informed of their privacy and data security policy.

## Disclaimer

- a) We acknowledge no liability for any injury or damage arising from the reliance upon the information.
- b) We shall bear no liability resulting from any inaccuracies or omissions, or from the use of the information contained herein.
- c) While we have made every effort to ensure that the functions and features under development are free from errors, it is possible that they could contain errors, inaccuracies, and omissions. Unless otherwise provided by valid agreement, we make no warranties of any kind, either implied or express, and exclude all liability for any loss or damage suffered in connection with the use of features and functions under development, to the maximum extent permitted by law, regardless of whether such loss or damage may have been foreseeable.
- d) We are not responsible for the accessibility, safety, accuracy, availability, legality, or completeness of information, advertising, commercial offers, products, services, and materials on third-party websites and third-party resources.

**Copyright © Quectel Wireless Solutions Co., Ltd. 2023. All rights reserved.**

# About the Document

## Revision History

Version	Date	Author	Description
-	2022-04-18	Hbingo HUANG	Creation of the Document
1.0	2023-04-23	Hbingo HUANG/ Aivin XU	First official release

## Contents

About the Document .....	3
Contents .....	4
Table Index.....	5
Figure Index .....	6
<b>1 Introduction .....</b>	<b>7</b>
<b>2 Panel Configuration File Modification .....</b>	<b>8</b>
2.1. Configure Panel Information .....	8
2.2. Configure Panel Resolution .....	9
2.3. Configure Panel Color Information .....	10
2.4. Configure Panel Command Information .....	10
2.4.1. Command Format .....	11
2.5. Configure Video Mode Panel .....	13
2.6. Configure Data Lane .....	13
2.7. Configure DSI Timings .....	14
2.7.1. Generate DSI Timings.....	15
<b>3 Kernel and UEFI Configuration .....</b>	<b>19</b>
3.1. Configure Kernel .....	19
3.1.1. Configure dts File .....	19
3.1.2. Update Kernel .....	23
3.2. Configure UEFI .....	23
<b>4 Appendix References .....</b>	<b>24</b>

## Table Index

Table 1: Panel Configuration Parameters .....	8
Table 2: Panel Resolution Configuration Parameters .....	9
Table 3: Panel Color Configuration Parameters .....	10
Table 4: Configuration Parameters of Panel Command Information .....	11
Table 5: Command Format.....	11
Table 6: Configuration Parameters of Video Mode Panel.....	13
Table 7: Configuration Parameters of Data Lane.....	13
Table 8: Configuration Parameters of DSI Timings.....	14
Table 9: Terms and Abbreviations .....	24

## Figure Index

Figure 1: Click "Enable Content" .....	15
Figure 2: DSI and MDP Registers Sheet .....	16
Figure 3: DSI PHY Timing Setting Sheet .....	16
Figure 4: Timing Values Generated in DSI PHY 2.0.0 Timing Setting sheet.....	17
Figure 5: Update mdss-dsi-panel-phy-timings .....	17
Figure 6: Update mdss-dsi-t-clk-post and mdss-dsi-t-clk-pre .....	18

# 1 Introduction

This document introduces how to use the Display Serial Interface (DSI) to bring up the LCD display panel of Quectel SC668S series module on Android platform, including important parameters of panel configuration files and the configuration steps in Kernel and UEFI.

## NOTE

1. In this document, LCD HX8394F on the EVB corresponding to the module is used as an example to outline the development flow of LCD display driver.
2. This document only describes important user configurations during LCD display driver development.
3. This document is applicable to multiple Android versions, and the kernel path can be divided into two paths: *kernel/msm-4.14* (For Android 10 and Android 11) and *UM.x.xx\kernel\msm-4.14* (For Android 12 or above). You need to select the corresponding path according to the specific Android version.



# 2 Panel Configuration File Modification

This panel configuration files introduced in this chapter are described as below:

- *dsi-panel-hx8394f-720p-video.dtsi* (**Chapter 2.1** to **2.6**)
- *trinket-sde-display.dtsi* (**Chapter 2.7**)

The two files are in the *kernel/msm-4.14/arch/arm64/boot/dts/qcom* directory. You can configure the required LCD by copying the default panel configuration files of the module and then modifying the corresponding MIPI parameters.

**NOTE**

This chapter only introduces important parameters which may be modified by users. Parameters not mentioned herein usually do not need to be modified.

## 2.1. Configure Panel Information

You can configure the panel information as required. Here is an example:

```
&mdss_mdp {
    dsi_hx8394f_720p_video: qcom.mdss-dsi-hx8394f-720p-video {
        qcom,mdss-dsi-panel-name = "hx8394f video mode dsi panel without DSC";
        qcom,mdss-dsi-panel-type = "dsi_video_mode";
        qcom,mdss-dsi-virtual-channel-id = <0>;
        qcom,mdss-dsi-stream = <0>;
        qcom,mdss-dsi-h-left-border = <0>;
        qcom,mdss-dsi-h-right-border = <0>;
        qcom,mdss-dsi-v-top-border = <0>;
        qcom,mdss-dsi-v-bottom-border = <0>;
        qcom,mdss-dsi-bpp = <24>;
        qcom,mdss-dsi-color-order = "rgb_swap_rgb";
        qcom,mdss-dsi-underflow-color = <0xff>;
        qcom,mdss-dsi-border-color = <0>;
    };
};
```

**Table 1: Panel Configuration Parameters**

Parameter	Description	Value
<i>mdss-dsi-panel-name</i>	Panel name	Panel name/configuration file value

<i>mdss-dsi-panel-type</i>	Panel type	" <i>dsi_video_mode</i> "	Video mode
		" <i>dsi_cmd_mode</i> "	Command mode

## 2.2. Configure Panel Resolution

You can configure panel resolution as required. Here is an example:

```
qcom,mdss-dsi-display-timings {
    timing@0{
        qcom,mdss-dsi-panel-width = <720>;
        qcom,mdss-dsi-panel-height = <1280>;
        qcom,mdss-dsi-h-front-porch = <50>;
        qcom,mdss-dsi-h-back-porch = <50>;
        qcom,mdss-dsi-h-pulse-width = <50>;
        qcom,mdss-dsi-h-sync-skew = <0>;
        qcom,mdss-dsi-v-back-porch = <4>;
        qcom,mdss-dsi-v-front-porch = <10>;
        qcom,mdss-dsi-v-pulse-width = <4>;
        qcom,mdss-dsi-panel-framerate = <60>;
        qcom,mdss-dsi-on-command = [
```

**Table 2: Panel Resolution Configuration Parameters**

Parameter	Description
<i>mdss-dsi-panel-width</i>	Panel width (pixel)
<i>mdss-dsi-panel-height</i>	Panel height (pixel)
<i>mdss-dsi-h-front-porch</i>	Horizontal front porch value
<i>mdss-dsi-h-back-porch</i>	Horizontal back porch value
<i>mdss-dsi-h-pulse-width</i>	Horizontal pulse width
<i>mdss-dsi-h-sync-skew</i>	Horizontal sync skew value
<i>mdss-dsi-v-back-porch</i>	Vertical back porch value
<i>mdss-dsi-v-front-porch</i>	Vertical front porch value
<i>mdss-dsi-v-pulse-width</i>	Vertical pulse width
<i>mdss-dsi-panel-framerate</i>	Panel framerate, which is the number of frames refreshed on panel per second

### 2.3. Configure Panel Color Information

You can configure panel color information as required. Here is an example:

```
qcom,mdss-dsi-bpp = <24>;
qcom,mdss-dsi-color-order = "rgb_swap_rgb";
qcom,mdss-dsi-underflow-color = <0xff>;
qcom,mdss-dsi-border-color = <0>;
```

Table 3: Panel Color Configuration Parameters

Parameter	Description	Value
<i>mdss-dsi-bpp</i>	Defines the number of bits per pixel	24 888_RGB
		18 666_RGB
		16 565_RGB
		12 444_RGB
		8 332_RGB
<i>mdss-dsi-color-order</i>	Specifies the R, G, B channel order	3 111_RGB
		"rgb_swap_rgb"
		"rgb_swap_rbg"
		"rgb_swap_brg"
		"rgb_swap_grb"
<i>mdss-dsi-color-order</i>	Specifies the R, G, B channel order	"rgb_swap_gbr"
		"rgb_swap_rbg"
		"rgb_swap_brg"
		"rgb_swap_grb"

### 2.4. Configure Panel Command Information

You can configure panel command information (for LCD initialization) as required. The information is provided by LCD module manufacturer. Here is an example:

```
qcom,mdss-dsi-on-command = [
    29 01 00 00 00 04 B9 FF 83 94
    29 01 00 00 00 07 BA 63 03 68 6b b2 c0
    29 01 00 00 00 00 0B B1 50 12 72 09 33 54 B1 31 6B 2F
    29 01 00 00 00 07 B2 00 80 64 0e 0d 2f
    29 01 00 00 00 00 16 B4 73 74 73 74 73 74 01 0C 86 75 00 3F 73 74 73 74 73 74 01 0C 86
    29 01 00 00 00 00 22 D3 00 00 07 07 40 07 10 00 08 10 08 00 08 54 15 0e 05 0e 02 15 06 05 06 47 44 0a 0a 4b 10 07 07
    29 01 00 00 00 00 2D D5 1a 1a 1b 1b 00 01 02 03 04 05 06 07 08 09 0a 0b 24 25 18 18 26 27 18 18 18 18 18 18 18 18
    29 01 00 00 00 00 2D D6 1a 1a 1b 1b 0b 0a 09 08 07 06 05 04 03 02 01 00 21 20 18 18 27 26 18 18 18 18 18 18 18 18
    29 01 00 00 00 00 3B E0 00 0D 1B 22 25 2A 2F 2C 5A 6B 7A 77 7E 8E 92 95 9F 9E 99 a1 b0 57 55 5C 5F 5F 67 6F 00 0D
    29 01 00 00 00 00 03 C0 1f 31
    29 01 00 00 00 00 02 CC 0B
    29 01 00 00 00 00 03 B6 78 78
    29 01 00 00 00 00 02 D4 02
    29 01 00 00 00 00 02 BD 02
    29 01 00 00 00 00 0D D8 FF FF FF FF FF FF FF FF FF FF FF
    29 01 00 00 00 00 02 BD 00
    29 01 00 00 00 00 02 BD 01
    29 01 00 00 00 00 02 B1 00
    29 01 00 00 00 00 02 BD 00
    29 01 00 00 00 00 08 BF 40 81 50 00 1A FC 01
    05 01 00 00 78 00 02 11 00
    05 01 00 00 05 00 02 29 00
];
qcom,mdss-dsi-off-command = [05 01 00 00 14 00 02 28 00
    05 01 00 00 78 00 02 10 00];
```

**Table 4: Configuration Parameters of Panel Command Information**

Parameter	Description
<i>mdss-dsi-on-command</i>	Array of variable length that lists the initialization commands of the panel
<i>mdss-dsi-off-command</i>	Array of variable length that lists the de-initialization commands of the panel

**2.4.1. Command Format**

Usually, only *PayloadSize* and *Payload* in the command need to be modified, but sometimes *Wait* also needs to be modified. See the requirements of initialization commands provided by the LCD module manufacturer for details. The parameter information is described as below:

```

qcom,mdss-dsi-on-command = [
29 01 00 00 00 00 04 B9 FF 83 94
29 01 00 00 00 00 07 BA 63 03 68 6b b2 c0
29 01 00 00 00 00 0B B1 50 12 72 09 33 54 B1 31 6B 2F
29 01 00 00 00 00 07 B2 00 80 64 0e 0d 2f
29 01 00 00 00 00 16 B4 73 74 73 74 73 74 01 0C 86 75 00 3F 73 74 73 74 73 74 01 0C 86
29 01 00 00 00 00 22 D3 00 00 07 07 40 07 10 00 08 10 08 00 08 54 15 0e 05 0e 02 15 06 05 06 47 44 0a 0a 4b 10 07 07
29 01 00 00 00 00 2D D5 1a 1a 1b 1b 00 01 02 03 04 05 06 07 08 09 0a 0b 24 25 18 18 26 27 18 18 18 18 18 18 18 18 18 18
29 01 00 00 00 00 2D D6 1a 1a 1b 1b 0b 0a 09 08 07 06 05 04 03 02 01 00 21 20 18 18 27 26 18 18 18 18 18 18 18 18 18
29 01 00 00 00 00 3B E0 00 0D 1B 22 25 2A 2F 2C 5A 6B 7A 77 7E 8E 92 95 9F 9E 99 a1 b0 57 55 5C 5F 5F 67 6F 7f 00 0D
29 01 00 00 00 00 03 C0 1f 31
29 01 00 00 00 00 02 CC 0B
29 01 00 00 00 00 03 B6 78 78
29 01 00 00 00 00 02 D4 02
29 01 00 00 00 00 02 BD 02
29 01 00 00 00 00 0D D8 FF FF FF FF FF FF FF FF FF FF FF FF
29 01 00 00 00 00 02 BD 00
29 01 00 00 00 00 02 BD 01
29 01 00 00 00 00 02 B1 00
29 01 00 00 00 00 02 BD 00
29 01 00 00 00 00 08 BF 40 81 50 00 1A FC 01
05 01 00 00 78 00 02 11 00
05 01 00 00 05 00 02 29 00
];
qcom,mdss-dsi-off-command = [05 01 00 00 14 00 02 28 00
05 01 00 00 78 00 02 10 00];
qcom,mdss-dsi-on-command-state = "dsi_lp_mode";
qcom,mdss-dsi-off-command-state = "dsi_hs_mode";
    
```

**Table 5: Command Format**

Parameter	Description	Length
<i>CommandType</i>	Data type of command	1
<i>Last</i>	Specifies whether this command packet is an individual command	1
<i>VC</i>	Virtual channel used to send this command	1
<i>Ack</i>	Indicates whether acknowledgement from the panel is needed	1
<i>Wait</i>	Waiting time in milliseconds before sending next command	1

<i>PayloadSize</i>	Payload size	2
<i>Payload</i>	Payload	Based on <i>PayloadSize</i>

*Payload* is generally provided by the LCD module manufacturer.

*Payload* provided by LCD module manufacturer in the following format are preferable:

```
CMD(Hex),Number(Hex),DATA(Hex),DATA(Hex),...
```

When *Payload* is provided in the above format, *mdss-dsi-on-command* will be in the following format:

```
Register = 29 01 00 00 (A collection of CommandType, Last, VC and Ack)
Wait (Unit: ms. The value is provided by LCD module manufacturer)
PayloadSize = Number+1
Payload = CMD DATA DATA ...
```

For example, if *Payload* provided by LCD module manufacturer is:

```
B9,3,FF,83,94
BA,6,63,3,68,6B,B2,C0
```

*mdss-dsi-on-command* will be configured as:

```
29 01 00 00 00 00 04 B9 FF 83 94
29 01 00 00 00 00 07 BA 63 03 68 6B B2 C0
```

Usually, the last two commands of *mdss-dsi-on-command* are given as below, where 11 means LCD exiting sleep (sleep out) and 29 means turning on LCD (display on).

```
05 01 00 00 78 00 02 11 00
05 01 00 00 05 00 02 29 00
```

**NOTE**

You can delete the above two commands if they are not needed for the LCD module used. For specific usage conditions of the commands, see LCD module hardware design or contact the corresponding LCD module manufacturer.

## 2.5. Configure Video Mode Panel

Usually, parameters for video mode panel do not need to be modified, except for *mdss-dsi-traffic-mode* since it may vary with LCD chip. Here is an example:

```
qcom,mdss-dsi-traffic-mode = "non_burst_sync_event";
```

**Table 6: Configuration Parameters of Video Mode Panel**

Parameter	Description	Value	
		"non_burst_sync_pulse"	Non-burst with synchronization pulse
<i>mdss-dsi-traffic-mode</i>	MIPI transmission mode	"non_burst_sync_event"	Non-burst with synchronization start event
		"burst_mode"	Burst mode

## 2.6. Configure Data Lane

You can configure data lane as required. The following is a configuration example when 4 data lanes are enabled. If one of the data lanes is disabled, then you do not need to configure the corresponding lane number. Please see the corresponding LCD module hardware design for details.

```
qcom,mdss-dsi-lane-0-state;
qcom,mdss-dsi-lane-1-state;
qcom,mdss-dsi-lane-2-state;
qcom,mdss-dsi-lane-3-state;
```

**Table 7: Configuration Parameters of Data Lane**

Parameter	Description
<i>mdss-dsi-lane-0-state</i>	Enable lane 0
<i>mdss-dsi-lane-1-state</i>	Enable lane 1
<i>mdss-dsi-lane-2-state</i>	Enable lane 2
<i>mdss-dsi-lane-3-state</i>	Enable lane 3

## 2.7. Configure DSI Timings

You can configure DSI timing sequence of the panel according to your needs. Here is an example:

```
&dsi_hx8394f_720p_video {
    qcom,mdss-dsi-t-clk-post = <0x0a>;
    qcom,mdss-dsi-t-clk-pre = <0x1c>;
    qcom,dsi-supported-dfps-list = <60 55 53 43>;
    qcom,mdss-dsi-pan-enable-dynamic-fps;
    qcom,mdss-dsi-pan-fps-update =
        "dfps_immediate_porch_mode_vfp";
    // qcom,esd-check-enabled;
    // qcom,mdss-dsi-panel-status-check-mode = "reg_read";
    // qcom,mdss-dsi-panel-status-command = [06 01 00 01 00 01 0a];
    // qcom,mdss-dsi-panel-status-command-state = "dsi_hs_mode";
    // qcom,mdss-dsi-panel-status-value = <0x9d 0x9d 0x9d 0x9d>;
    // qcom,mdss-dsi-panel-on-check-value = <0x9d 0x9d 0x9d 0x9d>;
    // qcom,mdss-dsi-panel-status-read-length = <4>;
    qcom,mdss-dsi-display-timings {
        timing@0{
            qcom,mdss-dsi-panel-phy-timings =
                [1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 0D 03 05 02 02 04 a0];

            qcom,display-topology = <1 0 1>;
            qcom,default-topology-index = <0>;
        };
    };
};
```

Table 8: Configuration Parameters of DSI Timings

Parameter	Description
<i>mdss-dsi-t-clk-pre</i>	Pre-value of DSI timing control clock (generated according to the steps in <b>Chapter 2.7.1</b> )
<i>mdss-dsi-t-clk-post</i>	Post value of DSI timing control clock (generated according to the steps in <b>Chapter 2.7.1</b> )
<i>mdss-dsi-panel-phy-timings</i>	An array with a length of 40 bytes that specifies the physical timing settings (generated according to the steps in <b>Chapter 2.7.1</b> )

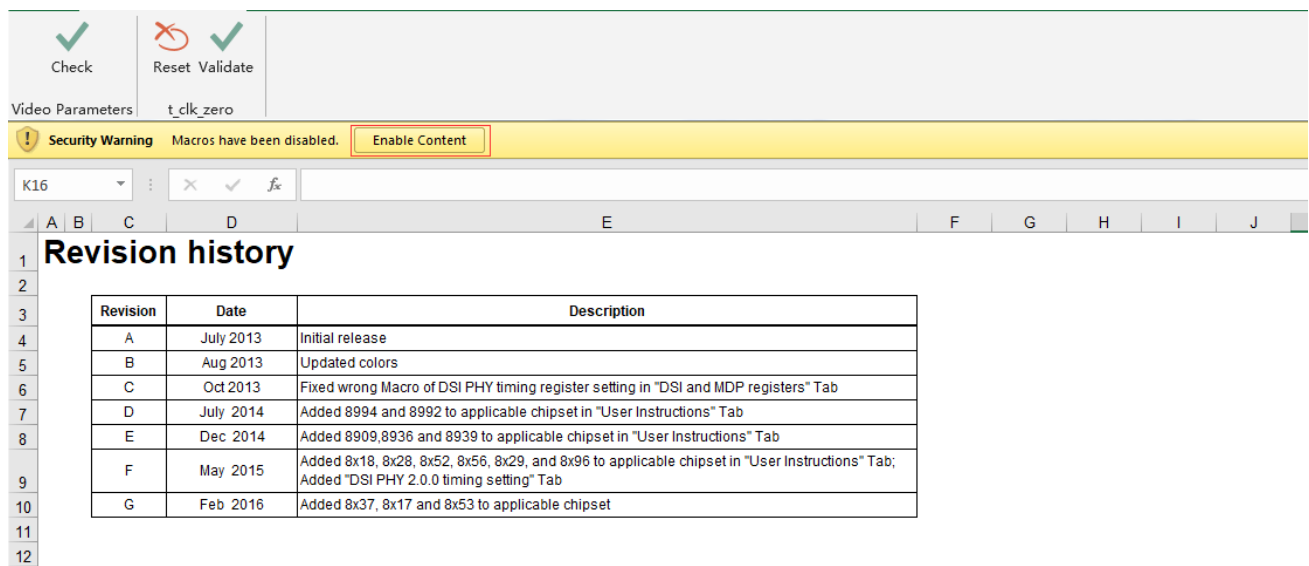
### 2.7.1. Generate DSI Timings

80-nh713-1\_yb\_dsi timing parameters user interactive spreadsheet.xlsm in 80-NH713-1\_DSI.zip can be used to calculate the DSI timings values automatically. The detailed steps are as below:

**NOTE**

1. Please contact Quectel Technical Supports for obtaining 80-NH713-1\_DSI.zip.
2. Please use Microsoft Excel (Microsoft Excel 2016 is recommended) to open 80-nh713-1\_yb\_dsi timing parameters user interactive spreadsheet.xlsm. The use of other tools such as WPS is not supported.

**Step 1:** Open 80-nh713-1\_yb\_dsi timing parameters user interactive spreadsheet.xlsm and click "Enable Content", as shown in the figure below:



**Figure 1: Click "Enable Content"**



**Step 2:** Open *DSI and MDP Registers* sheet. Input the values of *frame rate*, *lane config*, *pixel format BPP*, *Active Width*, *Active Height*, *Porch* and *Chip* to be configured to the specified area, as shown in the figure below:

Enter requirements (Enter values in blue)		
frame rate	60	frame per sec
lane config	4	lanes
pixel format BPP	3	bytes/pixel
Display Width	720	pixels (including reqd. border fill)
Display Height	1280	lines (including reqd. border fill)
Active Width	720	pixels (active image region)
Active Height	1280	lines (active image region)
Hsync Pulse Width	50	pcyks
Hori. Back Porch	50	pcyks
Hori. Back Porch + hsync pulse width	100	pcyks
Hori. Front Porch	50	pcyks
Vsync Pulse Width	4	lines
Vert. Back Porch	4	lines
Vert. Back Porch + VSync pulse width	8	lines
Vert. Front Porch	10	lines
Esclk source (mxo = 27MHz, pxo = 24MHz, cxo = 19.2MHz)	19.2	MHz
MMSS_CC ESCCLK PREDIV	1	
Chip	SM6125	
DSI PHY IP Catalog version (major)	2	
PHY mode (0 = DPHY; 1 = CPHY)	0	ok
periodic deskew calibration required (0 = no; 1 = yes)	0	
video mode operation (0 = command mode; 1 = video mode)	1	
DPHY timing margin (0 = regular margin; 1 = reduced margin)	0	
<b>MDP REGISTER PROGRAMMING</b>		
Hsync period	870	dclks/line
Vsync period	1298	lines/frame
Dot clock overhead (blanking %)	1.23	

**Figure 2: DSI and MDP Registers Sheet**

**NOTE**

If the LCD module manufacturer requires to change the *Porch* to be 4 or a multiple of 4. Please change it accordingly and also update the panel *Porch* node.

**Step 3:** Open *DSI PHY Timing Setting* sheet and press **Ctrl + J** at the same time to clear the previous timings data. Then press **Ctrl + K** simultaneously to regenerate timings data. After the operation is completed, the field *Check for T\_CLK\_ZERO* will be displayed as *VALID*, as shown below.

1. PHY Timing parameters calculated from bitclk calculated in "dsi and mdp registers" and esclk source set in "dsi and mdp registers" (User may overwrite the values in blue)								
Full Rate Bitclk	406.00	Mbps	Check for T_CLK_ZERO					VALID
esclk	19.2	MHz						
UI	2.463054187	ns						
TIpx	52.08333333	ns						
Treat	20	ns						
		MIPI PHY v1.1 requirement	Recommended register settings (dec)		program value (hardwired to PHY inputs)		theoretical value (ns)	
		min (ns)	max (ns)	min	max			
T_CLK_PREPARE	38	95	14	37	16	16	44.33497537	
T_CLK_ZERO	255.6650246		102	255	123	123	305.4187192	

**Figure 3: DSI PHY Timing Setting Sheet**

Step 4: Open DSI PHY 2.0.0 Timing Setting sheet to check the calculated timings values.

24	TEOT of clock lane		134.5566502					101.1330049	
25	T_CLK_POST	188.0788177		4	63	10	10	1004.926108	
26	T_CLK_PRE	19.7044335		24	63	28	28	110.8374384	
27	T_HS_RQST of clock lane	50				2	2	59.11330049	
28	DSIPHY_CKLN_CFG0.DSIPHY_HSTX_PREPARE_DLY					0	0		
29	DSIPHY_DLN[0123]_CFG0.DSIPHY_HSTX_PREPARE_DLY					0	0		
30	overhead in data transmission							3197.40353	
31									
32	<b>Deskew Calibration setting</b>	<b>MIPI PHY v1.2 requirement</b>		<b>Recommended register settings (dec)</b>		<b>program value</b>		<b>theoretical value (ns)</b>	
33		min (ns)	max (ns)	min	max				
34	initial deskew calibration	0	0	0	0	0	0	0	
35	periodic deskew calibration	0	0	0	0	0	0	0	
36									
37	<b>2. DSI PHY 2.x.x registers</b>								
38	PHY 2.x.x. Registers	value in hex							
39	DSIPHY_CKLN_TIMING_CTRL_4	1E		T_HS_EXIT of clk lane					
40	DSIPHY_CKLN_TIMING_CTRL_5	D		T_CLK_ZERO					
41	DSIPHY_CKLN_TIMING_CTRL_6	3		part of T_CLK_PREPARE of clk lane					
42	DSIPHY_CKLN_TIMING_CTRL_7	5		T_CLK_TRAIL					
43	DSIPHY_CKLN_TIMING_CTRL_8	2		T_HS_RQST of clk lane					
44	DSIPHY_DLN[0123]_TIMING_CTRL_4	1E		T_HS_EXIT					
45	DSIPHY_DLN[0123]_TIMING_CTRL_5	1B		T_HS_ZERO					
46	DSIPHY_DLN[0123]_TIMING_CTRL_6	4		T_HS_PREPARE					
47	DSIPHY_DLN[0123]_TIMING_CTRL_7	5		T_HS_TRAIL					
48	DSIPHY_DLN[0123]_TIMING_CTRL_8	2		T_HS_RQST of data lane					
49	DSIPHY_DLN[0123]_TIMING_CTRL_9	2							
50	DSIPHY_DLN[0123]_TIMING_CTRL_10	4							
51	DSIPHY_CKLN_CFG1.DSIPHY_HSTX_HALFBYTECLK_EN	0		part of T_CLK_PREPARE of clk lane					

Figure 4: Timing Values Generated in DSI PHY 2.0.0 Timing Setting sheet

Step 5: Update *trinket-sde-display.dtsi* of the corresponding LCD configuration node in the file *kernel/masm-4.14/arch/arm64/boot/dts/qcom/* using the values generated in the sheet. For example, the module currently uses *dsi\_hx8394f\_720p\_video* panel, so you should update *mdss-dsi-panel-phy-timings* of *dsi\_hx8394f\_720p\_video* node with the values. The corresponding relationship is shown as below:

```

2 &dsi_hx8394f_720p_video {
3   qcom,mdss-dsi-t-clk-post = <0x0a>;
4   qcom,mdss-dsi-t-clk-pre = <0x1c>;
5   qcom,dsi-supported-dfps-list = <60 55 53 43>;
6   qcom,mdss-dsi-pan-enable-dynamic-fps;
7   qcom,mdss-dsi-pan-fps-update =
8     "cfps_immediate_porch_mode_vfp";
9   // qcom,esd-check-enabled;
10  // qcom,mdss-dsi-panel-status-check-mode = "ree_read";
11  // qcom,mdss-dsi-panel-status-command = [06 01 00 01 00 00 01 0a];
12  // qcom,mdss-dsi-panel-status-command-state = "dsi_hs_mode";
13  // qcom,mdss-dsi-panel-status-value = <0x9d 0x9d 0x9d 0x9d>;
14  // qcom,mdss-dsi-panel-on-check-value = <0x9d 0x9d 0x9d 0x9d>;
15  // qcom,mdss-dsi-panel-status-read-length = <4>;
16  qcom,mdss-dsi-display-timings {
17    timing@0 {
18      qcom,mdss-dsi-panel-phy-timings =
19        1E 1B 04 05 02 02 04 a0
20        1E 1B 04 05 02 02 04 a0
21        1E 1B 04 05 02 02 04 a0
22        1E 1B 04 05 02 02 04 a0
23        1E 0D 03 05 02 02 04 a0;
24
25      qcom,display-topology = <1 0 1>;
26      qcom,default-topology-index = <0>;
27    };
28  };
29 };

```

Figure 5: Update mdss-dsi-panel-phy-timings

**Step 6:** Copy the value of *T\_CLK\_POST* and *T\_CLK\_PRE* generated in the sheet to replace the value of *mdss-dsi-t-clk-post* and *mdss-dsi-t-clk-pre* in file *trinket-sde-display.dtsi*. The value in the sheet is in decimal format. Before you updating the two parameters, please make sure that these two values are in hexadecimal format. Here is an example:

```
qcom,mdss-dsi-t-clk-post = <0x0a>;
qcom,mdss-dsi-t-clk-pre = <0x1c>;
```

**Figure 6: Update mdss-dsi-t-clk-post and mdss-dsi-t-clk-pre**

# 3 Kernel and UEFI Configuration

This chapter takes LCD HX8394F as an example to introduce how to configure Kernel and UEFI to add a new panel.

**NOTE**

LCD parameters should be configured in both UEFI and Kernel.

- After the module is booted, LCD will be driven using configuration parameters in UEFI before the module enters sleep mode for the first time.
- After the module sleeps and then wakes up, LCD will be driven using configuration parameters in Kernel.

## 3.1. Configure Kernel

### 3.1.1. Configure Device Tree File

**Step 1:** Modify the configuration file of the used panel. For example, the default panel configuration file of the module is *dsi-panel-hx8394f-720p-video.dtsi*. You can rename *dsi-panel-hx8394f-720p-video.dtsi* according to the actually used LCD, such as *dsi-panel-xxx-xxx-video.dtsi*. Then copy the file to the directory *kernel\msm-4.14\arch\arm64\boot\dts\qcom\*.

**Step 2:** Modify *dsi\_hx8394f\_720p\_video: qcom,mdss\_dsi\_hx8394f\_720p\_video* in *dsi-panel-xxx-xxx-video.dtsi* into the name of the panel actually used. Other parameters can be modified referring to **Chapter 2.1** to **2.6** as required.

```

* This program is distributed in the hope that it will be useful,
* but WITHOUT ANY WARRANTY; without even the implied warranty of
* MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
* GNU General Public License for more details.
*/

&mdss_md0 {
    dsi_hx8394f_720p_video: qcom,mdss_dsi_hx8394f_720p_video {
        qcom,mdss-dsi-panel-name = "hx8394f_video_mode dsi panel without DSC";
        qcom,mdss-dsi-panel-type = "dsi_video_mode";
        qcom,mdss-dsi-virtual-channel-id = <0>;
        qcom,mdss-dsi-stream = <0>;
        qcom,mdss-dsi-h-left-border = <0>;
        qcom,mdss-dsi-h-right-border = <0>;
        qcom,mdss-dsi-v-top-border = <0>;
        qcom,mdss-dsi-v-bottom-border = <0>;
        qcom,mdss-dsi-bpp = <24>;
    };
};

```

**NOTE**

You should configure `dsi_XXX_XXX_video: qcom,mdss_dsi_XXX_XXX_video` and make sure that `dsi_XXX_XXX_video` is consistent with the node name corresponding to `trinket-sde-display.dtsi` and `trinket-idp.dtsi`.

**Step 3:** Add panel configuration file actually used `dsi-panel-xxx-xxx-video.dtsi` to `trinket-sde-display.dtsi` in the `kernel/vmsm-4.14/arch/arm64/boot/dts/qcom/` directory. The format is `#include "dsi-panel-xxx-xxx-video.dtsi"`. Take the default panel configuration file `dsi-panel-hx8394f-720p-video.dtsi` as an example, as shown in the figure below:

```
#include "dsi-panel-nt36672-truly-fhd-video.dtsi"
#include "dsi-panel-hx8394f-720p-video.dtsi"
#include "dsi-panel-ili9881c-720p-video.dtsi"
#include "dsi-panel-ili9881d-720p-video.dtsi"
```

**Step 4:** Add `qcom,dsi-display` related configurations of the current panel in `trinket-sde-display.dtsi`. You can copy and modify the default panel configuration `dsi_hx8394f_720p_video`, as shown in the figure below:

```
dsi_hx8394f_720p_video_display: qcom,dsi-display@5 {
    label = "dsi_hx8394f_720p_video_display";
    qcom,display-type = "primary";

    qcom,dsi-ctrl-num = <0>;
    qcom,dsi-phy-num = <0>;
    qcom,dsi-select-clocks = "mux_byte_clk0", "mux_pixel_clk0";

    qcom,dsi-panel = <&dsi_hx8394f_720p_video>;
};
```

In the figure:

- `dsi_hx8394f_720p_video_display`: Panel name. You can modify it as required. Usually, you can refer to the panel node name in the panel configuration file `dsi-panel-xxx-xxx-video.dtsi`, and add `_display` after `dsi_XXX_XXX_video` to name it. For example, the default panel configuration file of the module is `dsi-panel-hx8394f-720p-video.dtsi`, and the node name of the panel is `dsi_hx8394f_720p_video`. Then the panel name can be configured as `dsi_hx8394f_720p_video_display`.
- `label`: Generally, it should be consistent with the panel name.
- `qcom,dsi-display@5`: The number followed by `@` is the serial number of the panel. The module is configured with multiple panels by default, which are numbered in sequence, and the number cannot be repeated.
- `qcom,display-type = "primary"`: `primary` indicates main panel.
- `qcom,dsi-panel`: The name of panel node in `dsi-panel-xxx-xxx-video.dtsi`. The format is `qcom,dsi-panel = <&dsi_XXX_XXX_video>;`. For example, `qcom,dsi-panel = <&dsi_hx8394f_720p_video>;`.

**NOTE**

If you modify the configuration of *label*, please inform Quectel, and Quectel will configure the name in UEFI to keep it consistent with the configuration of *label*.

**Step 5:** Add the configured *dsi\_XXX\_XXX\_video\_display* to *dsi-display-list*. For example, add *dsi\_hx8394f\_720p\_video\_display* to *dsi-display-list*, as shown in the figure below:

```
sde_dsi: qcom,dsi-display {
    compatible = "qcom,dsi-display";

    qcom,dsi-ctrl = <&mdss_dsi0>;
    qcom,dsi-phy = <&mdss_dsi_phy0>;

    clocks = <&mdss_dsi0_pll BYTE0_MUX_CLK>,
            <&mdss_dsi0_pll PIX0_MUX_CLK>,
            <&mdss_dsi0_pll BYTE0_SRC_CLK>,
            <&mdss_dsi0_pll PIX0_SRC_CLK>,
            <&mdss_dsi0_pll SHADOW_BYTE0_SRC_CLK>,
            <&mdss_dsi0_pll SHADOW_PIX0_SRC_CLK>;
    clock-names = "mux_byte_clk0", "mux_pixel_clk0",
                 "src_byte_clk0", "src_pixel_clk0",
                 "shadow_byte_clk0", "shadow_pixel_clk0";
    pinctrl-names = "panel_active", "panel_suspend";
    pinctrl-0 = <&sde_dsi_active &sde_te_active>;
    pinctrl-1 = <&sde_dsi_suspend &sde_te_suspend>;

    qcom,platform-te-gpio = <&tlmm 89 0>;

    vddio-supply = <&L12A>;
    // vdd-supply = <&L5P>;
    lab-supply = <&lcdb_ldo_vreg>;
    ibb-supply = <&lcdb_ncp_vreg>;

    qcom,dsi-display-list =
        <&dsi_td4330_truly_vid_display
        &dsi_td4330_truly_cmd_display
        &dsi_sim_vid_display
        &dsi_hx83112a_truly_vid_display
        &dsi_nt36672_truly_vid_display
        &dsi_hx8394f_720p_video_display
        &dsi_ili9881c_720p_video_display
        &dsi_ili9881d_720p_video_display>;
};
```

**Step 6:** Add the DSI timings configuration of the panel currently used to *trinket-sde-display.dtsi*. Copy the default panel configuration *dsi\_hx8394f\_720p\_video* of the current module, change *&dsi\_hx8394f\_720p\_video* into the customized panel *&dsi\_XXX\_XXX\_video*, and see **Chapter 2.7** for configuration. Take the default panel *dsi\_hx8394f\_720p\_video* of the module as an example, the configuration example is shown in the figure below:

```
&dsi_hx8394f_720p_video {
    qcom,mdss-dsi-t-clk-post = <0x0a>;
    qcom,mdss-dsi-t-clk-pre = <0x1c>;
    qcom,dsi-supported-dfps-list = <60 55 53 43>;
    qcom,mdss-dsi-pan-enable-dynamic-fps;
    qcom,mdss-dsi-pan-fps-update =
        "dfps_immediate_porch_mode_vfp";
    // qcom,esd-check-enabled;
    // qcom,mdss-dsi-panel-status-check-mode = "reg_read";
    // qcom,mdss-dsi-panel-status-command = [06 01 00 01 00 00 01 0a];
    // qcom,mdss-dsi-panel-status-command-state = "dsi_hs_mode";
    // qcom,mdss-dsi-panel-status-value = <0x9d 0x9d 0x9d 0x9d>;
    // qcom,mdss-dsi-panel-on-check-value = <0x9d 0x9d 0x9d 0x9d>;
    // qcom,mdss-dsi-panel-status-read-length = <4>;
    qcom,mdss-dsi-display-timings {
        timing@0{
            qcom,mdss-dsi-panel-phy-timings =
                [1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 1B 04 05 02 02 04 a0
                 1E 0D 03 05 02 02 04 a0];

            qcom,display-topology = <1 0 1>;
            qcom,default-topology-index = <0>;
        };
    };
};
```

**Step 7:** Modify the parameters in the file *trinket-idp.dtsi* in the directory *kernel\msm-4.14\arch\arm64\boot\dts\qcom\* as required. The default panel configuration parameters are shown as below:

```
&dsi_hx8394f_720p_video {
    qcom,panel-supply-entries = <&dsi_panel_pwr_supply>;
    qcom,mdss-dsi-bl-pmic-control-type = "bl_ctrl_pwm";
    pwms = <&pm6125_pwm 0 0>;
    qcom,bl-pmic-pwm-period-usecs = <100>;
    qcom,mdss-dsi-bl-min-level = <1>;
    qcom,mdss-dsi-bl-max-level = <4095>;
    qcom,platform-reset-gpio = <&tlmm 90 0>;
    // qcom,platform-bklight-en-gpio = <&pmi632_gpios 6 0>;
};
```

Copy the default panel configurations *dsi\_hx8394f\_720p\_video* and change *&dsi\_hx8394f\_720p\_video* into the currently used panel *&dsi\_XXX\_XXX\_video*.

- *qcom,mdss-dsi-bl-pmic-control-type = "bl\_ctrl\_pwm"*; means controlling backlight through PWM (default configuration).
- *qcom,platform-reset-gpio = <&tlmm 54 0>*; means configuring GPIO\_90 as LCD reset pin

(LCD\_RST). 0 is default value and there is no need to modify it. See the corresponding LCD hardware design for modification.

### 3.1.2. Update Kernel

Execute the following commands in sequence to compile and generate images.

```
source build/envsetup.sh
lunch trinket-userdebug
make bootimage
make dtboimage
```

Execute the following commands in sequence to burn the generated images to update the kernel.

```
adb reboot bootloader
fastboot flash boot boot.img
fastboot flash dtbo dtbo.img
fastboot reboot
```

## 3.2. Configure UEFI

The bootloader of SC668S series module is replaced by UEFI, and thus there is no need to debug LCD. You can send the configuration parameters debugged in Kernel to Quectel. Then Quectel will bring up the LCD in UEFI and send the updated image *xbi.elf* to you.



# 4 Appendix References

**Table 9: Terms and Abbreviations**

Abbreviation	Description
BPP	Bits Per Pixel
DSI	Display Serial Interface
EVB	Evaluation Board
LCD	Liquid Crystal Display
MDP	Mobile Display Processor
MIPI	Mobile Industry Processor Interface
PHY	Physical
PWM	Pulse Width Modulation
UEFI	Unified Extensible Firmware Interface