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Windows 10 IoT企业版显示设置

第1版—2024年5月29日 应用笔记

文档信息

信息	内容
关键词	Windows IoT、显示器、MIPI-DSI、LVDS、HDMI、EDID文件、LCD、GPU
摘要	本文档描述如何在采用恩智浦i.MX系列SoC的Windows 10 IoT板级支持包（BSP）上更改设置和配置自定义显示。

1 介绍

本文档描述如何在采用恩智浦i.MX系列SoC的Windows 10 IoT板级支持包（BSP）上更改设置和配置自定义显示。

支持的SoC：

- i.MX 8M Nano (i.MX 8MN)
- i.MX 8M Mini (i.MX 8MM)
- i.MX 8M Plus EVK (i.MX 8MP)
- i.MX 8M Quad (i.MX 8MQ)
- i.MX 8QuadXPlus (i.MX 8QXP)
- i.MX 93

2 显示支持

本章节提供关于显示支持的详细信息。

2.1 Windows系统提供的显示支持

表1. BSP 1.5.0版本的显示支持情况

平台	显示选项1 [U-Boot、UEFI、Windows]	显示选项2 [U-Boot、UEFI、Windows]	显示选项3 [U-Boot、UEFI、Windows]	多显示器 [可用数量，支持数量]
i.MX 8MN	1x MIPI-DSI [是, 是, 是][1]	-	-	1, 1
i.MX 8MM	1x MIPI-DSI [是, 是, 否][2]	-	-	1, 1 (仅UEFI)
i.MX 8MP	1x MIPI-DSI [是, 是, 是][1]	1x LVDS [否, 是, 是][1]	1x HDMI [否, 是, 是][1]	3, 3 (HDMI+LVDS+MIPI)
i.MX 8MQ	1x MIPI-DSI [否, 否, 否][2]	1x HDMI [是, 否, 是][1]	-	2, 1 (HDMI)
i.MX 8QXP	2x MIPI-DSI [否, 否, 否][2]	2x LVDS [是, 是, 是][1]	1x 并行RGB [否, 否, 否][2]	3, 2 (LVDS0 + LVDS1)
i.MX 93	1x MIPI-DSI [是, 是, 否][2]	1x LVDS [否, 是, 否][2]	1x 并行RGB [否, 否, 否][2]	1, 1 (仅UEFI)

[1] 支持Windows GPU驱动程序。

[2] 不支持Windows GPU驱动程序。

注意：

- *“显示选项X”列表示在SoC上该显示接口可用。方括号内分别表示在U-Boot、UEFI和Windows中的驱动程序支持情况。*
- *在“多显示器”列中，第一个数字表示SoC上可以同时运行的显示器数量，第二个数字表示Windows驱动程序可以同时支持的显示器数量。*

2.2 显示支持——最大分辨率

表2. 显示支持——最大分辨率

平台	显示选项1 [最大分辨率，*支持分辨率*]	显示选项2 [最大分辨率，*支持分辨率*]	显示选项3 [最大分辨率，*支持分辨率*]
i.MX 8MN	MIPI-DSI [1920x1200@60]	-	-
i.MX 8MM	MIPI-DSI [1920x1200@60]	-	-
i.MX 8MP	MIPI-DSI [1]	LVDS [2]	HDMI [3840x2160@30, *1920x1080@60*]
i.MX 8MQ	MIPI-DSI [[3], *无*]	HDMI [4096x2160p60, *1920x1080@60*]	-
i.MX 8QXP	MIPI-DSI [1920x1200@60, *无*]	LVDS [1920x1080p60]	并行RGB [1280x720@60, *无*]
i.MX 93	MIPI-DSI [1920x1200@60]	LVDS [1280x800@60]	并行RGB [1280x800@60, *无*]

[1] 如果同时使用的实例不超过2个，每个LCDIF最高支持1920x1200@60Hz显示。如果同时使用全部3个实例，则可支持2个1920x1080@60Hz + 1个3840x2160@30Hz（HDMI）。

[2] 单通道支持1280x800@60Hz，双通道请参考选项[1]。

[3] DCSS（不使用HDMI）理论上最大像素时钟为250MHz（2560x1440@60Hz），LCDIF可达1920x1080p60Hz。

斜体选项突出显示了Windows/UEFI驱动程序相对于最大分辨率的限制。

3 显示选项

本章节提供关于显示选项的详细信息。

3.1 UEFI驱动程序

自动检测的优先顺序如下所列。首先是MIPI-DSI转HDMI转换器的检测。如果初始化失败，系统将尝试下一个选项，依此类推。

可以在`iMX8LcdHwLib.c`文件中更改i.MX 8MP、i.MX 8MM和i.MX 8MN的优先级顺序，而对于i.MX 93则在`iMX93DisplayHwLib.c`文件中进行更改。这些文件位于`\mu_platform_nxp\Silicon\ARM\NXP\iMX8Pkg\Library\iMX8LcdHwLib\`。

自动检测的优先顺序如下：

1. MIPI-DSI到HDMI转换器（IMX-MIPI-HDMI，ADV7535）
2. LVDS到HDMI转换器（IMX-LVDS-HDMI，IT6263）
3. 原生HDMI（i.MX 8MP）
4. 参数`giMX8TokenSpaceGuid.PcdDisplayInterface`定义的显示接口（在`<Platform>.dsc`文件中）

LVDS和MIPI-DSI显示通常符合上述第4点。

有关其他dsc参数，请参见`\mu_platform_nxp\NXP<board>`目录下的描述。

`PcdDisplayI2CbaseAddr`——MIPI或LVDS到HDMI转换器的I2C基地址。

`PcdDisplayReadEDID`——TRUE/FALSE——启用/禁用读取EDID，适用于基于HDMI的接口（原生HDMI和转换器IMX-MIPI-HDMI、IMX-LVDS-HDMI）。

3.2 Windows驱动程序

下文说明如何设置两个显示接口，以i.MX 8MP为例。在这个例子中，我们将`Display0Interface`设置为LVDS，将`Display1Interface`设置为HDMI。这种设置适用于“Windows显示支持表”中列出的SoC。

第一个显示器通过`Display0Interface`参数选择，第二个显示器通过`Display1Interface`参数选择，依此类推。设置接口有两种方法。可以选择以下任一步骤进行修改：

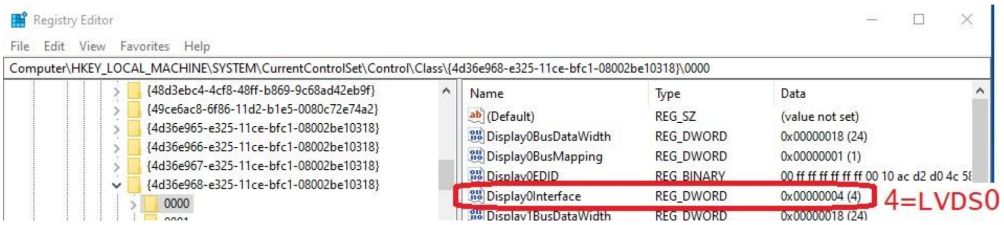
1. 更新`galcore.inf`文件，然后卸载并重新安装GPU驱动程序。

`galcore.inf`文件更新：

```
[GcWddmMP_AddReg] // Find appropriate platform (MP, MN, 8X)
; Enable support for multiple monitors
HKR,,EnableMultiMon,%REG_DWORD%,1 // Enable multiple monitors
; Display parameters for LVDS interface
HKR,,Display0Interface,%REG_DWORD%,%DISP_INTERFACE_LVDS0% //Select LVDS0 (first
 display)
HKR,,Display1Interface,%REG_DWORD%,%DISP_INTERFACE_HDMI% // Select HDMI (second
 display)
;Possible values for DisplayInterfaces,
DISP_INTERFACE_DISABLED = 0x0
DISP_INTERFACE_HDMI = 0x1
DISP_INTERFACE_MIPI_DSI0 = 0x2
DISP_INTERFACE_MIPI_DSI1 = 0x3
DISP_INTERFACE_LVDS0 = 0x4
DISP_INTERFACE_LVDS1 = 0x5
DISP_INTERFACE_LVDS_DUAL0 = 0x6
DISP_INTERFACE_PARALLEL_LCD = 0x7
```

2. 更新目标设备上的注册表数据库,然后重启GPU驱动程序：

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-
e325-11cebfc1-08002be10318}\0000
```



Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-bfc1-08002be10318}\0000

```
{48d3ebc4-4cf8-48ff-b869-9c68ad42eb9f}
{49ce6ac8-6f86-11d2-b1e5-0080c72e74a2}
{4d36e965-e325-11ce-bfc1-08002be10318}
{4d36e966-e325-11ce-bfc1-08002be10318}
{4d36e967-e325-11ce-bfc1-08002be10318}
{4d36e968-e325-11ce-bfc1-08002be10318}
    0000
    0001
```

Name	Type	Data
(Default)	REG_SZ	(value not set)
Display0BusDataWidth	REG_DWORD	0x00000018 (24)
Display0BusMapping	REG_DWORD	0x00000001 (1)
Display0EDID	REG_BINARY	00 ff ff ff ff ff ff 00 10 ac d2 d0 4c 5
Display0Interface	REG_DWORD	0x00000004 (4)
Display1BusDataWidth	REG_DWORD	0x00000018 (24)

图1. 注册表更新

显示接口仅由Windows注册表确定：

1. LVDS接口：
   - 如果检测到LVDS-HDMI转换器（IMX-LVDS-HDMI），则对其进行初始化。
   - 否则，初始化自定义LVDS显示。
2. MIPI-DSI接口：
   - 如果检测到MIPI-HDMI转换器（IMX-MIPI-HDMI），则对其进行初始化。
   - 否则，初始化IMX-DSI-OLED1恩智浦测试面板。更多详情，请参阅下文MIPI-DSI驱动程序自定义部分。
3. 原生HDMI接口

MIPI-DSI驱动程序定制：

- MIPI-DSI面板，即IMX-DSI-OLED1恩智浦测试面板。该面板有一个模板驱动程序，需要进行定制。要进行定制，请遵循以下步骤：
  - 在\imx-Windows-iot\driver\display\dispdll\mipi_dsi\路径下找到panel-raydium-rm67191.c驱动程序文件。
  - 根据支持的新面板的需求，自定义该驱动程序中的以下四个函数。
    例如，对于恩智浦IMX-DSI-OLED1面板：

```
static const struct drm_panel_funcs
rad_panel_funcs = {
 .prepare = rad_panel_prepare,
 .unprepare = rad_panel_unprepare,
 .enable = rad_panel_enable,
 .disable = rad_panel_disable,
};
```

这些函数的调用顺序及其内容如下：

rad_panel_probe - 为驱动对象分配内存，设置DSI格式，注册面板回调函数

rad_panel_prepare - 例如，取消面板复位

rad_panel_enable - 例如，在启动帧生成器前，在DSI低功耗通信中执行初始化序列

rad_panel_disable - 例如，在帧生成器停止后禁用序列

rad_panel_unprepare - 例如，面板复位置位

rad_panel_remove - 释放驱动对象

4 显示分辨率

本章节详细介绍了显示分辨率相关信息。

4.1 显示分辨率术语

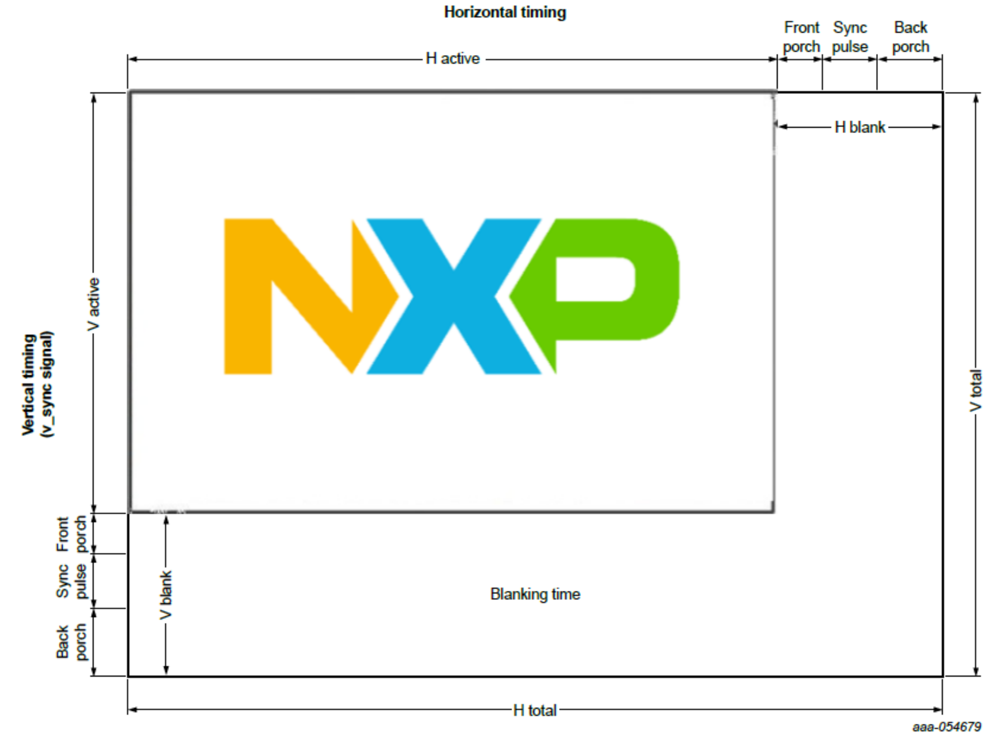


图2. 显示分辨率术语

- 前沿间隔 = 同步偏移 = FP
- 同步脉冲 = 同步 = 同步长度 = 同步宽度 = SW
- 后沿间隔 = BP
- 垂直刷新率 = 像素时钟 / (垂直总线 + 水平总线)
- 水平刷新率 = 像素时钟 / 水平总线

4.2 更改显示分辨率——UEFI驱动程序

默认分辨率设置为1920x1080。如需更改为自定义分辨率，请编辑以下文件：

对于i.MX 8MN、i.MX 8MM和i.MX 8MP，编辑位于`\mu_platform_nxp\Silicon\ARM\NXP\iMX8Pkg\Library\iMX8LcdHwLib\`的`iMX8LcdHwLib.c`文件。

对于i.MX 93，编辑位于`\mu_platform_nxp\Silicon\ARM\NXP\iMX8Pkg\Library\iMX8LcdHwLib\`的`iMX93DisplayHwLib.c`文件。

更改UEFI驱动程序中的显示分辨率：

```
/* Preferred timing mode. if PcdDisplayReadEDID == TRUE, it is overwritten with
 edid data */
IMX_DISPLAY_TIMING PreferredTiming;

/* Predefined modes - one selected is copied to PreferredTiming in
 LcdDisplayDetect */
/* 1080x1920@60Hz */
const IMX_DISPLAY_TIMING PreferredTiming_1080x1920_60 = {
 .PixelClock = 108000000,
  .HActive = 1080,
  .HBlank = 56,
  .VActive = 1920,
  .VBlank = 16,
  .HSync = 2,
  .VSync = 2,
  .HSyncOffset = 34,
  .VSyncOffset = 4,
  .HImageSize = 296,
  .VImageSize = 527,
  .HBorder = 0,
  .VBorder = 0,
  .EdidFlags = 0,
  .Flags = 0,
  .PixelRepetition = 0,
  .Bpp = 24,
  .PixelFormat = PIXEL_FORMAT_ARGB32,
};
//* Update the values highlighted in bold according to the display documentation
LcdDisplayDetect ( // Assign PreferredTiming in this function
  VOID
  )
….
/* Converter was not detected - select fixed default timimng */
  if (converter == transmitterUnknown) {
    if (displayInterface == imxMipiDsi)
      { videoModesCnt++;
      LcdInitPreferredTiming
(&PreferredTiming_1080x1920_60,&PreferredTiming);
 // For MIPI-DSI
      DEBUG((DEBUG_ERROR, "Mipi-dsi
 display interface. Default resolution used.
 %dx%d pclk=%d Hz\n",
            PreferredTiming.HActive,
 PreferredTiming.VActive,
 PreferredTiming.PixelClock));
      LcdDumpDisplayTiming(0,
 &PreferredTiming);
      return EFI_SUCCESS;
    } else if ((displayInterface == imxLvds0)
 || (displayInterface == imxLvds1) ||
 (displayInterface == imxLvds0dual)) {
      videoModesCnt++;
      LcdInitPreferredTiming
 (&PreferredTiming_1280x720_60,
 &PreferredTiming); // For LVDS
      DEBUG((DEBUG_ERROR, "LVDS%d
 display interface. Default resolution used.
 %dx%d pclk=%d Hz\n",
            displayInterface-2,
 PreferredTiming.HActive,
 PreferredTiming.VActive,
 PreferredTiming.PixelClock));
      LcdDumpDisplayTiming(0,
 &PreferredTiming);
      return EFI_SUCCESS;
    } else if (displayInterface ==
 imxNativeHdmi) {
```

iMX8LcdHwLib.c——仅适用于MIPI-DSI显示。

对于MIPI-DSI显示，还需要执行一个额外步骤。

```
EFI_STATUS
LcdSetMode ( // Find this function
  IN  UINT32     ModeNumber
  )
 {
  IMX_DISPLAY_TIMING *Timing =
 &PreferredTiming;

  if (ModeNumber >= videoModesCnt)
    { return EFI_INVALID_PARAMETER;
  }

  if (displayInterface == imxMipiDsi) { // For MIPI-DSI only
  /*--------------------------
MIPI ---------------------------------------------*/
    /* Mipi DSI set timing mode */

    CHECK_STATUS_RETURN_ERR(MipiDsiConfig(Timing, converter), "MIPI DSI
 config");
    if (converter == ADV7535) {
      /* ADV7535 set timing mode */

      CHECK_STATUS_RETURN_ERR(Adv7535SetMode(Timing), "ADV7535 config");
    } else {
      /* MIPI-DSI panel init must be called after MipiDsiConfig() */

      CHECK_STATUS_RETURN_ERR(Rm67191Init(
      displayInterface), "RM67191 config");
    } // Initialization for NXP IMX-DSI-OLED panel. Delete or put custom init in
 there, if needed.
```

4.3 自定义设置

以下是一个利用显示文档确定时序参数的示例，用于配置您想要使用的显示器。

关于硬件支持的视频模式，请参考视频时序计算器。

4.3.1 EV121WXM-N12显示器

EV121WXM-N12显示器：1280x800 LVDS面板，i.MX 93 EVK工业版配件。

表3. 文档中时序参数示例

条目			符号	最小值	典型值	最大值	单位
LCD	帧率		-	58	60	62	Hz
	像素率		-	66.3	72.4	78.9	MHz
时序	水平	水平总时间	tHP	1380	1440	1500	t_{CLK}
		水平有效时间	tHadr	1280			t_{CLK}
		水平后沿间隔	tHBP	-	80	-	t_{CLK}

表3. 文档中时序参数示例（续）

条目			符号	最小值	典型值	最大值	单位
		水平前沿间隔	tHFP	-	48	-	t_{CLK}
	垂直	垂直总时间	tvp	824	838	872	t_H
		垂直有效时间	tVadr	800			t_H
		垂直后沿间隔	tVBP	-	14	-	t_H
		垂直前沿间隔	tVFP	-	9	-	t_H
通道				-	1	-	通道

从表3中可读取或计算得出的参数列表：

- 像素时钟 = 72.4 MHz
- 水平总像素数 = 1440
- 水平有效像素数 = 1280
- 水平同步偏移 = 48
- 水平后沿间隔 = 80
- 水平消隐期 = 水平总像素数 - 水平有效像素数 = 160
- 水平同步脉冲宽度 = 水平消隐期 - 水平后沿间隔 - 水平前沿间隔 = 32
- 垂直总行数 = 838
- 垂直有效行数 = 800
- 垂直同步偏移 = 9
- 垂直后沿间隔 = 14
- 垂直消隐期 = 垂直总行数 - 垂直有效行数 = 38
- 垂直同步脉冲宽度 = 垂直消隐期 - 垂直后沿间隔 - 垂直前沿间隔 = 15

4.3.2 安富利AMA-121A01-DU2511-G010显示器

安富利AMA-121A01-DU2511-G010是一款1280x800分辨率的LVDS面板

表4. 显示器文档中的时序参数示例（2）

参数	符号	最小值	典型值	最大值	单位
时钟频率	1/t_c	67	71	75	MHz
水平显示区域	thd	-	1280	-	tc
水平周期	th	1290	1440	-	tc
垂直显示区域	tvd	-	800	-	th
垂直周期	tv	810	823	-	th
帧率	F	-	60	-	Hz
VDD=3.3V，GND=0V，Ta=25°C					

并非所有参数都能直接通过表4确定。

本文件中提供的所有信息均受法律免责声明的约束。

- 像素时钟 = 71MHz
- 总水平像素数 = 1440
- 有效水平像素数 = 1280
- 水平前沿间隔 = ??
- 水平后沿间隔 = ??
- 水平消隐区 = 总水平像素数 - 有效水平像素数 = 160
- 水平同步脉冲宽度 = ??
- 总垂直像素数 = 823
- 有效垂直像素数 = 800
- 垂直前沿间隔 = ??
- 垂直后沿间隔 = ??
- 垂直消隐区 = 总垂直像素数 - 有效垂直像素数 = 23
- 垂直同步脉冲宽度 = ??

为确定缺失的参数，可以使用VESA协调视频时序标准（CVT）。

水平同步脉冲的持续时间和位置

水平同步脉冲的持续时间始终为32像素时钟，其位置被设定为使水平同步脉冲的尾边正好位于水平消隐期的中心。这意味着水平后沿间隔固定为80像素时钟。

- HSYNC = 32
- HBP = 80
- HFP = HBlank − HBP − Hsync = 48

垂直同步脉冲的持续时间和位置

垂直前沿间隔（VFP）始终固定为3行。垂直后沿间隔（VBP）必须是垂直消隐时间的剩余部分。

- VSync = 6
- VFP = 3
- VBP = VBlank − VBP − VSync = 14

表5. 垂直同步持续时间

垂直同步宽度	纵横比
3或更少	CVT不使用，留给现有DMT和GFT
4	4:3
5	16:9
6	16:10

另外，为确定缺失的参数，也可以使用在线计算器，详见视频时序计算器。

4.4 Windows驱动程序

对于HDMI接口，分辨率和时序参数设置的EDID数据是通过显示接口获取的。而对于其他接口（如MIPI-DSI和LVDS），这些参数必须存储在寄存器中。

对于第一个显示器，EDID二进制数据中编 码的分辨率和时序参数存储在`Display0EDID`参数，对于第二个显示器，EDID二进制数据中编码的分辨率和时序参数存储在`Display1EDID`参数，依此类推。要使用EDID编辑器，请参阅第4.5节了解EDID设置。

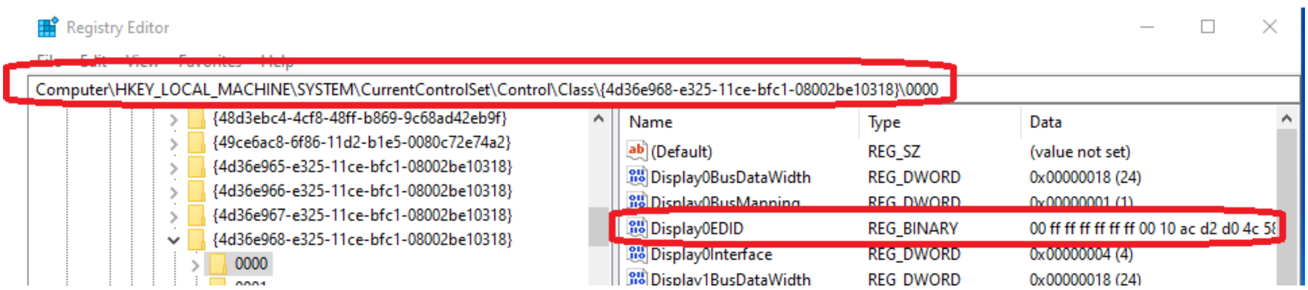
进行此修改可以使用以下任一步骤：

1. 更新galcore.inf文件并卸载/重新安装GPU驱动程序。
   `Galcore.inf`更新：

```
[GcWddmMN_AddReg] // Find appropriate platform (MP, MN, 8X)
…
;EDID - 128 bytes total length expected
;1280x720@60
HKR,,Display0EDID,%REG_BINARY%,\
0x00,0xFF,0xFF,0xFF,0xFF,0xFF,0xFF,0x00,0x10,0xAC,0x7A,0xA0,0x53,0x4B,0x35,0x32,\
0x1E,0x1A,0x01,0x03,0x80,0x34,0x20,0x78,0xEA,0xEE,0x95,0xA3,0x54,0x4C,0x99,0x26,\
0x0F,0x50,0x54,0xA1,0x08,0x00,0x81,0x40,0x81,0x80,0xA9,0x40,0xB3,0x00,0xD1,0xC0,\
0x01,0x01,0x01,0x01,0x01,0x01,0x01,0x1D,0x00,0x72,0x51,0xD0,0x1E,0x20,0x6E,0x28,\
0x55,0x00,0x40,0x44,0x21,0x00,0x00,0x1A,0x00,0x00,0x00,0xFF,0x00,0x59,0x50,0x50,\
0x59,0x30,0x36,0x37,0x56,0x32,0x35,0x4B,0x53,0x0A,0x00,0x00,0x00,0xFC,0x00,0x44,\
0x45,0x4C,0x4C,0x20,0x55,0x32,0x34,0x31,0x32,0x4D,0x0A,0x20,0x00,0x00,0x00,0xFD,\
0x00,0x32,0x3D,0x1E,0x53,0x11,0x00,0x0A,0x20,0x20,0x20,0x20,0x20,0x20,0x00,0x6D
```

2. 更新目标设备上的注册表数据库并重启GPU驱动程序：

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-
e325-11cebfc1-08002be10318}\0000
```



Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-bfc1-08002be10318}\0000

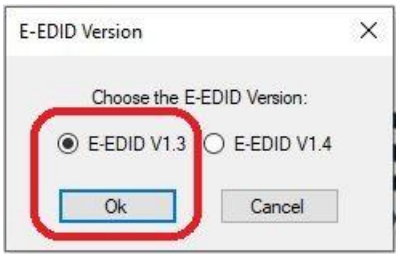
{48d3ebc4-4cf8-48ff-b869-9c68ad42eb9f}
{49ce6ac8-6f86-11d2-b1e5-0080c72e74a2}
{4d36e965-e325-11ce-bfc1-08002be10318}
{4d36e966-e325-11ce-bfc1-08002be10318}
{4d36e967-e325-11ce-bfc1-08002be10318}
{4d36e968-e325-11ce-bfc1-08002be10318}
0000
0001

Name	Type	Data
(Default)	REG_SZ	(value not set)
Display0BusDataWidth	REG_DWORD	0x00000018 (24)
Display0BusMapping	REG_DWORD	0x00000001 (1)
Display0EDID	REG_BINARY	00 ff ff ff ff ff ff 00 10 ac d2 d0 4c 58
Display0Interface	REG_DWORD	0x00000004 (4)
Display1BusDataWidth	REG_DWORD	0x00000018 (24)

图3. 注册表更新

4.5 EDID设置

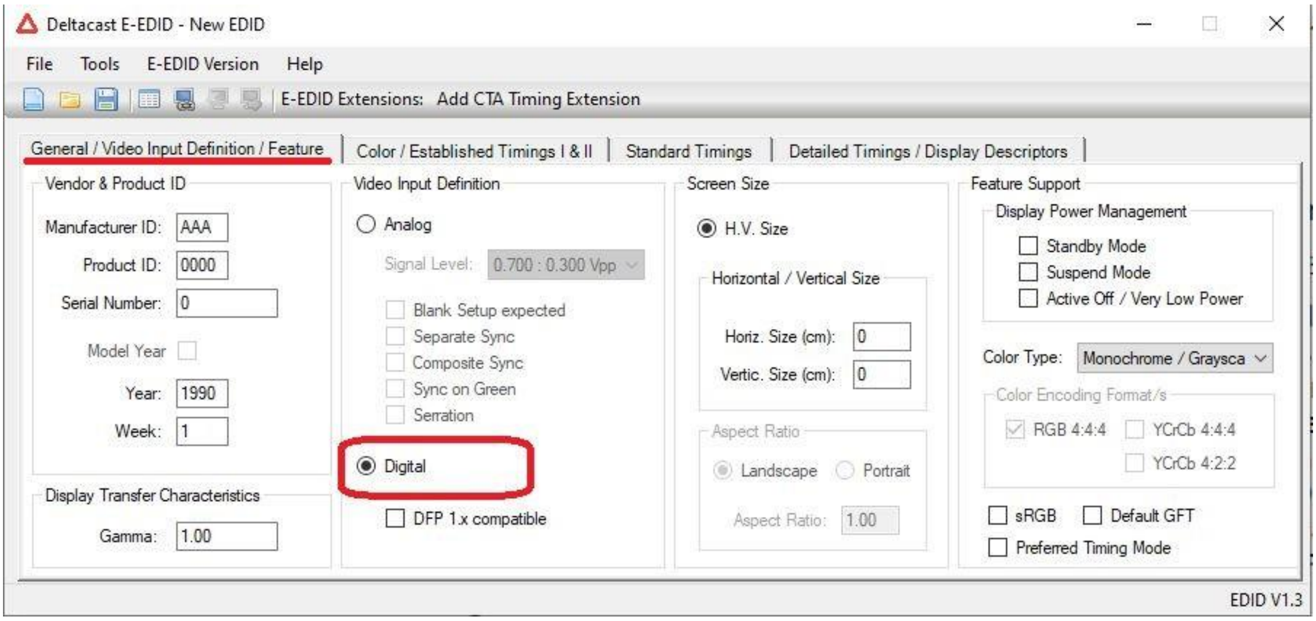
要编辑EDID二进制数据，可以使用适当的编辑程序。在本例中，我们使用DELTACAST编辑器，但也可以使用其他在线可用的EDID编辑器来实现相同的目的。


E-EDID Version

Choose the E-EDID Version:

● E-EDID V1.3 ○ E-EDID V1.4

图4. E-DID版本选择


Deltacast E-EDID - New EDID
File
Tools
E-EDID Version
Help
E-EDID Extensions:
Add CTA Timing Extension
General / Video Input Definition / Feature
Color / Established Timings I & II
Standard Timings
Detailed Timings / Display Descriptors
EDID V1.3

Vendor & Product ID

Manufacturer ID: AAA

Product ID: 0000

Serial Number: 0

Model Year □

Year: 1990

Week: 1

Display Transfer Characteristics

Gamma: 1.00

Video Input Definition

○ Analog

Signal Level: 0.700 : 0.300 Vpp

□ Blank Setup expected

□ Separate Sync

□ Composite Sync

□ Sync on Green

□ Serration

● Digital

□ DFP 1.x compatible

Screen Size

● H.V. Size

Horizontal / Vertical Size

Horiz. Size (cm): 0

Vertic. Size (cm): 0

Aspect Ratio

● Landscape ○ Portrait

Aspect Ratio: 1.00

Feature Support

Display Power Management

□ Standby Mode

□ Suspend Mode

□ Active Off / Very Low Power

Color Type: Monochrome / Grayscale

Color Encoding Format/s

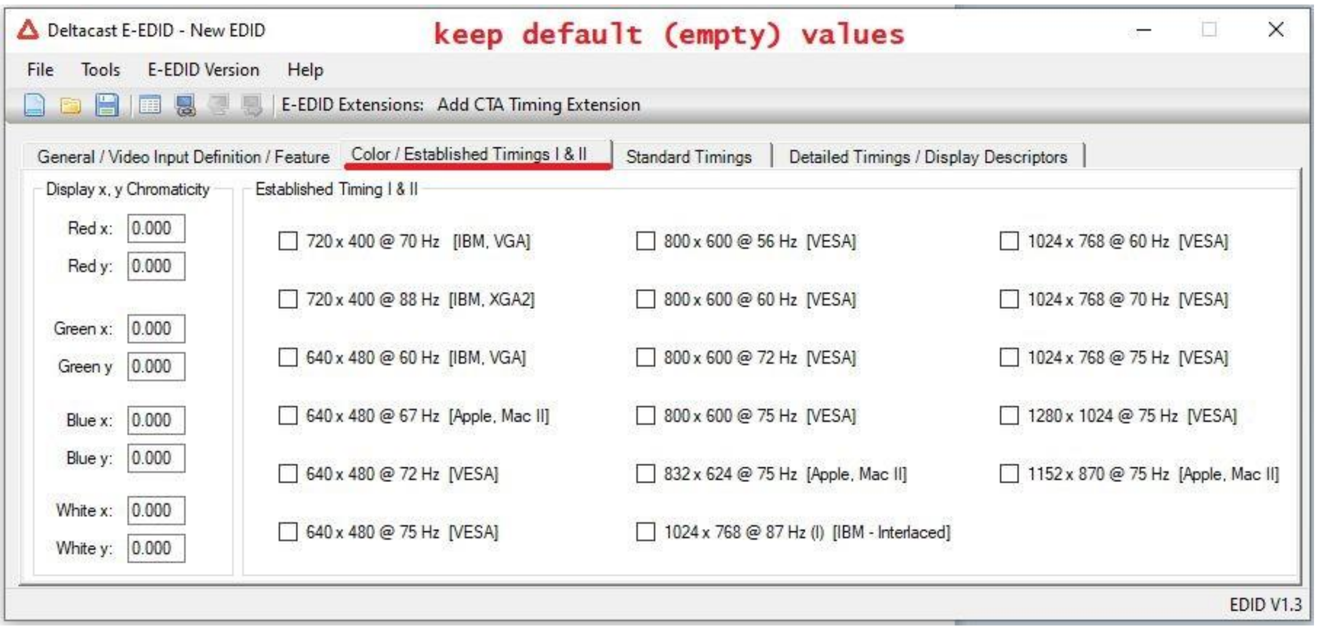
☑ RGB 4:4:4 □ YCrCb 4:4:4

□ YCrCb 4:2:2

□ sRGB □ Default GFT

□ Preferred Timing Mode

图5. E-DID常规设置


Deltacast E-EDID - New EDID
keep default (empty) values
File
Tools
E-EDID Version
Help
E-EDID Extensions:
Add CTA Timing Extension
General / Video Input Definition / Feature
Color / Established Timings I & II
Standard Timings
Detailed Timings / Display Descriptors
EDID V1.3

Display x, y Chromaticity

Red x: 0.000

Red y: 0.000

Green x: 0.000

Green y 0.000

Blue x: 0.000

Blue y: 0.000

White x: 0.000

White y: 0.000

Established Timing I & II

□ 720 x 400 @ 70 Hz [IBM, VGA]

□ 720 x 400 @ 88 Hz [IBM, XGA2]

□ 640 x 480 @ 60 Hz [IBM, VGA]

□ 640 x 480 @ 67 Hz [Apple, Mac II]

□ 640 x 480 @ 72 Hz [VESA]

□ 640 x 480 @ 75 Hz [VESA]

□ 800 x 600 @ 56 Hz [VESA]

□ 800 x 600 @ 60 Hz [VESA]

□ 800 x 600 @ 72 Hz [VESA]

□ 800 x 600 @ 75 Hz [VESA]

□ 832 x 624 @ 75 Hz [Apple, Mac II]

□ 1024 x 768 @ 87 Hz (I) [IBM - Interlaced]

□ 1024 x 768 @ 60 Hz [VESA]

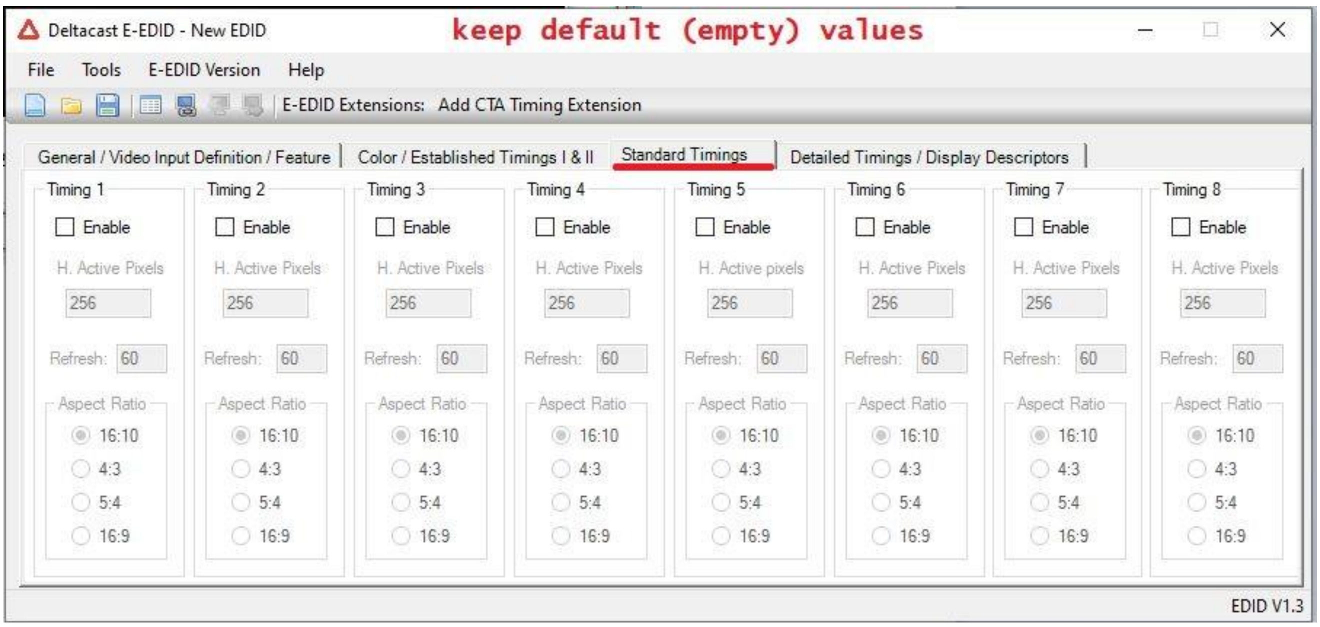
□ 1024 x 768 @ 70 Hz [VESA]

□ 1024 x 768 @ 75 Hz [VESA]

□ 1280 x 1024 @ 75 Hz [VESA]

□ 1152 x 870 @ 75 Hz [Apple, Mac II]

图6. E-DID颜色和时序设置



Deltacast E-EDID - New EDID   keep default (empty) values

File Tools E-EDID Version Help

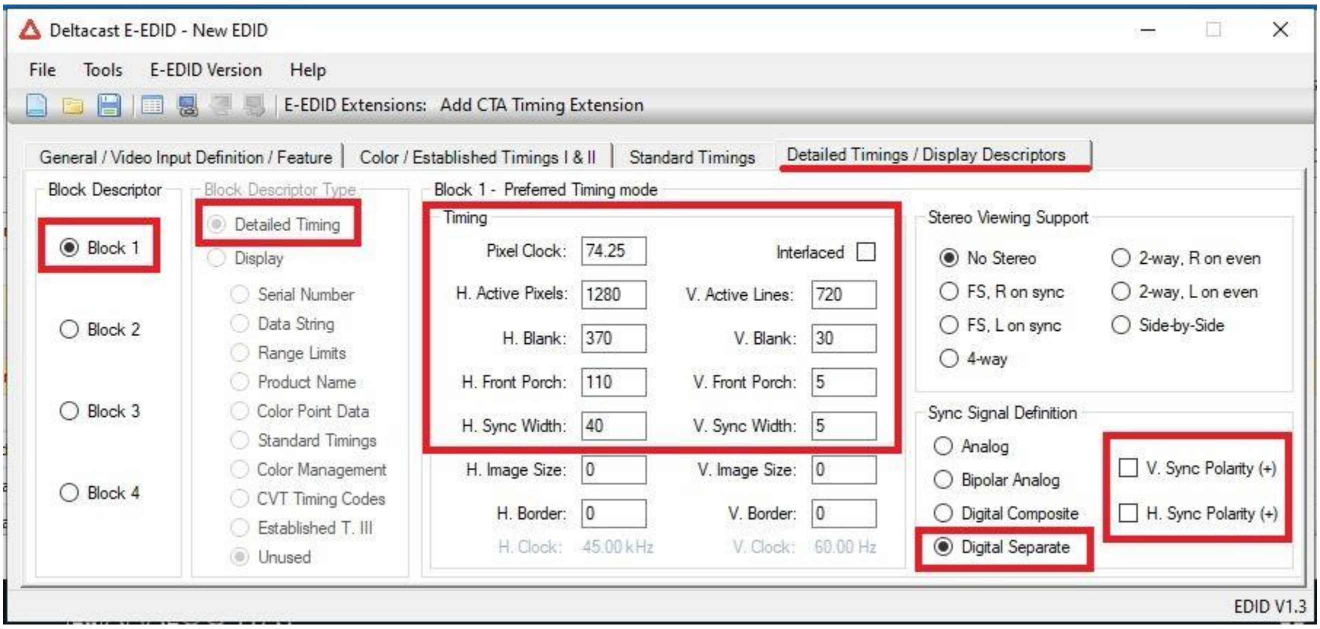
E-EDID Extensions: Add CTA Timing Extension

General / Video Input Definition / Feature | Color / Established Timings I & II | Standard Timings | Detailed Timings / Display Descriptors

	Timing 1	Timing 2	Timing 3	Timing 4	Timing 5	Timing 6	Timing 7	Timing 8
Enable	□	□	□	□	□	□	□	□
H. Active Pixels	256	256	256	256	256	256	256	256
Refresh:	60	60	60	60	60	60	60	60
Aspect Ratio	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9	● 16:10 ○ 4:3 ○ 5:4 ○ 16:9

EDID V1.3

图7. E-DID标准时序设置



Deltacast E-EDID - New EDID

File Tools E-EDID Version Help

E-EDID Extensions: Add CTA Timing Extension

General / Video Input Definition / Feature | Color / Established Timings I & II | Standard Timings | Detailed Timings / Display Descriptors

Block Descriptor: ● Block 1 ○ Block 2 ○ Block 3 ○ Block 4

Block Descriptor Type: ● Detailed Timing ○ Display ○ Serial Number ○ Data String ○ Range Limits ○ Product Name ○ Color Point Data ○ Standard Timings ○ Color Management ○ CVT Timing Codes ○ Established T. III ○ Unused

Block 1 - Preferred Timing mode

Timing

Pixel Clock:	74.25	Interlaced	□
H. Active Pixels:	1280	V. Active Lines:	720
H. Blank:	370	V. Blank:	30
H. Front Porch:	110	V. Front Porch:	5
H. Sync Width:	40	V. Sync Width:	5
H. Image Size:	0	V. Image Size:	0
H. Border:	0	V. Border:	0
H. Clock:	45.00 kHz	V. Clock:	60.00 Hz

Stereo Viewing Support: ● No Stereo ○ FS, R on sync ○ FS, L on sync ○ 4-way ○ 2-way, R on even ○ 2-way, L on even ○ Side-by-Side

Sync Signal Definition: ○ Analog ○ Bipolar Analog ○ Digital Composite ● Digital Separate

□ V. Sync Polarity (+)
□ H. Sync Polarity (+)

EDID V1.3

图8. E-DID详细时序设置

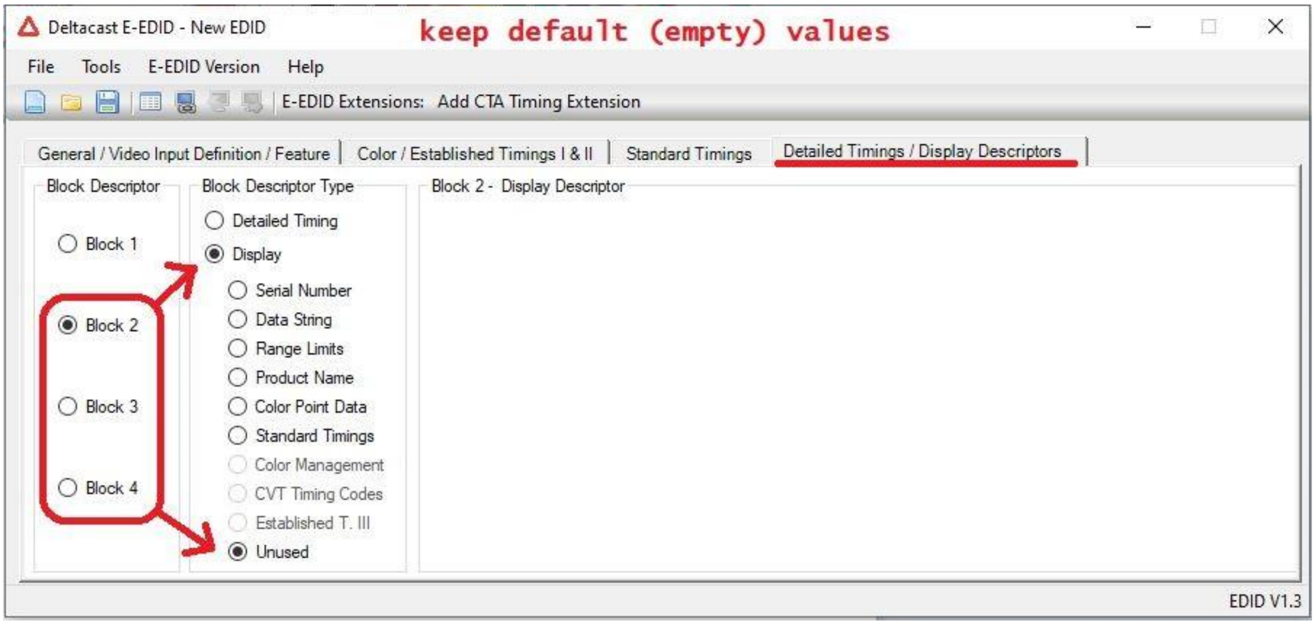


图9. E-DID显示块选择

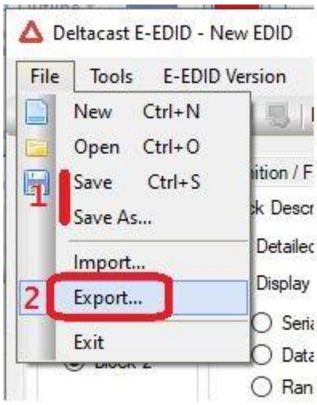


图10. E-DID设置导出

导出后，打开`.dat`文件并编辑字符串，使其看起来与`galcore.inf`文件中的格式相同。

5 LVDS信号

本章节详细介绍LVDS信号和LVDS显示器的相关信息。

5.1 从4通道到3通道的方案

某些显示器支持3通道（18bpp）而非4通道（24bpp）。详细信息,请参见以下章节。

5.1.1 24bpp和18bpp

图11描述了LVDS中24bpp和18bpp的区别：

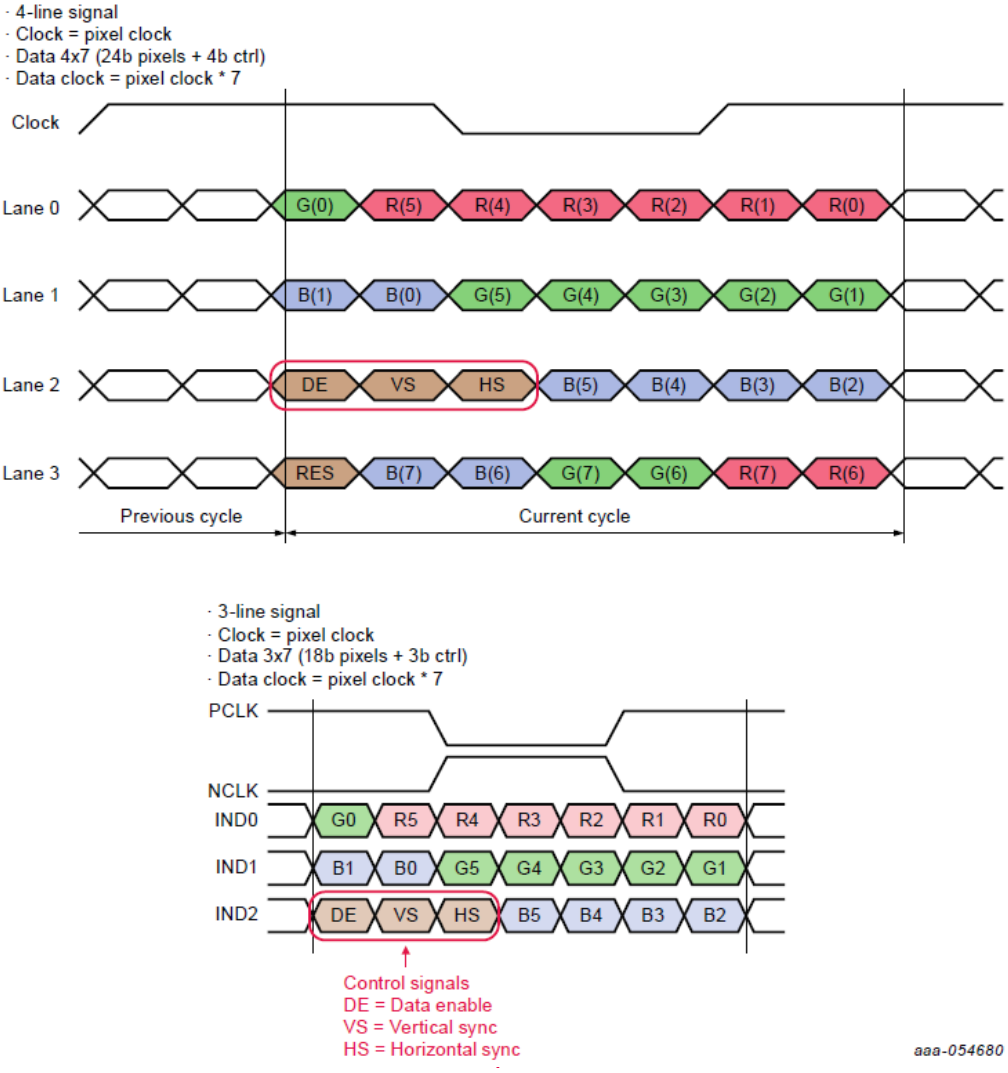


图11. 24bpp 和 18bpp LVDS 信号的区别

5.1.1.1 VESA和JEIDA标准

如下所示，24bpp映射有两种不同的标准。默认情况下，恩智浦EVK板使用VESA标准。但是，也可以切换到JEIDA标准。

表6. SPWG/PSWGNESA 24bpp数据映射

序列化输入	时隙0	时隙1	时隙2	时隙3	时隙4	时隙5	时隙6
data0	G0	R5	R4	R3	R2	R1	R0
data1	B1	B0	G5	G4	G3	G2	G1
data2	DE	VSYNC	HSYNC	B5	B4	B3	B2
data3	CTL	B7	B6	G7	G6	R7	R6

表7. JEIDA 24bpp数据映射

序列化输入	时隙0	时隙1	时隙2	时隙3	时隙4	时隙5	时隙6
data0	G2	R7	R6	R5	R4	R3	R2
data1	B3	B2	G7	G6	G5	G4	G3
data2	DE	VSYNC	HSYNC	B7	B6	B5	B4
data3	CTL	B1	B0	G1	G0	R1	R0

5.1.2 从24位色深映射到18位色深

i.MX 8QXP和i.MX 8MP处理器可以在24位色深和18位色深之间进行选择。对于其他处理器，可以使用以下变通方法：

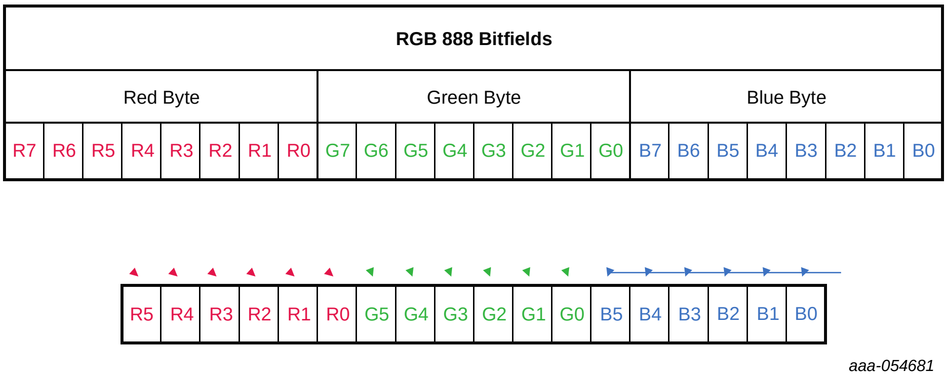

RGB 888 Bitfields
Red Byte
Green Byte
Blue Byte
R7 R6 R5 R4 R3 R2 R1 R0 G7 G6 G5 G4 G3 G2 G1 G0 B7 B6 B5 B4 B3 B2 B1 B0
R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0
aaa-054681

图12. 24bpp 信号和 18bpp 信号的位映射

在JEIDA 24位色深数据映射中进行如下调整，最低有效位（LSB）将被舍弃：

表8. SPWG/PSWG/VESA 24位色深数据映射

序列化输入	时隙0	时隙1	时隙2	时隙3	时隙4	时隙5	时隙6
data0	G0	R5	R4	R3	R2	R1	R0
data1	B1	B0	G5	G4	G3	G2	G1
data2	DE	VSYNC	HSYNC	B5	B4	B3	B2
data3	CTL	B7	B6	G7	G6	R7	R6

表9. JEIDA 24位色深数据映射

序列化输入	时隙0	时隙1	时隙2	时隙3	时隙4	时隙5	时隙6
data0	G2	R7	R6	R5	R4	R3	R2
data1	B3	B2	G7	G6	G5	G4	G3
data2	DE	VSYNC	HSYNC	B7	B6	B5	B4
data3	CTL	B1	B0	G1	G0	R1	R0

***注意：**如果忽略24位色深 JEIDA信号的第四行，就可以得到一个有效的3线18位色深VESA信号。如图12所示，R7信号会变为R5信号，G7信号会变为G5信号，依此类推。这意味着对于恩智浦i.MX EVK板，需要从VESA模式切换到JEIDA模式，并将数据通道减少到三个。*

5.2 LVDS信号设置

在进行LVDS（低电压差分信号）相关更改时，需要同时编辑UEFI驱动程序和Windows驱动程序。

5.2.1 UEFI驱动程序

必须根据所使用的EVK板更新平台特定的LVDS驱动源代码。

有关寄存器的描述，请参阅SoC参考手册：

i.MX 8MP：UEFI驱动程序中的`ldb.c`文件，`LcdConfig()`函数。

i.MX 93：UEFI驱动程序中的`iMX9xLvds.c`文件，`LcdEnable()`函数。

上述文件位于`\mu_platform_nxp\Silicon\ARM\NXP\iMX8Pkg\Library\iMX8LcdHwLib\`。

BSP 1.5.0版本已经添加了i.MX 8QXP的UEFI LVDS驱动程序。

i.MX 8QXP：UEFI驱动程序中的`ldb_imx8x.c`文件，`Imx8xLdbConfigure`函数。

以下是i.MX 93平台更改为JEIDA格式的示例：

```
EFI_STATUS LdbEnable(IN INTN Ldb, IN
CONST IMX_DISPLAY_TIMING *Timing)
{
  if (Ldb < 0 || Ldb >= LVDS_MAX_DEV)
    { return EFI_DEVICE_ERROR;
  }
  (VOID)Timing;
  /*
  * Leave default negative polarity, SPWG
 mapping,
  * set 24bit data width, LDB data always
 from source 0.
  */
  MmioWrite32(BasePtrs[Ldb] + LDB_CTRL,
 CH0_ENABLE | CH0_DATA_WIDTH | CH0_BIT_MAPPING
  return EFI_SUCCESS;
}
```

5.2.2 Windows驱动程序

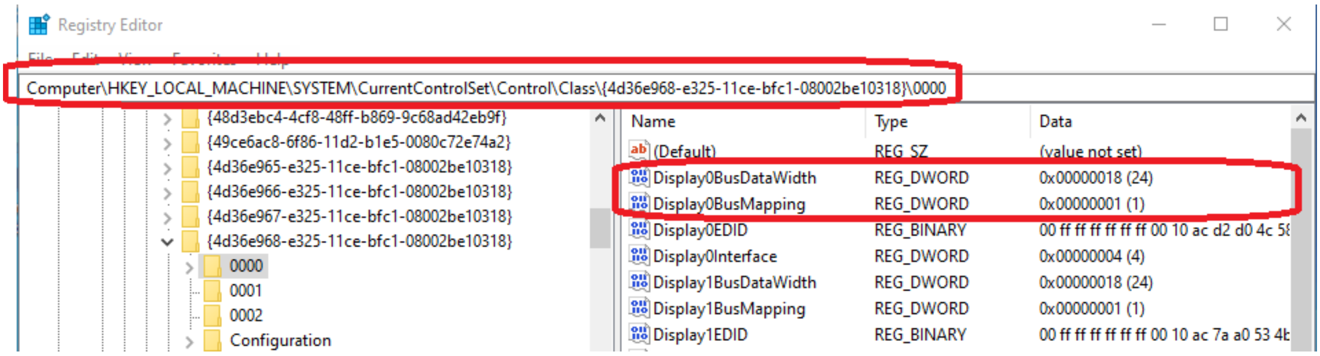
LVDS信号的属性通过第一个显示器的`Display0BusDataWidth`参数设置，其值可以为18或24。第一个显示器的`Display0BusMapping`参数的值可以是1（VESA标准）或2（JEIDA标准）。有两种方式：

1. 更新`galcore.inf`文件，然后卸载并重新安装GPU驱动程序。

   `Galcore.inf`更新

   ```
   [GcWddmMP_AddReg] // Find
   appropriate platform (MP, MN,
   8X)
   …
   ;Following parameters relevant do LVDS interface
   HKR,,Display0BusDataWidth,%REG_DWORD%,24
   HKR,,Display0BusMapping,%REG_DWORD%,%DISP_BUS_MAPPING_SPWG%
   ```

2. 更新目标设备上的注册表数据库并重启GPU驱动程序，路径：`HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11cebfc1-08002be10318}\0000`



Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-bfc1-08002be10318}\0000

```
> {48d3ebc4-4cf8-48ff-b869-9c68ad42eb9f}
> {49ce6ac8-6f86-11d2-b1e5-0080c72e74a2}
> {4d36e965-e325-11ce-bfc1-08002be10318}
> {4d36e966-e325-11ce-bfc1-08002be10318}
> {4d36e967-e325-11ce-bfc1-08002be10318}
v {4d36e968-e325-11ce-bfc1-08002be10318}
    > 0000
      0001
      0002
    > Configuration
```

Name	Type	Data
(Default)	REG_SZ	(value not set)
Display0BusDataWidth	REG_DWORD	0x00000018 (24)
Display0BusMapping	REG_DWORD	0x00000001 (1)
Display0EDID	REG_BINARY	00 ff ff ff ff ff ff 00 10 ac d2 d0 4c 5
Display0Interface	REG_DWORD	0x00000004 (4)
Display1BusDataWidth	REG_DWORD	0x00000018 (24)
Display1BusMapping	REG_DWORD	0x00000001 (1)
Display1EDID	REG_BINARY	00 ff ff ff ff ff ff 00 10 ac 7a a0 53 4

图13. 注册表更新

5.3 调整背光

调整显示器的背光是可选的。通常只能控制背光的开启或关闭状态，无法调节亮度强度。

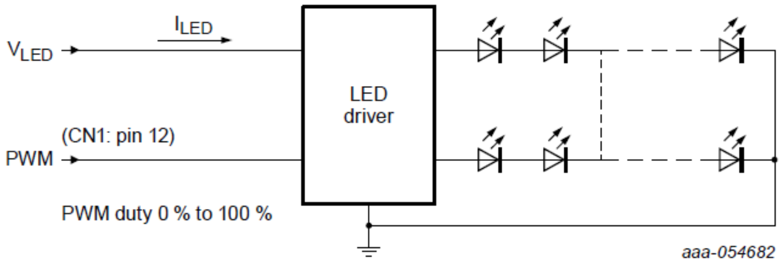


图14. 背光框图示例

表10是EV121WXM-N12的一个示例：这是一款分辨率为1280x800的LVDS面板，是i.MX 93 EVK工业版的配件。

表10. EV121WXM-N12 LVDS面板的引脚布线

引脚编号	符号	描述	备注
1	PWM	亮度控制	
2	BRTC	背光开/关控制	高电平或开路：背光开启； 低电平：背光关闭
3	GND	接地	
4	GND	接地	
5	VDD	电源	
6	VDD	电源	

表10表明，BRTC引脚必须保持高电平，而PWM引脚则决定亮度强度。要实现最大亮度，这两个引脚都必须为高电平。设置这些引脚的合适位置是固件中的`BoardInit.c`驱动文件。该文件中已有引脚布线和设置的示例。例如，对于i.MX 8MP平台，BoardInit文件位于`/mu_platform_nxp/NXP/MX8M_PLUS_EVK/Library/iMX8BoardLib/iMX8BoardInit.c`。

6 MIPI-DSI设置

需要进行与MIPI-DSI相关的更改时，必须同时编辑UEFI驱动程序和Windows驱动程序。

6.1 UEFI驱动程序

默认情况下，系统设置为使用4条MIPI-DSI通道。

UEFI驱动程序适用于i.MX 8MN、i.MX 8MM、i.MX 8MP：文件`MipiDsi.c`中的`MipiDsiConfig`函数，位于：

```
\mu_platform_nxp\Silicon\ARM\NXP\iMX8Pkg\Library\iMX8LcdHwLib\
```

MIPI-DSI通道接口：

```
EFI_STATUS
MipiDsiConfig
   ( IMX_DISPLAY_TIMING* Timing,
   imxConverter MipiDsiConverter
   )
…
   MipiDsiPktRegisterCallback(&MipiDsiPktSend);
   /* Dafault 4 MIPI DSI lanes */
   lanes = 4U; // 4-lane DSI interface
   MipiDsiDisplayClockConfig(Timing)
```

6.2 Windows驱动程序

MIPI-DSI连接的通道（数据线）数量可以通过以下参数设置：

`Display0NumLanes`参数用于第一个显示器，`Display1NumLanes`参数用于第二个显示器，依此类推。有两种方式：

1. 更新`galcore.inf`文件，然后卸载并重新安装GPU驱动程序。

   MIPI-DSI通道设置：

   ```
   [GcWddmMN_AddReg] // Find appropriate platform (MP, MN, 8X)
   …
   ;Following parameters relevant do MIPI-DSI interface
   HKR,,Display0NumLanes,%REG_DWORD%,4 // 4-lane DSI interface
   HKR,,Display0ChannelId,%REG_DWORD%,0
   ```

2. 更新目标设备上的注册表数据库并重启GPU驱动程序：

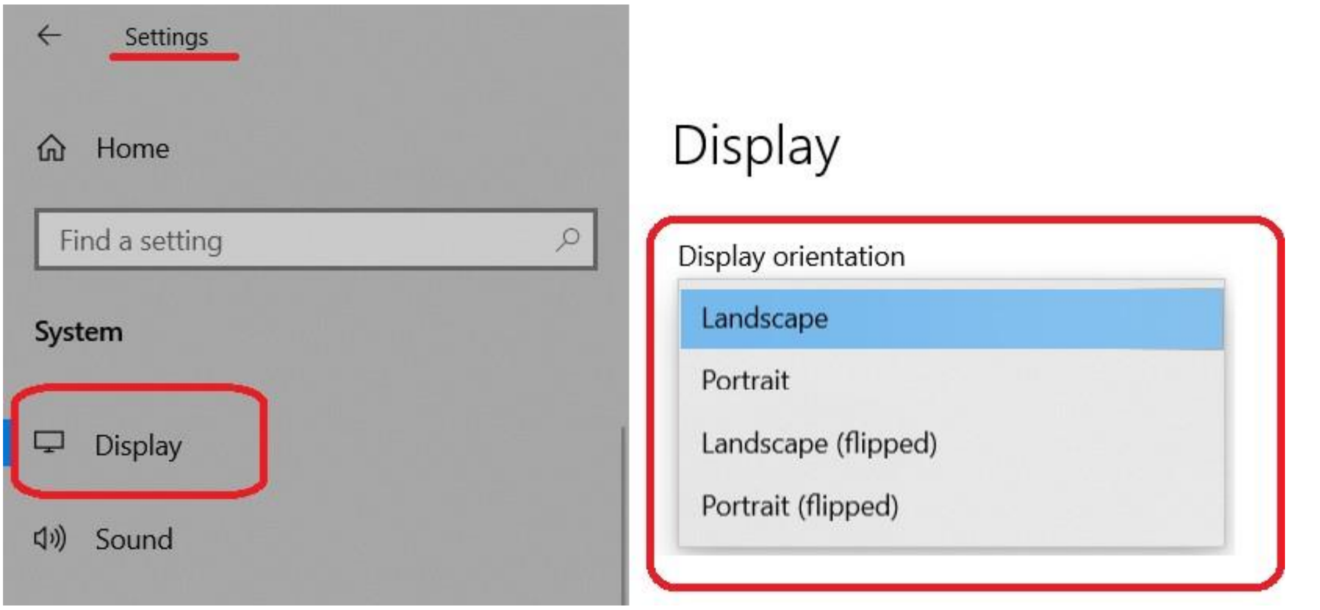
```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-
e325-11cebfc1-08002be10318}\0000
```

7 虚拟模式

显示器的物理分辨率和屏幕位置保持不变。

合成器可创建虚拟模式，如旋转和/或分辨率调整。

1. 显示器旋转（适用于“显示支持”章节提到的所有SoC）。

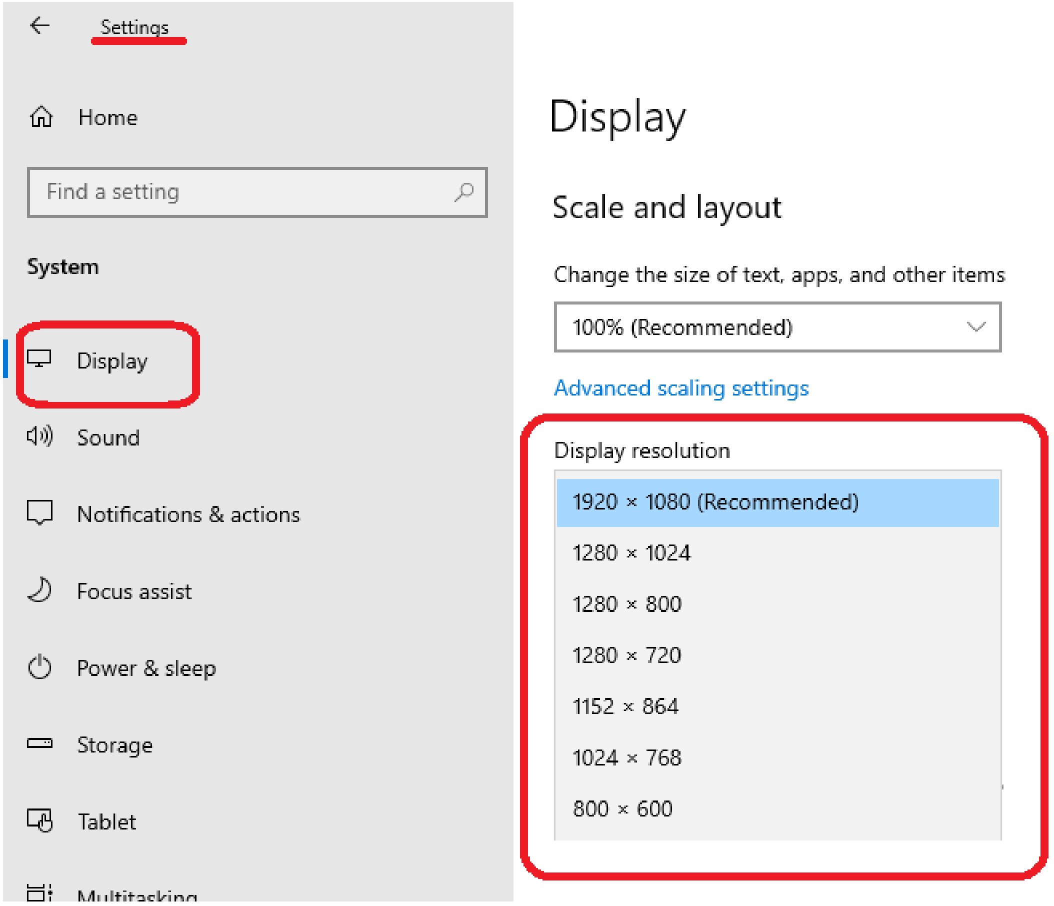


Display

Display orientation
- Landscape
- Portrait
- Landscape (flipped)
- Portrait (flipped)

图15. 显示方向设置

2. 更改屏幕分辨率仅适用于i.MX 8MP的原生HDMI显示接口。



Display

Scale and layout

Change the size of text, apps, and other items: 100% (Recommended)

Advanced scaling settings

Display resolution
- 1920 × 1080 (Recommended)
- 1280 × 1024
- 1280 × 800
- 1280 × 720
- 1152 × 864
- 1024 × 768
- 800 × 600

图16. 显示器分辨率设置

8 i.MX 8MP上LVDS1的方案

要将接口更改为LVDS1，请按以下步骤操作：

1. 使用HDMI显示器（默认设置）启动Windows 10以查看屏幕。在注册表数据库中切换到LVDS1显示：`Display0Interface = 0x5 (HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet \Control\Class\{4d36e968-e325-11cebfc1-08002be10318}\0000)`
2. 关闭Windows，断开板卡电源。将显示器和LVDS-HDMI转换器安装到LVDS1接口。
3. 按以下步骤更新固件：
   a. `/mu_platform_nxp/NXP/MX8M_PLUS_EVK/MX8M_PLUS_EVK.dsc`。更新参数：

      -
        ```
        giMX8TokenSpaceGuid.PcdDisplayInterface|3
        ```

      -
        ```
        giMX8TokenSpaceGuid.PcdDisplayI2CBaseAddr|0x30A40000
        ```
   b. `/mu_platform_nxp/NXP/MX8M_PLUS_EVK/AcpiTables/Dsdt-Gfx.asl`。更改LVDS-HDMI转换器的I2C地址：

      -
        ```
        I2CSerialBus(0x4C, ControllerInitiated, 400000, AddressingMode7Bit, \
        \_SB.I2C3)
        ```

      -
        ```
        I2CSerialBus(0x33, ControllerInitiated, 400000, AddressingMode7Bit, \
        \_SB.I2C3)
        ```
4. 编译固件，将其加载到SD卡或eMMC中。
5. 使用LVDS1显示器启动Windows。

9 i.MX 8MP上的IMX-DLVDS-LCD显示方案

默认接口为HDMI。要更改为双LVDS，请按以下步骤操作：

针对1920x1200@60双LVDS面板：

- **Windows**：（`.reg`脚本可在第12节找到）。
  1. 使用默认HDMI显示器启动Windows。
  2. 将显示器更改为双LVDS：设置`Display0Interface` = 0x6（参见第12节的示例11）。
  3. 将显示分辨率更改为1920x1200@60：修改`Display0EDID`参数（参见第12节的示例8）。
  4. 关闭Windows，断开板卡电源。
  5. 移除HDMI显示器，使用两根mini-SAS线缆连接IMX-DLVDS-LCD，其中 chan0=J8=LVDS1，chan1=J9=LVDS0。
  6. 继续进行固件更新。
- **UEFI固件：**
  1. 在`MX8M_PLUS_EVK.dsc`：`giMX8TokenSpaceGuid.PcdDisplay Interface|4`中选择双LVDS接口
  2. 在MX8M_PLUS_EVK.dsc中增加帧缓冲区（FB）大小，约9MB（4*1920*1200）：`gArmPlatformTokenSpaceGuid. PcdArmLcdDdrFrameBufferSize | 0x008CA000`
  3. 在MX8M_PLUS_EVK.dsc中相应地移动后续内存区域：
     `giMXPlatformTokenSpaceGuid.PcdGlobalDataBaseAddress | 0x408CA000`
     `gOpteeClientPkgTokenSpaceGuid.PcdTpm2AcpiBufferBase | 0x408CB000`
- 在`iMX8LcdHwLib.c`文件的`LcdDisplayDetect`函数中设置1920x1200@60分辨率。
  i.MX8MP的双LVDS设置：

  ```
  EFI_STATUS
  LcdDisplayDetect (
  ```

```
  VOID
  )
…
/* Converter was not detected - select fixed
default timimng */
  if (converter == transmitterUnknown) {
    if (displayInterface == imxMipiDsi) {
      videoModesCnt++;
      LcdInitPreferredTiming
 (&PreferredTiming_1080x1920_60,
 &PreferredTiming);
      DEBUG((DEBUG_ERROR, "Mipi-dsi
 display interface. Default resolution used.
 %dx%d pclk=%d Hz\n",
            PreferredTiming.HActive,
 PreferredTiming.VActive,
 PreferredTiming.PixelClock));
      LcdDumpDisplayTiming(0,
 &PreferredTiming);
      return EFI_SUCCESS;
    } else if ((displayInterface == imxLvds0)
 || (displayInterface == imxLvds1) ||
 (displayInterface == imxLvds0dual))
      { videoModesCnt++;
      LcdInitPreferredTiming
 (&PreferredTiming_1280x720_60,
 &PreferredTiming); // Set default 1920x1200@60
      DEBUG((DEBUG_ERROR, "LVDS%d
 display interface. Default resolution used.
 %dx%d pclk=%d Hz\n",
            displayInterface-2,
 PreferredTiming.HActive,
 PreferredTiming.VActive,
 PreferredTiming.PixelClock));
      LcdDumpDisplayTiming(0,
 &PreferredTiming);
      return EFI_SUCCESS;
    } else if (displayInterface ==
 imxNativeHdmi) {
      videoModesCnt++;
      LcdInitPreferredTiming
 (&PreferredTiming_1920x1080_60,
 &PreferredTiming);
      DEBUG((DEBUG_ERROR, "HDMI display
 interface. Fixed default resolution used. %
 dx%d pclk=%d Hz\n",
            PreferredTiming.HActive,
      PreferredTiming.VActive,
      PreferredTiming.PixelClock));
      LcdDumpDisplayTiming(0,
 &PreferredTiming);
      return EFI_SUCCESS;
```

- 编译UEFI固件，将其加载到SD卡或eMMC中，然后启动Windows。
- 在Windows中，依次进入设置 -> 系统 -> 显示 -> 缩放和布局，将文本、应用和其他项目的大小更改为200%。

10 在i.MX 8MP上配置多显示器（3个显示器）的方法

要在8MP EVK板上启用3个显示器，请按以下步骤操作：

1. 使用默认的`Galcore.inf`文件（无需编辑）。
2. 安装操作系统时最好只连接一个显示器（默认HDMI）。
3. 将第二和第三个显示器连接到板卡。
4. 运行`LVDS0_HDMI_MIPI0_multimon.reg`以启用多显示器模式，然后重启板卡。（参见示例15）
5. 所有3个显示器应按以下方式激活：
   显示器1和显示器3是复制的，显示器2是扩展的。
   1号显示器 - LVDS0
   2号显示器 - MIPI DSI
   3号显示器 - HDMI
6. 要恢复注册表设置，运行`HDMI_multimon.reg`，然后重启板卡。（参见示例16）
7. 此时只有一个显示器（HDMI显示器）工作。

***注意：**要独立设置3个显示器，请按以下说明操作：*

1. *以管理员身份打开regedit（注册表编辑器），转至：*
   `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class{4d36e968-e325-11ce-bfc1-08002be10318}\0000`
2. *将**GdiAccLevel**更改为**0***
3. *重启板卡。现在，3个显示器可以独立显示（扩展模式）。*

11　使用EDID文件设置显示分辨率

本例说明如何将分辨率从1920x1080更改为1080x1920，以及如何切换回原始分辨率。

1. 将IMX-MIPI-HDMI转换器连接到设备上(如i.MX8MN-EVK板)。
2. 上电板卡并启动Windows系统。
3. 使用第12节中适当分辨率的`.reg`文件，并将它们复制到目标设备。
4. 运行`1080x1920EDID.reg`脚本，将1080x1920分辨率设置写入注册表。
5. 关闭Windows系统，并切断板卡电源。
6. 断开IMX-MIPI-HDMI转换器与EVK板的连接，改为连接mx8-dsi-oled1面板。
7. 上电板卡并启动Windows系统。
8. [可选]如果需要恢复到1920x1080分辨率以配合IMX-MIPI-HDMI转换器使用，请运行`1920x1080EDID.reg`脚本。
9. 关闭Windows系统，并切断板卡电源。

12　EDID .reg脚本示例

以下脚本示例可用于简化Windows注册表中特定显示功能的编辑过程。下面的EDID .reg脚本适用于i.MX 8MN、i.MX 8QXP和i.MX 8MP上的MIPI和LVDS显示器，用于设置自定义分辨率。创建一个`.reg`文件，并复制下面相应的文本进行自定义编辑。

- 示例1：`1024x768EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 34, 20, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, A1, 08, 00, 81, 40, 81, 80, A9, 40, B3, 00, D1, C0,\
 01, 01, 01, 01, 01, 01, 64, 19, 00, 40, 41, 00, 26, 30, 18, 88,\
 36, 00, 40, 44, 21, 00, 00, 1A, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 32, 3D, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, 1D
```

- 示例2：`1080x1920EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 20, 34, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, 00, 00, 00, 01, 01, 01, 01, 01, 01, 01, 01, 01, 01,\
 01, 01, 01, 01, 01, 01, 30, 2A, 38, 38, 40, 80, 10, 70, 14, 02,\
 A2, 00, 44, 26, 12, 00, 00, 18, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 28, 3D, 1E, 78, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, 23
```

- 示例3：`1280x1024EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 34, 20, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, A1, 08, 00, 81, 40, 81, 80, A9, 40, B3, 00, D1, C0,\
 01, 01, 01, 01, 01, 01, 30, 2A, 00, 98, 51, 00, 2A, 40, 30, 70,\
 13, 00, 40, 44, 21, 00, 00, 1A, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 32, 3D, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, E7
```

- 示例4：`1280x720EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 34, 20, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, A1, 08, 00, 81, 40, 81, 80, A9, 40, B3, 00, D1, C0,\
 01, 01, 01, 01, 01, 01, 01, 1D, 00, 72, 51, D0, 1E, 20, 6E, 28,\
 55, 00, 40, 44, 21, 00, 00, 1A, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 32, 3D, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, 6D
```

- 示例5：`1280x800EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
  00, ff, ff, ff, ff, ff, ff, 00, 0e, 14, 0a, 14, 00, 00, 00, 00, \
  26, 11, 01, 03, 80, 21, 15, 78, 0a, 09, 2d, 9d, 56, 4f, 90, 27, \
  21, 50, 54, 00, 00, 00, 01, 01, 01, 01, 01, 01, 01, 01, 01, 01, \
  01, 01, 01, 01, 01, 01, ea, 1a, 00, 80, 50, 20, 10, 30, 15, 20, \
  13, 00, 4b, cf, 10, 00, 00, 19, 00, 00, 00, 0f, 00, 00, 00, 00, \
  00, 00, 00, 00, 00, 20, 6e, 05, 0f, 00, 00, 00, 00, fe, 00, 46, \
  44, 31, 36, 33, 30, 31, 35, 34, 57, 42, 34, 20, 00, 00, 00, fe, \
  00, 2d, 40, 50, 59, 7d, a9, c8, ff, 01, 01, 20, 20, 20, 00, a3
```

- 示例6：`1366x768EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 34, 20, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, 00, 00, 00, 01, 01, 01, 01, 01, 01, 01, 01, 01, 01,\
 01, 01, 01, 01, 01, 01, 66, 21, 56, AA, 51, 00, 1E, 30, 46, 8F,\
 33, 00, 40, 44, 21, 00, 00, 1A, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 32, 3D, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, A7
```

- 示例7：`1920x1080EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, D2, D0, 4C, 58, 37, 30,\
 0B, 1C, 01, 03, 80, 35, 1E, 78, EE, 21, 95, A9, 54, 4E, 9C, 26,\
 0F, 50, 54, A5, 4B, 00, 71, 4F, 81, 80, A9, C0, D1, C0, 01, 01,\
 01, 01, 01, 01, 01, 01, 02, 3A, 80, 18, 71, 38, 2D, 40, 58, 2C,\
 45, 00, 0F, 28, 21, 00, 00, 1E, 00, 00, 00, FF, 00, 42, 47, 4D,\
 50, 44, 4D, 32, 0A, 20, 20, 20, 20, 20, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 53, 32, 34, 31, 39, 48, 0A, 20, 00, 00, 00, FD,\
 00, 38, 4C, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, B6
```

- 示例8：`1920x1200_156_68EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
00, FF, FF, FF, FF, FF, FF, 00, 04, 21, 00, 00, 00, 00, 00, 00,\
01, 00, 01, 03, 80, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00,\
00, 00, 00, 00, 00, 00, 01, 00, 01, 00, 01, 00, 01, 00, 01, 00,\
01, 00, 01, 00, 01, 00, 34, 3D, 80, E6, 70, B0, 0F, 40, 5A, 28,\
55, 00, 00, 00, 00, 00, 00, 18, 00, 00, 00, 10, 00, 00, 00, 00,\
00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 10, 00, 00,\
00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00,\
00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, FF
```

- 示例9：`800x480EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 36, 09, 01, 70, 01, 01, 01, 01,\
 22, 15, 01, 03, 80, 29, 1A, 78, EE, E5, B5, A3, 55, 49, 99, 27,\
 13, 50, 54, AC, 00, 00, 01, 01, 01, 01, 01, 01, 01, 01, 01, 01,\
 01, 01, 01, 01, 01, 01, 8D, 0B, 20, C0, 30, E0, 11, 10, 10, 50,\
 13, 00, FF, FF, 00, 00, 00, 1C, 00, 00, 00, FC, 00, 4D, 50, 49,\
 37, 30, 30, 31, 0A, 20, 20, 20, 20, 20, 00, 00, 00, FD, 00, 32,\
 4C, 1C, 51, 0E, 00, 0A, 20, 20, 20, 20, 20, 20, 00, 00, 00, FF,\
 00, 42, 33, 34, 33, 32, 38, 34, 35, 0A, 20, 20, 20, 20, 00, 5E
```

- 示例10：`800x600EDID.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0EDID"=hex:\
 00, FF, FF, FF, FF, FF, FF, 00, 10, AC, 7A, A0, 53, 4B, 35, 32,\
 1E, 1A, 01, 03, 80, 34, 20, 78, EA, EE, 95, A3, 54, 4C, 99, 26,\
 0F, 50, 54, A1, 08, 00, 81, 40, 81, 80, A9, 40, B3, 00, D1, C0,\
 01, 01, 01, 01, 01, 01, A0, 0F, 20, 00, 31, 58, 1C, 20, 28, 80,\
 14, 00, 40, 44, 21, 00, 00, 1A, 00, 00, 00, FF, 00, 59, 50, 50,\
 59, 30, 36, 37, 56, 32, 35, 4B, 53, 0A, 00, 00, 00, FC, 00, 44,\
 45, 4C, 4C, 20, 55, 32, 34, 31, 32, 4D, 0A, 20, 00, 00, 00, FD,\
 00, 32, 3D, 1E, 53, 11, 00, 0A, 20, 20, 20, 20, 20, 20, 00, F7
```

- 示例11：`DLVDS.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0Interface"=dword:00000006
```

- 示例12：`HDMI.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0Interface"=dword:00000001
```

- 示例13：`LVDS0.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0Interface"=dword:00000004
```

- 示例14：`LVDS1.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"Display0Interface"=dword:00000005
```

- 示例15：`LVDS0_HDMI_MIPI0_multimon.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
"EnableMultiMon"=dword:00000001
"Display0Interface"=dword:00000004
"Display0BusDataWidth"=dword:00000018
"Display0BusMapping"=dword:00000001
"Display2Interface"=dword:00000002
"Display2NumLanes"=dword:0000004
"Display2ChannelId"=dword:00000000
"Display1Interface"=dword:00000001
```

- 示例16：`HDMI_multimon.reg`文件

```
Windows Registry Editor Version 5.00
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Class\{4d36e968-e325-11ce-
bfc1-08002be10318}\0000]
```

```
"EnableMultiMon"=dword:00000001
"Display0Interface"=-
"Display1Interface"=dword:00000001
"Display2Interface"=-
```

13 关于本文中源代码的说明

本文中所示的示例代码具有以下版权和BSD-3-Clause许可：

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14 修订历史

表11. 修订历史

文档编号	发布日期	描述
AN14187 v.1.0	2024年5月29日	初始版本

Legal information

Definitions

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