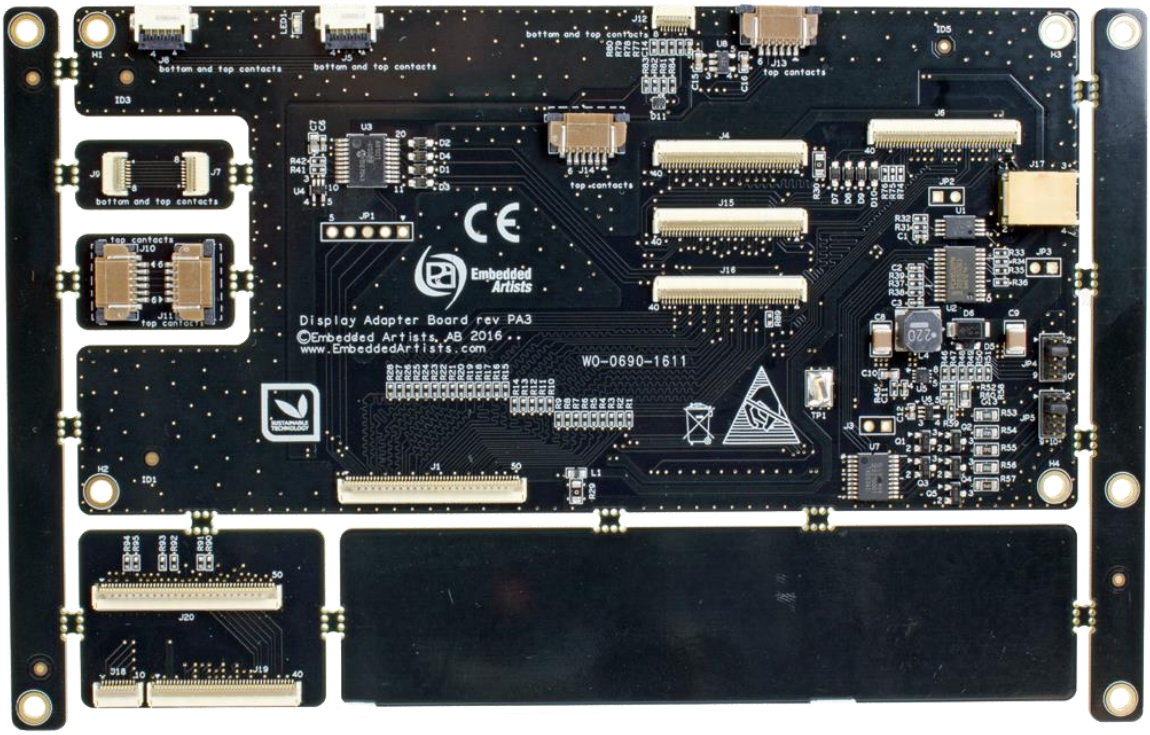
Adding Displays to iMX Developer's Kits



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1 Document Revision History

Revision	*Date*	*Description*
A	2016-05-30	Initial release
B	2019-10-11	Updated with information about COM Carrier board V2 as well as the new COM boards iMX7ULP uCOM, iMX8M COM, and iMX8M Mini uCOM.

2 Introduction

This document describes the process of adding a display to an *iMX Developer's Kit*. The different display interfaces and how to connect to them will be presented. Available commands in the bootloader and Linux kernel will also be presented.

There are many different *iMX Developer's Kits*, for different COM boards, and this document refers to all of these kits collectively as *iMX Developer's Kits*.

The focus of the document is how to connect a display via the *iMX Developer's Kit*, which is based on the *COM Carrier board* design. The process of adding a display to a custom designed carrier board is the same, but details of allocated pins can differ slightly. As illustrated in the picture below, both situations are addressed in this document.

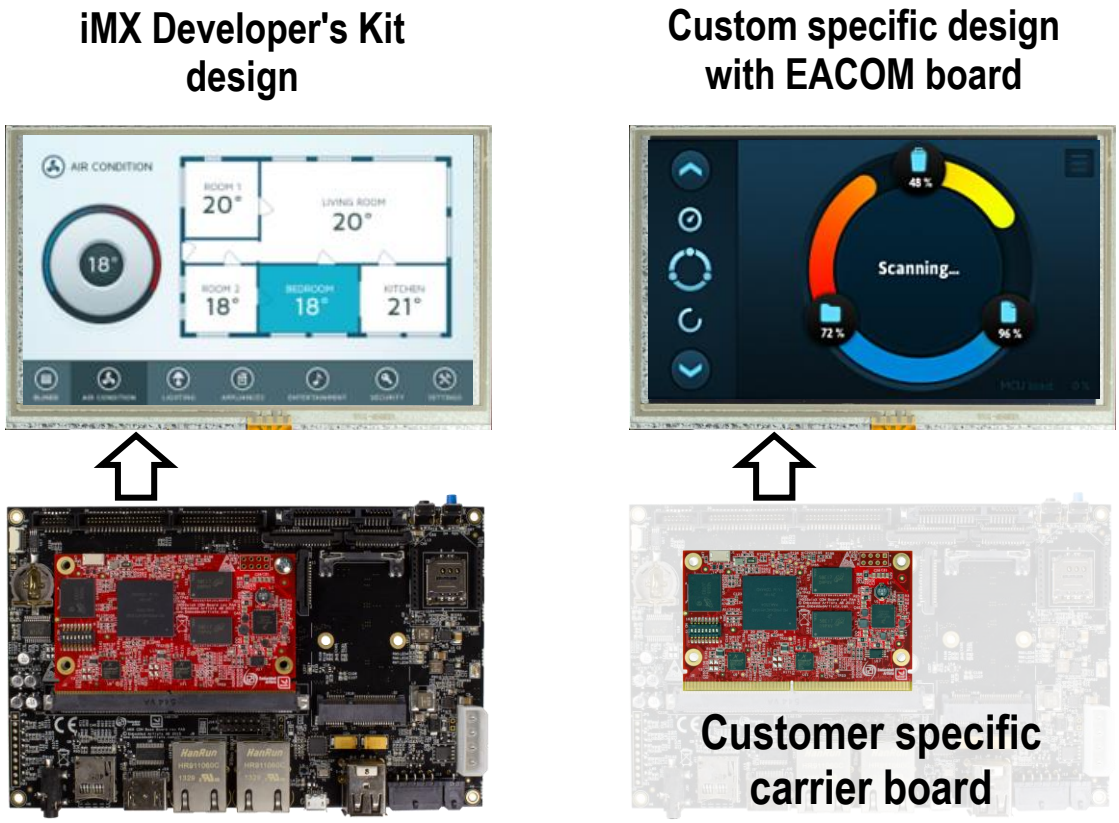


Figure 1 –Applicable Hardware Structures

In the proof-of-concept and prototype stage of a project, the hardware available is typically based on the *iMX Developer's Kit*. The final solution can be based on a customer specific carrier board, where the COM Carrier board design has been used as reference. In both cases, this document applies.

Additional documentation you might need is.

- The *Getting Started* document for the *iMX Developer's Kit* you are using.
- *COM Carrier Board Datasheet*
- *EACOM Board Specification*

2.1 Conventions

A number of conventions have been used throughout to help the reader better understand the content of the document.

`Constant width text` – is used for file system paths and command, utility and tool names.

```
$ This field illustrates user input in a terminal running on the
development workstation, i.e., on the workstation where you edit,
configure and build Linux
```

```
# This field illustrates user input on the target hardware, i.e.,
input given to the terminal attached to the COM Board
```

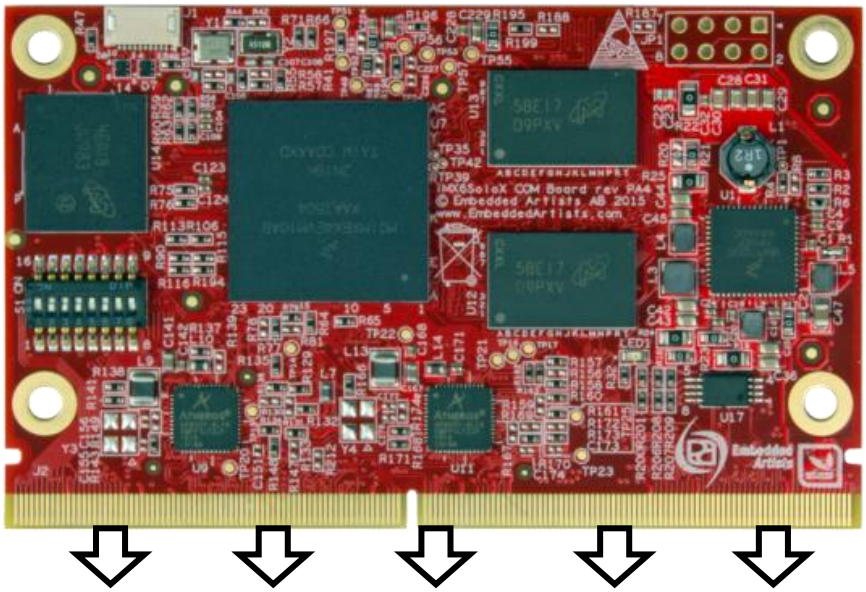
```
This field is used to illustrate example code or excerpt from a
document.
```

This field is used to highlight important information

3 Display Interfaces

The i.MX application processors are very versatile and have a large number of peripherals. In this document only the display interfaces will be addressed. There are up to five different display interfaces and a number (typically 2-4) of these display interfaces can be active simultaneous, outputting different display content.

All display interface signals are available on the 314 pos MXM3 edge connector that is defined by the EACOM standard. The picture below illustrates which display interfaces are available on different iMX COM boards.



COM Board	Parallel RGB	LVDS #0	LVDS #1	HDMI/TDMS	MIPI-DSI
iMX6 UltraLite COM	√				
iMX6 SoloX COM	√	√			
iMX6 DualLite COM	√	√	√	√	√
iMX6 Dual COM	√	√	√	√	√
iMX6 Quad COM	√	√	√	√	√
iMX7 Solo COM	√				√
iMX7 Dual COM	√				√
iMX7 Dual uCOM	√				√
iMX7ULP uCOM				√1)	√
iMX8M COM				√	√
iMX8M Mini uCOM				√1)	√

Figure 2 – Display Interfaces on EACOM boards

1) Via MIPI-DSI to HDMI bridge on uCOM Adapter board.

All options give a lot of flexibility but also some decisions that must be made, specifically when selecting which display interface to use. Below the different interfaces are presented with some comments:

- **Parallel RGB**
  This interface is most common for smaller, internal displays with horizontal resolution up to about 800-1024 pixels. Typically, this is up to, and including, 7 inch displays.
  The interface has up to 24 data bits and up to 4 control signals. 16, 18 and 24 data bits are common data (=color) widths. This results in 20-28 signals in the interface that must be routed.
- **LVDS** (Low-Voltage Differential Signaling)
  This interface is common for larger, internal displays/monitors. The breakpoint is around 7-10 inch displays. Below the breakpoint, the parallel RGB interface is common. Above this the LVDS interface (or other differential signaling interface) is most common.
  For 18-bit color depth, one clock and three data lanes are used resulting in 8 signals (4 differential pairs) that must be routed.
  For 24-bit color depth one more data lane is added, resulting in 10 signals.
- **HDMI/DVI** (TMDS - Transition-Minimized Differential Signaling)
  This interface is common for larger, external displays/monitors. Both HDMI and DVI-I uses the same underlying signaling technology, TMDS, which reduces electromagnetic interference over copper cables. It also enables robust clock recovery at the receiver (in other words, the receiver has high skew tolerance and long/cheap cables can be used).
  The interface has four differential signals and up to four control signals, resulting in up to 12 signals.
  An HDMI interface can also carry an audio stream (without additional signals).
- **MIPI-DSI** (Mobile Industry Processor Interface - Display Serial Interface)
  This interface is common on small, high-resolution displays for handheld equipment, like mobile phones and tablets.
  It is a high-speed differential signaling point-to-point serial bus. It includes one high speed clock lane and one or more data lanes.

Because of radiated EMI, the parallel RGB interface should only be used over short distances, well controlled trace impedance and at lower pixel clock rates. When the pixel clock approach 30MHz (and above) the severity of the problems increase. In general, wide parallel busses can easily generate (i.e., radiate) significant interference. Note that it is not the traces that run on the pcb that is the problem. It is the FPC that interface the display that is the problem. The traces on the FPC act like antennas and lack proper ground plane (for impedance control).
For longer distances (>10 cm) and higher pixel clock rates (>15MHz), considers using differential signaling instead, like LVDS, HDMI or MIPI-DSI. Differential signaling generates lower levels of EMI.

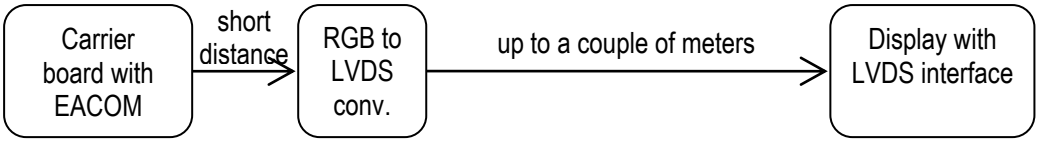
Displays with MIPI-DSI are not easy to buy. Most suppliers will only sell to customers buying very high volumes. Even if you can buy displays in low volume, the risk is very high that the display is obsolete (not available) the next time it's time to buy.

End-user products that provide an HDMI interface might be subject to HDMI royalty. Check the HDMI website for details, http://www.hdmi.org/manufacturer/terms.aspx.
An alternative is to use a DVI-I connector instead. Another alternative is the DisplayPort interface.

3.1 Interface Conversion

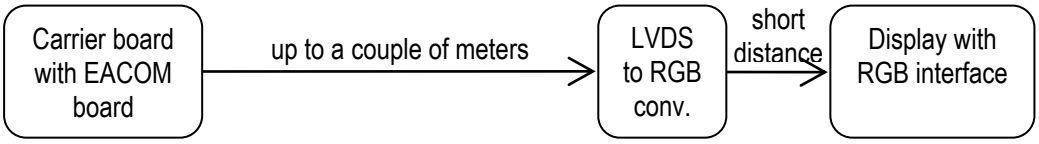
It is simple to convert between the different interfaces. For example, at first glance, the *iMX6 UltraLite* and *iMX7 COM boards* might seem limited when it comes to display interfaces, but below a number of commonly used conversions are presented:

- **Parallel RGB to LVDS converter**
  This solution is suitable when higher-resolution displays shall be used and no LVDS interfaces are available. In general because of EMI it is recommended to use differential signaling (like LVDS) when using high-resolution displays (high-resolution = high frequency content of the signals).
  The maximum length of an LVDS cable depends on display resolution and cable quality but can be up to a few meters.



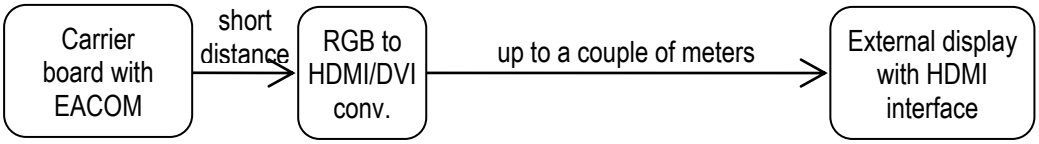
  There are many LVDS transmitters on the market, for example the Texas Instrument DS90Cxxx, SN75LVDSxxx and SN65LVDSxxx series. A good start is the DS90C383BMT.

- **LVDS to Parallel RGB converter**
  This solution is suitable if a smaller display with parallel RGB interface is located at a distance from the carrier and EACOM board. The display data is transmitted over LVDS, resulting in low EMI, and is converted back to parallel RGB at the receiving end.
  Consider using differential signaling (like LVDS) if the distance is more than 10-15 cm.



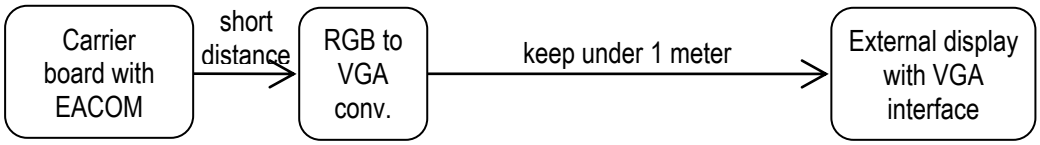
  There are many LVDS transmitters on the market, for example the Texas Instrument DS90CFxxx family. A good start is the DS90CF384A.

- **Parallel RGB to HDMI/DVI-I/DisplayPort converter**
  This solution is suitable when external higher-resolution displays shall be used. The exact display might not be known at design time and can vary over time.
  Consider using the DVI-I or DisplayPort interfaces since HDMI is an interface that might require licensing.
  As with all differential signaling interfaces, EMI is less of a problem.
  The maximum length of an HDMI cable depends on display resolution and cable quality but can easily be up to a few meters.



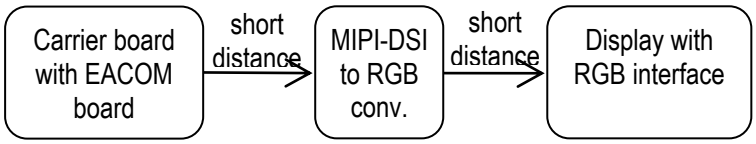
  There are HDMI, DVI and DisplayPort transmitters available. For HDMI, NXP's TDA19988 and Silicon Image's SiI9022ACNU are good to start looking at. For DVI/DisplayPort, Texas Instrument's TFP410 and related family are also good starting points.

- **Parallel RGB to VGA converter**
  This solution is suitable when external not-so-high-resolution displays shall be used. Since VGA is a standard interface there is no need to know the exact monitor type. Many external monitors still have an analog VGA interface. It is however recommended to consider a digital interface if high-resolution is needed or if the distance to the monitor is over 1 meter.



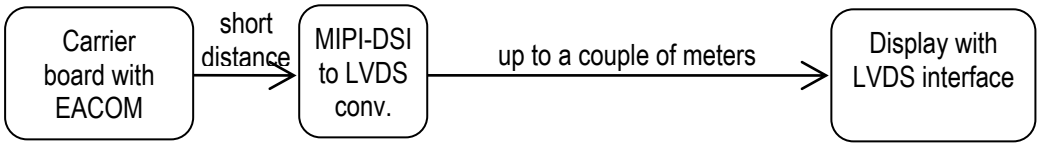
  There are VGA transmitters available. A good start is Analog Device's ADV7125KST50.

- **MIPI-DSI to Parallel RGB converter**
  This solution is suitable when the parallel RGB interface is already allocated for one display and a second lower-resolution display is needed and still mounted close to the carrier and EACOM board.
  The maximum length of the MIPI-DSI interface depends on display resolution can routing but should in general be kept below 25 cm.



  A good start for a MIPI-DSI to parallel RGB converter is Toshiba's TC358762XBG.

- **MIPI-DSI to LVDS converter**
  This solution is suitable when the parallel RGB interface is already allocated for one display and a second higher-resolution display is needed, possibly also mounted a not away from the carrier and EACOM board.
  The maximum length of the MIPI-DSI interface depends on display resolution can routing but should in general be kept below 25 cm.
  The maximum length of an LVDS cable depends on display resolution and cable quality but can be up to a few meters.



  A good start for a MIPI-DSI to parallel LVDS converter is Toshiba's TC358764/65 and Texas Instrument's SN65DSI83/84.

3.2 Touch Panel Interface

Many graphical user interfaces (GUIs) also have a touch panel over the display. Adding a display to an i.MX system typically also means adding a touch panel interface.

There are two basic types of touch panels; resistive and capacitive. The pros and cons with these technologies and all variations of them are not covered in this document. A good starting point for more information is Wikipedia: https://en.wikipedia.org/wiki/Touchscreen

Both types need a touch panel controller. The i.MX 6UltraLite application processor actually has an on-chip resistive touch controller (as a peripheral unit), but that is an exception to the rule.

Common interfaces to these controllers are:

- I2C - this is by far the most common interface for smaller touch panel controllers. The interface is somewhat slow but since it is typically handled by a driver in the background it does not matter.
- SPI - for faster communication with the touch panel controller some controllers also offer this interface.
- USB, typically the HID profile - this interface is common for larger, external displays.
- UART - some USB interface controllers also offer a UART interface as alternative.

If the touch panel is resistive a calibration procedure must typically also be implemented in the system. This procedure has nothing to do with the hardware, except that the calibrated parameters should be stored in non-volatile memory so users of the final system do not have to recalibrate the system every time it is powered.

Capacitive touch panel controllers typically have automatic built-in calibration procedures. Check each specific touch panel (and associated controller) for details.

3.3 COM Carrier Board V2

The *iMX Developer's Kits* build upon the *COM Carrier board*. As outlined in chapter 2 , *iMX Developer's Kits* are typically used in the proof-of-concept and prototype stage of a project. Hence, the task of "adding a display" will typically be the same as interfacing it to the *COM Carrier Board*. The picture below illustrates the location of the display interface connectors on the *COM Carrier board V2* (see section 3.4 if you have the older COM Carrier board **V1**).

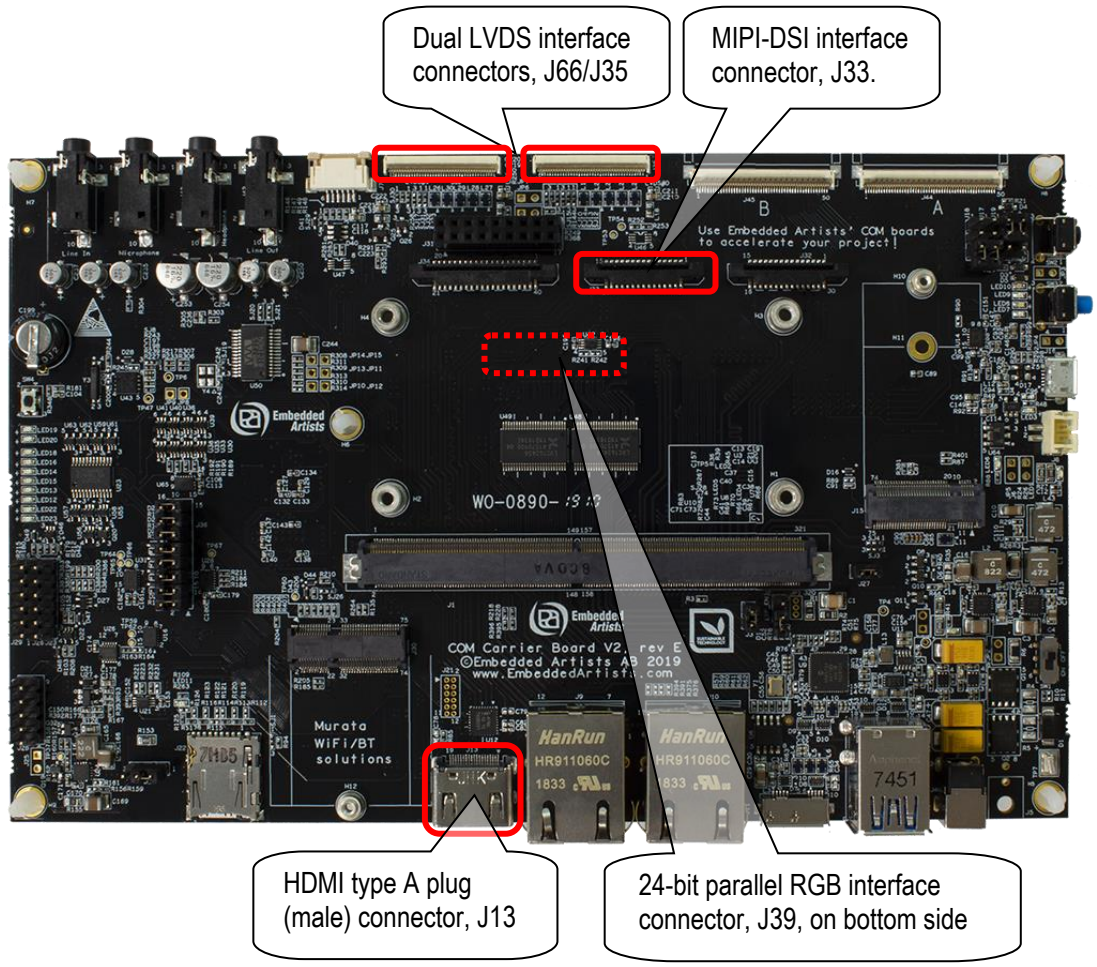


Figure 3 - Display Interfaces on COM Carrier Board V2

Below are the details of each interface. For even more details, see the *COM Carrier Board V2 Datasheet* and *COM Carrier Board V2 Schematic*.

- **Parallel RGB interface connector**, J39
  The 50-pos 0.5mm pitch FPC connector is located on the bottom side. The connector carries several different signal groups:
  - 24-databits, horizontal and vertical synchronization signals, pixel clock and data enable signal.
  - Display power supply
  - Backlight power supply and control (PWM for contrast control).
  - I2C communication channels for a touch panel controller. This also always-on power supply, includes an interrupt from, and a reset signal to, the touch panel controller.

  The connector is not designed to directly connect to a display. A small adapter board much be designed to interface the display to be used. See section 3.5 for more information about the

Display Adapter Board - a reference adapter design that is compatible with a large number of displays.

- **Dual LVDS interface connectors**, J66/J35
  The 40-pos 0.5 mm pitch connectors are located on the top-side. The connector carries several different signal groups:
  - 4+1 data+clock signal lanes
    Both 18-bit color depth (three data lanes plus clock) and 24-bit color depth are supported by default.
  - Display Power
  - Backlight power and control (PWM for contrast control).
  - An I2C communication channel for reading out possible display information (for example in EDID format). It is this I2C channel that can be traded for a fourth data lane (in 24-bit color mode).
  - Touch panel interfaces are available on connectors J70 and J37.

  The LVDS interface connector is designed to be compatible with the New Haven display NHD-10.1-1024600AF-LSXV-CTP, a 10.1 inch 1024x600 px LVDS display. For other displays, an adapter cable is likely needed.
- **HDMI interface connector**, J13
  The 10 pos connector is called 'type A female' in the HDMI standard.
  The HDMI connector standard defines one clock and three data lanes for display content. It also contains an I2C channel for reading display information and hot plug detect. Optionally the one-wire, CEC bus, can be used for communication between connected HDMI devices.
- **MIPI-DSI interface connector**, J33
  The 15-pos 1mm pitch FPC connector carries 3.3V voltage and one clock and two data lanes.

Interfaces for typical touch panel controllers are available via the following connectors;

- I2C via Parallel RGB interface connector, J39. This connector also contains two signals for interrupt and reset.
- I2C via J70 – touch panel connector for LVFS channel 1 or via J37 – touch panel connector for LVDS channel 0.
- I2C, SPI and UART via Expansion connector, J46. This is a general expansion connector with SPI, I2C and UART interfaces.

USB via USB Host interface connector, J12. This interface is typically used for external monitors where the touch panel controller has USB interface (USB HID profile).

3.4 COM Carrier Board

The *iMX Developer's Kits* build upon the *COM Carrier board*. As outlined in chapter 2 , *iMX Developer's Kits* are typically used in the proof-of-concept and prototype stage of a project. Hence, the task of "adding a display" will typically be the same as interfacing it to the *COM Carrier Board*. The picture below illustrates the location of the display interface connectors for the COM Carrier board V1 (see section 3.3 if you have the COM Carrier board **V2**).

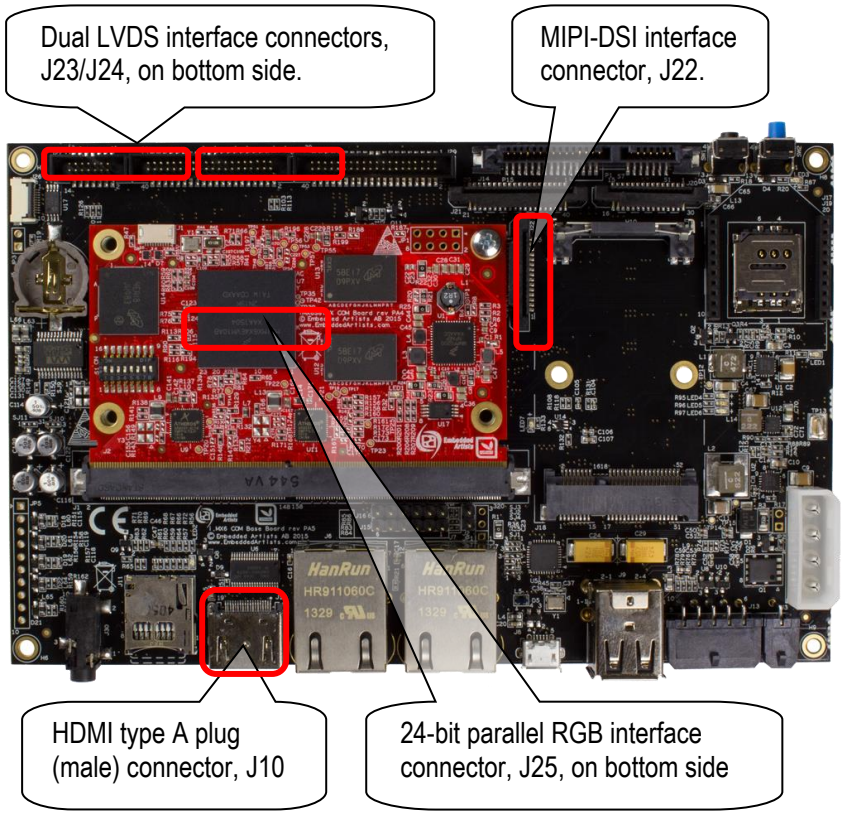


Figure 4 – Display Interfaces on COM Carrier Board

Below are the details of each interface. For even more details, see the *COM Carrier Board Datasheet* and *COM Carrier Board Schematic*.

- **Parallel RGB interface connector**, J25
  The 50-pos 0.5mm pitch FPC connector is located on the bottom side. The connector carries several different signal groups:
  - 24-databits, horizontal and vertical synchronization signals, pixel clock and data enable signal.
  - Display power supply
  - Backlight power supply and control (PWM for contrast control).
  - I2C communication channels for a touch panel controller. This also always-on power supply, includes an interrupt from, and a reset signal to, the touch panel controller.

  The connector is not designed to directly connect to a display. A small adapter board much be designed to interface the display to be used. See section 3.5 for more information about the *Display Adapter Board* - a reference adapter design that is compatible with a large number of displays.

- **Dual LVDS interface connectors**, J23/J24
  The 30 pos 1 mm pitch connectors are located on the bottom side. The connector carries several different signal groups:
  - 3+1 or 4+1 data+clock signal lanes
    18-bit color depth (three data lanes plus clock) is supported by default. For 24-bit color depth (requiring a fourth data lane) a smaller hardware modification must be done on the board. See *COM Carrier Board Datasheet* for details.
  - Display Power Enable control signal
  - Backlight power and control (PWM for contrast control).
  - I2C communication channels for a touch panel controller. This also includes an interrupt signal from the touch panel controller.
  - A second I2C communication channel for reading out possible display information (for example in EDID format). It is this I2C channel that can be traded for a fourth data lane (in 24-bit color mode).

  The LVDS interface connector is designed to be compatible with NXP's/Freescale's 10.1 inch display (1024x768 pixel) that has capacitive touch. For other displays, an adapter cable is likely needed.
- **HDMI interface connector**, J10
  The 10 pos connector is called 'type A female' in the HDMI standard.
  The HDMI connector standard defines one clock and three data lanes for display content. It also contains an I2C channel for reading display information and hot plug detect. Optionally the one-wire, CEC bus, can be used for communication between connected HDMI devices.
- **MIPI-DSI interface connector**, J22
  The 15-pos 1mm pitch FPC connector carries 3.3V voltage and one clock and two data lanes.

Interfaces for typical touch panel controllers are available via the following connectors;

- I2C via Parallel RGB interface connector, J25. This connector also contains two signals for interrupt and reset.
- I2C via LVDS interface connectors, J23/J24. These connectors also contain two signals for interrupt and reset.
- I2C, SPI and UART via Expansion connector, J28. This is a general expansion connector with SPI, I2C and UART interfaces.
- USB via USB Host interface connector, J9. This interface is typically used for external monitors where the touch panel controller has USB interface (USB HID profile).

Note that *COM Carrier Board* rev A has the parallel RGB interface connector split into two connectors; J25 has 40 positions on the rev A board (instead of the 50 positions described in this document). J26 is a 10 pos FPC connector.
On *COM Carrier Board* rev B, J26 has been merged into J25 (J26 no longer exist on this board).

3.5 COM Display Adapter - for Parallel RGB Interface

The *COM Display Adapter* board is a reference design for the small adapter board that is needed when connecting an RGB display. The board connects to the 50-pos FPC Parallel RGB interface connector on the *COM Carrier Board* in one end and the actual display/LCD in the other end.

The *COM Display Adapter* board contains an adjustable current backlight driver. Currents between 20mA and 160mA can be set via jumpers or under software control. The board contains a resistive touch panel controller, AR1021 from Microchip. It also contains connectors to different capacitive controllers to supported displays via I2C. For more information, see the *COM Display Adapter* board datasheet.

A typical connection setup with the *COM Display Adapter* board is illustrated in the picture below.

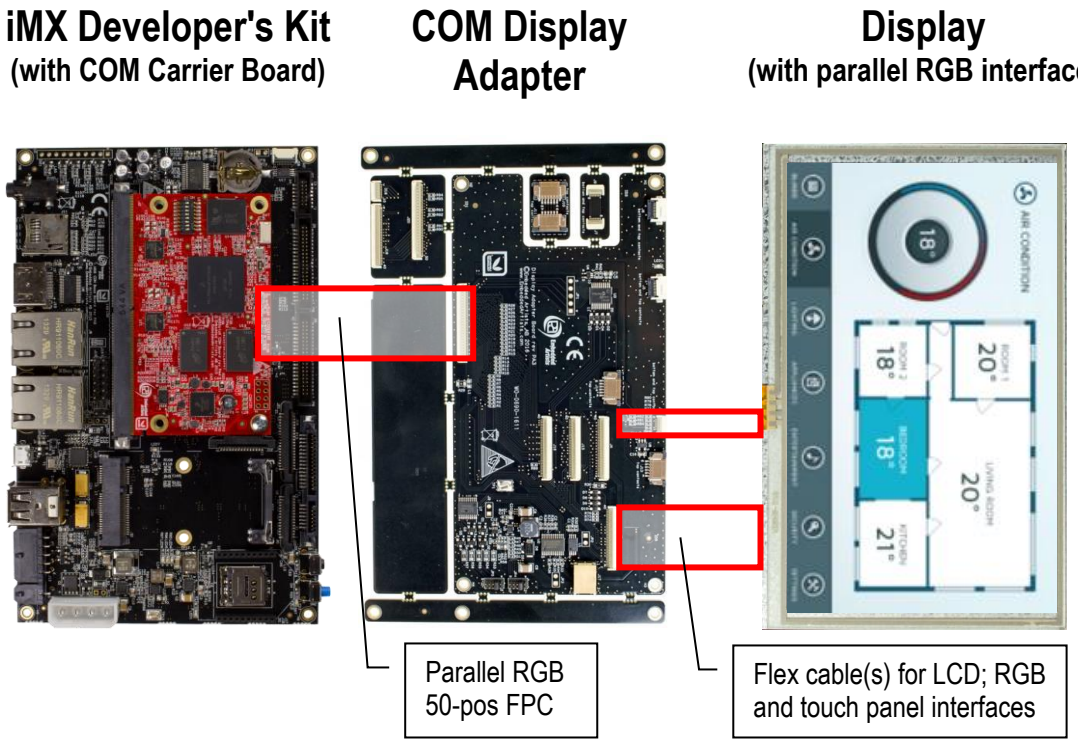


Figure 5 – Display Adapter Board Connection

There are four different main display interfaces on the *COM Display Adapter* board, supporting a large number of displays:

STD There is a 40 pos interface that is commonly supported by many LCD manufacturers. It supports both 18 and 24 color depth.

UNI The ***Unified TFT interface*** from EDT (Emerging Display Technologies) is a connector standard that is supported by many displays from 3.5 to 7 inch in size. 18-bit color depth is supported.

A Supports 18-bit color depth and is common for some 7.0" LCDs.

B Supports 18-bit color depth and is common for many displays from U.R.T.

The table below lists ***some*** displays that are compatible with the four connectors. There are many more compatible displays.

Connector on Display Adapter	Display Size (inch)	Display Resolution	Touch Panel	Manufacturer	Part Number
STD	4.3	480 x 272	Resistive	Rogin	RX043A-0207
STD	5.0	800 x 480	Resistive	Rogin	RX050A-05
STD	4.3	480 x 272	No	Newhaven	NHD-4.3-480272EF-ATXL#
STD	4.3	480 x 272	Resistive	Newhaven	NHD-4.3-480272EF-ATXL#-T
STD	4.3	480 x 272	Capacitive	Newhaven	NHD-4.3-480272EF-ATXL#-CTP
STD	4.3	480 x 272	Capacitive	Newhaven	NHD-4.3-480272EF-ASXV#-CTP
STD	4.3	480 x 272	No	Newhaven	NHD-4.3-480272EF-ASXN#
STD	4.3	480 x 272	Resistive	Newhaven	NHD-4.3-480272EF-ASXN#-T
STD	4.3	480 x 272	No	Newhaven	NHD-4.3-480272EF-ASXV#
STD	4.3	480 x 272	Resistive	Newhaven	NHD-4.3-480272EF-ASXV#-T
STD	5.0	800 x 480	No	Newhaven	NHD-5.0-800480TF-ATXL#
STD	5.0	800 x 480	Resistive	Newhaven	NHD-5.0-800480TF-ATXL#-T
STD	5.0	800 x 480	Capacitive	Newhaven	NHD-5.0-800480TF-ATXL#-CTP
STD	7.0	800 x 480	No	Newhaven	NHD-7.0-800480EF-ATXL#
STD	7.0	800 x 480	Resistive	Newhaven	NHD-7.0-800480EF-ATXL#-T
STD	7.0	800 x 480	Capacitive	Newhaven	NHD-7.0-800480EF-ATXL#-CTP
STD	7.0	800 x 480	No	Newhaven	NHD-7.0-800480EF-ATXV#
STD	7.0	800 x 480	Resistive	Newhaven	NHD-7.0-800480EF-ATXV#-T
STD	7.0	800 x 480	Capacitive	Newhaven	NHD-7.0-800480EF-ATXV#-CTP
STD	4.3	480 x 272	Resistive	HAOYU Electronics	HY43-LCD
STD	5.0	800 x 480	Resistive	HAOYU Electronics	HY5-LCD-HD
STD	7.0	800 x 480	Resistive	HAOYU Electronics	HY7-LCD
STD	7.0	800 x 480	Capacitive	HAOYU Electronics	HY070CTP-A
STD	4.3	480 x 272	Resistive	EastRising	ER-TFT043-3
STD	5.0	480 x 272	Resistive	EastRising	ER-TFT050-2
STD	7.0	800 x 480	Resistive	EastRising	ER-TFT070-4
UNI	3.5	320 x 240	No	EDT	ET035080DM6
UNI	3.5	320 x 240	Resistive	EDT	ET035080DH6
UNI	4.3	480 x 272	No	EDT	ET043080DM6

UNI	4.3	480 x 272	Resistive	EDT	ET043080DH6
UNI	5.0	800 x 480	No	EDT	ET050080DM6
UNI	5.0	800 x 480	Resistive	EDT	ET050080DH6
UNI	7.0	800 x 480	No	EDT	ET070080DM6
UNI	7.0	800 x 480	Resistive	EDT	ET070080DH6
A	7.0	800 x 480	Resistive	Innolux	AT070TN83
B	4.3	480 x 272	Capacitive	U.R.T	UMSH-8864MD-8T
B	5.0	800 x 480	Capacitive	U.R.T	UMSH-8837MD-4T
B	7.0	800 x 480	Capacitive	U.R.T	UMSH-8596MD-30T

If a specific display is not supported by the *COM Display Adapter* board, then it can be used as a reference to create an adapter board that fits the specific display perfectly. This document will not go into details about all design issues and considerations. See the *COM Display Adapter* board datasheet for information.

The COM Display Adapter board supports the *COM Carrier Board rev A* via a small adapter board that merges J25 and J26 from *COM Carrier rev A* boards into the 50 position connector that is used on *COM Carrier rev B* boards.

The COM Display Adapter board contains a resistive touch panel controller, AR1021 from Microchip. This controller is placed on the *COM Carrier Board rev A*. See details in the *COM Display Adapter* board datasheet for how to disable the controller on the *COM Carrier Board rev A*.

4 Step by Step Guide

This chapter is a step-by-step guide of how to add a display to an *iMX Developer's Kit*. There are two things involved with this:

- Electrically connect the display to the system. This is a hardware issue, involving:
  - pin mapping of RGB signals
  - pin mapping of touch panel signals and associated touch panel controller
  - backlight driver with constant current control and contrast adjustment
  - power management of voltages to display
- Program the system to interface the display. This is a software issue, involving:
  - configuring the bootloader
  - configuring the OS kernel (Android, Linux, etc)
- Program the system to interface the touch panel controller, if used. This is a software issue, involving:
  - in some cases, configuring the bootloader, although there are no touch events in the boot loader
  - configuring the OS kernel (Android, Linux, etc)

4.1 Hardware

First, the hardware side of the task is addressed:

- **Step 1:** Does the display to be added have a parallel RGB interface?
  If no, continue to step 2.
  If yes, use the *COM Display Adapter* design as a starting point for developing your own adapter board. See *COM Display Adapter* board datasheet and design files for details.
- **Step 2:** Does the display to be added have an LVDS interface?
  If no, continue to step 3.
  If yes, create a small adapter board between the LVDS connector on the *COM Carrier Board* and the display.
- **Step 3:** Does the display to be added have HDMI/DVI-I/DisplayPort interface?
  If no, continue to step 4.
  If yes, the interface is already there. Note that the *COM Carrier board* has a type A plug (male) connector. If another connector is needed, for example type C (mini) or type D (micro), an adapter cable is needed.
- **Step 4:** Does the display to be added have MIPI-DSI interface?
  If no, there are no more interface types available!
  If yes, start by asking again if this is the route to go. Unless the production volumes are very high (10K+/year) we strongly recommend you to reconsider.

4.2 Software – u-boot and Linux Configuration

Secondly, the software side of the task is addressed and it involves configuring the u-boot bootloader and OS kernel correctly. This document only presents the configuration process for the Linux OS kernel.

There are two methods to handle the software configuration; at run-time or at compile-time. The methods are called *Run-time Configuration* and *Compile-time Configuration*, respectively.

Action	Run-time Configuration	Compile-time Configuration
Add a new display	Execute u-boot command	Modify u-boot source. Modify Linux driver and/or device tree. Compile and flash.
Select which displays to have enabled/disabled	Execute u-boot command	Modify u-boot source Modify Linux driver and/or device tree. Compile and flash.
Select which touch controller to have enabled/disabled	Execute u-boot command	Modify Linux device tree. Compile and flash.
Add new touch controller	Modify Linux device tree. Compile and flash.	Modify Linux driver and/or device tree. Compile and flash.
When are changes made?	Typically, first time the system is booted. Must be done on each board.	Before compiling. The finished image files will be the same for all boards.
Select which display is used as a desktop / main display	Partially possible with u-boot command. Alternative is to manipulate root file system to change which frame buffer that is used by the GUI.	Possible by reordering of device tree.

The two methods are useful in different situations during a typical development project. Initially, during the development phase, it is common to test out different displays. Then *Run-time Configuration* is a quick and flexible way to accomplish this. Later on, during the deployment phase, when the final display has been selected it is common to make a final *Compile-time Configuration* of the system. This will likely simplify the production process (avoiding having to manually configure every system that is produced).

A typical embedded system where the display is built-in is a static system in the sense that the display will not change during the lifetime of the product. Embedded systems that rely on external displays/monitors are different. For these, different displays can be connected and it can happen during run-time, for example when an HDMI monitor is connected. The HDMI driver can handle this by reading the EDID information of the connected display and adjust the settings according to display capabilities.

There are a few pros and cons with the two methods (*Run-time and Compile-time Configuration*) that are worth considering in different phases:

	Run-time Configuration	Compile-time Configuration
Pros/ Advantages	• Quick and simple to test a new display during prototyping • Configuration only in u-boot	• Full control • Possible to completely remove unused interfaces • Display detected automatically (or actually by detecting touch controller) • Does not have to manually configure every produced unit (in volume production)
Cons/ Disadvantages	• Does not help in all cases. Some changes (typically frame buffer order) may require compilation of the Linux kernel anyway • Will increase the size of the u-boot (flash and RAM) • Requires the use of bootscript • No detection of availability of display	• Configuration must be changed both in u-boot and Linux • Changes requires compilation and flashing of u-boot and Linux kernel and/or device tree files • Display detection only detects interface and not actual display on that interface

4.3 Example of Run-time and Compile-time Configuration

In this example, the goal is to only have the HDMI display interface enabled on the *iMX6 Quad COM board*.

4.3.1 Run-time Configuration

Run the following commands in the u-boot (Note that the disable commands only need to be run if those interfaces have previously been enabled):

```
=> eadisp conf hdmi 3
=> eadisp enable hdmi
=> eadisp disable rgb
=> eadisp disable lvds0
=> eadisp disable lvds1
=> eatouch disable rgb
=> eatouch disable lvds0
=> eatouch disable lvds1
=> saveenv
=> reset
```

The u-boot and Linux kernel will now use only the HDMI display (the number 3 is for the display configuration list which can be seen in section 5.5 below).

4.3.2 Compile-time Configuration

Start by modifying the u-boot:

- Look at section 6.1.4 below on the u-boot configuration. Remove all but the HDMI structure from the `displays` list.
- Update the `xres`, `yres` and `pixclock` members to match the wanted resolution.

Then modify the Linux kernel:

- Look at section 6.2.3.3 below for HDMI configuration. Change the default resolution to the wanted default resolution.
- Locate and disable the LVDS and parallel RGB interfaces by changing the `status` members to `disabled`.
- Locate and disable the touch controller configurations, for example AR1021 and eGalax.

5 Run-time Configuration: Display

A new (non-standard) command has been added to the u-boot, `eadisp`, to support this method.

5.1 Background

The original way to add a new display (LVDS and/or parallel RGB) involves modification of the u-boot and modification of either the Linux device tree or a Linux driver depending on interface type.

The `eadisp` command aims to:

- Provide a set of preconfigured displays. This list exists only in the u-boot
- Make it possible to add new displays to that list in runtime
- Make it possible to enable/disable/configure display interfaces in runtime
- Take the configuration made in the u-boot and modify the Linux device tree before booting into Linux.

5.2 How does it work?

The simplified configuration has two parts – the `eadisp` command and a bootscript. The `eadisp` command modifies a set of environment variables. The bootscript is executed before booting into Linux and it loads the device tree, modifies it according to the environment variables and then passes the modified device tree to the Linux kernel.

> The `eadisp` command modifies the u-boot's environment but it does not save the changes. To make the changes persistent use the u-boot's saveenv command.

To save the changes made by `eadisp` and to reset the board so that the changes take effect:

```
=> saveenv
=> reset
```

5.3 Examples on iMX6 SoloX COM Board

To get help:

```
=> eadisp help
eadisp - Configure Display Support

Usage:
eadisp  - Show current configuration for all displays
eadisp prefer (rgb|lvds0) - Set preferred display
eadisp enable (rgb|lvds0) - Enable selected display
eadisp disable (rgb|lvds0) - Disable selected display
eadisp conf (rgb|lvds0) num - Select configuration for display
eadisp add (rgb|lvds0)
["mode_str[:[m][j][s][18|24]:pixclkfreq,xres,yres,hback-porch,
hfront-porch,vback-porch,vfront-porch,hsync,vsync,hsact,vsact,
deact,clkact]"]
eadisp rm num - Remove added configuration
```

To show current configuration:

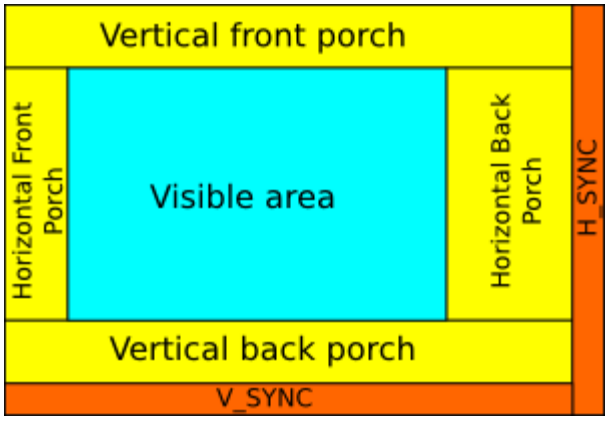
```
=> eadisp

Available display configurations:
    0) lvds0  hannstar:18:64998375,1024,768,220,40,21,7,60,10,...
    1) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10

Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    Innolux-AT070TN:24:33336667,800,480,...
  lvds0:    yes     yes   hannstar:18:64998375,1024,768,...
```

The command above shows that both parallel RGB and LVDS have been enabled and the configuration that will be used for each of them. The LVDS display is preferred meaning that it will be used to show the u-boot logo.

The strings above (e.g. "hannstar:18:64998375,1024,768,220,40,21,7,60,10,0,0,0,0") describe the display characteristics.



Name	hannstar
Pixel format	18 = RGB666
Pixel clock	64998375Hz
Resolution	1024x768
Horizontal back porch	220
Horizontal front porch	40
Vertical back porch	21
Vertical front porch	7
Horizontal Sync	60
Vertical Sync	10
H-Sync active high/low	0 (= active low)
V-Sync active high/low	0 (= active low)
Display enable active	1 (= active high)
Pixel clock data driven	0 (= falling edge)

To add a new parallel RGB display "rogin" with a 65MHz pixel clock, 1280x720 resolution and using RGB888 format, timing parameters horizontal 10/20, vertical 30/40, sync 50/60 and pixel data driven on rising edge:

```
=> eadisp add rgb \
rogin:24:65000000,1280,720,10,20,30,40,50,60,0,0,1,0

=> eadisp conf rgb 2
selecting rgb=rogin

=> eadisp
Available display configurations:
    0) lvds0  hannstar:18:64998375,1024,768,220,40,21,7,60,10,...
    1) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10
    2) rgb  rogin:24:65000000,1280,720,10,20,30,40,50,60,0,0,1,0

Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    rogin:24:65000000,1280,720,10,20,30,...
  lvds0:    yes     yes   hannstar:18:64998375,1024,768,220,40,...
```

Note that it is recommended to always use 24=RGB888 when configuring the parallel RGB interface. The reason for this is compatibility between different EACOM boards and simplicity to switch between 18- and 24-bit color depth displays.

For LVDS interfaces, either 18 or 24-bit color depth can be selected without compromising compatibility or portability.

Example: enable the LVDS #0 interface:

```
=> eadisp enable lvds0
```

Example: disable the parallel RGB interface:

```
=> eadisp disable rgb
```

To configure a display, use the index in the table of available displays (as shown with the `eadisp` command):

```
=> eadisp

Available display configurations:
    0) lvds0  hannstar:18:64998375,1024,768,220,40,21,7,60,10,...
    1) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10
    2) rgb  rogin:24:65000000,1280,720,10,20,30,40,50,60,...

Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    rogin:24:65000000,1280,720,10,20,30,...
  lvds0:    yes     yes   hannstar:18:64998375,1024,768,220,40,...

=> eadisp conf rgb 0
invalid index (0) for rgb (wrong type)

=> eadisp conf rgb 2
selecting rgb=rogin

=> eadisp conf rgb 1
selecting rgb=Innolux-AT070TN

=> eadisp

...
Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    Innolux-AT070TN:24:33336667,800,480,...
  lvds0:    yes     yes   hannstar:18:64998375,1024,768,220,40,...
```

5.4 Examples on iMX6 UltraLite COM Board

The `eadisp` command works in the same way as described above for *iMX6 SoloX COM Board*, but since the *iMX6 UltraLite COM Board* doesn't support LVDS only the parallel RGB interface is available.

```
=> eadisp

Available display configurations:
    0) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10

Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    Innolux-AT070TN:24:33336667,800,480,...
```

5.5 Examples on iMX6 Quad COM Board

The `eadisp` command works in the same way as described for *iMX6 SoloX COM Board*, but since the *iMX6 Quad COM Board* supports dual LVDS and HDMI it will have two new types: lvds2 and hdmi.

```
=> eadisp

Available display configurations:
    0) lvds0  hannstar:18:64998375,1024,768,220,40,21,7,60,10,...
    1) lvds1  hannstar:18:64998375,1024,768,220,40,21,7,60,10,...
    2) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10
    3) hdmi  1280x720M@60:m24:74161969,1280,720,220,110,20,5,40,5
    4) hdmi  920x1080M@60:m24:148500148,1920,1080,148,88,36,4,44,5
    5) hdmi  640x480M@60:m24:25200342,640,480,48,16,33,10,96,2,...
    6) hdmi  720x480M@60:m24:27027027,720,480,60,16,30,9,62,6,...

Current Selection:
          enabled prefer  configuration
  rgb:      no      no    Innolux-AT070TN:24:33336667,800,480,...
  lvds0:    no      no    hannstar:18:64998375,1024,768,220,40,...
  lvds1:    no      no    hannstar:18:64998375,1024,768,220,40,...
  hdmi:     no      no    1280x720M@60:m24:74161969,1280,720,...
```

5.6 Examples on iMX7 Dual uCOM/COM Board

The `eadisp` command works in the same way as described for *iMX6 SoloX COM Board*, but the *iMX7 Quad uCOM/COM Board* only supports the RGB interface.

```
=> eadisp

Available display configurations:
    0) rgb  Innolux-AT070TN:24:33336667,800,480,89,164,75,75,10,10

Current Selection:
          enabled prefer  configuration
  rgb:      yes     no    Innolux-AT070TN:24:33336667,800,480,...
```

5.7 iMX7ULP uCOM, iMX8M Mini uCOM and iMX8M COM

These boards don't have the `eadisp` command enabled. Instead, look at Chapter 6 about Compile-time configuration.

5.8 Limitations

At the time this document is written there are a couple of known limitations:

- On the *iMX6 SoloX COM Board*, if the parallel RGB display is enabled it will always be the preferred display in Linux regardless of the `eadisp` configuration. This means that the `eadisp` prefer command only selects which display shows the u-boot logo.

5.9 How do I add my own display to the predefined display list?

The purpose of the `eadisp` command is to make it easy to configure displays without having to compile the u-boot but in case the built-in list of displays has to be modified the display configurations are stored in the board file in the u-boot (replace <board> with the name of the COM board you are using):

- `board/embeddedartists/<board >/<board>.c`

The list looks like this:

```
static const struct display_info_t displays[] = {
    EADISP_HANNSTAR10(LVDS0, 0, 0),
    EADISP_INNOLUX_AT070TN(RGB, 0, 0),
};
```

The `EADISP_` macros are defined in `arch/arm/include/asm/mach-imx/eadisp.h`. Copy one of the existing macros into the board file and modify it to match the wanted display. Add a line with the new macro to the `displays` list.

The first display configuration of each type will be used as default configuration so add the new display to the top of the list.

The detect-part of the macro is not used.

5.10 Bootscript

The u-boot supports scripts so that instead of having to manually run a set of commands over and over again those commands can be written in a text file. The text file is compiled into a binary file that the u-boot can execute.

This functionality is used by the run-time configuration method to run the commands that modifies the device tree before booting into Linux.

The script is stored in the `board/embeddedartists/common/bootscript.txt`. This is an excerpt of the script:

```
setenv args_from_script ''

if run loadfdt ; then
        fdt addr ${fdt_addr}
        setenv fdt_high 0xffffffff
else
        echo "!!!! Error loading ${fdt_file}";
        exit;
fi

if run loadimage; then
        run mmcargs;
```

```
        bootz ${loadaddr} - ${fdt_addr}
fi

echo "Error loading kernel image"
```

To convert the script into the image file accepted by the u-boot: (commands below are executed on a PC in the u-boot's source folder. Please note that actual paths will depend on the toolchain you are using):

```
$ source /opt/fsl-imx-fb/3.14.52-1.1.0/environment-setup-
cortexa9hf-vfp-neon-poky-linux-gnueabi
$ mkimage -T script -C none -n 'EA BootScript' -d
board/embeddedartists/common/bootscript.txt boot.scr
```

The resulting boot.scr file must be transferred to the target board which is easy to do with the manufacturing tool which is described in the *Working with Yocto* document. Just replace the boot.scr file that comes with the manufacturing tool with the one you converted and then use the manufacturing tool to transfer it to your hardware.

6 Compile-time Configuration: Display

The run-time configuration option is a good way to get started but as the project gets into the final stages and a final display setup has been selected it is recommended to have a specific configuration for the selected display. There is no need for run-time configuration in a closed end-product.

The compile-time configuration steps:

1. U-boot: Disable the `eadisp` command that was used for Run-time Configuration
2. U-boot: Add the wanted display configuration(s)
3. U-boot: Optionally remove unwanted display configuration(s)
4. Linux: Modify timing parameters for the wanted display in the device tree file
5. Linux: Optionally disable unwanted interfaces in the device tree file

The setup varies between CPUs and has been divided into separate sections below.

The sections below only point to the origin of the display settings (driver code and/or device tree files) to give a starting point when adapting to a new display.

> The u-boot and Linux kernel each have a set of display parameters. When adding a new display those parameters must be altered in both places.

6.1 U-boot

Below, `<uboot>` will be used as an abbreviation of the path to the root folder in which the u-boot has been unpacked. In Yocto that path will contain version numbers and other build-specific data. An example of the path:

`<uboot>`

`/home/user/ea-bsp/build_ultra_fb_core/tmp/work/imx6ulea_com-poky-linux-gnueabi/u-boot-imx/2015.04-r0/git`

The u-boot has an environment variable `panel`, which can be used on CPUs that support more than one display interface to specify which interface to use. The value of the variable should be one of the names from the displays list.

6.1.1 Disable Run-time Configuration Mode

The `eadisp` command can be removed by disabling CONFIG_CMD_EADISP (note that the `eatouch` command uses the same configuration). Depending on which u-boot version you are using the configuration is either set in the `defconfig` file or in the header file for the board you are using. Below you can see an example of where these files are located (for iMX6 SoloX COM board)

- `<uboot>/include/configs/mx6sxea-com.h`
- `<uboot>/configs/mx6sxea-com_defconfig`

Disabling the `eadisp` command switches the configuration into compile-time mode.

6.1.2 iMX6 UltraLite COM Board

The *iMX6 UltraLite COM Board* only supports the parallel RGB Interface. The u-boot comes configured with a 7 inch display from Innolux that can be found in

<uboot>/board/embeddedartists/mx6ulea-com/mx6ulea-com.c. Open the file and search for this structure:

```
static struct lcd_panel_info_t const displays[] = {{
    .lcdif_base_addr = LCDIF1_BASE_ADDR,
    .depth = 24,
    .enable     = do_enable_parallel_lcd,
    .mode = {
          .name           = "Innolux-AT070TN",
          .xres           = 800,
          .yres           = 480,
          .pixclock       = 29850,
          .left_margin    = 89,
          .right_margin   = 164,
          .upper_margin   = 75,
          .lower_margin   = 75,
          .hsync_len      = 10,
          .vsync_len      = 10,
          .sync           = 0,
          .vmode          = FB_VMODE_NONINTERLACED
}}};
```

6.1.3 iMX6 SoloX COM Board

The *iMX6 SoloX COM Board* supports parallel RGB, and one LVDS interface. The u-boot configuration can be found in <uboot>/board/embeddedartists/mx6sxea-com/mx6sxea-com.c. Open the file and search for this structure:

```
static struct lcd_panel_info_t const displays[] = {{
    .lcdif_base_addr = LCDIF2_BASE_ADDR,
    .depth = 18,
    .enable     = do_enable_lvds,
    .mode = {
          .name           = "Hannstar-XGA",
          .xres           = 1024,
          .yres           = 768,
          .pixclock       = 15385,
          .left_margin    = 220,
          .right_margin   = 40,
          .upper_margin   = 21,
          .lower_margin   = 7,
          .hsync_len      = 60,
          .vsync_len      = 10,
          .sync           = 0,
          .vmode          = FB_VMODE_NONINTERLACED
} }, {
    .lcdif_base_addr = LCDIF1_BASE_ADDR,
    .depth = 24,
    .enable     = do_enable_parallel_lcd,
    .mode = {
          .name           = "Innolux-AT070TN",
          .xres           = 800,
          .yres           = 480,
          .pixclock       = 29850,
          .left_margin    = 89,
          .right_margin   = 164,
          .upper_margin   = 75,
          .lower_margin   = 75,
```

```
            .hsync_len      = 10,
            .vsync_len      = 10,
            .sync           = 0,
            .vmode          = FB_VMODE_NONINTERLACED
} } };
```

If the `panel` environment variable is set to one of the names in the displays list then that is the default display. If the variable is not set or the value is not one of the names in the list, then the first display in the list will be used as default.

6.1.4 iMX6 Quad COM Board

The *iMX6 Quad COM Board* supports parallel RGB, LVDS and HDMI. The u-boot configuration can be found in `<uboot>/board/embeddedartists/mx6qea-com/mx6qea-com.c`. Open the file and search for this structure:

```
static struct display_info_t const displays[] = {{
    .bus  = -1,
    .addr = 0,
    .pixfmt     = IPU_PIX_FMT_RGB666,
    .detect     = NULL,
    .enable     = do_enable_lvds1,
    .mode = {
            .name           = "Hannstar-XGA-LVDS1",
            .refresh        = 60,
            .xres           = 1024,
            .yres           = 768,
            .pixclock       = 15385,
            .left_margin    = 220,
            .right_margin   = 40,
            .upper_margin   = 21,
            .lower_margin   = 7,
            .hsync_len      = 60,
            .vsync_len      = 10,
            .sync           = FB_SYNC_EXT,
            .vmode          = FB_VMODE_NONINTERLACED
} }, {
    .bus  = -1,
    .addr = 0,
    .pixfmt     = IPU_PIX_FMT_RGB666,
    .detect     = NULL,
    .enable     = do_enable_lvds0,
    .mode = {
            .name           = "Hannstar-XGA-LVDS0",
            .refresh        = 60,
            .xres           = 1024,
            .yres           = 768,
            .pixclock       = 15385,
            .left_margin    = 220,
            .right_margin   = 40,
            .upper_margin   = 21,
            .lower_margin   = 7,
            .hsync_len      = 60,
            .vsync_len      = 10,
            .sync           = FB_SYNC_EXT,
            .vmode          = FB_VMODE_NONINTERLACED
} }, {
```

```
    .bus  = -1,
    .addr = 0,
    .pixfmt     = IPU_PIX_FMT_RGB24,
    .detect     = NULL,
    .enable     = do_enable_hdmi,
    .mode = {
          .name           = "HDMI",
          .refresh        = 60,
          .xres           = 640,
          .yres           = 480,
          .pixclock       = 39721,
          .left_margin    = 48,
          .right_margin   = 16,
          .upper_margin   = 33,
          .lower_margin   = 10,
          .hsync_len      = 96,
          .vsync_len      = 2,
          .sync           = 0,
          .vmode          = FB_VMODE_NONINTERLACED
} }, {
    .bus  = -1,
    .addr = 0,
    .pixfmt     = IPU_PIX_FMT_RGB24,
    .detect     = NULL,
    .enable     = do_enable_parallel_rgb,
    .mode = {
          .name           = "Innolux-AT070TN",
          .refresh        = 60,
          .xres           = 800,
          .yres           = 480,
          .pixclock       = 29850,
          .left_margin    = 89,
          .right_margin   = 164,
          .upper_margin   = 75,
          .lower_margin   = 75,
          .hsync_len      = 10,
          .vsync_len      = 10,
          .sync           = 0,
          .vmode          = FB_VMODE_NONINTERLACED
} } };
```

If the `panel` environment variable is set to one of the names in the displays list then that is the default display. If the variable is not set or the value is not one of the names in the list, then the first display in the list will be used as default.

6.1.5 iMX7 Dual uCOM/COM Board

The *iMX7 Dual uCOM / COM Board* only supports the parallel RGB Interface. The u-boot comes configured with a 7 inch display from Innolux that can be found in `<uboot>/board/embeddedartists/mx7dea-com/mx7dea-com.c`. Open the file and search for this structure:

```
static struct lcd_panel_info_t const displays[] = {{
    .lcdif_base_addr = LCDIF1_BASE_ADDR,
    .depth = 24,
    .enable     = do_enable_parallel_lcd,
    .mode = {
          .name           = "Innolux-AT070TN",
          .xres           = 800,
```

```
            .yres           = 480,
            .pixclock       = 29850,
            .left_margin    = 89,
            .right_margin   = 164,
            .upper_margin   = 75,
            .lower_margin   = 75,
            .hsync_len      = 10,
            .vsync_len      = 10,
            .sync           = 0,
            .vmode          = FB_VMODE_NONINTERLACED
}}};
```

6.1.6 iMX7ULP uCOM Board

The *iMX7ULP uCOM Board* only supports MIPI-DSI Interface. The u-boot comes configured with a MIPI-DSI display and this can be found in `<uboot>/board/embeddedartists/mx7ulpea-ucom/mx7ulpea-ucom.c`.

```
struct display_info_t const displays[] = {{
    .bus = LCDIF_RBASE,
    .addr = 0,
    .pixfmt = 24,
    .detect = NULL,
    .enable     = do_enable_mipi_dsi,
    .mode = {
            .name             = "HX8363_WVGA",
            .xres           = 480,
            .yres           = 854,
            .pixclock       = 41042,
            .left_margin    = 40,
            .right_margin   = 60,
            .upper_margin   = 3,
            .lower_margin   = 3,
            .hsync_len      = 8,
            .vsync_len      = 4,
            .sync           = 0,
            .vmode          = FB_VMODE_NONINTERLACED
} } };
```

6.1.7 iMX8M Mini uCOM Board

The *iMX8M Mini uCOM Board* only supports MIPI-DSI interface, but if you are using the uCOM Adapter board there is a MIPI-DSI to HDMI bridge available so it is possible to use an HDMI display. The code can be found in `<uboot>/board/embeddedartists/mx8mmea-ucom/mx8mmea-ucom.c`.

6.1.8 iMX8M COM Board

The *iMX8M COM Board* only supports HDMI and MIPI-DSI interfaces. By default only HDMI interface is setup and used in the u-boot. The code can be found in `<uboot>/board/embeddedartists/mx8mqea-com/mx8mqea-com.c`

6.2 Linux Kernel

Below, `<kernel>` will be used as an abbreviation of the path to the root folder in which the Linux kernel has been unpacked. In Yocto that path will contain version numbers and other build-specific data. An example of the path:

`<kernel>`

```
/home/user/ea-bsp/build_ultra_fb_core/tmp/work/imx6ulea_com-
poky-linux-gnueabi/linux-imx/3.14.38-r0/git
```

6.2.1 iMX6 UltraLite COM Board

The *iMX6 UltraLite COM Board* only supports the parallel RGB Interface. The Linux kernel comes configured with a 7 inch display from Innolux that can be found in the device tree file (example: `<kernel>/arch/arm/boot/dts/imx6ulea-com-kit.dts)`. Open the file search for the `lcdif` structure:

```
&lcdif {
    pinctrl-names = "default";
    pinctrl-0 = <&pinctrl_lcdif_dat
                 &pinctrl_lcdif_ctrl>;
    display = <&display0>;
    status = "okay";

    display0: display {
          bits-per-pixel = <32>;
          bus-width = <24>;

          /* EA 7 inch display */
          display-timings {
                native-mode = <&timing0>;
                timing0: timing0 {
                      clock-frequency = <33500000>;
                      hactive = <800>;
                      vactive = <480>;
                      hback-porch = <89>;
                      hfront-porch = <164>;
                      vback-porch = <75>;
                      vfront-porch = <75>;
                      hsync-len = <10>;
                      vsync-len = <10>;
                      hsync-active = <0>;
                      vsync-active = <0>;
                      de-active = <1>;
                      pixelclk-active = <1>;
                };
          };
    };
};
```

6.2.2 iMX6 SoloX COM Board

The *iMX6 SoloX COM Board* supports parallel RGB and one LVDS (LVDS #0) interface.

6.2.2.1 Parallel RGB Interface

The Linux kernel comes configured with a 7 inch display. To see an example of how this could look like open the device tree file you are using the the Developer's Kit (example: `<kernel>/arch/arm/boot/dts/imx6sxea-com-kit.dts)`.

```
&lcdif1 {
    pinctrl-names = "default";
    pinctrl-0 = <&pinctrl_lcdif_dat
```

```
                &pinctrl_lcdif_ctrl>;
    lcd-supply = <&reg_lcd_3v3>;
    display = <&display0>;
    status = "okay";

    display0: display {
          bits-per-pixel = <32>;
          bus-width = <24>;

          /* EA 7 inch display */
          display-timings {
                native-mode = <&timing0>;
                timing0: timing0 {
                      clock-frequency = <33500000>;
                      hactive = <800>;
                      vactive = <480>;
                      hback-porch = <89>;
                      hfront-porch = <164>;
                      vback-porch = <75>;
                      vfront-porch = <75>;
                      hsync-len = <10>;
                      vsync-len = <10>;
                      hsync-active = <0>;
                      vsync-active = <0>;
                      de-active = <1>;
                      pixelclk-active = <1>;
                };
          };
    };
};
```

6.2.2.2 LVDS Interface

The LVDS interface is called "ldb" in the device tree. An example of how this looks like is shown below. `<kernel>/arch/arm/boot/dts/imx6sxea-com-kit.dts`.

```
&lcdif2 {
    display = <&display1>;
    disp-dev = "ldb";
    status = "okay";

    display1: display {
          bits-per-pixel = <16>;
          bus-width = <18>;
    };
};

&ldb {
    status = "okay";

    lvds-channel@0 {
          fsl,data-mapping = "spwg";
          fsl,data-width = <18>;
          crtc = "lcdif2";
          status = "okay";

          /* Hannstar 10 inch */
          display-timings {
                native-mode = <&timing1>;
```

```
                timing1: hsd100pxn1 {
                        clock-frequency = <65000000>;
                        hactive = <1024>;
                        vactive = <768>;
                        hback-porch = <220>;
                        hfront-porch = <40>;
                        vback-porch = <21>;
                        vfront-porch = <7>;
                        hsync-len = <60>;
                        vsync-len = <10>;
                };
        };
    };
};
```

6.2.3 iMX6 Quad COM Board

The *iMX6 Quad COM Board* supports parallel RGB, two LVDS interfaces and HDMI.

6.2.3.1 Parallel RGB Interface

In the Linux kernel the device tree comes with device tree nodes for the different display interfaces on the iMX6 Quad. As an example, open `<kernel>/arch/arm/boot/dts/imx6qea-com-kit.dts`. and search for mxcfb. Below you can see an example where mxcfb3 has been setup for the RGB interface (called lcd in the device tree)

```
    mxcfb3: fb@2 {
            compatible = "fsl,mxc_sdc_fb";
            disp_dev = "lcd";
            interface_pix_fmt = "RGB24";
            mode_str ="EA7-WVGA";
            default_bpp = <32>;
            int_clk = <0>;
            late_init = <0>;
            dispctrl-gpios = <&gpio6 31 GPIO_ACTIVE_HIGH>, <&gpio5 0
GPIO_ACTIVE_HIGH>;
            status = "disabled";
    };

...

    lcd: lcd@0 {
            compatible = "fsl,lcd";
            ipu_id = <0>;
            disp_id = <0>;
            default_ifmt = "RGB24";
            pinctrl-names = "default";
            pinctrl-0 = <&pinctrl_ipu1>;
            status = "okay";
    };

...

&lcd {
        status = "okay";
        display = <&display0>;
```

```
        display0: display {
                bits-per-pixel = <32>;
                bus-width = <24>;

                display-timings {
                        native-mode = <&t_lcd>;
                        t_lcd: t_lcd_default {
                                clock-frequency = <33500000>;
                                hactive = <800>;
                                vactive = <480>;
                                hback-porch = <89>;
                                hfront-porch = <164>;
                                vback-porch = <75>;
                                vfront-porch = <75>;
                                hsync-len = <10>;
                                vsync-len = <10>;
                                hsync-active = <0>;
                                vsync-active = <0>;
                                de-active = <1>;
                                pixelclk-active = <1>;
                        };
                };
        };
};
```

6.2.3.2 LVDS Interface

The LVDS interface is called "ldb" in the device tree. An example of how this looks like is shown below.

`<kernel>/arch/arm/boot/dts/imx6qea-com-kit.dts`.

```
    mxcfb1: fb@0 {
          compatible = "fsl,mxc_sdc_fb";
          disp_dev = "ldb";
          interface_pix_fmt = "RGB666";
          default_bpp = <16>;
          int_clk = <0>;
          late_init = <0>;
          status = "disabled";
    };
    mxcfb4: fb@3 {
          compatible = "fsl,mxc_sdc_fb";
          disp_dev = "ldb";
          interface_pix_fmt = "RGB666";
          default_bpp = <16>;
          int_clk = <0>;
          late_init = <0>;
          status = "disabled";
    };

&ldb {
    status = "okay";

    lvds-channel@0 {
          fsl,data-mapping = "spwg";
          fsl,data-width = <18>;
          status = "okay";

          display-timings {
                native-mode = <&timing0>;
```

```
                timing0: hsd100pxn1 {
                        clock-frequency = <65000000>;
                        hactive = <1024>;
                        vactive = <768>;
                        hback-porch = <220>;
                        hfront-porch = <40>;
                        vback-porch = <21>;
                        vfront-porch = <7>;
                        hsync-len = <60>;
                        vsync-len = <10>;
                };
        };
    };

    lvds-channel@1 {
        fsl,data-mapping = "spwg";
        fsl,data-width = <18>;
        primary;
        status = "okay";

        display-timings {
            native-mode = <&timing1>;
            timing1: hsd100pxn1 {
                        clock-frequency = <65000000>;
                        hactive = <1024>;
                        vactive = <768>;
                        hback-porch = <220>;
                        hfront-porch = <40>;
                        vback-porch = <21>;
                        vfront-porch = <7>;
                        hsync-len = <60>;
                        vsync-len = <10>;
            };
        };
    };
};

&ldb {
    lvds-channel@0 {
        crtc = "ipu2-di0";
    };
    lvds-channel@1 {
        crtc = "ipu2-di1";
    };
};
&mxcfb1 {
    status = "okay";
};
&mxcfb4 {
    status = "okay";
};
```

6.2.3.3 HDMI Interface

The HDMI interface is called "hdmi" in the device tree. An example of how this looks like is shown below.

`<kernel>/arch/arm/boot/dts/imx6qea-com-kit.dts`.

```
    mxcfb2: fb@1 {
            compatible = "fsl,mxc_sdc_fb";
            disp_dev = "hdmi";
            interface_pix_fmt = "RGB24";
            mode_str ="1920x1080M@60";
            default_bpp = <24>;
            int_clk = <0>;
            late_init = <0>;
            status = "disabled";
    };

&mxcfb1 {
    status = "okay";
};
```

Note that HDMI includes EDID information and audio. Only video is handled here.

6.2.4 iMX7 Dual uCOM / COM Board

The *iMX7 Dual uCOM / COM Board* only supports the parallel RGB Interface. The Linux kernel comes configured with a 7 inch display from Innolux that can be found in the device tree file, for example: `<kernel>/arch/arm/boot/dts/imx7dea-com-kit.dts`. Open the file and search for the `lcdif` structure.

6.2.5 iMX7ULP uCOM Board

The *iMX7ULP uCOM Board* only supports MIPI-DSI interface. The Linux kernel comes configured with timing parameters for a display which can be found in the device tree file, for example: `<kernel>/arch/arm/boot/dts/imx7ulpea-ucom-kit_v2.dts`. Open the file and search for the `lcdif` structure. If you are using the uCOM adapter board there is a MIPI-DSI to HDMI bridge (ADV7535) available so you can use an HDMI display instead of a MIPI-DSI display.

6.2.6 iMX8M Mini uCOM Board

The *iMX8M Mini uCOM Board* only supports MIPI-DSI interface, but if you are using the uCOM Adapter board there is a MIPI-DSI to HDMI bridge (ADV7535) available so you can use an HDMI display instead of a MIPI-DSI display. The device tree file has been setup to use the MIPI-DSI to HDMI bridge. Open the device tree file and search for adv7535 to see how the bridge has been setup.

`<kernel>/arch/arm64/boot/dts/freescale/fsl-imx8mm-ea-ucom-kit_v2.dts`.

6.2.7 iMX8M COM Board

The *iMX8M COM Board* supports MIPI-DSI and HDMI interface, but by default only the HDMI interface has been setup in the device tree file. Open the device tree file and search for hdmi to see how this interface is setup.

`<kernel>/arch/arm64/boot/dts/freescale/fsl-imx8mq-ea-com-kit_v2.dts`.

7 Run-time Configuration: Touch Controller

Touch events are only available in Linux, not in the u-boot.

This chapter describes *Run-time Configuration* of touch panel controllers. Chapter 8 describes *Compile-time Configuration*.

> Note that a touch panel controller is defined by the:
> 1. The interface it is connected to (such as the I2C-bus)
> 2. An address, if needed (such as I2C-address of the controller)
> 3. Pins used for interrupt, reset, etc.
> 4. Linux driver
>
> In *Compile-time Configuration*, a touch panel controller is a node in the device tree (for example under a specific I2C-bus if it is an I2C-based touch controller).
>
> In *Run-time Configuration*, a touch panel controller is associated with a specific display interface connector (on the *COM Carrier Board* - because the connector defines which I2C-bus and pins are routed to the connector).

Note that all lists of supported touch controllers represent the state at the time this document was written. Support for specific touch panel controllers can be added and deleted over time.

7.1 New Run-time Command in u-boot: eatouch

A new (non-standard) command has been added to the u-boot, `eatouch`, to support run-time configuration.

7.2 Background

With the `eadisp` command (described in section 5 above) it is possible to add a new display, but what if that display has a touch controller? The normal way to enable a touch controller is to make sure it is configured in the kernel, modify the device tree and then add the touch controller information to the correct i2c bus.

The `eatouch` command was added to make this process a bit easier. It aims to:

- Provide a way to select which touch controller to use for each *COM Carrier Board* display interface connector.
- Make it possible to enable/disable/configure touch controllers in run-time.
- Take the configuration made in the u-boot and modify the Linux device tree before booting into Linux.

7.3 How does it work?

The run-time configuration has two parts – the `eatouch` command and a bootscript. The `eatouch` command modifies a set of environment variables. The bootscript is executed before booting into Linux and it loads the device tree, modifies it according to the environment variables and then passes the modified device tree to the Linux kernel.

> The `eatouch` command modifies the u-boot's environment but it does not save the changes. To make the changes persistent use the u-boot's `saveenv` command.

To save the changes made by `eatouch` and to reset the board so that the changes take effect:

```
=> saveenv
=> reset
```

7.4 Examples

The command examples in this section are all for the *iMX6 DualLite COM board* but they work in the same way for all the iMX COM Boards that support the eatouch command.

To get help:

```
=> eatouch help
eatouch - Configure Touch Controller Support for each display
interface connector

Usage:
eatouch  - Show current configuration
eatouch disable (rgb|lvds0|lvds1) num - Disable touch controller
from list for connector
eatouch enable (rgb|lvds0|lvds1) num - Enable touch controller
from list for connector
```

To show current configuration:

```
=> eatouch

Available Touch Controllers:
    1) ar1021
    2) ilitek
    3) sitronix
    4) egalax
    5) ft5x06

Current Setup:
                      rgb conn.      lvds0 conn.    lvds1 conn.
            ar1021      Disabled       Disabled       Disabled
            ilitek    Enabled 0x41     Disabled       Disabled
          sitronix      Disabled       Disabled       Disabled
            egalax      Disabled       Disabled     Enabled 0x04
            ft5x06      Disabled       Disabled       Disabled
```

The command above shows that there is an enabled Ilitek touch controller on the RGB display interface connector and an eGalax touch controller on the LVDS1 display interface connector. The numbers after the touch controller name is the I2C address of that touch controller.

> The eGalax touch controller is the touch controller that is used on NXP's/Freescale's 10.1 inch LVDS reference display (MCIMX-LVDS1).

Run the command below to enable the Sitronix touch controller for the LVDS0 display interface:

```
=> eatouch enable lvds0 3

Current Setup:
                      rgb conn.      lvds0 conn.    lvds1 conn.
            ar1021      Disabled       Disabled       Disabled
            ilitek    Enabled 0x41     Disabled       Disabled
          sitronix      Disabled     Enabled 0x55     Disabled
```

```
              egalax      Disabled       Disabled     Enabled 0x04
              ft5x06      Disabled       Disabled       Disabled
```

The number 3 comes from the list of available touch controllers.

Note that after issuing an enable or disable command the new status is printed automatically.

To disable a touch controller for a display interface connector (in this case Ilitek for the RGB contact):

```
=> eatouch disable rgb 2

Current Setup:
                        rgb conn.      lvds0 conn.    lvds1 conn.
              ar1021      Disabled       Disabled       Disabled
              ilitek      Disabled       Disabled       Disabled
            sitronix      Disabled     Enabled 0x55     Disabled
              egalax      Disabled       Disabled     Enabled 0x04
              ft5x06      Disabled       Disabled       Disabled
```

7.5 Limitations

At the time this document is written there are a couple of known limitations:

- The Ilitek driver can only be enabled for one display interface at a time due to a limitation in the driver. Enabling it for more than one display interface connector will result in a crash when booting into Linux.

7.6 How do I add my own touch controller to the predefined list?

Adding a touch controller to the `eatouch` command requires modifying the u-boot as well as making changes to the device tree. There is, in general, no point in doing this as it is essentially the same as the *Compile-time Configuration* (described below in section 8).

8 Compile-time Configuration: Touch Controller

The run-time configuration option is a good way to get started but as the project gets into the final stages and a final display setup has been selected it is recommended to have a specific configuration for the selected touch controller. There is no need for run-time configuration in a closed end-product.

The compile-time configuration steps:

1. U-boot: Disable the `eatouch` command that was used for the run-time configuration
2. Linux: Configure the wanted touch controller in the device tree file
3. Linux: Optionally disable unwanted touch controllers in the device tree file

The setup varies between CPUs and has been divided into separate sections below.

8.1 U-boot

Below, `<uboot>` will be used as an abbreviation of the path to the root folder in which the u-boot has been unpacked. In Yocto that path will contain version numbers and other build-specific data. An example of the path:

```
<uboot>
```

```
/home/user/ea-bsp/build_ultra_fb_core/tmp/work/imx6ulea_com-poky-linux-gnueabi/u-boot-imx/2015.04-r0/git
```

8.1.1 Disable Run-time Configuration Mode

The `eatouch` command can removed by disabling CONFIG_CMD_EADISP (note that the `eadisp` command uses the same configuration). Depending on which u-boot version you are using the configuration is either set in the defconfig file or in the header file for the board you are using. Below you can see an example of where these files are located (for iMX6 SoloX COM board)

- `<uboot>/include/configs/mx6sxea-com.h`
- `<uboot>/configs/mx6sxea-com_defconfig`

Disabling the `eatouch` command switches the configuration into compile-time mode.

8.2 Linux Kernel

Below, `<kernel>` will be used as an abbreviation of the path to the root folder in which the Linux kernel has been unpacked. In Yocto that path will contain version numbers and other build-specific data. An example of the path:

```
<kernel>
```

```
/home/user/ea-bsp/build_ultra_fb_core/tmp/work/imx6ulea_com-poky-linux-gnueabi/linux-imx/3.14.38-r0/git
```

8.2.1 Adding a New Driver

If the kernel doesn't support the touch driver then it has to be either written from scratch or based on a driver from the supplier. This work is beyond the scope of this document but will include these steps:

1. Add the driver source and header files to drivers/input/touchscreen/
2. Add a configuration for the driver to drivers/input/touchscreen/Kconfig
3. Add the source file path to drivers/input/touchscreen/Makefile

4. Configure/enable the driver in the device tree
5. Enable the configuration option from step 2 in the kernel configuration (menuconfig)

8.2.2 Using an Existing Driver

If the kernel supports the touch driver but it has not been enabled, then take the following steps:

1. Configure/enable the driver in the device tree
2. Enable the configuration option the kernel configuration (menuconfig)

The touch controllers that Embedded Artists has tested are most likely already available in the device tree and also enabled in the kernel configuration. They might however be disabled in the device tree so you need to enable them if you want to use some of them.

Open the device tree (dts) file for the board you are using, such as `<kernel>/arch/arm/boot/dts/imx6sxea-com-kit.dts` for the iMX6 SoloX COM board.

Each touch controller will have a node under the i2c-bus that it belongs to. For the AR1021 controller on an *iMX6 SoloX COM Board* it looks like this:

```
&i2c1 {
        ...

/* AR1021 touch controller through RGB contact on Carrier Board */
        ar1021_rgb@4d {
                compatible = "microchip,ar1021-i2c";
                reg = <0x4d>;
                pinctrl-names = "default";
                pinctrl-0 = <&pinctrl_rgb_contact>;
                interrupt-parent = <&gpio1>;
                interrupts = <17 IRQ_TYPE_EDGE_FALLING>;
                ar1021,swap_xy;
                ar1021,invert_x;
                #ar1021,invert_y;
                status = "disabled";
        };
        ...
```

To enable this controller, change the status from "disabled" to "okay". To completely remove unused touch controllers simply delete the entire ar1021_rgb@4d node from the file. There is no real run-time difference between deleting the node and disabling it. However, trying to keep the device tree file as clean and simple as possible will make it easier to maintain.

In compile-time configuration, a touch controller has a node under the I2C-bus it is connected to. This is unlike run-time configuration, where the display interface connector (on the *COM Carrier Board*) is used as identifier - but a specific I2C-bus is routed to the different connectors also.