Slides and Resources at http://www.elinux.org/BoardBringupLCD
Introduction

- Dave Anders aka prpplague
Introduction

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- Currently Contracted with TI
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- Partners in TinCanTools
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- Board Bring Up: LCD and Display Interfaces
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- Board Bring Up: LCD and Display Interfaces
  - Challenges of LCD Bring Up
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- Board Bring Up: LCD and Display Interfaces
  - Challenges of LCD Bring Up
  - Interface Timings
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  - Interface Timings
  - Display Interface Types
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- Board Bring Up: LCD and Display Interfaces
  - Challenges of LCD Bring Up
  - Interface Timings
  - Display Interface Types
  - Debugging
Challenges of LCD Bring Up

- Simple User Display
Challenges of LCD Bring Up

- Simple User Display
Challenges of LCD Bring Up

- Simple User Display
  - Easy to visualize
  - Easy to measure
  - Easy to program
Challenges of LCD Bring Up

- Simple User Display
- Evolution of Displays
Challenges of LCD Bring Up

- Simple User Display
- Evolution of Displays
  - Clocking
  - Multiple signals
  - Introduction of controllers
Challenges of LCD Bring Up

- Simple User Display
- Evolution of Displays
- Transition to LCD
Challenges of LCD Bring Up

- Simple User Display
- Evolution of Displays
- Transition to LCD
  - Higher frequency
  - More signals
  - Complex Controllers
Interface Timings

- TFT Parallel Interface
Interface Timings

- TFT Parallel Interface
  - PCLK (Pixel Clock)
Interface Timings

- TFT Parallel Interface
  - PCLK (Pixel Clock)
  - HSYNC (Horizontal Sync)
Interface Timings

- TFT Parallel Interface
  - PCLK (Pixel Clock)
  - HSYNC (Horizontal Sync)
  - VSYNC (Verticle Sync)
Interface Timings

- TFT Parallel Interface
  - PCLK (Pixel Clock)
  - HSYNC (Horizontal Sync)
  - VSYNC (Verticle Sync)
  - DE (Data Enable)
Interface Timings

- TFT Parallel Interface
  - PCLK (Pixel Clock)
  - HSYNC (Horizontal Sync)
  - VSYNC (Verticle Sync)
  - DE (Data Enable)
  - R/G/B (Data Lines)
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
  - 640 Width x 480 Height
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
  - 640 Width x 480 Height
  - $640 \times 480 = 307200$ clocks for one frame
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
  - 640 Width x 480 Height
  - $640 \times 480 = 307200$ clocks for one frame
  - $307200 \times 60 = 18432000$ for 60 frames per second
Interface Timings

- TFT Parallel Interface

- Pixel Clock and RGB Data
  - 640 Width x 480 Height
  - \(640 \times 480 = 307200\) clocks for one frame
  - \(307200 \times 60 = 18432000\) for 60 frames per second
  - Estimated PCLK = 18.432MHz
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
  - 640 Width x 480 Height
  - \(640 \times 480 = 307200\) clocks for one frame
  - \(307200 \times 60 = 18432000\) for 60 frames per second
  - Estimated PCLK = 18.432MHz
  - What if your SoC can not create exactly 18.432MHz?
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
  - 640 Width x 480 Height
  - 640 x 480 = 307200 clocks for one frame
  - 307200 x 60 = 18432000 for 60 frames per second
  - Estimated PCLK = 18.432MHz
- What if your SoC can not create exactly 18.432MHz?
- Good question!!!!!
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
- Line Timing – HSYNC and DE
Interface Timings

Horizontal SYNC and Data Enable

- **Pixel clock**
- **RGB Data**
- **Enable**
- **Horizontal Sync**
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
- Line Timing – HSYNC and DE
- Frame Timing - VSYNC
Interface Timings

Vertical SYNC

Diagram showing interface timings with pixel clock, RGB data, and vertical sync.
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
- Line Timing – HSYNC and DE
- Frame Timing – VSYNC
- Front Porch / Back Porch / Sync Width
  - Remember the question about exact pixel clock?
Interface Timings

HORIZONTAL TIMING

CLK

HSYNC

ENB

VALID DATA

One Line (TH)

VERTICAL TIMING

VSYNC

VALID LINES

One Frame (TV)
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
- Line Timing – HSYNC and DE
- Frame Timing – VSYNC
- Front Porch / Back Porch / Sync Width
  - Remember the question about exact pixel clock?
  - Values in the datasheet
Interface Timings

- TFT Parallel Interface
- Pixel Clock and RGB Data
- Line Timing – HSYNC and DE
- Frame Timing – VSYNC
- Front Porch / Back Porch / Sync Width
  - Remember the question about exact pixel clock?
  - Values in the datasheet
  - Lots of numbers to keep track of
Display Interface Types

- Disadvantages of Parallel Interface
Display Interface Types

- Disadvantages of Parallel Interface
  - Large Number of Signals
  - Limited Distance
  - Lack of Standardization
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
  - Reduced number of signals
  - Longer distances
  - Standardized
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
  - LVDS – Low Voltage Differential Signaling
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
  - LVDS – Low Voltage Differential Signaling
  - DVI - Digital Visual Interface
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
  - LVDS – Low Voltage Differential Signaling
  - DVI - Digital Visual Interface
  - HDMI - High-Definition Multimedia Interface
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
  - LVDS – Low Voltage Differential Signaling
  - DVI - Digital Visual Interface
  - HDMI - High-Definition Multimedia Interface
  - DisplayPort
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
  - LVDS SN75LVDS83B – SN75LVDS82
  - DVI TFP410 – TFP401
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
- Combination Interfaces
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
- Combination Interfaces
- EDID
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
- Combination Interfaces
- EDID
  - Extended Display Identification Data
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
- Combination Interfaces
- EDID
  - Extended Display Identification Data
  - Contents
Display Interface Types

- EDID Contents
  - Multiple Configurations
  - Pixel Clock Frequency
  - Resolution
  - Color Depth
  - Front Porch / Back Porch
  - SYNC width
Display Interface Types

- Disadvantages of Parallel Interface
- Differential Interfaces
- Common Differential Interfaces
- Why learn TFT when working with Differential?
- Combination Interfaces
- EDID
  - Extended Display Identification Data
  - Contents
  - I2C EEPROM at 0x50
Display Interface Types

- Disadvantages of Parallel Interface
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  - I2C EEPROM at 0x50
  - parse-edid
Debugging

- Logic Analyzer
  - Importance of visualization
Debugging

- Logic Analyzer
  - Importance of visualization
  - Pixel clock frequency
Debugging

- Logic Analyzer
  - Importance of visualization
  - Pixel clock frequency
  - Open source (or open source friendly)
Debugging

- Logic Analyzer
  - Importance of visualization
  - Pixel clock frequency
  - Open source (or open source friendly)
    - SIGROK
    - ChronoVu LA8 (less than $200)
Debugging

- Logic Analyzer
- Reference Platform
  - Same platform – different display
  - Different platform – same display
  - Compatible display
  - Kernel sources
Debugging

- Logic Analyzer
- Reference Platform
- Display Simulation
  - Lower resolution
  - Transmitter Chips TFP410 to DVI display
  - Receive Chips LVDS to SN75LVDS82
Debugging

- Logic Analyzer
- Reference Platform
- Display Simulation
- Userspace debugging
Debugging

- `cat /dev/urandom > /dev/fb0`
Debugging

- fb-test
Debugging

Missing Green Data Bit
Debugging

Missing Blue Signals
Debugging

LSB/MSB
Signal Swap
Debugging

Red/Blue
Signal Swap
Conclusion

- Summary
  - Challenges of LCD bring up
  - Interface Timings
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Questions?