Introduction

References and Presentation at: http://www.elinux.org/elce-i2c
Introduction

- Dave Anders aka prpplague
Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
Dave Anders aka prpplague
Currently Contracted with TI
Partners in TinCanTools
Board Bring: You, Me, and I2C
Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
- Board Bring: You, Me, and I2C
  - Communication Principles
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  - Communication Principles
  - Drivers and Software Tools
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- Board Bring: You, Me, and I2C
  - Communication Principles
  - Drivers and Software Tools
  - Board Bringup Use Cases
Communication Principles

- Asynchronous Communication
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
Communication Principles
Communication Principles
Communication Principles
Communication Principles
Communication Principles

DOT
Communication Principles

DOT
Communication Principles
Communication Principles
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
Asynchronous Communication
- No External Clock Signal
- Morse Code / Telegraph
- RS-232/UART
  - Universal
  - Asynchronous
  - Receiver
  - Transmitter
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
    - DOT / DASH
    - Baud Rate
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
  - Accurate Timing Device
Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
  - Accurate Timing Device
    - Crystals
    - Oscillators
    - System Clock Dividers
      - Atmel AVR with 10MHz clock
      - \( \frac{10MHz}{20} / 4 = 125000 \)
      - 115200 vs. 125000 = 8.5% error
Communication Principles

- Asynchronous Communication
- The Problem
Communication Principles

- Asynchronous Communication
- The Problem
  - Simple peripherals
  - Reduced external components
  - No need to set period length
  - Wide range of frequencies
Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes
Communication Principles

CLOCK

DATA
Communication Principles

- CLOCK
- DATA
Communication Principles
Communication Principles

CLOCK

DATA

1
Communication Principles

CLOCK

DATA

1

0
Communication Principles

![Diagram of communication principles](image)

- **CLOCK**
- **DATA**

1

0
Communication Principles

CLOCK

DATA

1

0

1
Communication Principles

CLOCK

DATA

1

0

1
Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes
  - NXP Developed I2C
Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes
  - NXP Developed I2C
  - Intel Refined with SMBus
Interfacing

- Physical Connections
Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
  - Address
Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
  - Address
    - 7-bits
    - LSB Read/Write
Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
  - Address
  - Level Shifters
Interfacing

- Physical Connections
- Drivers
Interfacing

- Physical Connections
- Drivers
  - Bootloaders
Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
  - GPIO Bit-Bang
- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
  - GPIO Bit-Bang
  - I2C CharDev
Interfacing

- Physical Connections
- Drivers
- I2C Tools
Interfacing

- Physical Connections
- Drivers
- I2C Tools
  - i2cdetect
Interfacing

- Physical Connections
- Drivers
- I2C Tools
  - i2cdetect
  - i2cdump
Interfacing

- Physical Connections
- Drivers
- I2C Tools
  - `i2cdetect`
  - `i2cdump`
  - `i2cget`
  - `i2cset`
Board Bringup

- I2C GPIO Expanders
Board Bringup

- I2C GPIO Expanders
  - Devices
Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events
Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events
    - Voltage range support
Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events
    - Voltage range support
    - Generic PCF857X
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
    - Different Voltage Levels
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
    - Different Voltage Levels
    - New GPIOs are Transparent
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOs from Host
    - Different Voltage Levels
    - New GPIOs are Transparent
    - Inputs used for versioning
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection

![Four Wire Connection Diagram](image)

- Power
- Data
- Clock
- Ground
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
    - Provide LEDS for Low Level Feedback
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
    - Provide LEDs for Low Level Feedback
    - Easily Prototyped
Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
    - Provide LEDS for Low Level Feedback
    - Easily Prototyped
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Typical 256 KBytes
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Typical 256 KBytes
    - Can be Write Protected
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Typical 256 KBytes
    - Can be Write Protected
    - Low Cost
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Typical 256 KBytes
    - Can be Write Protected
    - Low Cost
    - Multiples per System
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID
      - Extended
      - Display
      - Identification
      - Data
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID
    - BeagleBone Capes
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID
    - BeagleBone Capes
    - Part/Board Identifications
<table>
<thead>
<tr>
<th>Name</th>
<th>Offset</th>
<th>Size (bytes)</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>0</td>
<td>4</td>
<td>0xAA, 0x55, 0x33, 0xEE</td>
</tr>
<tr>
<td>EEPROM Format</td>
<td>4</td>
<td>2</td>
<td>Revision number of the overall format of this EEPROM in ASCII = A0</td>
</tr>
<tr>
<td>Revision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board Name</td>
<td>6</td>
<td>32</td>
<td>Name of board in ASCII</td>
</tr>
<tr>
<td>Version</td>
<td>38</td>
<td>4</td>
<td>Hardware version code for board in ASCII</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>42</td>
<td>16</td>
<td>ASCII name of the manufacturer</td>
</tr>
<tr>
<td>Part Number</td>
<td>58</td>
<td>16</td>
<td>ASCII Characters for the part number</td>
</tr>
<tr>
<td>Number of Pins</td>
<td>74</td>
<td>2</td>
<td>Number of pins used by the daughter board</td>
</tr>
<tr>
<td>Serial Number</td>
<td>76</td>
<td>12</td>
<td>Serial number of the board. This is a 12 character string which is: WWYY4P13nnnn where: WW = 2 digit week of the year of production YY = 2 digit year of production nnnn = incrementing board number</td>
</tr>
</tbody>
</table>
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
  - Four Wire Connection

- Power
- Data
- Clock
- Ground
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data
    - Configure Test/Boot Modes
Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data
    - Configure Test/Boot Modes
    - Easily Prototyped
Conclusion

- Communication Principles
Conclusion

- Communication Principles
- Drivers and Software Tools
Conclusion

- Communication Principles
- Drivers and Software Tools
- Board Bringup Use Cases
Conclusion

Questions?