ECE 471 – Embedded Systems
Lecture 17

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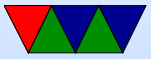
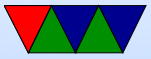
Announcements

- HW#7 is out
- Pick your projects by Friday. Please e-mail even if you've asked in person.



HW6 Review

- Now you can do 271 final project
- Errors – mostly just C mistakes, read/write and other minor confusions
- i2c turns out to be fairly robust, everyone's code worked even when big chunks were coded wrong
- Difficulty, should I have given you the data sheet and said have fun?

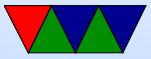


- ASCII conversion. 1960s. Lucky to be american. `man ascii` 7-bit code. EBCDIC
  - 48 (0x30-0x39) is 0 through 9.
  - 65 (0x41-0x5A) is A through Z.
  - 97 (0x61-0x7A) is a through Z.

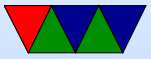
  Unicode. UTF8.

- Hard/Soft/Firm. Brakes=Hard. Radio button=Soft. Video playing=Firm (linux increasingly used in infotainment)

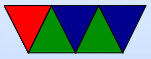
- Mailbox or Doorbell Interrupt?



- Prints yes forever? yes — fsck.
  Use it to pipe yes answers to programs asking for lots of confirmations. Standard set of utils somewhat frozen at what someone from the 1970s thought was useful. Causes system load? odd answer (Wikipedia?)

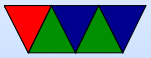


More Busses

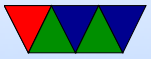


Rasp-pi Headers

- Main header. Has power, ground, gpios, i2c (with pull ups), UART,
- P2 – video card jtag
- p3 – Lan jtag
- p5 – on rev2. Has gpios and another i2c bus
- p6 – reset button

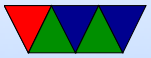


- Other
  - GPIO16 – status LED D5 (SD card access)
  - GPIO28-31 – board ID and resistors R3 to R10 (on Rev1.0 boards)
  - GPIO40 and 45 – used for PWM audio
  - GPIO46 – HDMI hotplug detect
  - GPIO47-53 are – used by the SD card interface GPIO47 is SD card detect

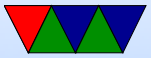


USB Bus

- USB 1.0 – 1996 – 1.5Mbit/s (keyboard, etc), 12Mbit/s (disk)
- USB 1.1 –
- USB 2.0 – 2000 – 470MBit/s
- USB 3.0 – 2008 – 5GBit/s
- 2-5m cables

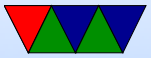


- 4 pins. 5V, GND, D+, D-. Differential signalling (subtractor). More resistant to noise.
- Unit load, 100ma. Can negotiate up to 500ma (more USB 3.0)
- Up to 127 devices (by using hubs)
- Enumeration



USB Protocol

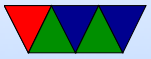
- Each device has endpoint
- isochronous – guaranteed data rate but with some potential data loss (video)
- interrupt – low-latency, like keyboards
- bulk – disk access



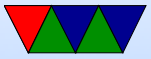
USB Linux

- Linux drivers
  - Device classes – HID, audio, etc. One common driver can handle all devices of a class
  - Specific – device driver is board specific and must have a list of all vendor/device IDs that are supported

- libusb
  Allow direct userspace access to USB interface
  Used by low-level things that might not need driver

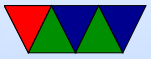


old cameras (not standardized), custom hardware



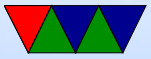
USB on Rasp-pi

- USB-OTG – on the go. Allows device to act like a host (so can hook up devices as per normal) or as normal USB device. Decides which based on whether A or B cable plugged in, check ID pin (micro/mini have 5th pin)
  The Pi-B does not support running in gadget mode externally (a hub in the way) and the OTG hardware requires more software support than (it is simpler) than regular USB.



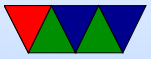
- USB 2.0 (sorta). Cannot supply full power (why? Only 1A power suppy typical). Also cannot handle high-bandwidth things like audio cards and USB-cameras well.

- USB-host – standard USB port. Cannot provide high current, so use a powered hub if using anything more than keyboard or mouse



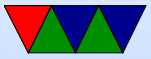
Audio Ports

- In the old days audio used to be just open `/dev/dsp` or `/dev/audio`, then `ioctl()`, `read()`, `write()`
- These days there's ALSA (Advanced Linux Sound Architecture)
  The interface assumes you're using the ALSA library, which is a bit more complicated.



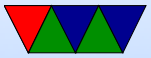
i2s

- PWM audio not that great
- i2s lets you send packets of PWM data directly to a DAC
- At least 3 lines. bit clock, word clock (right/left stereo), data
- Pi support i2s on header 5

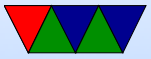


SDIO/MMC

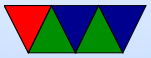
- MultiMediaCard (MMC) 1997
- SD is an extension (1999)
- SDSC (standard capacity), SDHC (high capacity), SDXC (extended capacity), SDIO (I/O)
- Standard/Mini/Micro sizes
- SDHC up to 32GB, SDCX up to 2TB



- Support different amounts of sustained I/O. Class rating 2, 4, 6, 10 (MB/s)
- SDIO – can have I/O like GPS, wireless,
- Patents. Need license for making.
- SPI bus mode
- One bit mode – separate command and data channels
- Four-bit mode
- 9 pins

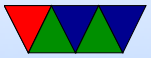


- Initially communicate over 1-bit interface to report sizes, config, etc.
- Starts in 3.3V, can switch to 1.8V



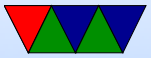
Camera Port

- The SoC has dedicated hardware for driving cameras
- 5megapixel, CSI port (Camera Serial Interface) plus i2c bus to command it.
- Can read data in parallel, directly, without needing USB overhead.
- These chips often used in cell-phones, so makes sense to have support for camera-phone without extra chip being needed.



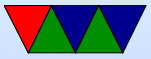
Ethernet

- Old, complicated standard, whole way up to 100GBps
- Modern form is often RJ-45, twisted pairs
- Power over ethernet (no pi suport)
- Board has 10/100 Mbpss ethernet port
- Connected to on-board USB hub

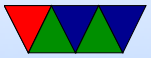


UART – serial port

- Often useful on embedded boards and old systems, might be only way to reliably connect
- RS-232, originally for teletypes
- 3-15V high, -3 to -15V low
- start/stop bits, parity, bit-size
- Hardware vs Software flow control

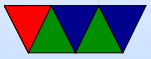


- Speeds 300bps - 115000bps and beyond
- 50feet (15m) w/o special cables
- 3-pin version (transmit, receive ground). Also 5-pin HW flow control (CTS/RTS). Can have 2-pin version if only want to transmit
- These days often hook up USB conector



HDMI

- High-Definition Multimedia Interface (2003)
- Compatible with DVI (if no copy protection used)
- Video, audio (up to 8 channels), CEC (consumer electronics control), ethernet
- No support for captions
- DDC – i2c bus, used for EDID (getting device info) and HDCP (copy protection)



- TDMS – transition minimized differential signaling
  Video, then during scan line breaks, audio, etc
- CEC – control up to 15 devices with one remote control
  (one wire serial bus)
- Various versions, various fees