ECE 471 – Embedded Systems
Lecture 19

Vince Weaver

http://www.eece.maine.edu/~vweaver

vincent.weaver@maine.edu

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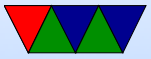
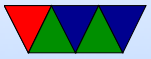
Announcements

- Project ideas! Should have gotten an e-mail
- Any HW#8 Problems?
- Will e-mail the HW#7 grades



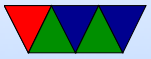
PWM

- Get around the fact that you can't get good timings w/o real-time OS
- Available on GPIO18 (pin 12)
- Can get 1us timing with PWM, 100us with Wiring Pi, probably less with GPIO interface.
- Which would you want for hard vs soft realtime?
- Other things can do? Beaglebone black as full



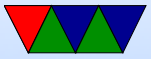
programmable real-time unit (PRU)

200MHz 32-bit processor, own instruction set, can control pins and memory, etc.

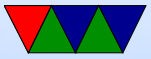


Audio Ports

- 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.
- Pi lacks a microphone input, so if want audio in on your pi probably need a USB adapter.

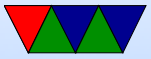


- Also can get audio out over HDMI.



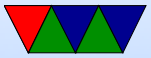
i2s

- 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 (high=right/low=left stereo), data
- Pi support i2s on header 5

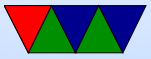


SD/MMC

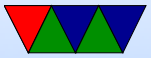
- MultiMediaCard (MMC) 1997
- Secure Digital (SD) is an extension (1999)
- SDSC (standard capacity), SDHC (high capacity), SDXC (extended capacity), SDIO (I/O)
- Standard/Mini/Micro sizes
- SDHC up to 32GB, SDCX up to 2TB



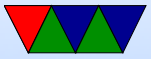
- Support different amounts of sustained I/O. Class rating 2, 4, 6, 10 (MB/s)
- SDIO – can have I/O like GPS, wireless, camera
- Patents. Need license for making.
- SPI bus mode
- One bit mode – separate command and data channels
- Four-bit mode
- 9 pins (8 pins on micro)



- Initially communicate over 1-bit interface to report sizes, config, etc.
- Starts in 3.3V, can switch to 1.8V
- Write protect notch. Ignored on pi?
- DRM built in, on some boards up to 10% of space to handle digital rights
- Can actually fit full Linux ARM server on a wireless SDIO card

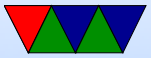


- eMMC = like SD card, but soldered onto board



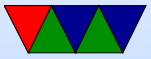
Camera Port

- 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.



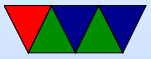
Ethernet

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

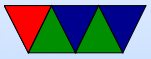


UART – serial port

- 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

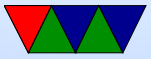


- Speeds 300bps - 115000bps and beyond
- 50feet (15m) w/o special cables
- 3-pin version (transmit, receive ground). Also 5-pin HW flow control (CTS/RTS). Can have 2-pin version if only want to transmit
- These days often hook up USB connector

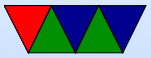


HDMI

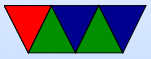
- High-Definition Multimedia Interface (2003)
- Compatible with DVI (if no copy protection used)
- Video, audio (up to 8 channels), CEC (consumer electronics control), ethernet
- No support for captions
- DDC – i2c bus, used for EDID (getting device info) and HDCP (copy protection)



- 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

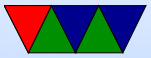


Other Busses not found on Rasp-Pi



Wireless

- No built-in wireless support, can use USB wireless



Bluetooth

- No built-in support.
- Sort of like serial, but wireless
- Not going to go over it in detail in this class though.