6.270: Autonomous Robot Design Competition

- Assignment 1: General Comments
- Sensor store and $30 Electronics Rule
- Electronics review
- Handy Board hardware and interface
- Sensors and motors
- Interactive C development environment
- Assignment 2 handed out

LECTURE 2: Building the Basic Robot

Teams ***NOT*** Checked Off

- You know who you are!
- We think you are:
  - 6, 47, 48

Updates

- Course notes
- Assignment 2

Rules Clarifications

- Scoring moving balls
  - We score the match once all game objects have stopped moving
- Programming the HandyBoard without IC
  - You can try (but you shouldn't)
- Position and orientation?
  - You can't tell your robot about position/orientation
- How many servos?
  - We'll talk about that in a second
- Can we melt rubber bands and dip LEGO in them?
  - No.
- Can we add things like a PIC?
  - Yes.

Other general announcements

- Don't wander into the office
  - If you need something, ask a staff member (should be nearby)
- Staff parts (motors, sensors, etc…)
  - Please don't take these
  - They're for looking at or use where they live

The Contest: Points and Dollars

- Two sensor budgets for every team
  - 30 (of your) dollars
  - 20 "sensor points"
- See Chapter 2 of course notes for more details

Spending Your Money ($30 Electronics Rule)

- May be spent on electronics and actuators (and related parts)
  - Sorry, you can't buy more LEGO
  - We sell things at cost – our prices are probably the best you'll find
  - Provide receipts, or fair estimates; and make sure we agree before you buy
  - General rule of thumb – we should be able to get 500 of your part at the same price you're claiming
  - If you're getting free samples, they don't count as free
- Make sure you know what you are doing
- Check out our stuff before you start looking elsewhere
- Tools do not count towards the allotment
- Replacements for servos do not count towards your $30 allotment—only based on what's on your final robot

A Little More About the Servos…

- Yes, you have 6 servo ports
- But you can only have 4 (or maybe 5) servos
- Each cost $10
  - Except the old ones, which are $7
- To replace broken, $15; does not count towards $30 allotment
- For those wishing to get the servo elsewhere:
  - Futaba S3003

Sensor Points

- Sensor points can go to mechanical switches, sensors, LEDs, and motors
  - We have some sensors you haven't seen yet
  - Full catalog of components available are displayed by the 6.270 office
- Generally, LEDs, mechanical switches, and phototransistors cost 1 point
- Motors cost 1 point
- Distance sensors costs 3 points
- Be sure to test similar sensors; not all are the same

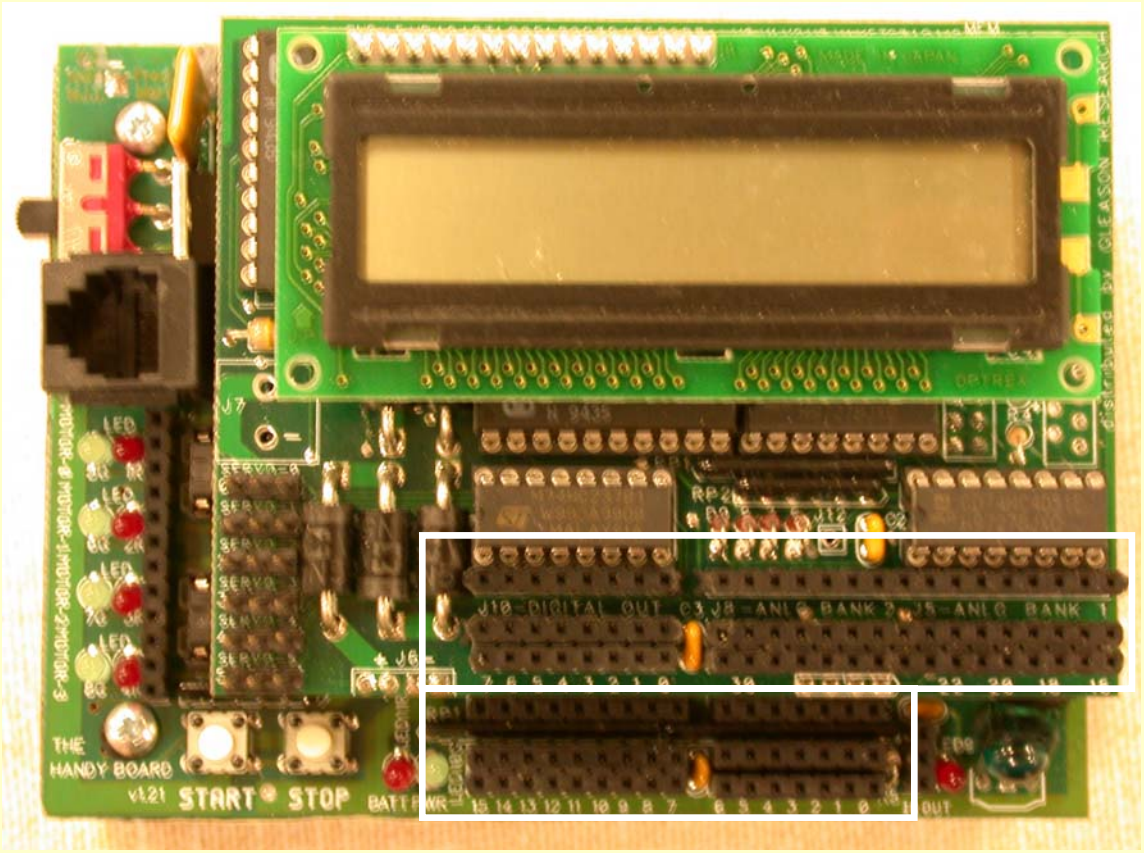
Trading

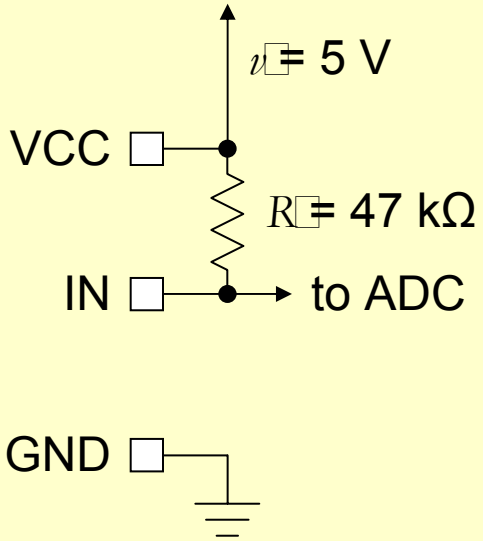
- You can trade sensors using our point scheme
- You can trade sensors in your original kit with the sensor store, but we'll be picky ("like-new condition")
- If you want to purchase a replacement from us, it's $5 or the cost of the part, whichever is *higher* (won't cost towards the $30; we're not an electronics store)
- ***NO LEGO TRADING***, unless it's for color
  - … well, don't trade gray for black pegs, either

What Are Sensors?

- Devices that change resistance due to
  - Light
  - Pressure
  - Position (angle)
  - etc…
- Range is limited (with IC: analog 0 to 255; digital 0 to 1)

HandyBoard Sensor Inputs



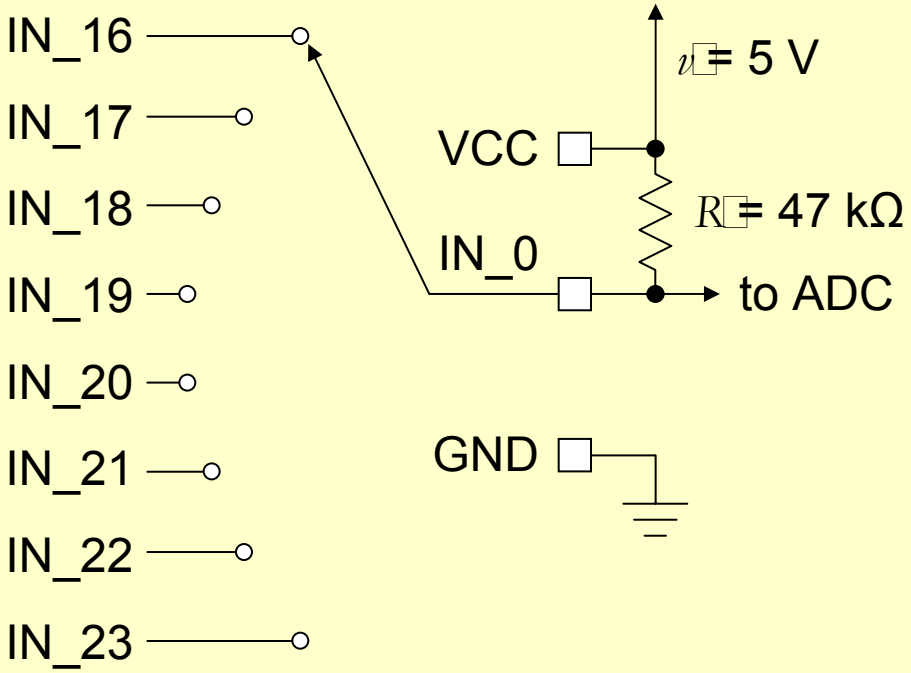


HandyBoard Sensor Inputs

- HandyBoard has digital and analog hardware ports
  - You can read both types of ports as digital or analog values
  - BUT, digital ports read as analog values always give 0 or 255
  - Analog ports read as digital values use a cutoff to decide if it is 0 or 1
  - Analog ports: 0-6, 16-31
  - Digital ports: 7-15

Expansion Board Sensor Inputs

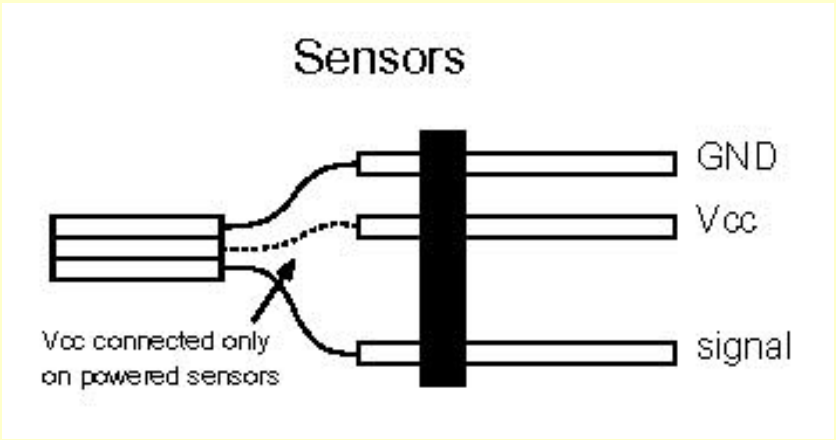
- Expansion inputs are multiplexed
- Need to read inputs twice when using a different expansion port

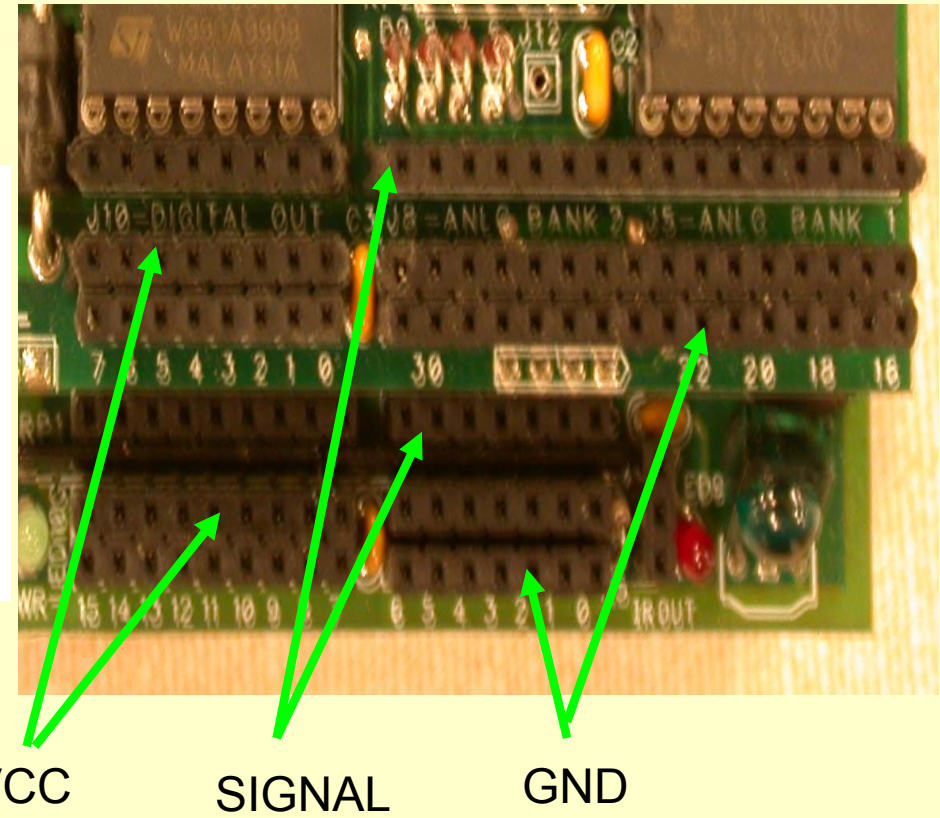


Sensors

- Potentiometer
- Phototransistor
- Breakbeam
- Distance

Sensor Connection



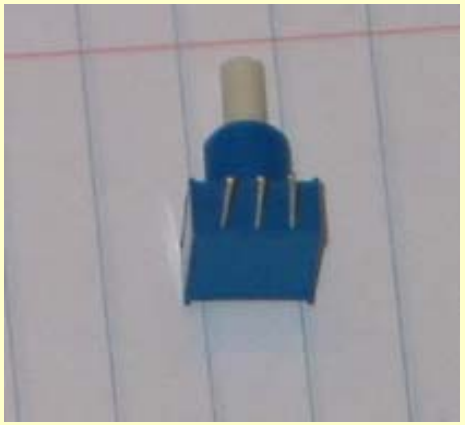


Sensors

- Bumpers
- Internal sensors
- One terminal to GND, other to Signal (IN)
- NC (normally closed) vs. NO (normally open)

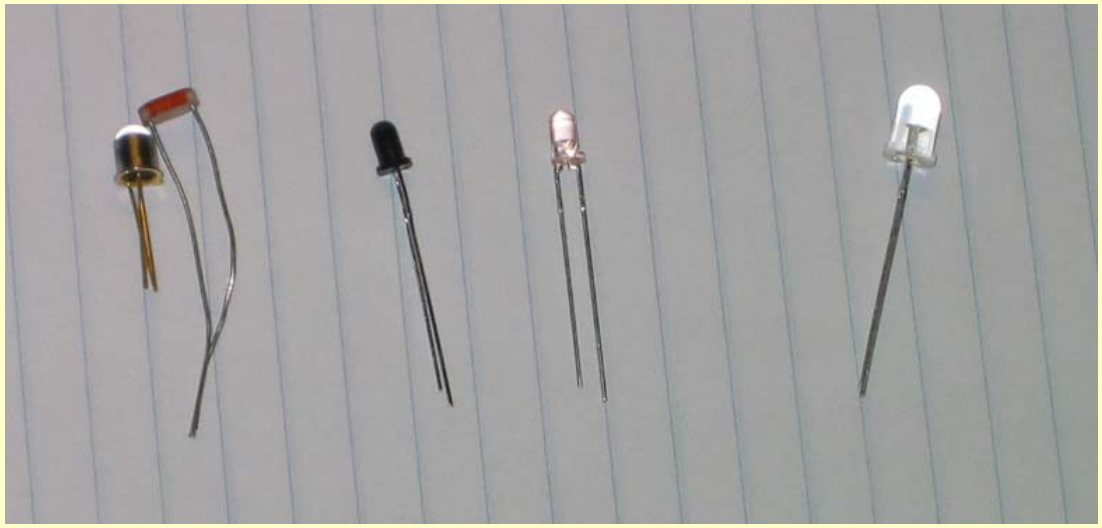
Potentiometers (Variable Resistors)

- Useful for precise shaft encoding



Phototransistor

- More sensitive to IR than to visible light
- Polarized
- More in Lecture 3



Breakbeam Sensors

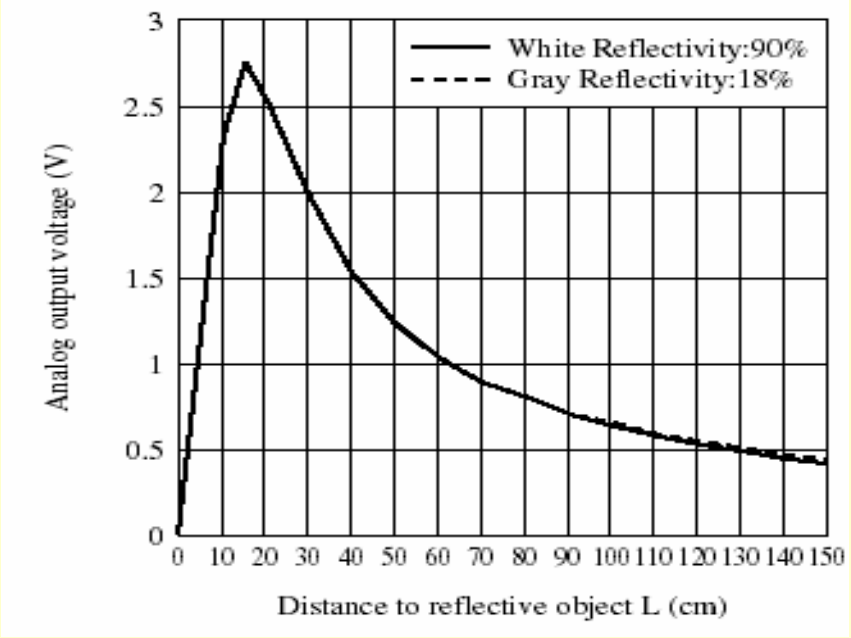
- Shaft Encoding
- Works on certain HB ports
- Count number of interruptions
- More in Lecture 3

Sharp Distance Sensor

- Useful for measuring distances from 6.5” to a couple feet
- 3 sensor points
- More in lecture 3

Sharp Distance Sensor

- Response curve



The Gyroscope!

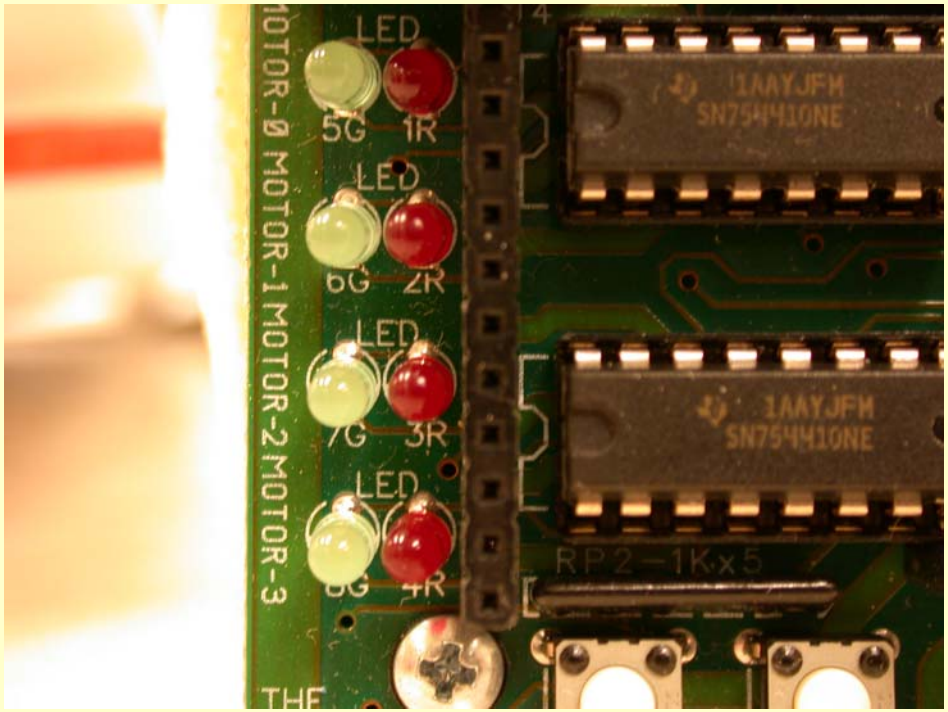
- Now, a word from Analog Devices

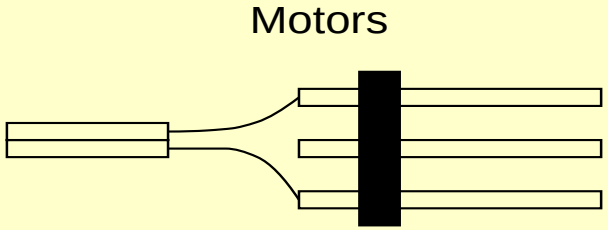
Motors

- Two kinds of motors available
- Need to "LEGOize" motors
- Can use glue or tape to mount them

Motor Connections

- Three pins
- Use first and third pin
- Current can flow either direction, motor runs in either direction





Interactive C

- Originally developed for 6.270 by Randy Sargent
- Supports Handy Board, RugWarrior and RugWarrior Pro

Where to Develop

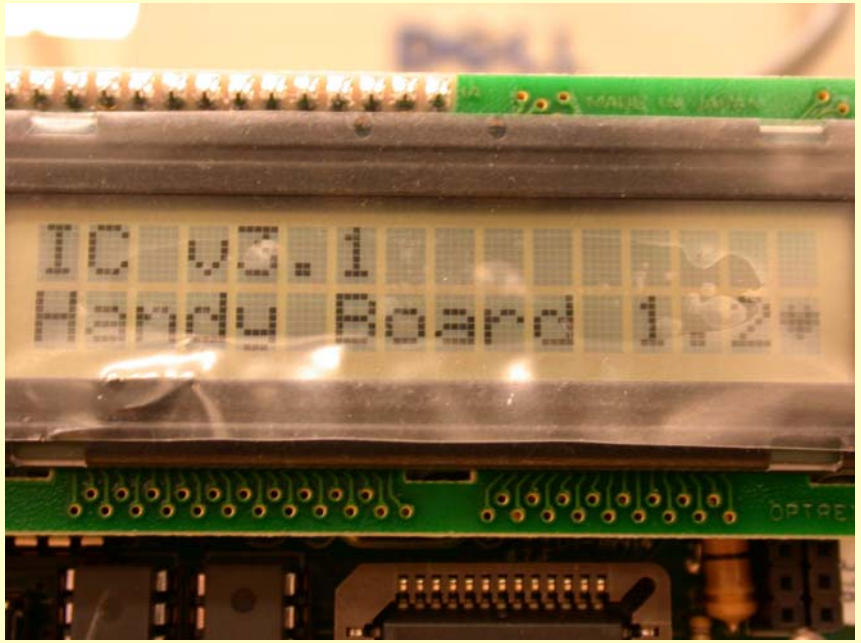
- Work at Lab
  - IC 3.1
  - Laptops in lab
- Work at Home
  - IC 3.2 for Windows
  - http://www.kipr.org

Starting Off: Download pcode

- Initially do this to load machine instructions and libraries to HB
  - IC provides some libraries, 6.270 provides more
  - Be sure HB has been charged
- May want to do this if HB is acting strangely
- Set HB to download mode (hold STOP and turn on)

Starting IC

- Add 6.270 locker
- Type: **`ic`**
- Make sure HB is on
  - LCD: **`IC v3.1`** **`SMOOTHPWM`** with beating heart
- Prompt: **`C>`**



Basic Commands

- `load <filename>`
  - IC looks in current directory first, then IC library path
  - Several files may be loaded into IC at once
  - A program can be defined in multiple files
  - Downloads all loaded files to HandyBoard
- `unload <filename>`
  - Unloads the named file
  - Re-downloads remaining files

Basic Commands

- `help`
  - Help screen of IC commands
- `quit`
  - Exits IC
  - `<Ctrl-C>` also works

Editing

- IC has a line editor and command history
- Scan through history with ↑ and ↓ arrows or **<Ctrl-P>** (previous command) and **<Ctrl-N>** (next command) respectively

KEY MAPPINGS

<Ctrl-A> beginning of line	**<Ctrl-E>** end of line
<Ctrl-B> back one character	**<Ctrl-F>** forward one character
<Ctrl-D> delete character	**<Ctrl-K>** kill line

C

- At prompt, C-language expression may be entered
- End with semicolon
  - Example:

```
C> 6 * 10;
Downloading 7 bytes (addresses C200-C206): 7 loaded
Returned <int> 60
```

- Can also evaluate series of expressions by creating a block with curly braces
  - Example:

```
C> { int i = 10; printf( "%d\n", i ); }
Downloading 22 bytes (addresses C200-C215): 22 loaded
(LCD displays "10")
```

Program Development

- Develop in favorite editor (vi, emacs, Notepad)
- In IC: `load <filename>`
- Reboot HB by turning it off then on

How the HB Runs Code

- When turned on, HB runs **`main()`** function
- Reset HB without running **`main()`**
  - Hold START button while turning on
  - HB will display **`IC 3.1 SMOOTHPWM`**
  - Files are not lost

How the HB Runs Code

- Global variables initialized whenever reset condition occurs
- Reset occurs when
  - New code downloaded
  - **`main()`** is run
  - System hardware is reset
- Local variables initialized when function containing them is called

Conflicting Files

- Occurs when multiple files downloaded have a **`main()`** (or any other) function
- Error occurs
- See the manual for more details

Persistent Global Variables

- Special uninitialized global variable
- Preface with keyword **`persistent`**:
  `persistent int i`
- Initial values cannot be specified in declaration
- These variables keep their state when:
  - HB is turned off and on
  - **`main()`** is run
  - System reset occurs

Persistent Variables

- If declared at the beginning of the code, before any function or other non-persistent globals, they will be re-assigned to the same location in memory when code is re-compiled
- Can preserve values over multiple downloads
- If program is divided into multiple files, all persistent variables should be in one file
  - File should be placed first in the load ordering of the files

Why Use Persistent Variables?

- Store calibration and configuration values that do not need to be re-calculated every time
- Robot learning algorithms

List Files (`.lis`)

- List multiple files needed for download in a `.lis` file
- Remember: if you have persistent variables in code, ensure that file containing them is listed first
- `load <listfile>` loads files in the order prescribed

Printing to LCD

- Only 31 characters (16 x 2 – ♥)
- Characters printed beyond final character position are cut off
- `printf()` treats the LCD screen as one long line instead of two
- Cannot print long 32-bit integers

Arrays and Pointers

- Arrays are one-dimensional only
- Pointers to only data items and arrays

Motors

- `void fd(int m)`
- `void bk(int m)`
- `void off(int m)`

  motor ports: $0 \leq$ **`m`** ≤ 5
- `void alloff()`
- `void ao()`

- `void motor(int m, int speed)`

  $-100 \leq$ **`speed`** ≤ 100 100: full forward -100: full backward

More About Motors

- `motor(m,0)` and `off(m)` are the same command
- Motor ports 4 and 5 do not have speed controls
  - They turn on full power
  - `speed` parameter does not matter

Servos

- `void disable_servos()`
- `void enable_servos()`
  - Must be called for servos to work
  - Disable servos when processor performance is needed
- `void servo(int port, int period)`

$0 \leq$ **`port`** ≤ 5 $0 \leq$ **`period`** ≤ 4000 ($\approx 180^\circ$)

Sensors

- `int analog(int port)`
  - Returns integer between 0 and 255
- `int digital(int port)`
  - Returns 0 (false) or 1 (true)

  $0 \leq$ **`port`** ≤ 31
- You can plug analog sensors into digital ports and vice versa

Other Doodads

- `int stop_button()`
- `int start_button()`
  - Returns 1 (pressed) or 0 (released)

- `void start_press()`
- `void stop_press()`
  - Waits for button to be pressed and released
  - Beeps afterwards

- `int knob()`
  - Returns position of knob as integer between 0 to 255

Time

- **`void reset_system_time()`**
  - Reset time to 0 milliseconds
- **`long mseconds()`**
- **`float seconds()`**
  - 1 millisecond resolution
  - **`int`** vs. **`float`** (the period)
- **`void sleep(float sec)`**
  - At **`sec`** or a little longer than **`sec`** seconds
- **`void msleep(long msec)`**
  - At **`msec`** or longer than **`msec`** milliseconds

Tones

- `void beep()`

- And for the bored:
- `void tone(float freq, float length)`
  - `freq` Hertz for `length` seconds
- `void set_beeper_pitch(float freq)`

Assignment 2

- Due Thursday night (TOMORROW!) at 11:45 pm
- Four tasks to complete:
  1. Build and test the expansion board
  2. Build and test the RF receiver
  3. Build a robot (guidelines are enumerated in assignment)
  4. Program the robot to move around
- Pick up assignment after lecture
- Assignment 3 is dependent on the robot you made for Assignment 2
- The robot just needs to work: remember that it doesn't have to be the best robot you've ever made

What's Next

- Wednesday, January 5, and Thursday, January 6
- Workshop 3 – Electronics Assembly
  - How to solder
  - Soldering RF receiver (Assignment 2)
- Workshop 4 – Code & Sensors I: Basic Control and Robot Skills
  - Programming the HB (Assignment 2)
- Don't forget to sign up on the 6th floor lab