HCDC Software Demo

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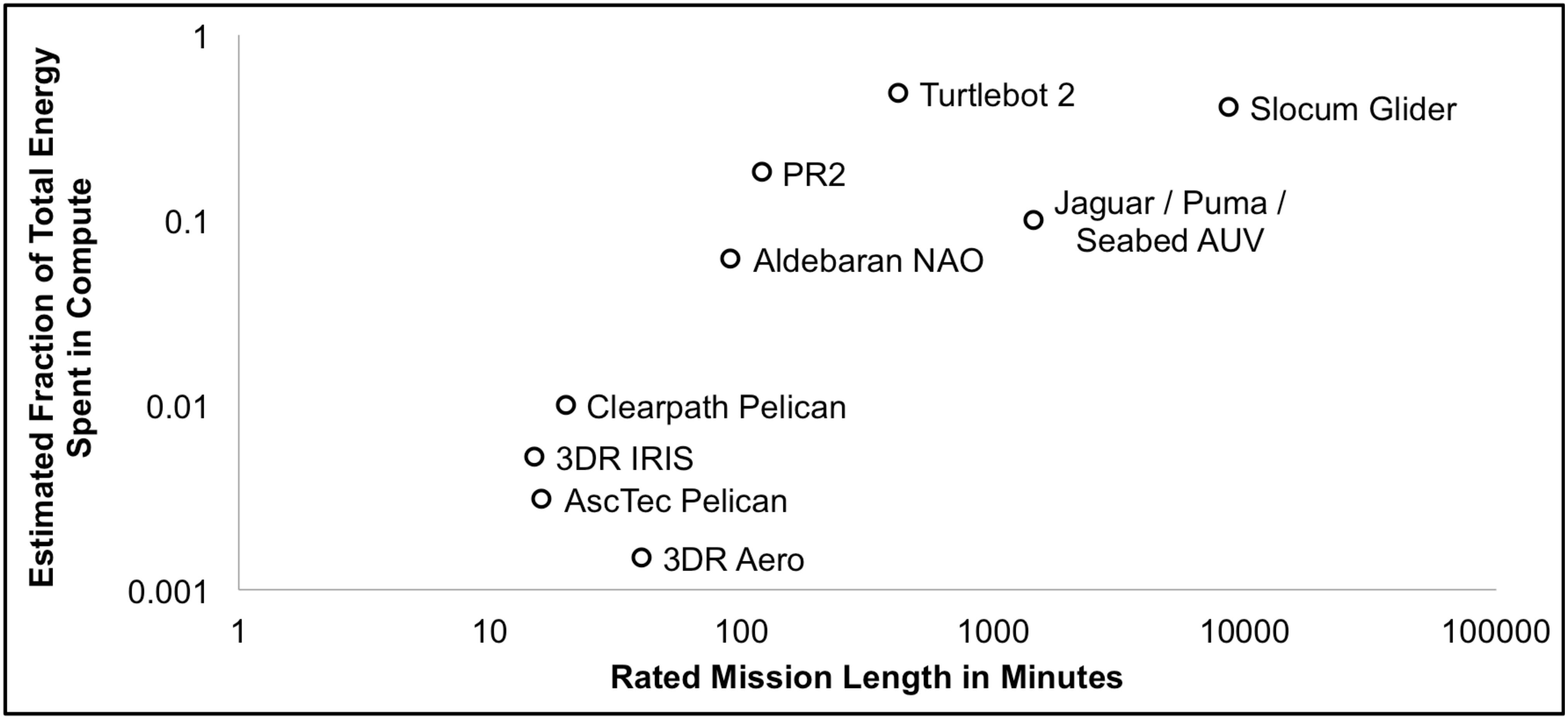
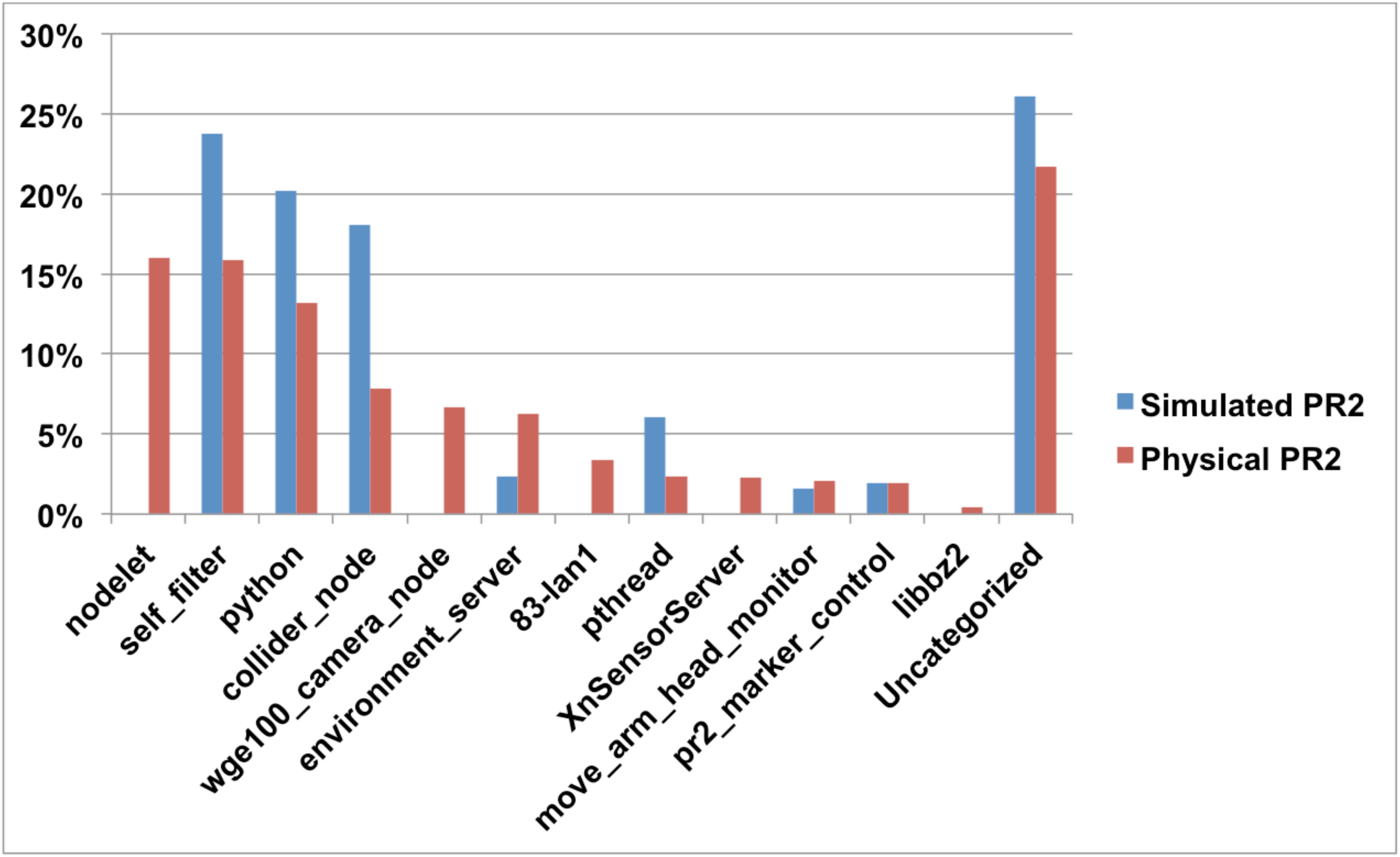
Case for Energy Efficient Robots



Computation on a Robot



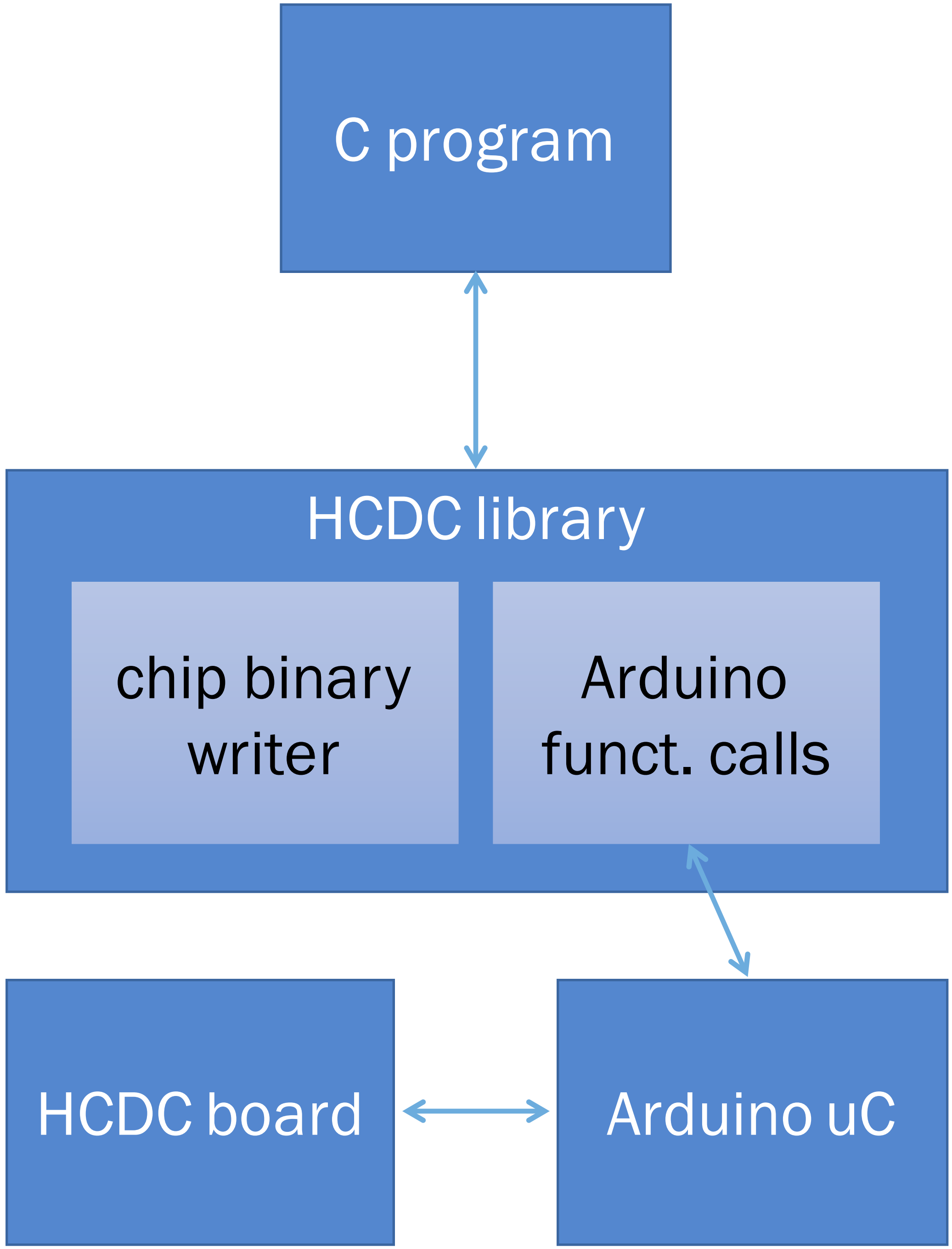
Outline

- **HCDC Workloads**
  - What can we run on the HCDC chip, now and future
- **HCDC Programming Language**
  - Accessing the HCDC through annotated C code
- **HCDC Compiler**
  - How HCDC configurations are generated
- **HCDC API Library**
  - Lower level interface to HCDC functions

HCDC Workloads

- **HCDC & computational robotics**
  - Speeding up modelling forward dynamics
- **HCDC & smooth optimization**
  - Solving constrained and unconstrained quadratic programming with gradient descent
- **HCDC & solving linear equations**
  - Inverting matrices using gradient descent on analog circuits
- **HCDC & solving ordinary differential equations**
  - Simulating nonlinear ODEs of up to fourth order

HCDC System Architecture

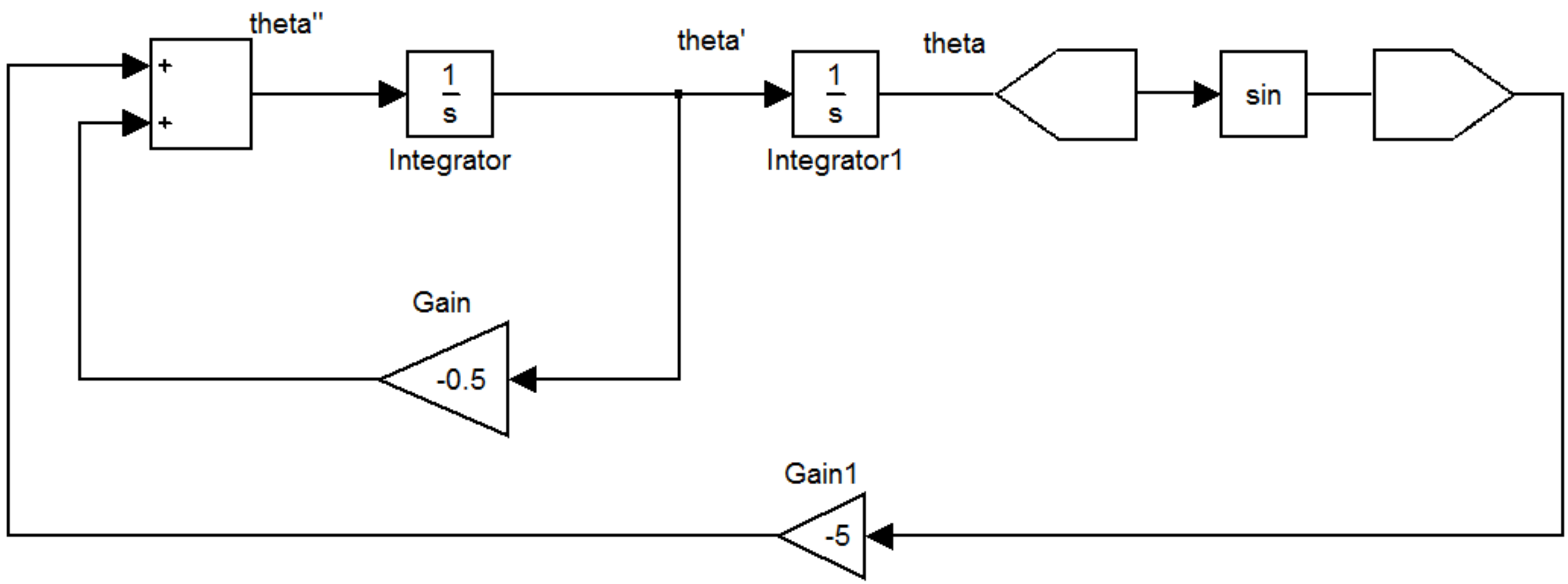


HCDC Programming Language

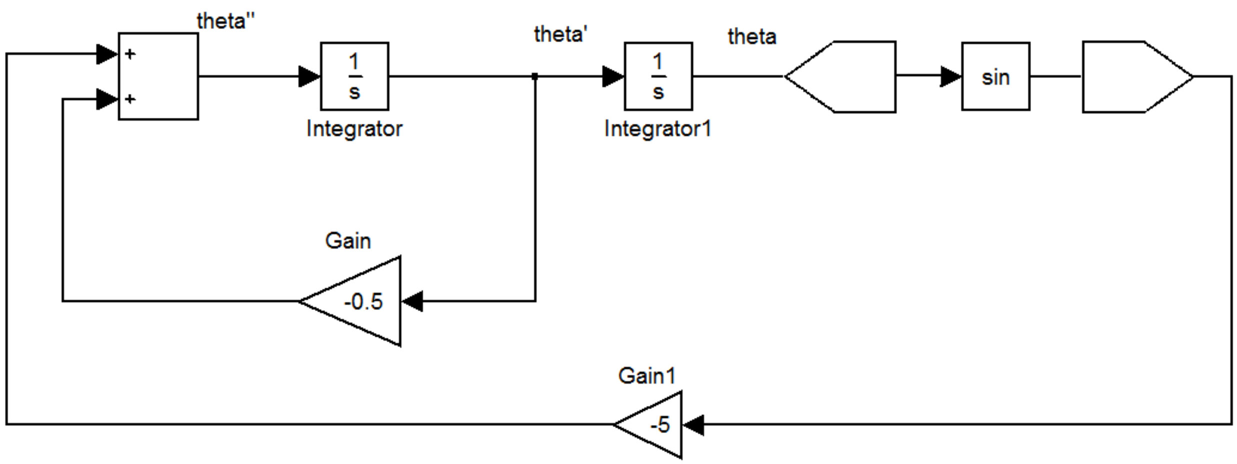
```
int main (int argc, char** argv) {

     // Outputs
     double a, b;

     #pragma HCDC_begin y' = y*y + y, y(0)=5.0, y(10)=?
     #pragma HCDC_map y a
     #pragma HCDC_map y' b
     #pragma HCDC_scale 10.0
     //--- Optional digital code here ---//
     #pragma HCDC_end

     return 0;
}
```

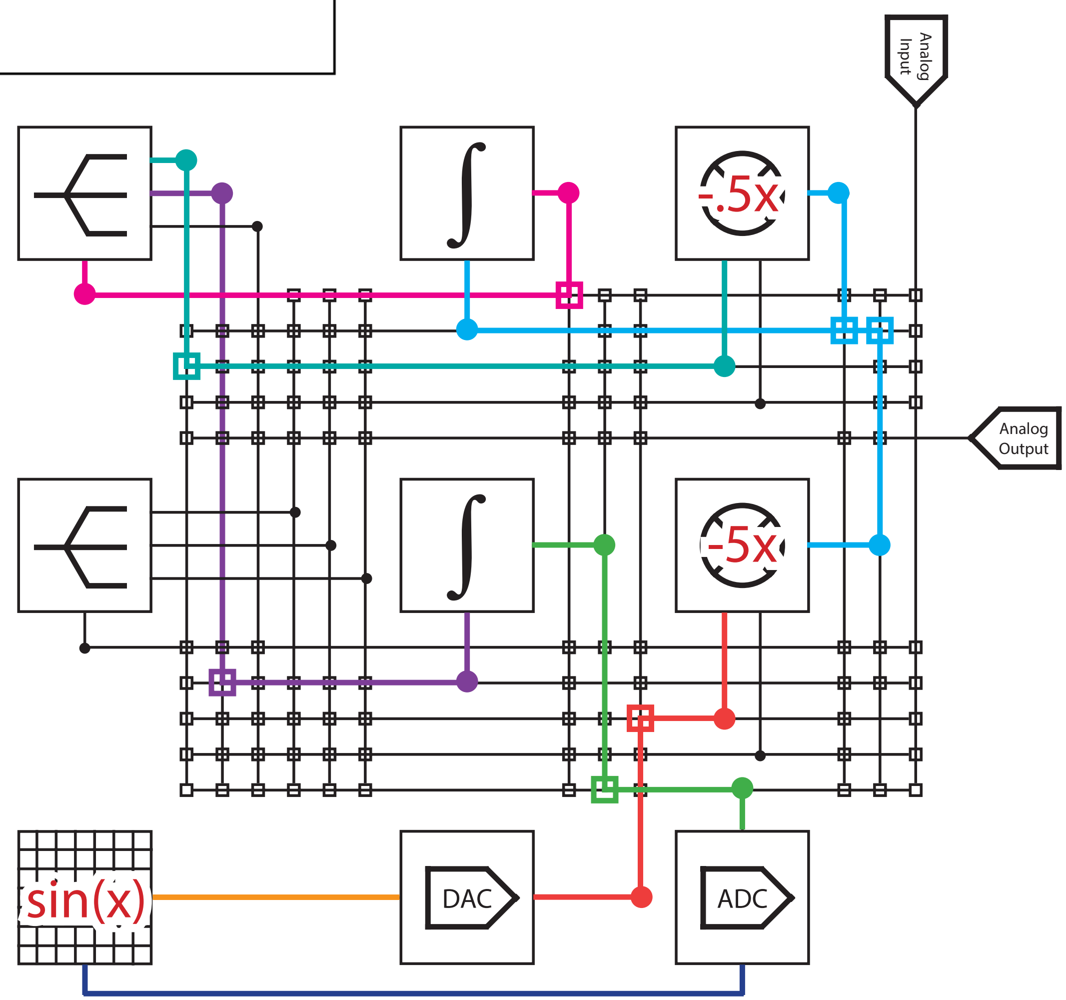
Job of HCDC Compiler

$$\Theta = -0.5 * \Theta - 5*\sin\Theta, \quad \Theta(0) = 1$$



Job of HCDC Compiler





HCDC API Library Calls

```
hcdcInit();

// Set initial integrator values
float initial_y0 = 5.000000;

// Call HCDC wiring instructions
setSimpleConn ( {fans[0], out0, muls[0], in0} );
setSimpleConn ( {fans[0], out1, muls[0], in1} );
setSimpleConn ( {fans[0], out2, ints[0], in0} );

setSimpleConn ( {muls[0], out0, ints[0], in1} );

setIntInitial ( ints[0], initial_y0 );
setSimpleConn ( {ints[0], out0, fans[0], in0} );
```

Some Advance Warning!

- **We have a working example of converting damped oscillator differential equation -> complete HCDC code**

- **Realistically, user of HCDC would write a mix of compliable C code & HCDC instructions**
  - Most controllers are not system of differential equations
  - Getting accurate results requires trial & error
  - Working with the limited dynamic range of HCDC may be unfamiliar