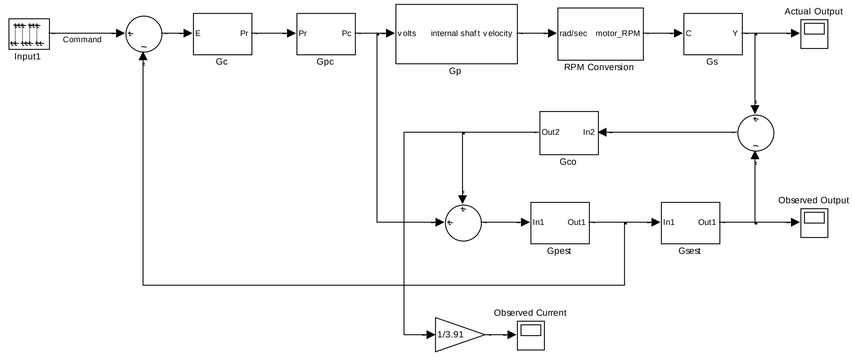
Observer-based Engine Cooling Control System (OBCOOL)

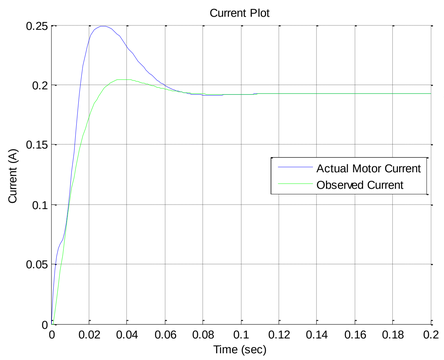
Students:
Kurtis Liggett & Andrew Fouts

Advisor:
Dr. Gary Dempsey

Engine System Observer

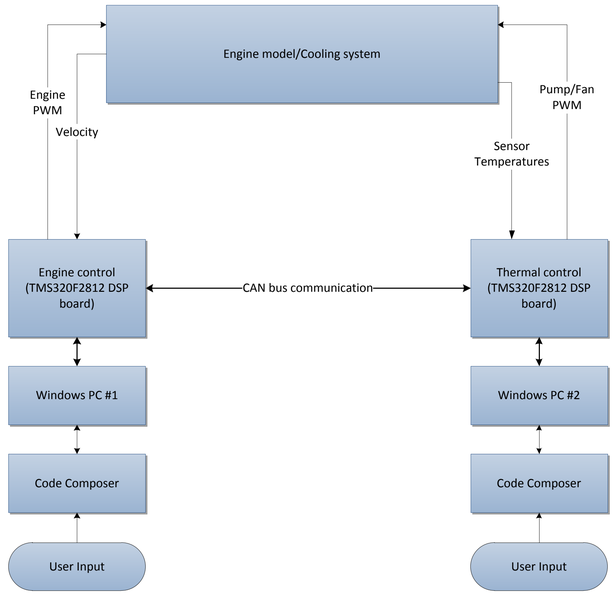


Actual vs Observed Current



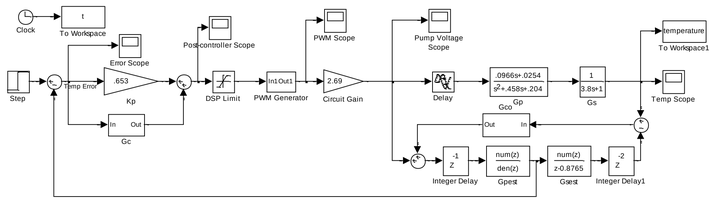
Observed current matches actual current at steady state

System Block Diagram

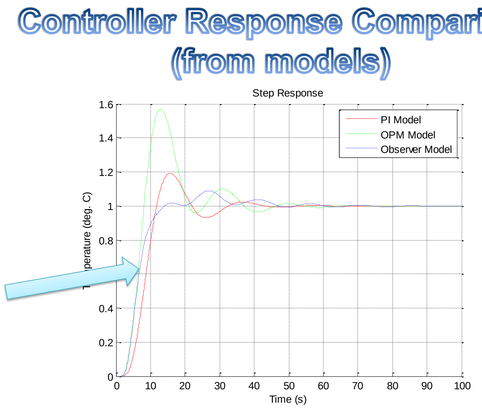


- Description
  - Our project consists of researching observer-based control systems and applying this knowledge to design closed-loop controllers for velocity control and temperature regulation of an engine cooling system. The controllers are implemented using DSP boards with Simulink auto-code generation. In addition, energy management and controller performance has been evaluated.
- Goals
  - Learn software packages
  - Design several types of controllers & evaluate performance of each
  - Develop energy management control system in Simulink environment to regulate voltage/current to each subsystem
  - Determine the limitations of the Simulink/DSP interface

Cooling System Observer



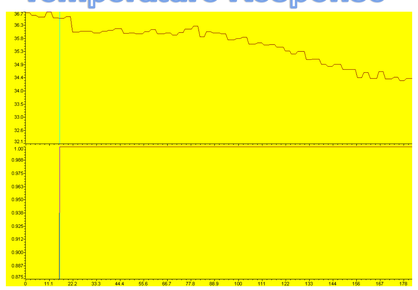
Controller Response Comparison (from models)



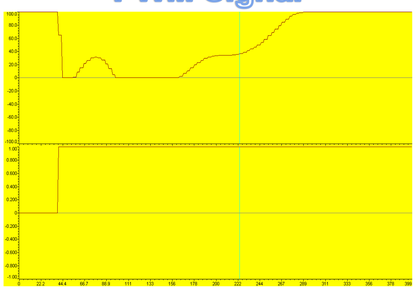
Stability improvement from observer implementation

Observer-based Controller Response (from actual system)

Temperature Response

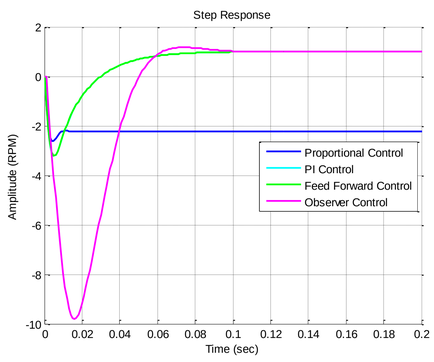


PWM Signal

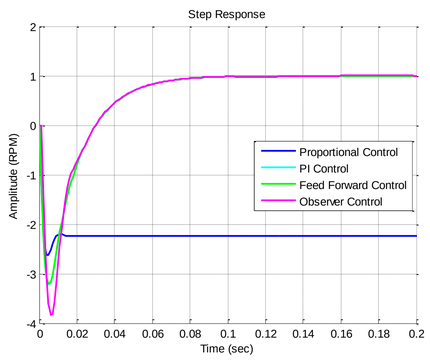


Controller Response Comparison (from models)

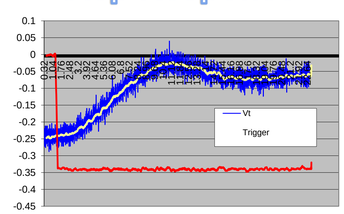
Only Observer



Switched Observer



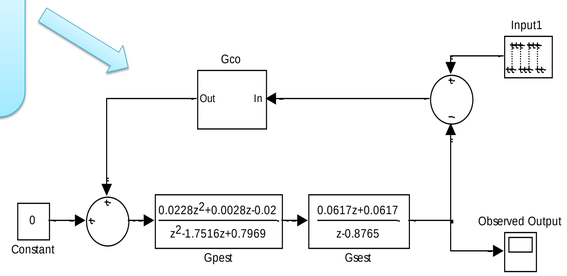
Thermistor Voltage Step Response



System identification used to create model for observer

Tune observer PI controller independent of control system

Observer Tuning Model



Functional Requirements

Engine control system	Thermal control system
Steady-state error = ± 5 RPM	Steady-state error = ±2° C
Percent overshoot ≤ 10%	Percent overshoot ≤ 25%
Rise time ≤ 30 ms	Rise time ≤ 2 seconds
Settling time ≤ 100 ms	Settling time ≤ 10 seconds
Phase margin = 45°	Phase margin = 45°

Calculated Plant Parameters

Settings	
Rpot	44890
Fan PWM	100%
Value #1 PWM	50%
Value #2 PWM	90%

Gain									
Test	Before Step	After Step	Difference		Rt #1	Rt #2	Difference	Temp #1	Temp #2	Difference
#1	-0.244	-0.072	0.172		44454	44760.903	306.90143	29.05374	28.87773	0.17600585
#2	0.536	0.676	0.14		45862.87	46120.461	257.59066	28.24576	28.09803	0.147726468
#3	0.744	0.848	0.104		46246.11	46438.939	192.83356	28.02598	27.91539	0.110588714

Measurements									
Test	(time offset)	(step offset)	Td	Ts	tp	Peak value	Final value	%OS	ζ (damping ratio)
#1	1.1	-0.244	1.64	13.34	8.35	0.22	0.172	27.9%	0.376
#2	0.52	0.512	1.71	13.41	8.06	0.204	0.164	24.4%	0.41
#3	1.12	0.748	2	12.49	7.81	0.132	0.1	32.0%	0.341