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Robust Motor Controller Design Implemented with TMS320F240 DSP

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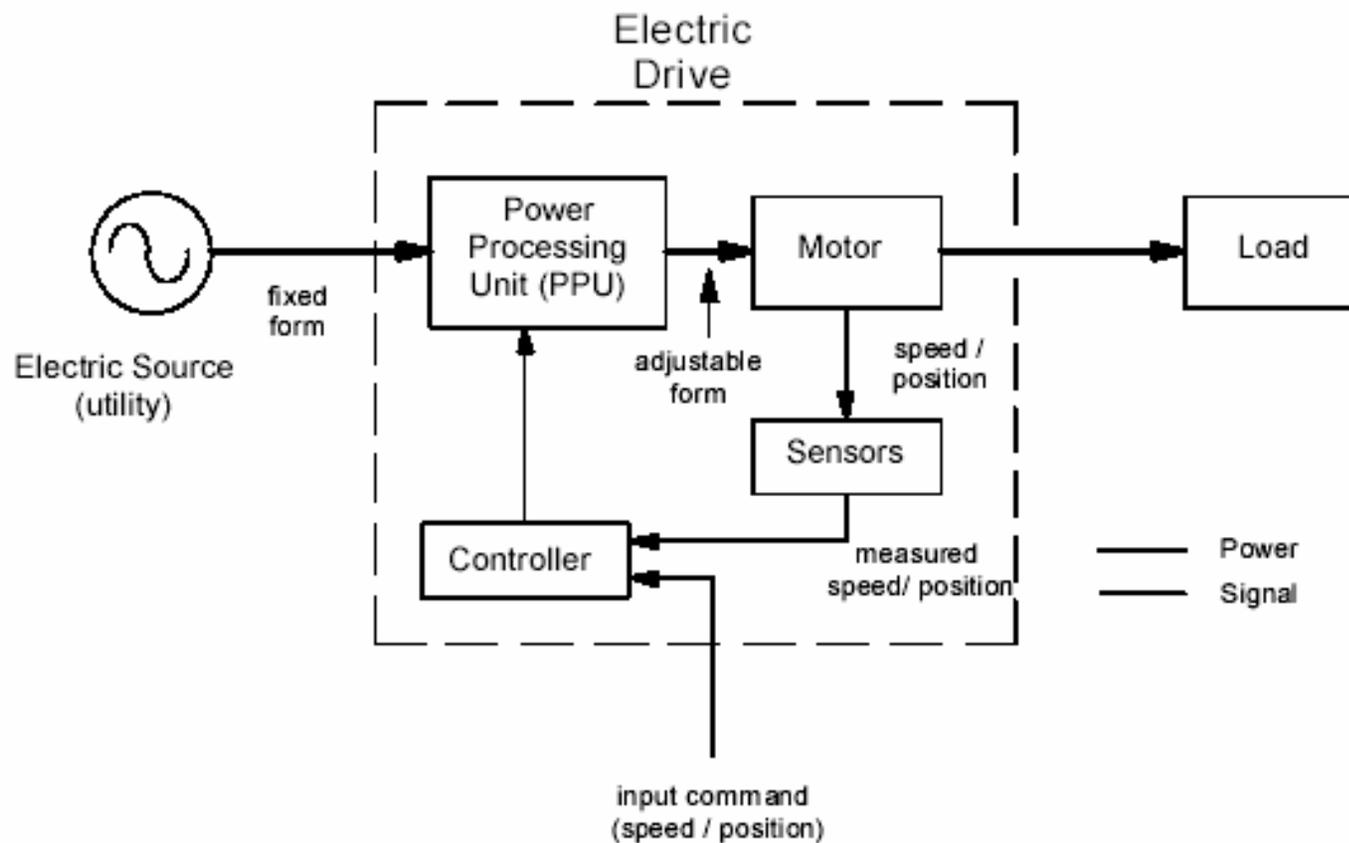
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Outline

- **Introduction**

- **Internal Model Control**

- **Disturbance Rejection**

- **Summary**

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Advantages of Direct Motor Drive

◆ **Simpler in mechanical structure, more reliable, of high performance.**

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# Challenge and Solution

- **Challenges:**
  - without mechanical transmissions
  - parameter uncertainties
  - disturbance variations

- **DSP Solutions:**
  - digital signal processors (DSP)
 - switch power devices
  - software (algorithm)

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MATLAB/SIMULINK to Programs TI TMS320F240

- ◆ MATLAB/SIMULINK
- ◆ DSP programming (C / assembly)

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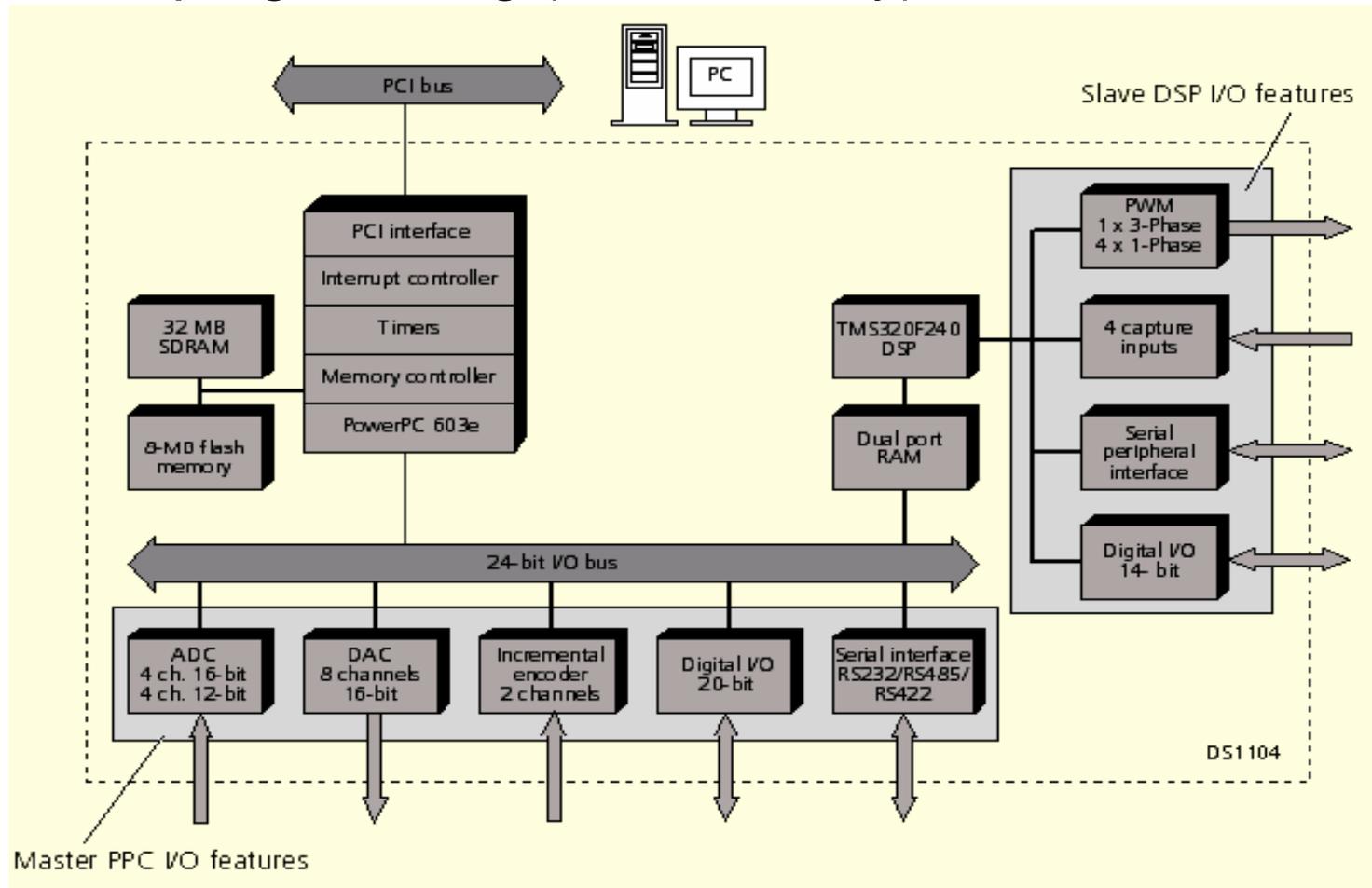
Resulting Mixed-Signal System

- **Hybrid system, or sampled-data system**

- **analog system + digital controller**

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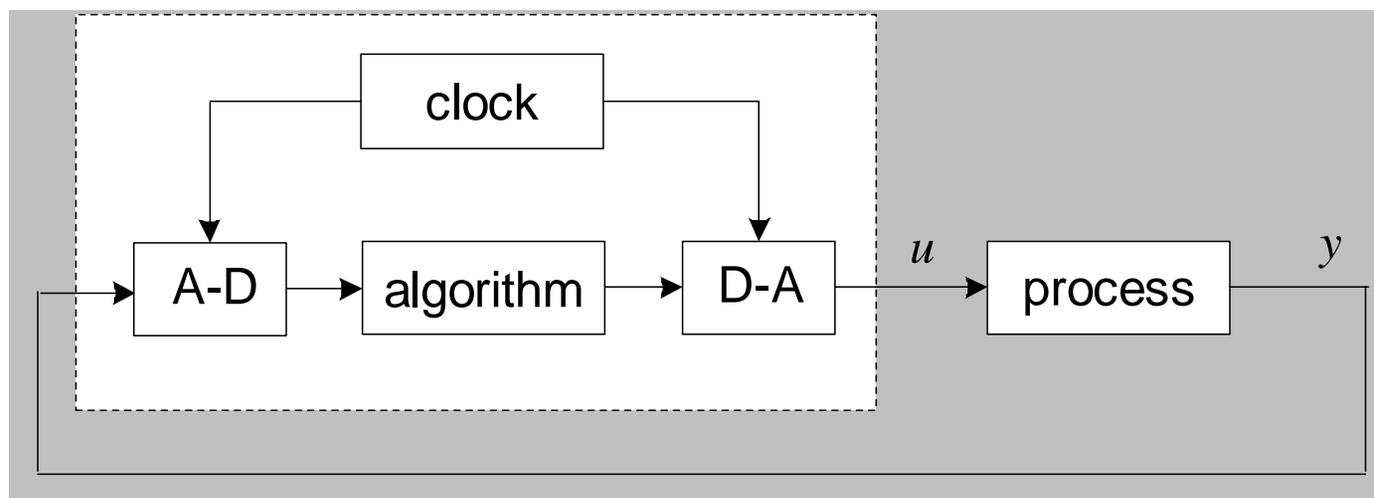
DSP-based Motor Drive System
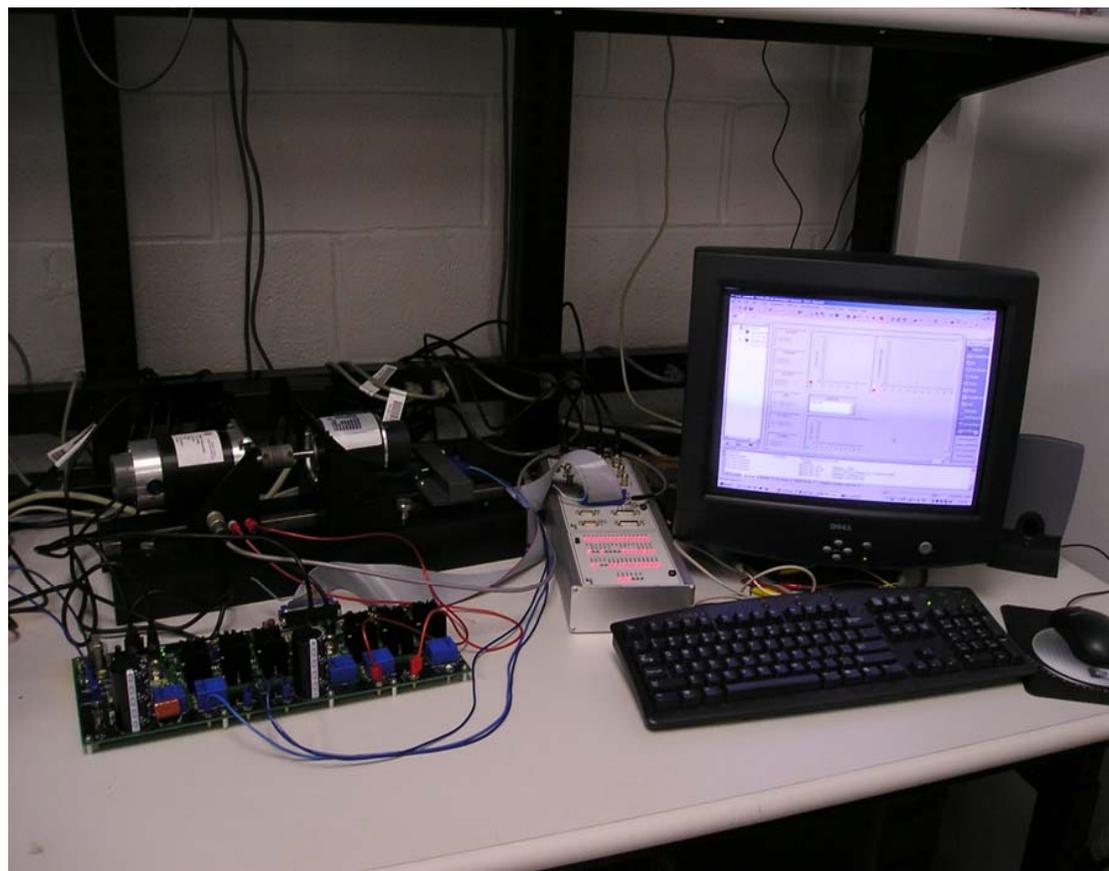
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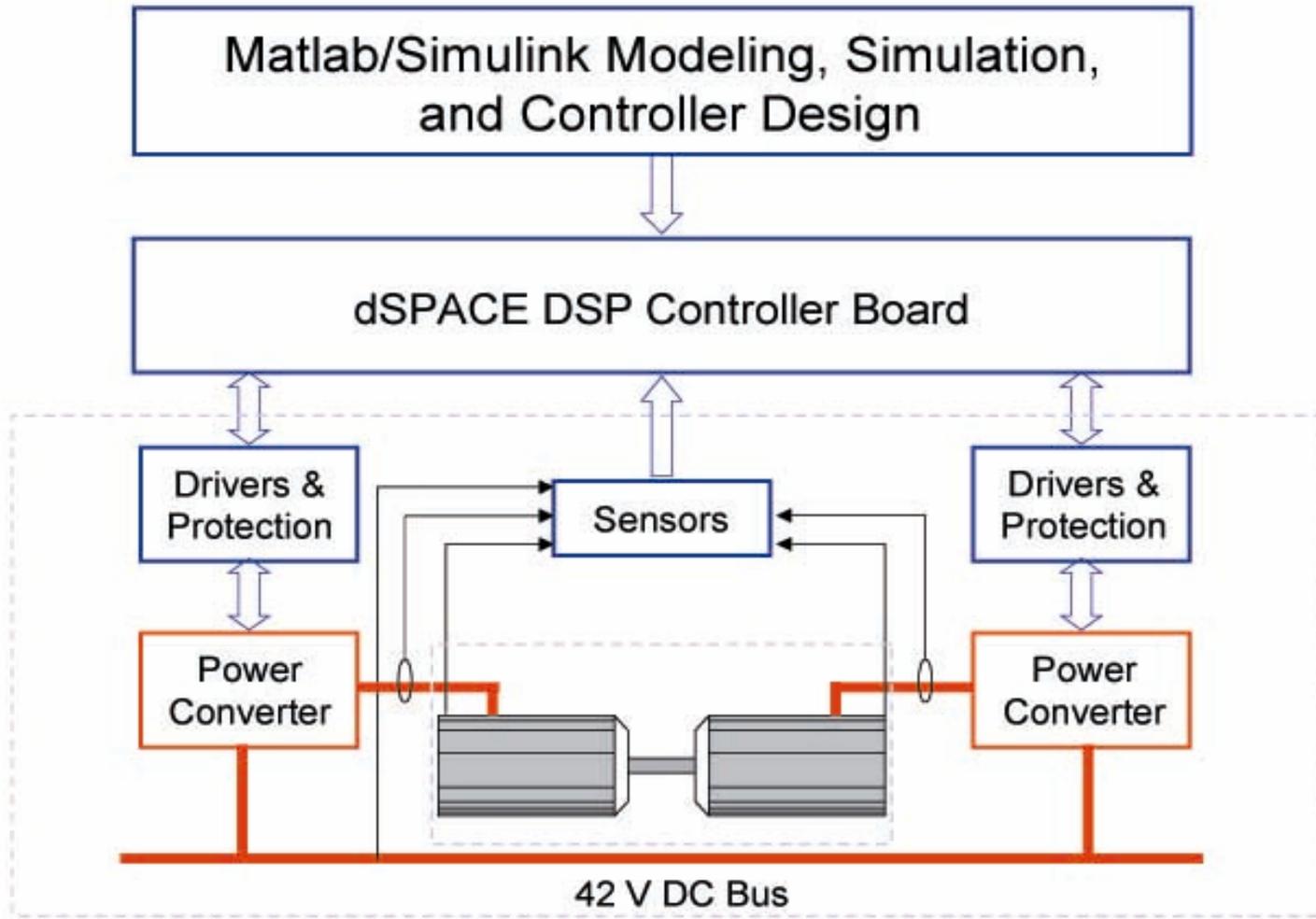
Internal Model Control (IMC)
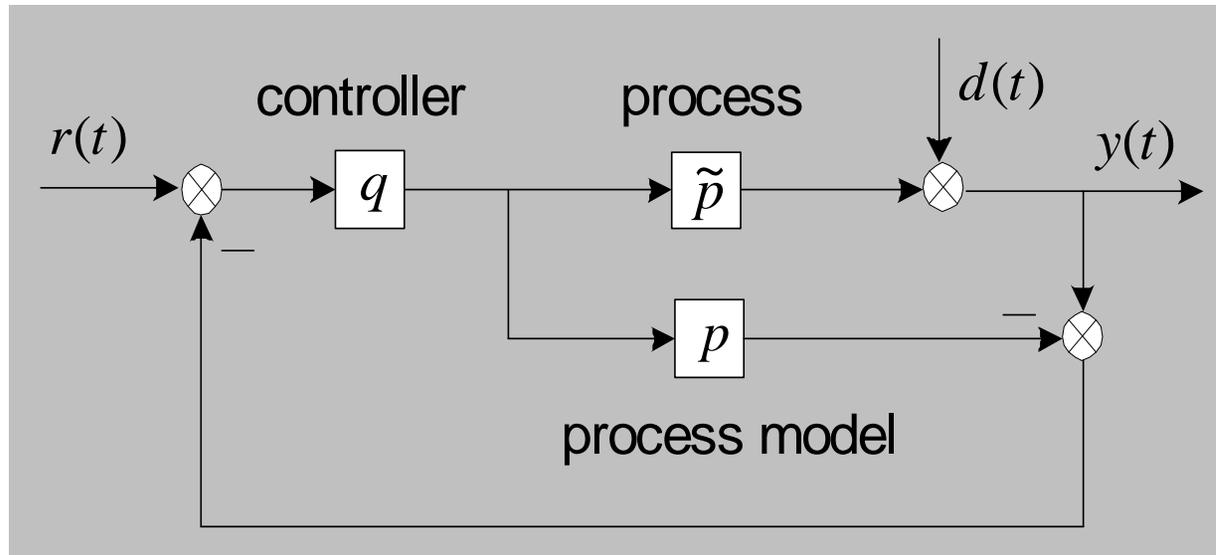
- More stable, on-line tuning, anti-windup, etc
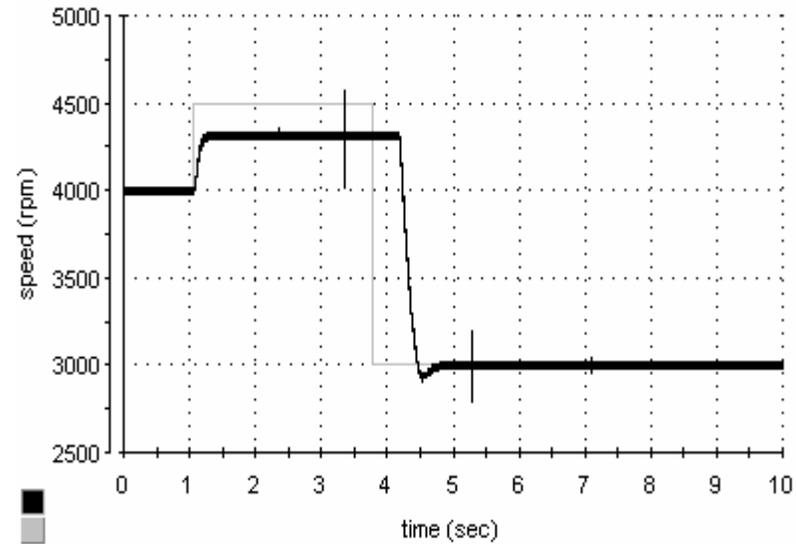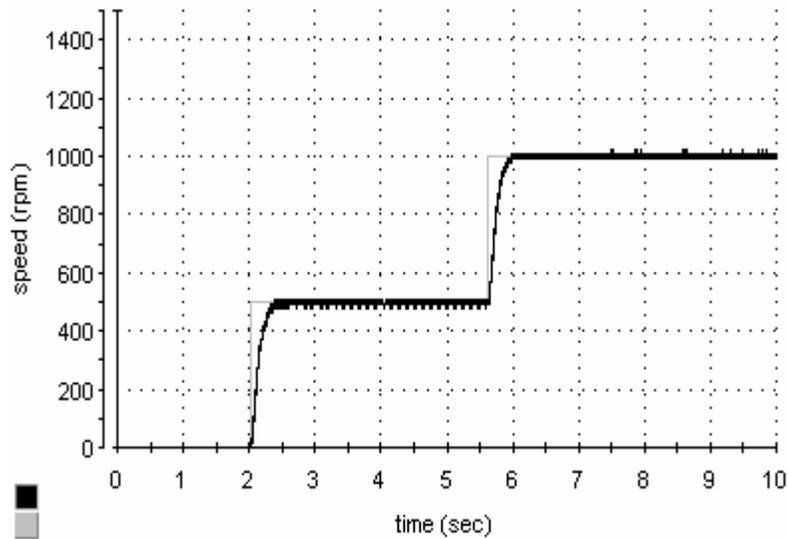- Transformation is needed: we can not rely on model uncertainty to construct the closed-loop structure.

Practical IMC model

- ◆ Input Saturation
- ◆ Modeling error

Physical Implementation

- **dSPACE DSP**

- **power converter**

- **PMDC motor, 200W, 5A, 42V**

- **PMSM motor, 250W, 5A, 42V**

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Robust Performance

- **Command tracking**
- **Input saturation**

Disturbance Rejection

The diagram shows a control system: i_{ref} enters a summing junction, then signal i passes through block K_T, producing T_{em}. The load torque T_L is subtracted at another summing junction, then through block $\frac{1}{Js+B}$, producing output ω. Feedback goes to a disturbance observer producing $\hat{T}_L$, then to a current compensator feeding back to the first summing junction.
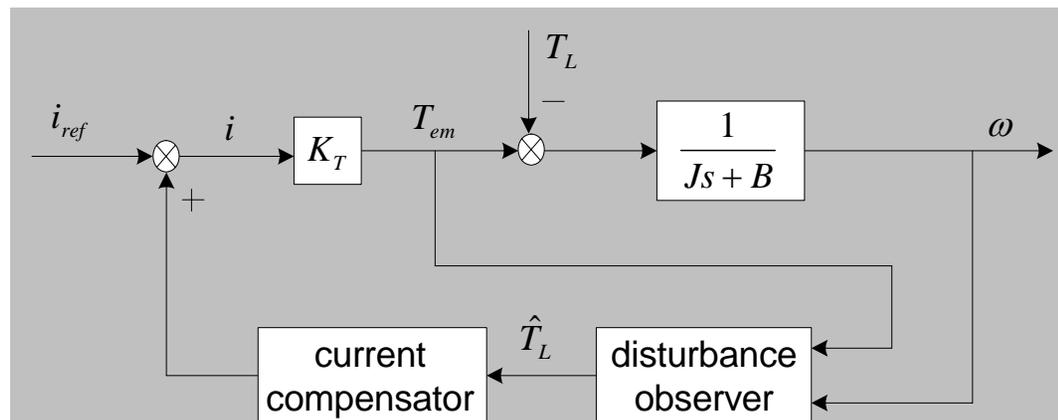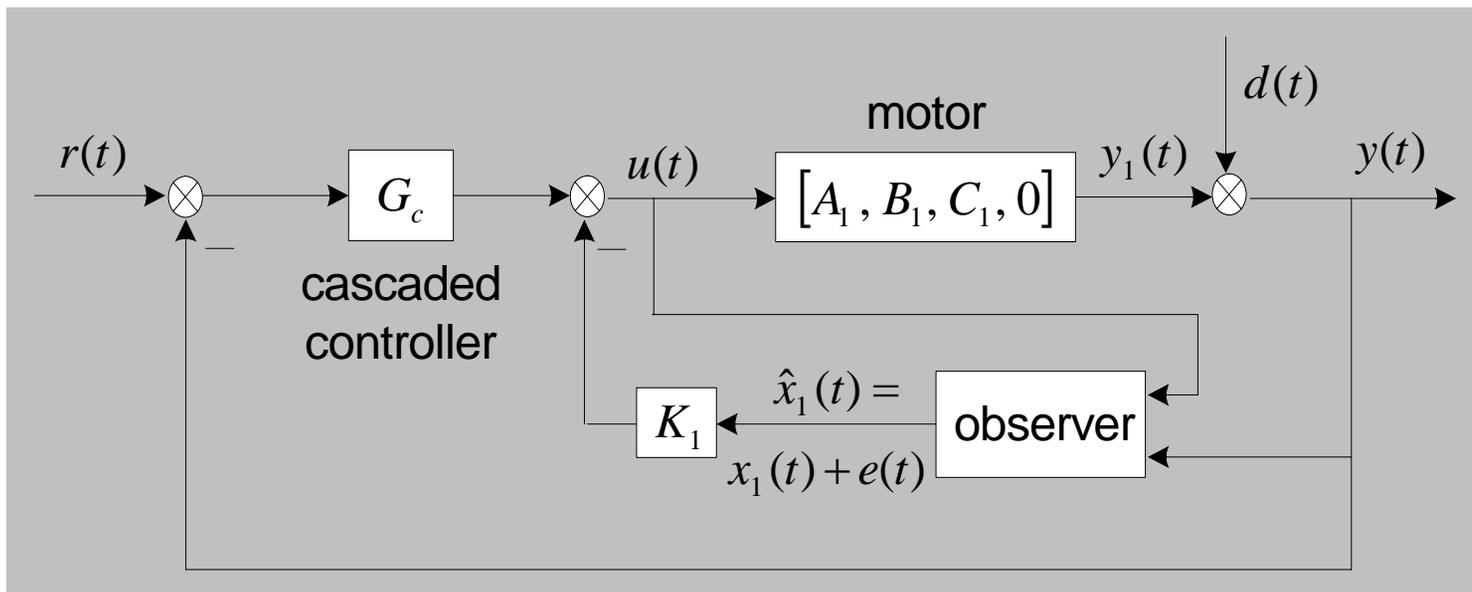
- ## **2DOF (2-degree-of-freedom)**

- ## **Advantage:**
  - ❖ satisfy the conflicted requirements of command tracking and disturbance rejection

- ## **Disadvantages:**
  - ❖ Fast depression leads to too much variation in control signal

Patented Novel Method

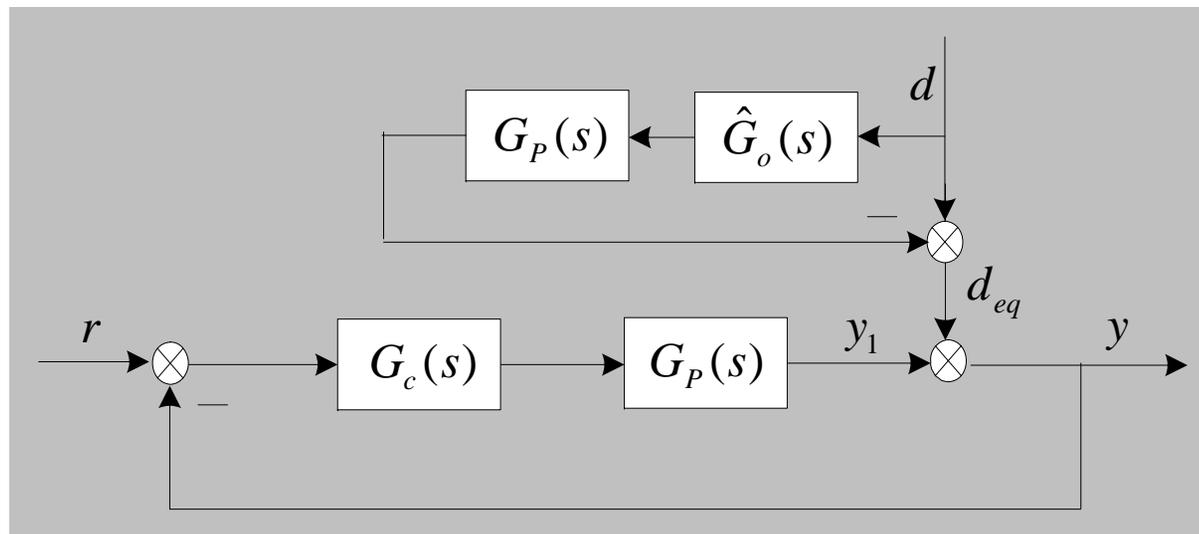- **Due to load disturbance, observation error is inevitable.**

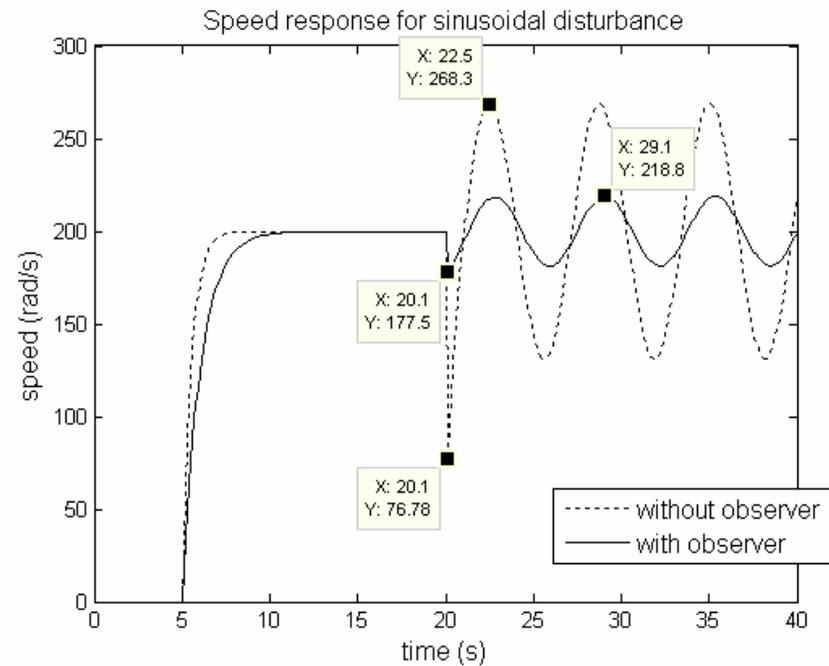$$\dot{e}(t) = (A_1 - J_o C_1)e(t) + J_o d(t)$$
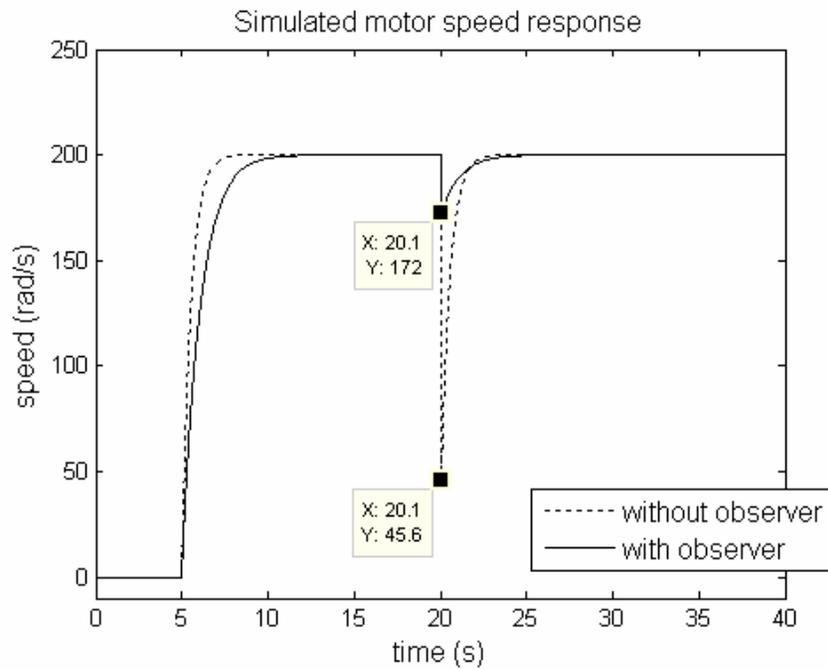
Feedforward Compensation

- **The observation error state feedback constructs a feedforward compensation for the load disturbance.**

- **The "residual disturbance" after compensation can be predicted as**

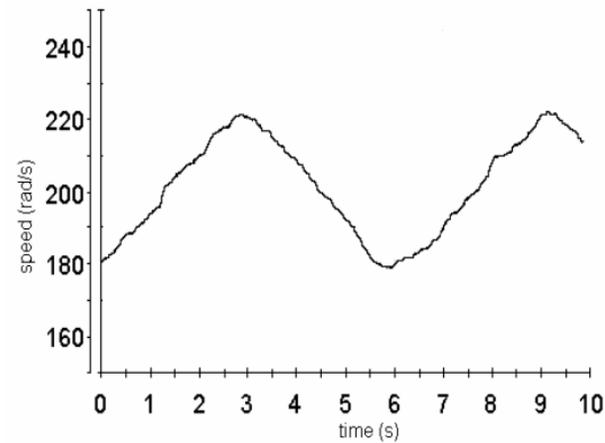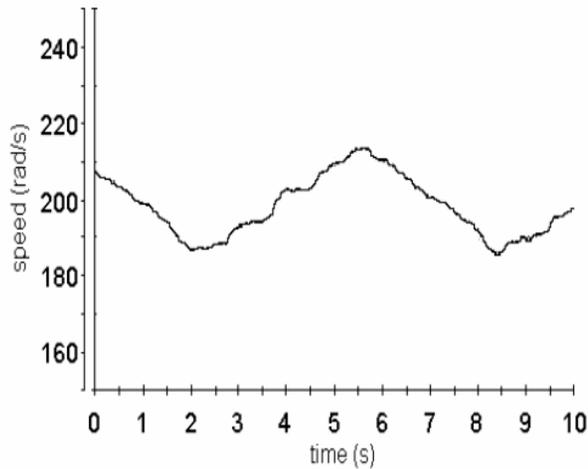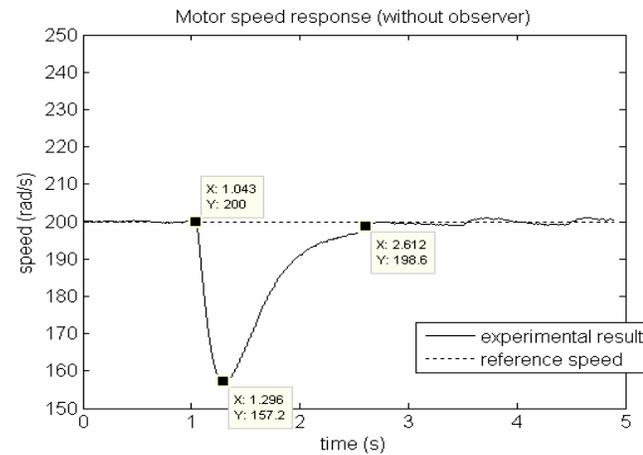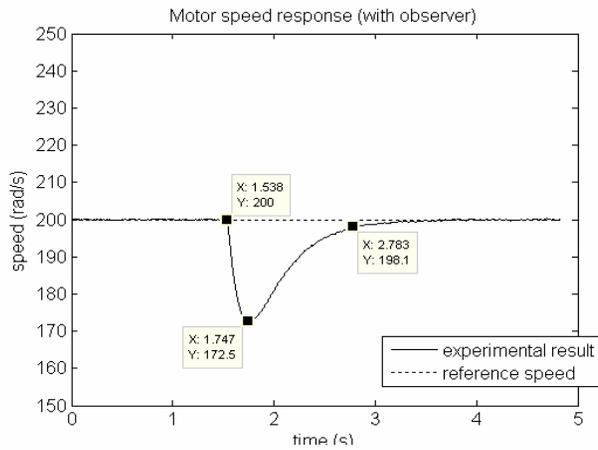$$d_{re}(s) = [I - G_P(s)\hat{G}_o(s)] \cdot d(s)$$

Simulated Results

- **Constant load disturbance**
- **Sinusoidal load disturbance**

Experiment Results

- ◆ **1/8 of the simulated load torque applied**

Patent and Publications

- Motor Control Method and Apparatus with Multi-Objective Observer for Disturbance Rejection, (Application No. 60666106).

1. W. Ali, Yongpeng Zhang, C.M. Akujuobi, C.L. Tolliver, L.S. Shieh, "DSP-based PID Controller Design for the PMDC Motor", *International Journal of Modeling and Simulation*, Vol. 22, No. 3, 2006, (in press).

2. Yongpeng Zhang, C.M. Akujuobi, W. Ali, L.S. Shieh, C.L. Tolliver, "Disturbance Resistance Speed Controller Design for PMSM", *IEEE Trans. On Industrial Electronics*, (accepted).

3. Yongpeng Zhang, C.M. Akujuobi, L.S. Shieh and X. Gu, "Observer-based Load Disturbance Compensation for Motor Drive with DSP Implementation", 31th Annual Conference of the IEEE Industrial Electronics Society (IECON'05), Raleigh, North Carolina, Nov 6-10, 2005.

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