Robust Motor Controller Design Implemented with TMS320F240 DSP

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Outline

- Introduction
- Internal Model Control
- Disturbance Rejection
- Summary
Advantages of Direct Motor Drive

- Simpler in mechanical structure, more reliable, of high performance.
Challenge and Solution

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

- **DSP Solutions:**
  - digital signal processors (DSP)
  - switch power devices
  - software (algorithm)
MATLAB/SIMULINK to Programs TI TMS320F240

- MATLAB/SIMULINK
- DSP programming (C / assembly)
Resulting Mixed-Signal System

- Hybrid system, or sampled-data system
- Analog system + digital controller
DSP-based Motor Drive System
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
Robust Performance

- Command tracking
- Input saturation
Disturbance Rejection

- **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
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**

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**Motor speed response (with observer)**

**Motor speed response (without observer)**

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**Speed (rad/s)**

**Time (s)**

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


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