Lab 10

IM Indirect Field Oriented Control

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EE-595S

Group Members

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Overview

- Objective
- Procedure
- Simulation
- Analysis of the effects of parameter variations
  - Torque Transducer
  - Transient Behavior
  - Steady-State Behavior
- Conclusion
- Questions

Objective

- Determine the effect of parameter sensitivity on field oriented control

Procedure

- Step 1. Determine the machine parameters from the provided Lab #10 data
- Step 2. Design the indirect field oriented controller using Lab #9 parameters
- Step 3. Compare the commanded torque to the machine's output torque
- Step 4. Study the effects of parameter variation

Indirect Field Oriented Control

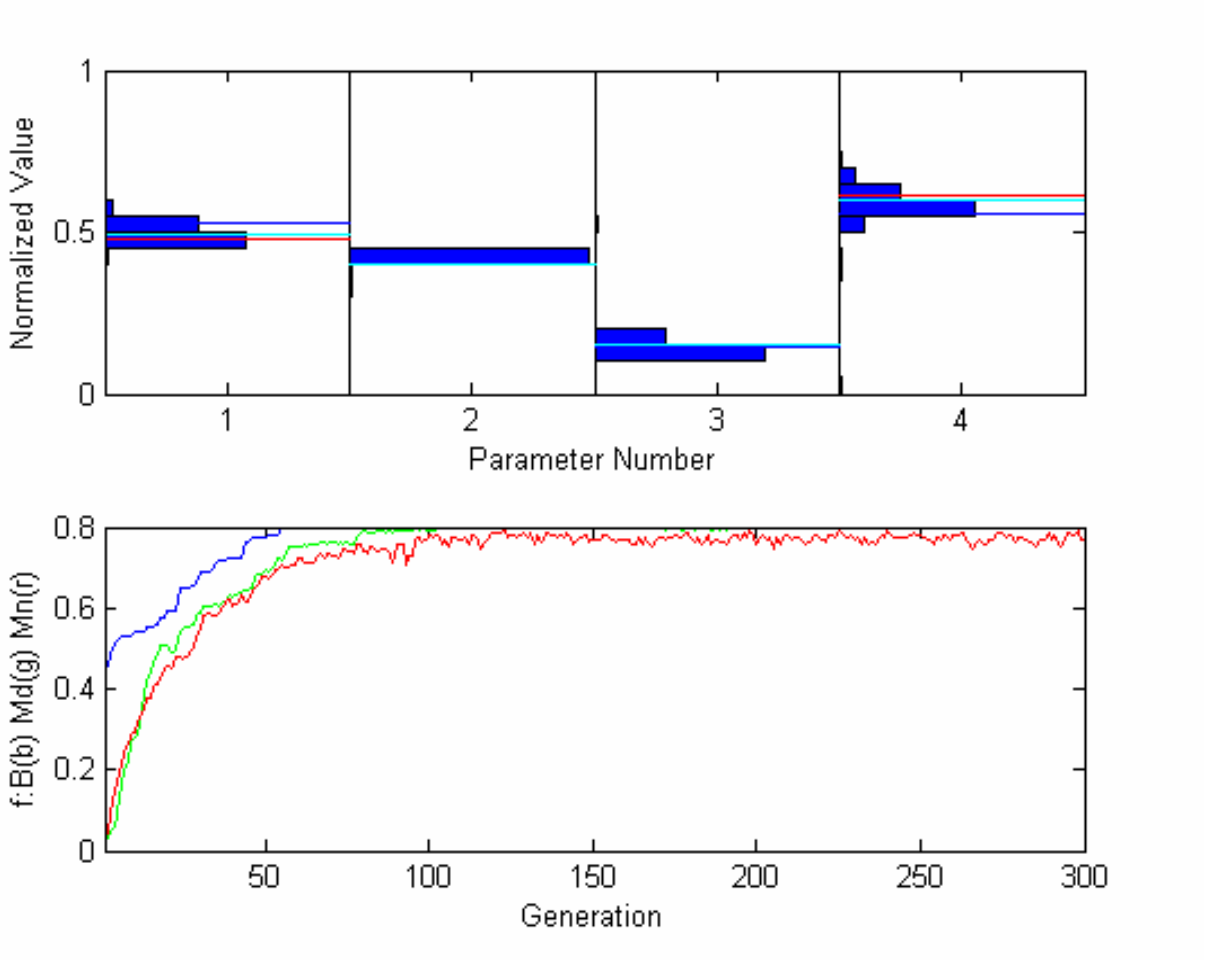


Figure 1 GOSET Parameter Approximation

Indirect Field Oriented Control

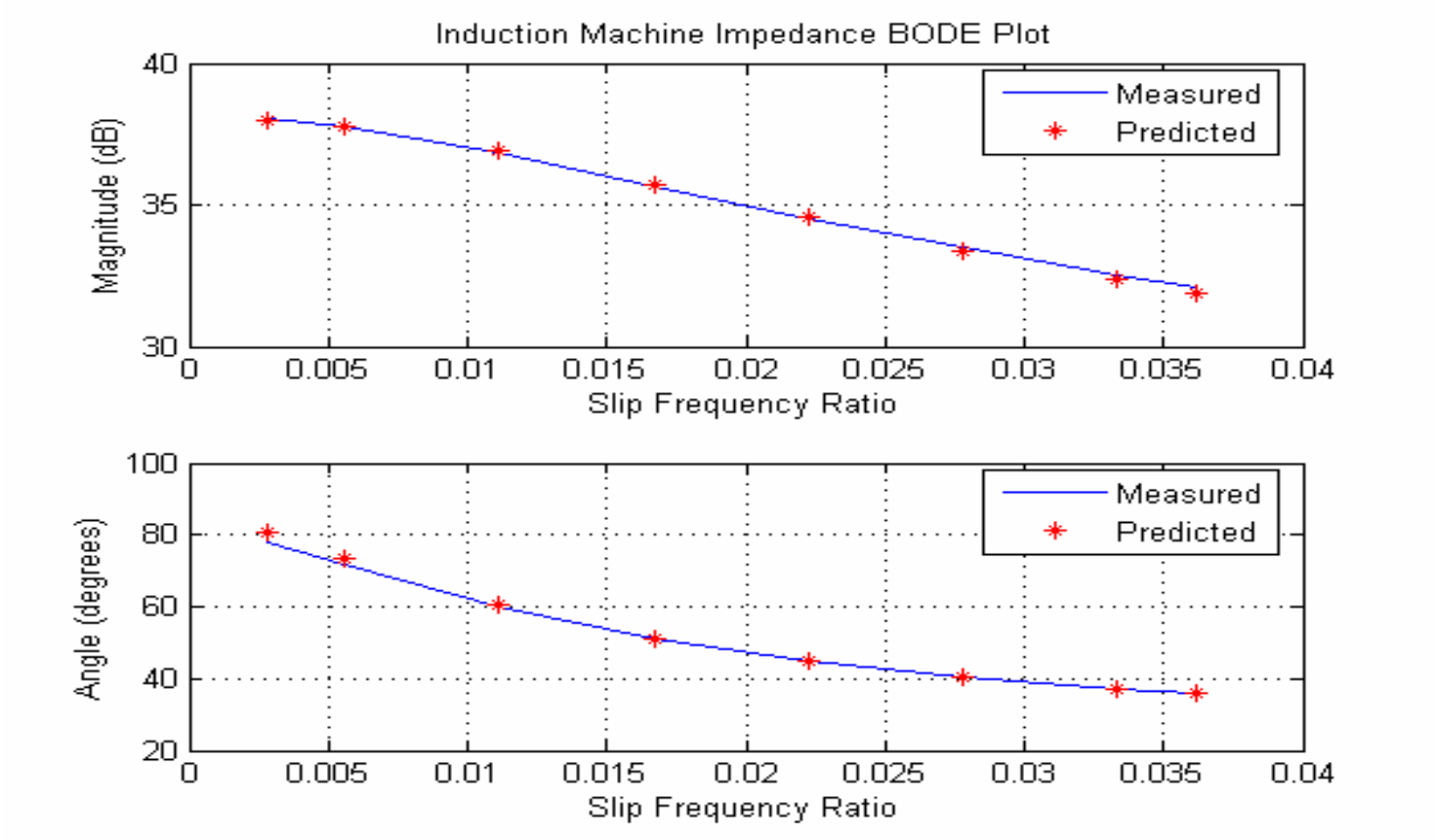


Figure 2 Impedance Magnitude and Phase Angle Diagrams

Indirect Field Oriented Control

Parameter	Lab # 9 Data	Lab # 10 Data
$\ell\ell s$	13.62 mH	9.88 mH
$\ell\ell r$	6.853 mH	11.94 mH
L_M	192.8 mH	202.26 mH
r'_r	1.156 Ω	1.499 Ω
r_s	2.125 Ω	2.515 Ω

Table 1 Parameters

Indirect Field Oriented Control

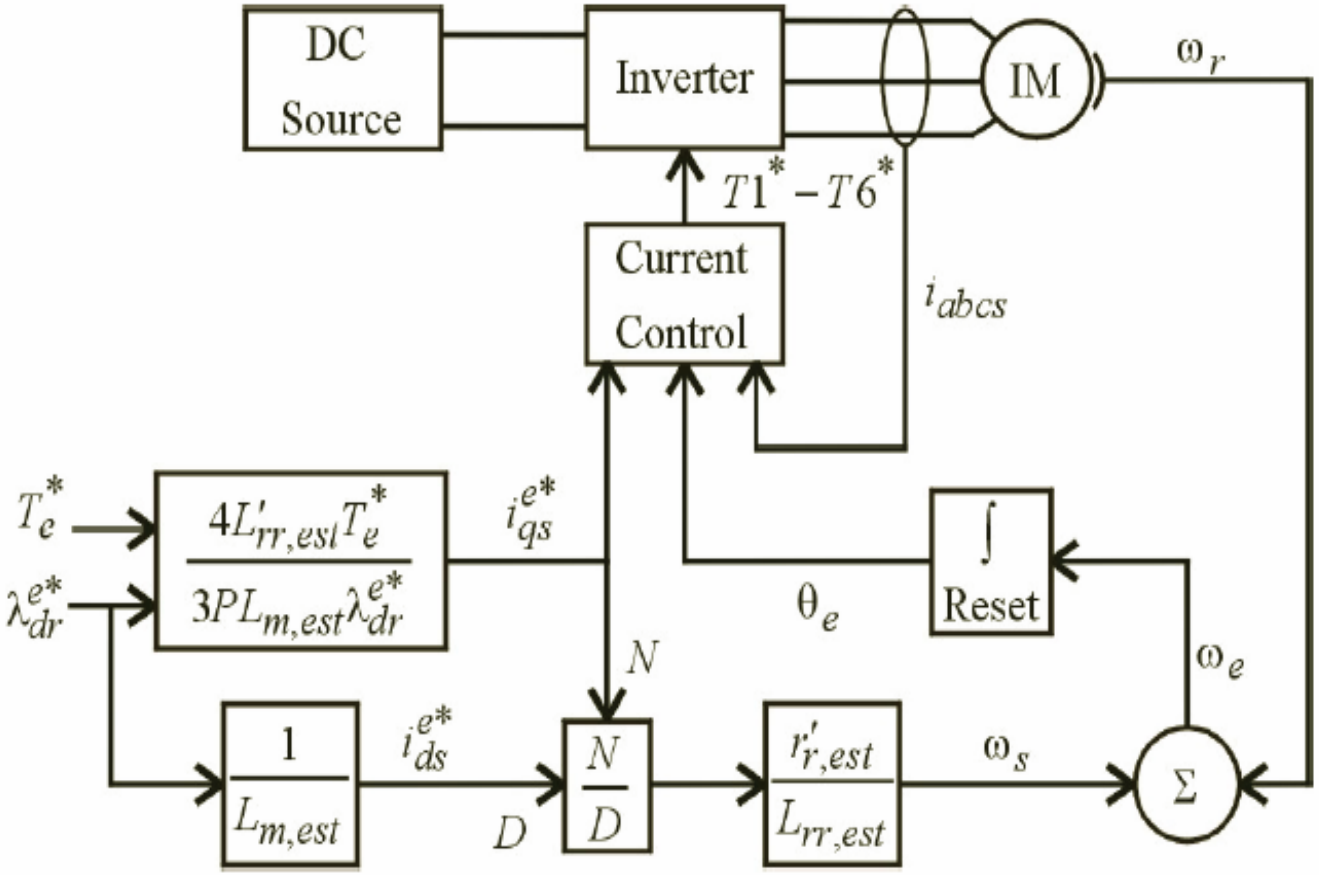


Figure 3 Indirect rotor field-oriented control

Indirect Field Oriented Control

Commanded flux linkage equation:

$$\lambda_{dr}^{e*} = \frac{230\sqrt{2}}{\sqrt{3}} \left| \frac{j\omega_e L_M}{rs + j\omega_e L_{\ell s} + j\omega_e L_M} \right| \frac{1}{\omega_e}$$

Commanded q and d axis currents:

$$i_{qs}^{e*} = \frac{4L_{rr,est}^{'} Te^{*}}{3PL_{m,est}\lambda_{dr}^{e*}} \qquad i_{ds}^{e*} = \frac{1}{L_{m,est}}$$

Frequency and position of the controller

$$\omega e = \omega r + \frac{r_r^{'}}{L_{rr}^{'}} \frac{i_{qs}^{e*}}{i_{ds}^{e*}} \qquad \text{where} \quad \omega s = \frac{r_r^{'}}{L_{rr}^{'}} \frac{i_{qs}^{e*}}{i_{ds}^{e*}}$$

$$\theta_e = \int \omega_e dt$$

Indirect Field Oriented Control

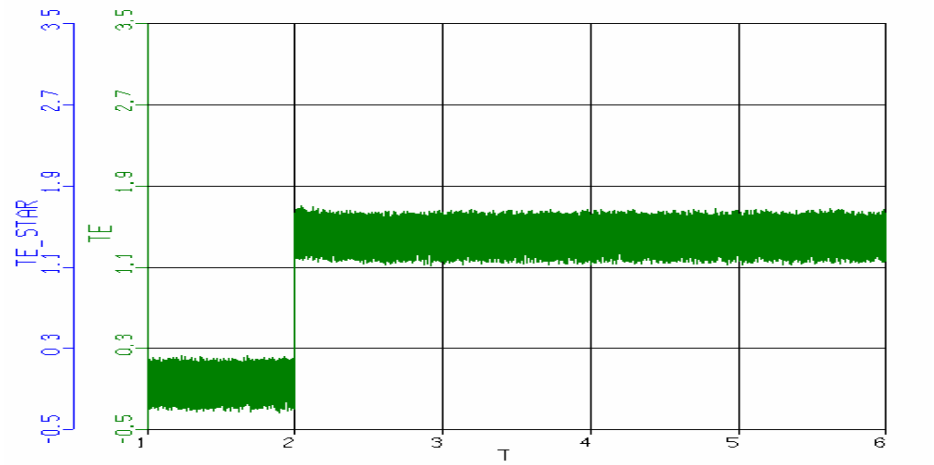


Figure 4

Indirect Field Oriented Control parameters are machine parameters

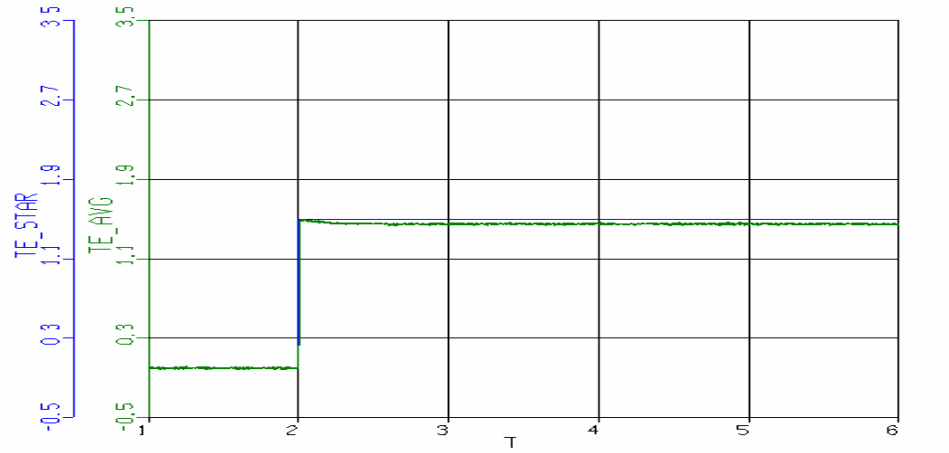


Figure 5

Low-Pass Filtered Output Torque

Indirect Field Oriented Control

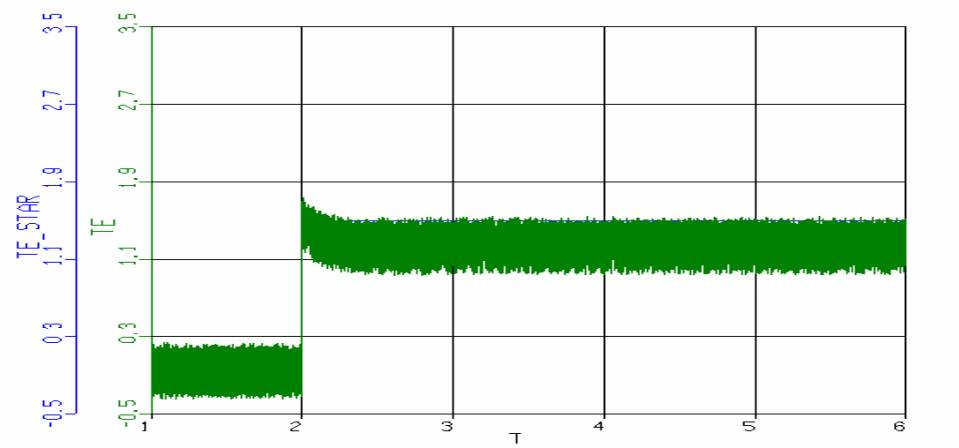


Figure 6

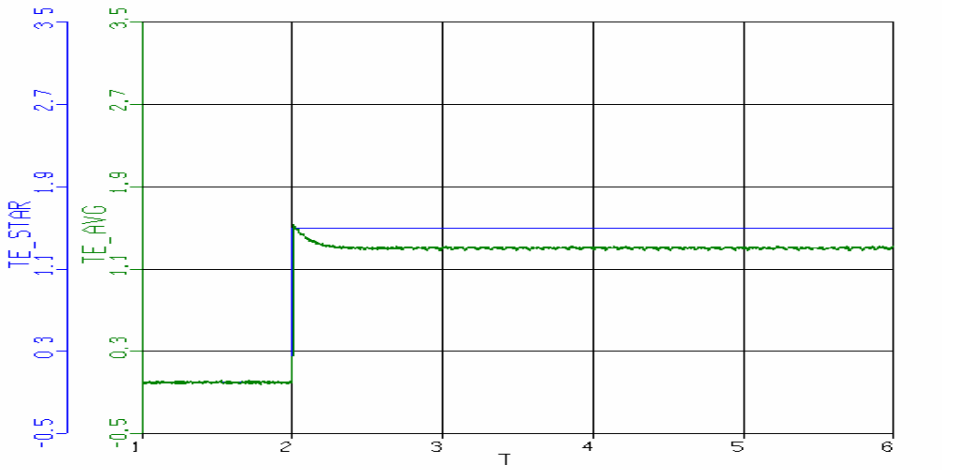


Figure 7

Indirect Field Oriented Control with estimated parameters from Lab#9

Indirect Field Oriented Control

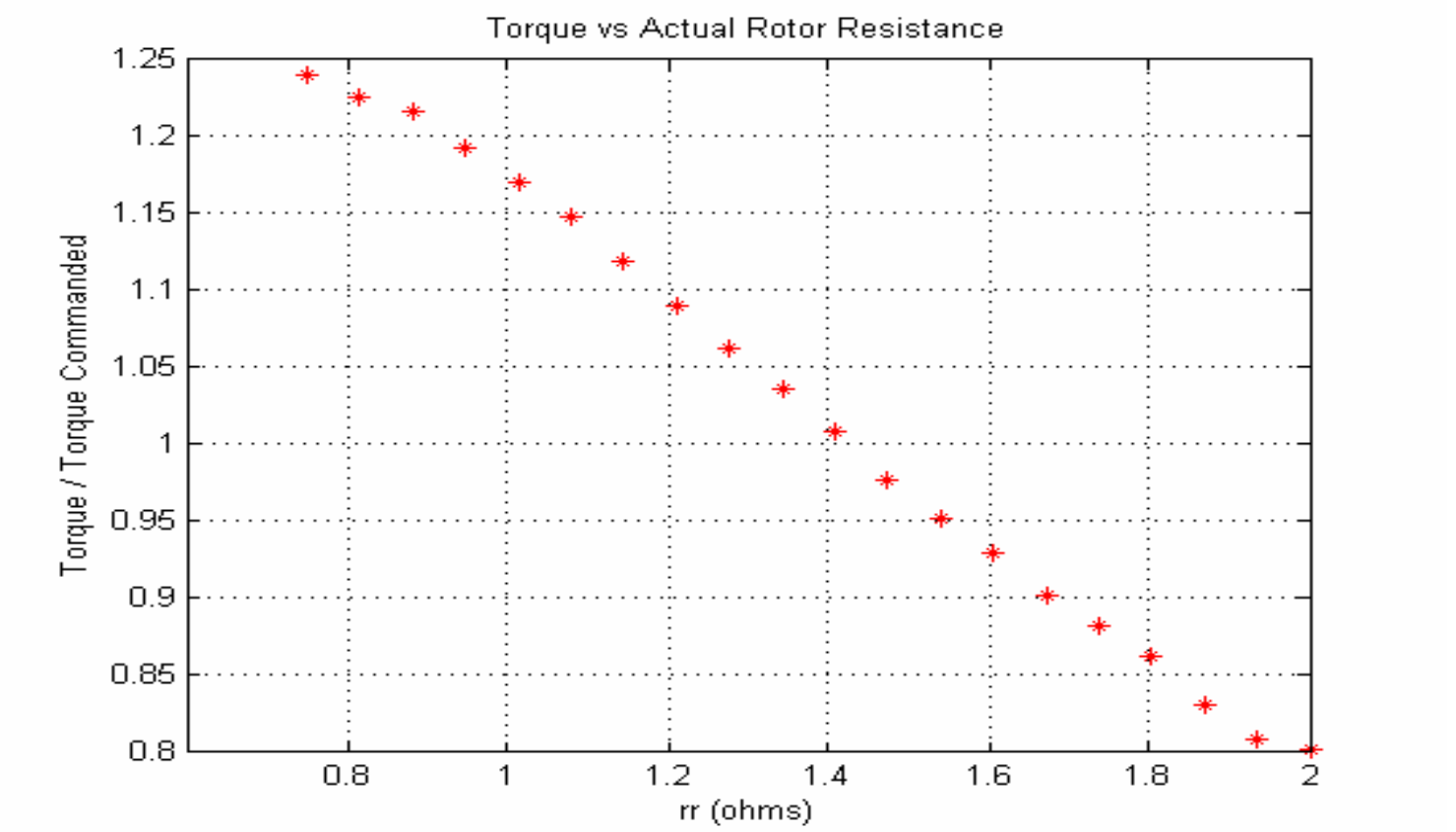


Figure 8

Indirect Field Oriented Control

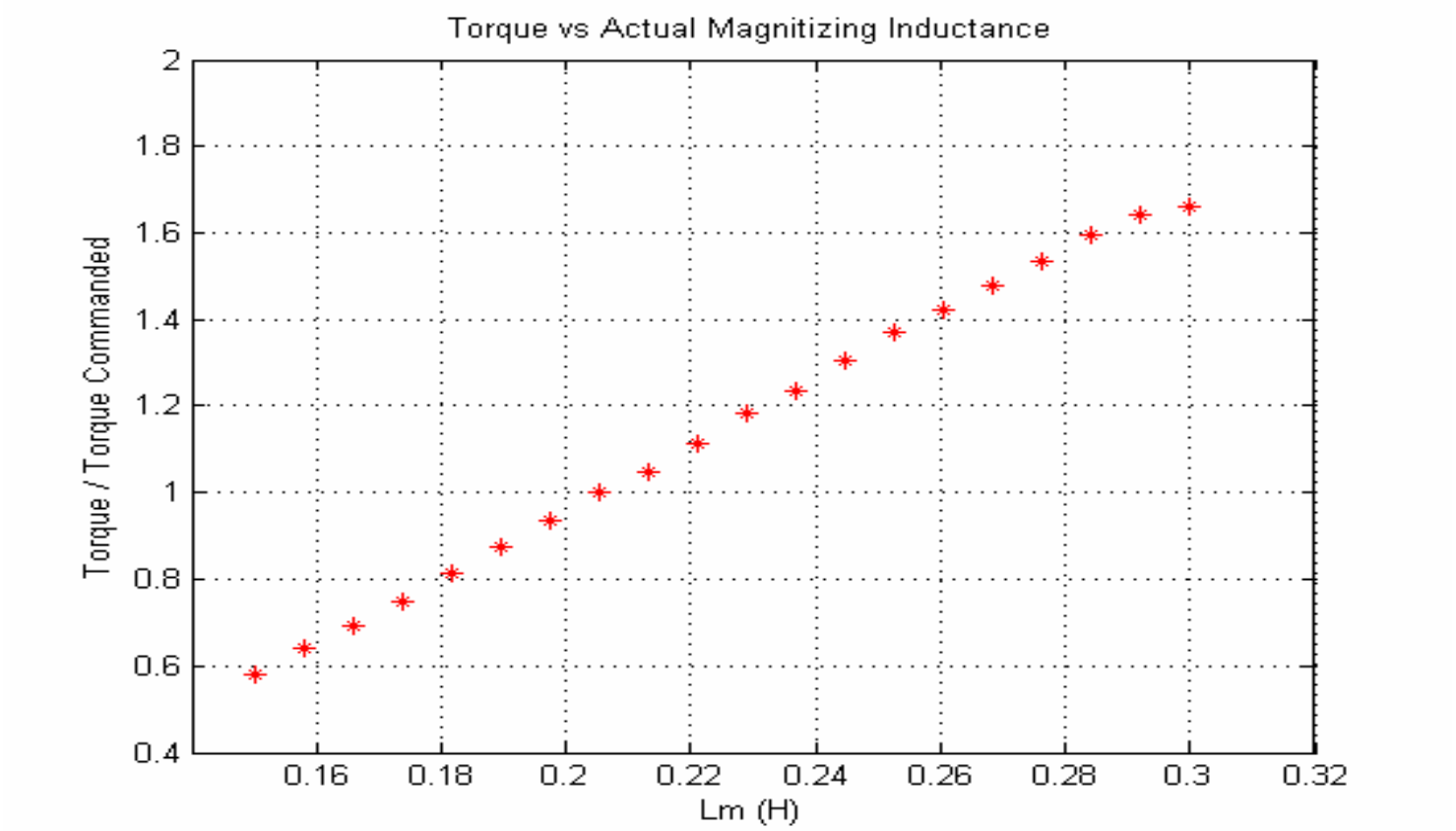


Figure 9

Indirect Field Oriented Control

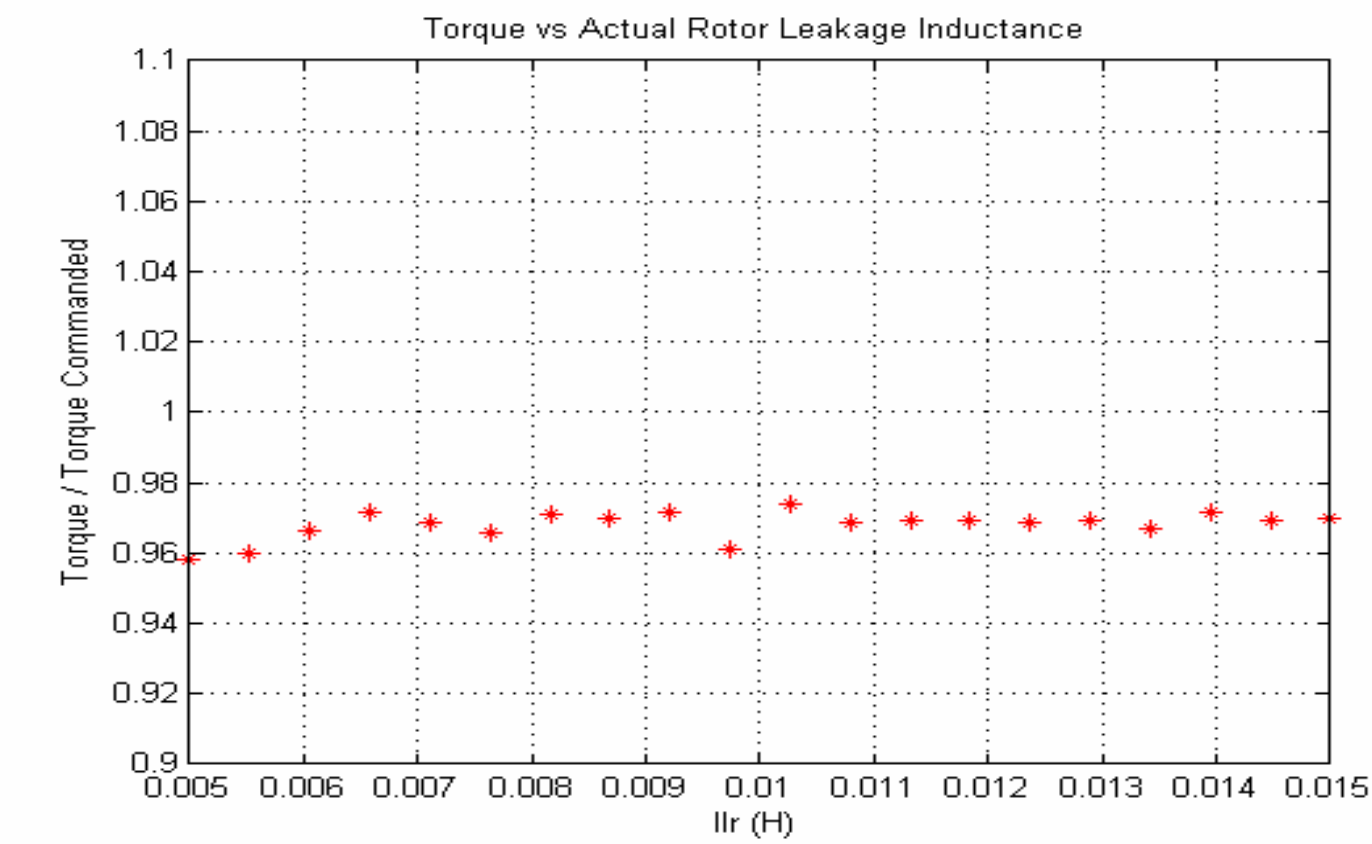


Figure 10

Indirect Field Oriented Control

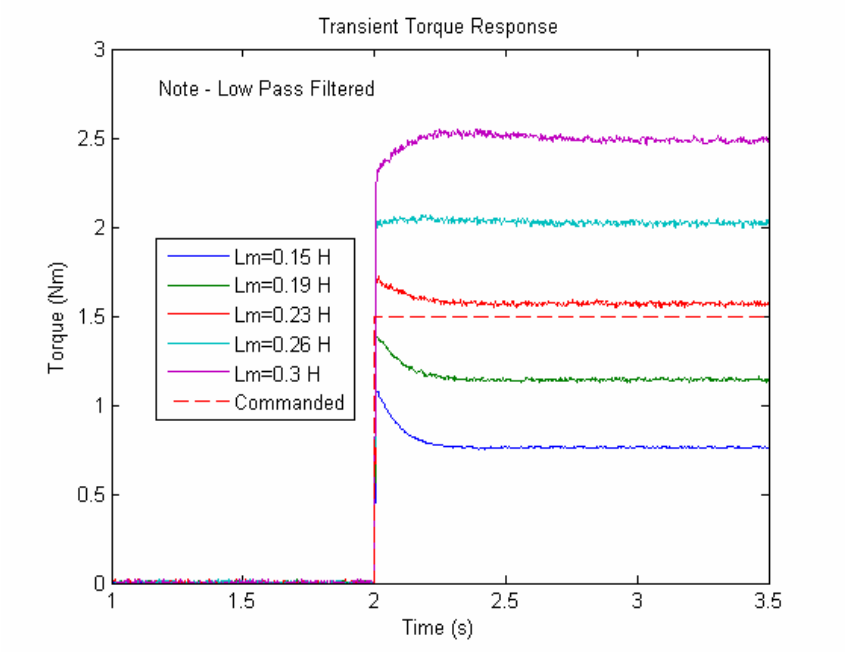


Figure 11

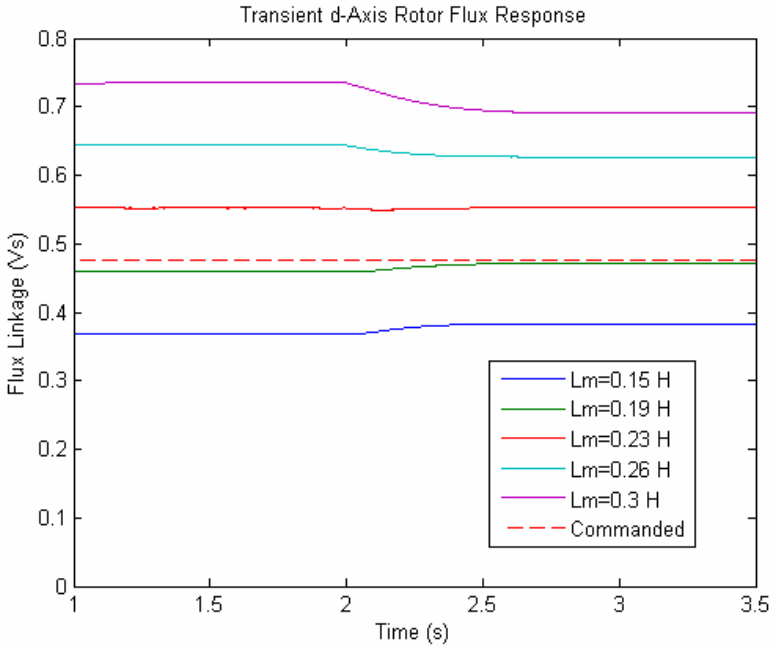


Figure 12

Indirect Field Oriented Control

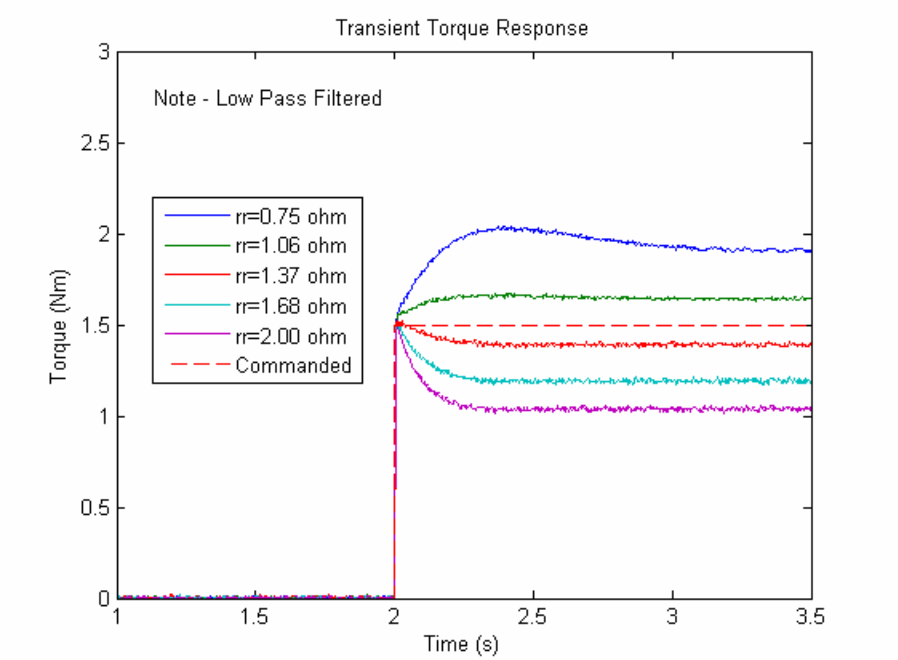


Figure 13

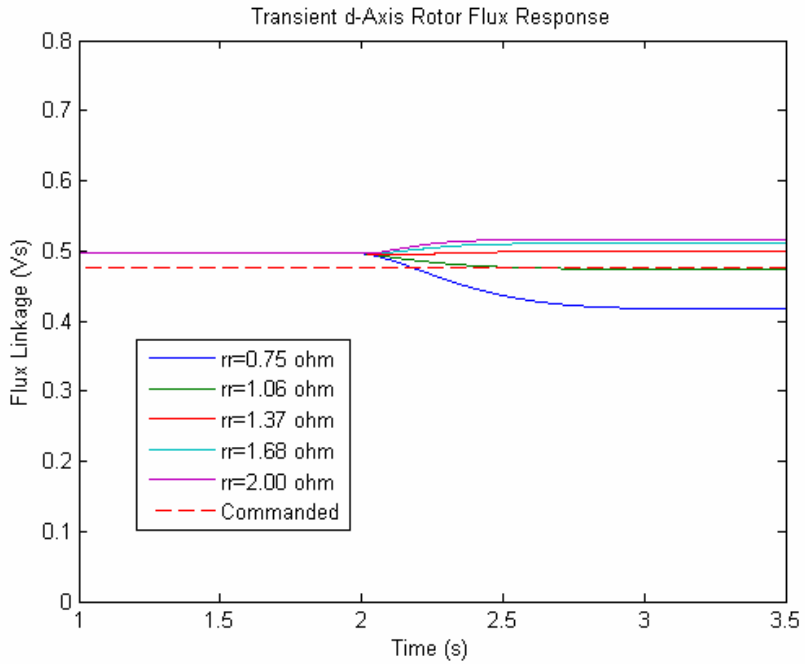


Figure 14

Indirect Field Oriented Control

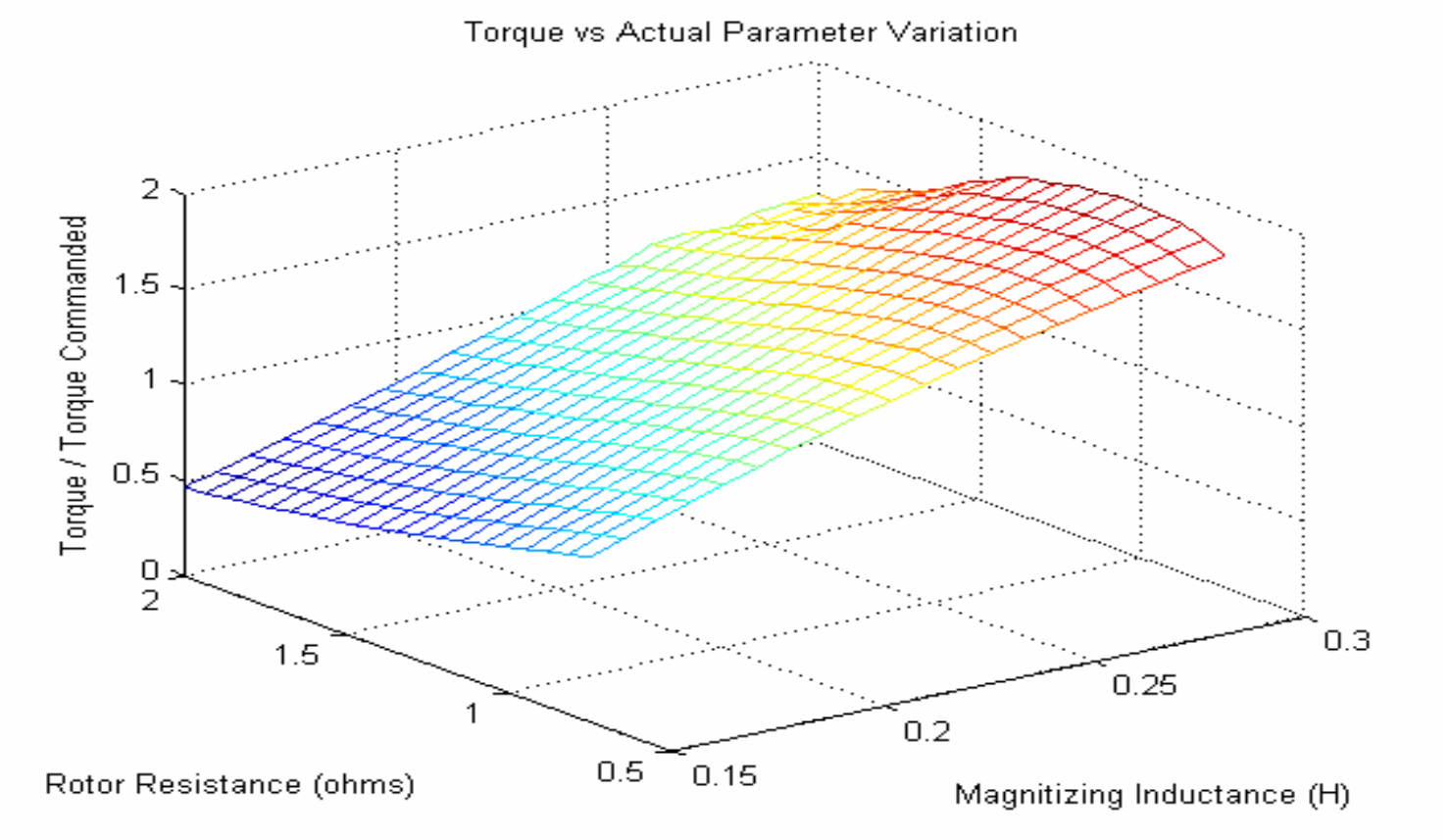


Figure 15

Indirect Field Oriented Control

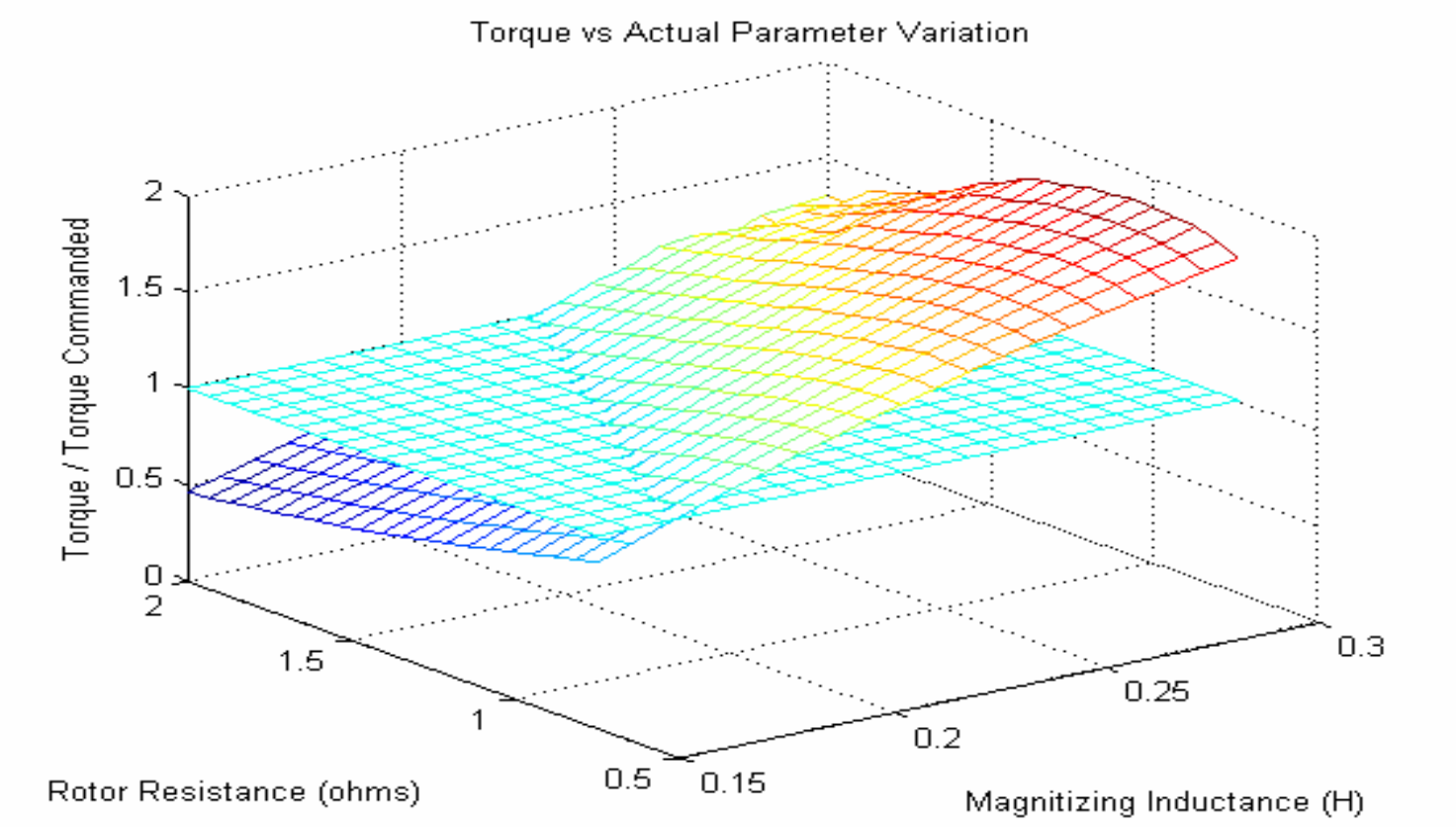


Figure 16

Indirect Field Oriented Control

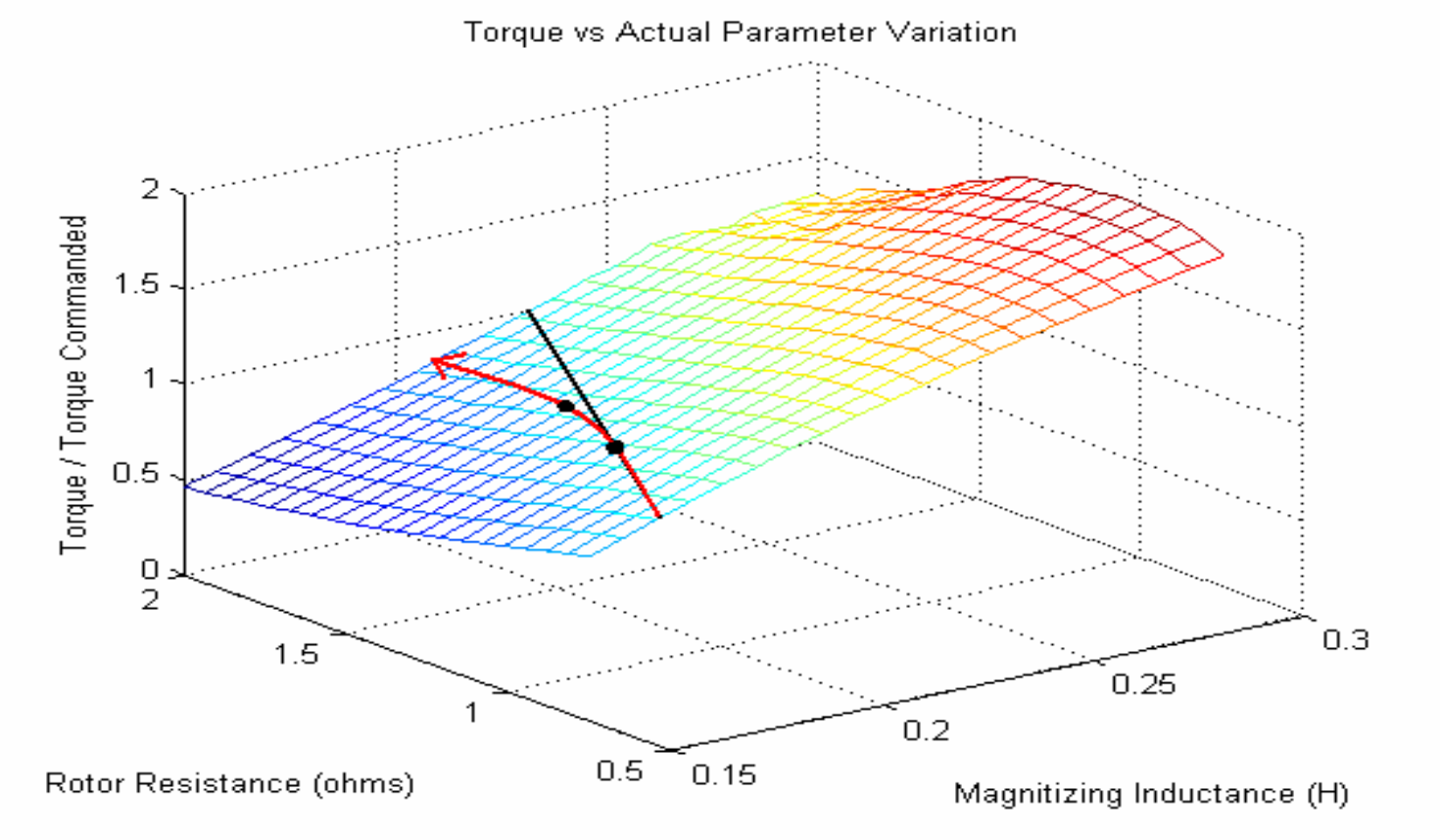
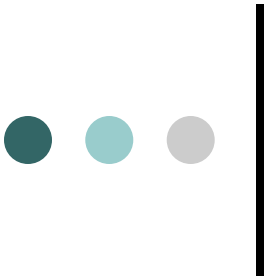


Figure 17

Conclusion

- Indirect Field Oriented Controller is sensitive to machine parameters
  - Especially sensitive to magnetizing inductance and rotor resistance
  - If torque error can be greater than 20%, then method is applicable as a torque transducer
    - examples: electric vehicle,robot



Questions?