

CONTROL I

ELEN3016

System Modelling

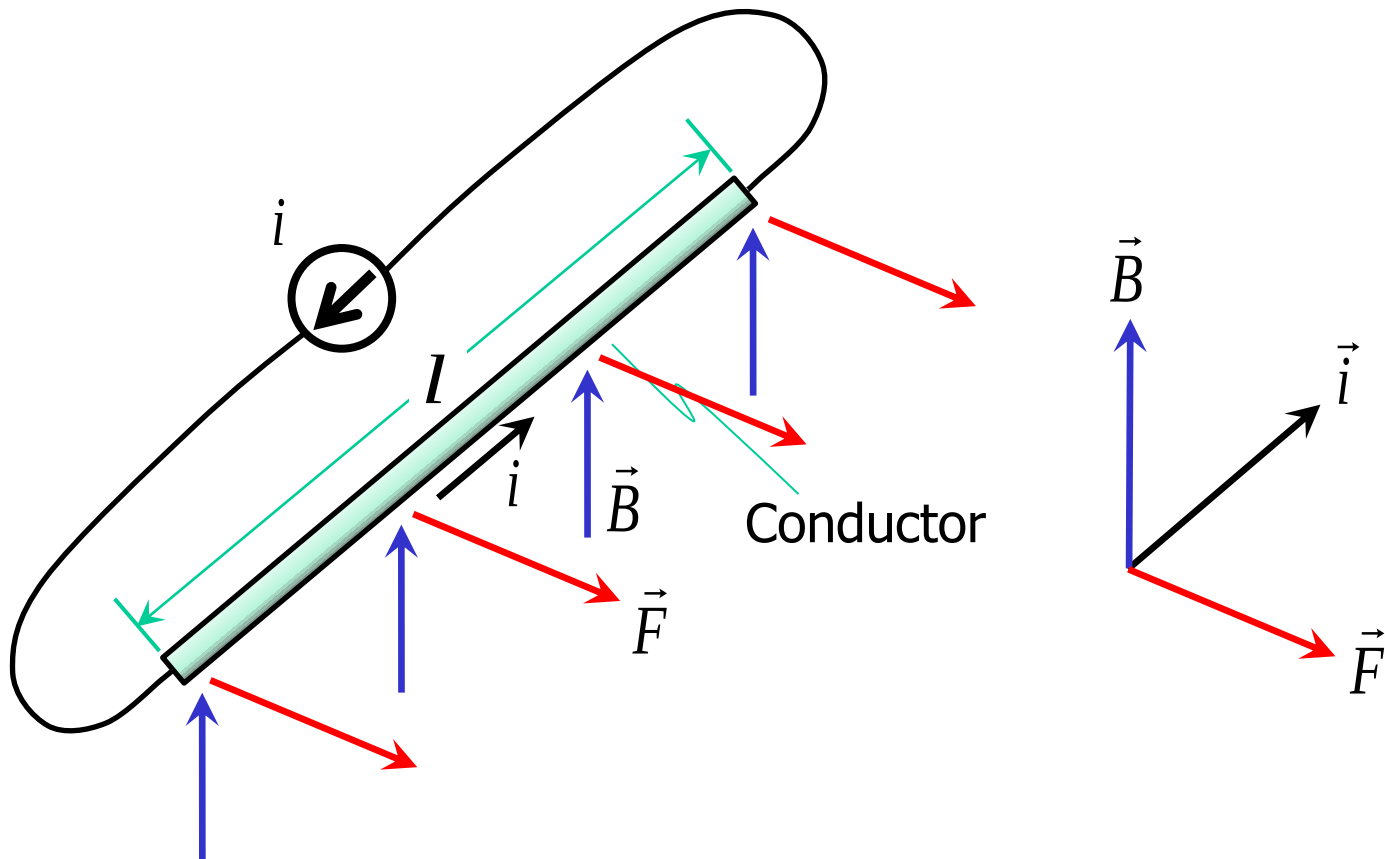
(Lecture 4)

Overview

- Electromechanical Energy Conversion
- Modelling of a PM DC Motor
- Tutorial Exercises & Homework
- Next Attraction!

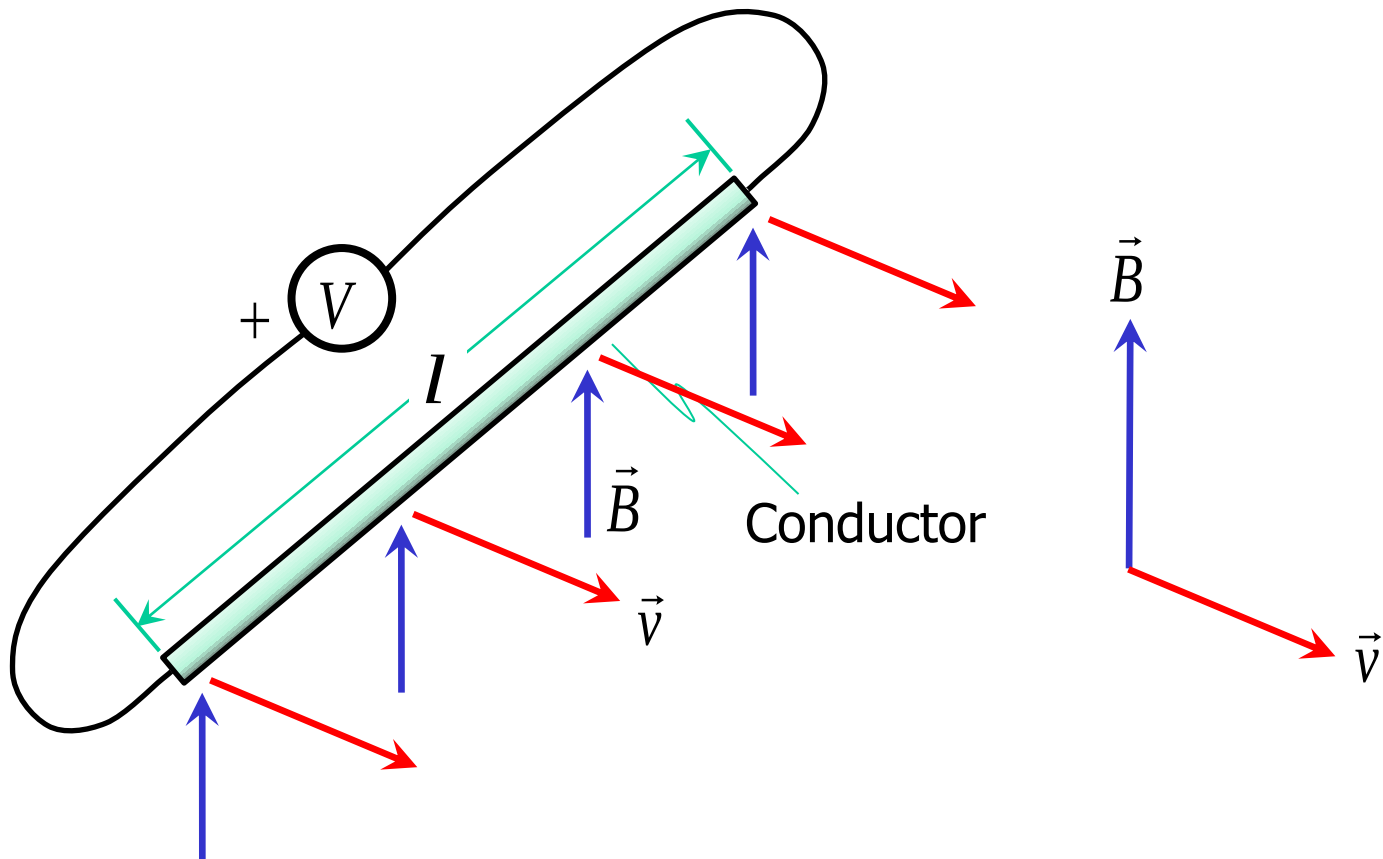
Electromechanical Systems

- Motor Law: $F = Bli$



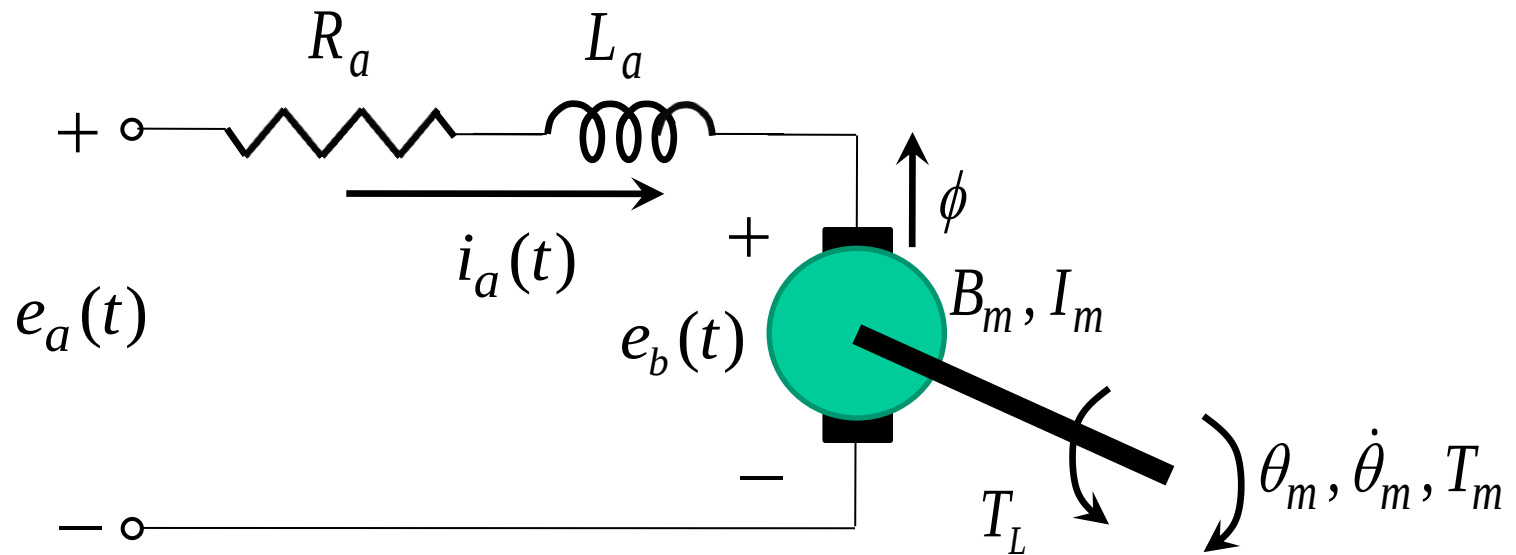
Electromechanical Systems

- Generator Law: $e = Blv$



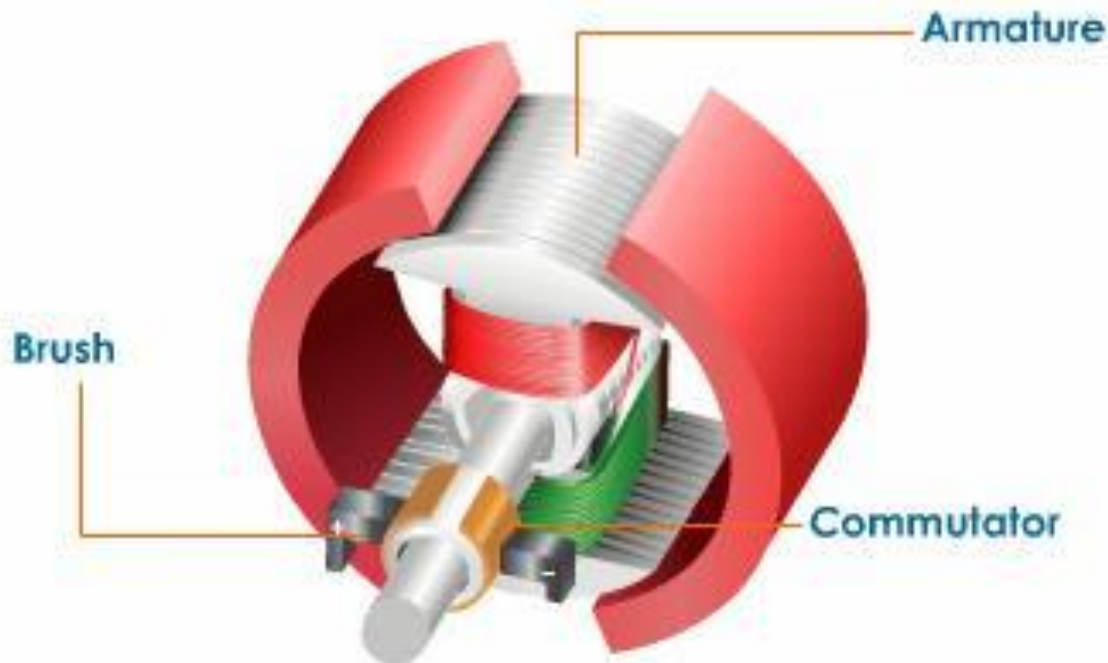
Electromechanical Systems

- Permanent-Magnet Direct-Current Motor



PM DC Motor

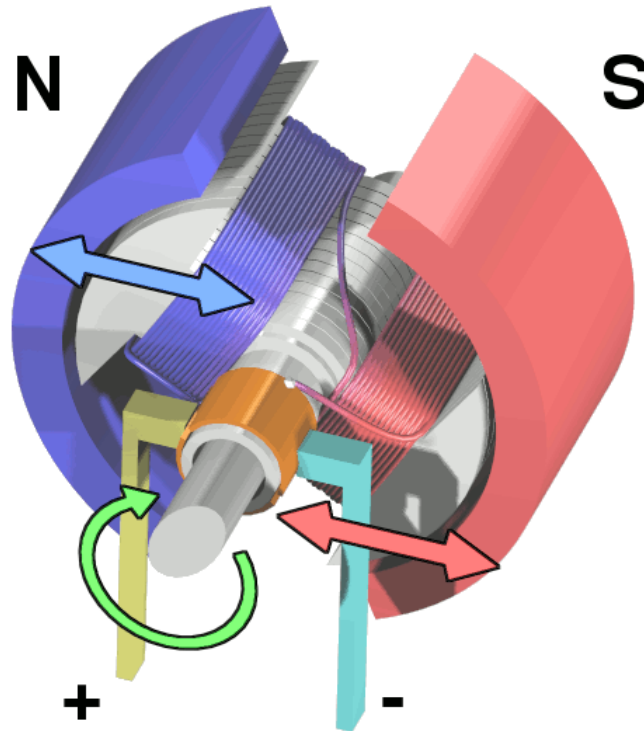
- Graphical Depiction of Construction



Parts of a DC Motor

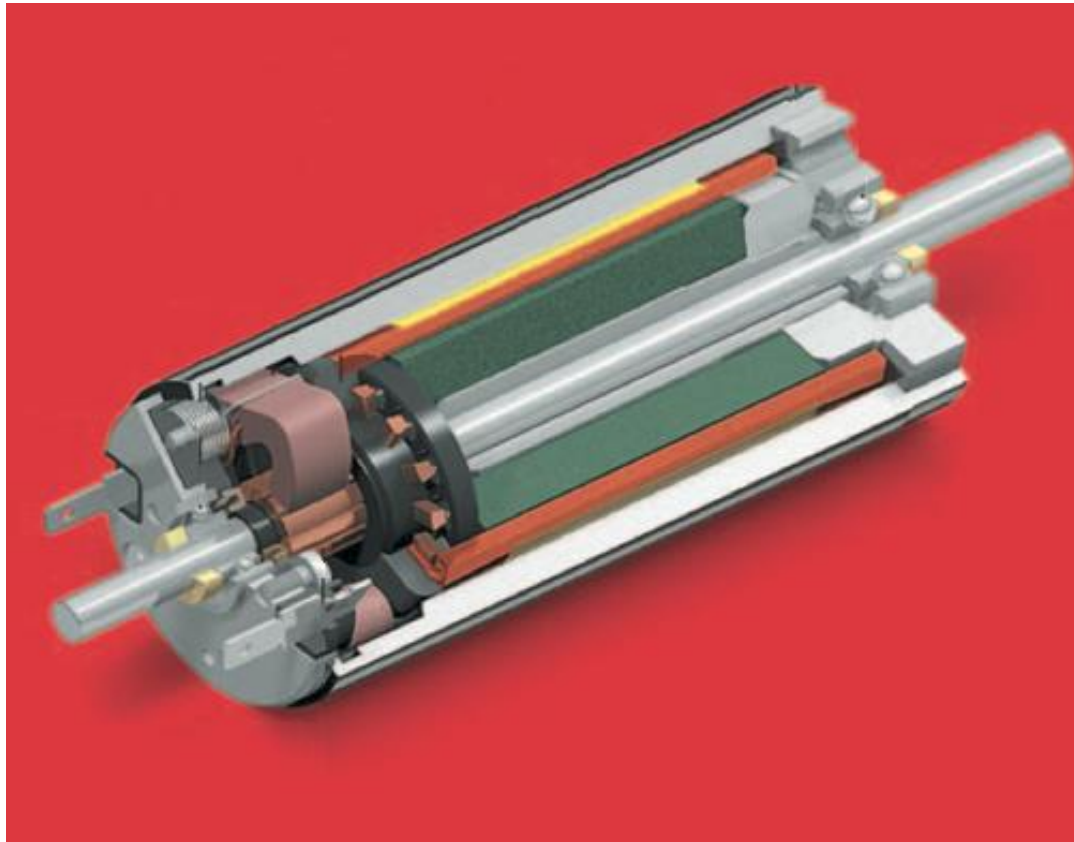
PM DC Motor

- Electromagnetic Forces



PM DC Motor

- Cross-Sectional View of a Real Motor



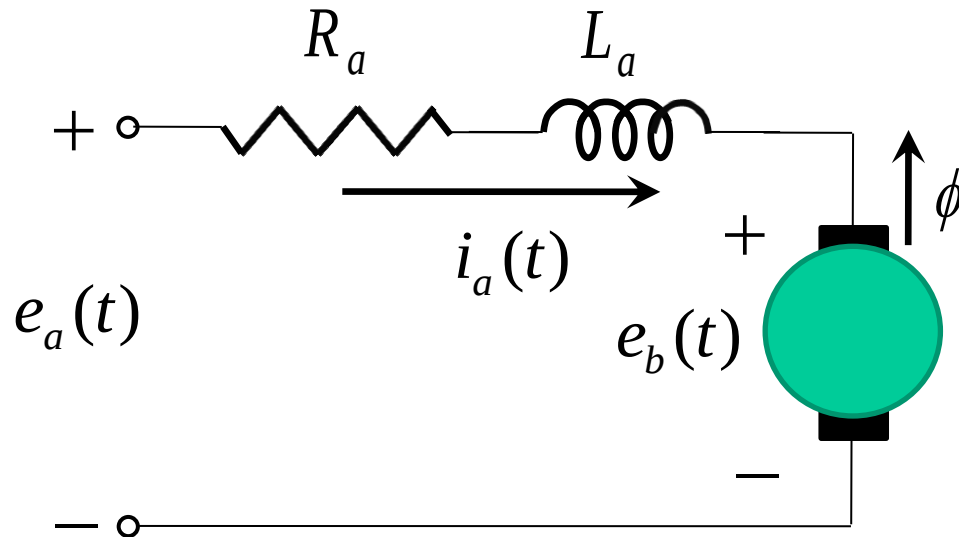
PM DC Motor

- Typical Specifications

... Precious Metal Brushes CLL, 1.6 W, sleeve bearings, 1 shaft			118643
1	Assigned power rating	W	1.6
2	Nominal voltage	Volt	3.00
3	No load speed	rpm	7740
4	Stall torque	mNm	4.07
5	Speed/torque gradient	rpm/mNm	1950
6	No load current	mA	27.0
7	Starting current	mA	1130
8	Terminal resistance	Ohm	2.66
9	Max. permissible speed	rpm ⁻¹	11000
10	Max. continuous current	mA	500
11	Max. continuous torque	mNm	1.81
12	Max. power output at nominal voltage	mW	811
13	Max. efficiency	%	71.9
14	Torque constant	mNm/A	3.61
15	Speed constant	rpm/V	2640
16	Mechanical time constant	ms	10.3
17	Rotor inertia	gcm ²	0.503
18	Terminal inductance	mH	0.05
19	Thermal resistance housing-ambient	K/W	35.00
20	Thermal resistance rotor-housing	K/W	8.20

Electromechanical Systems

- Electrical Side:



PM DC Motor

- Analysis of Electrical Side:

$$e_a(t) = v_{R_a}(t) + v_{L_a}(t) + e_b(t)$$

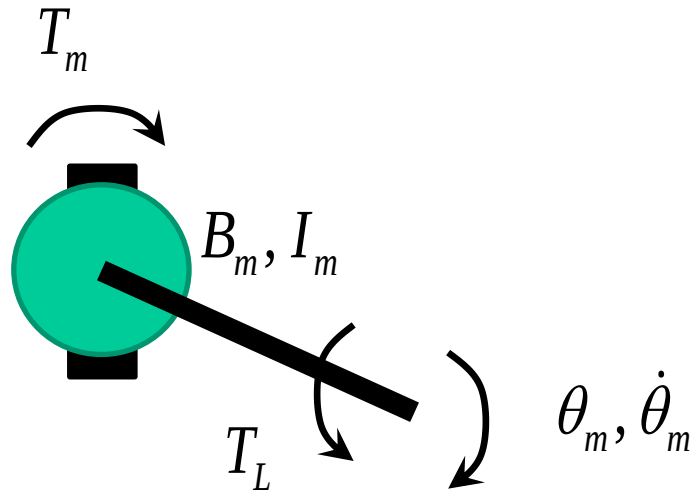
$$\frac{di_a(t)}{dt} = -\frac{R_a}{L_a} i_a(t) - \frac{1}{L_a} e_b(t) + \frac{1}{L_a} e_a(t)$$

$$e_b(t) = K_b \dot{\theta}_m(t) \quad (\text{Generator law})$$

$$K_b = \text{Back-emf constant [Vs/rad]}$$

Electromechanical Systems

- Mechanical Side:



PM DC Motor

- Analysis of Mechanical Side:

$$T_m(t) - T_L(t) - B_m \dot{\theta}_m(t) - I_m \ddot{\theta}_m(t) = 0$$

$$\ddot{\theta}_m(t) = \frac{1}{I_m} T_m(t) - \frac{1}{I_m} T_L(t) - \frac{B_m}{I_m} \dot{\theta}_m(t)$$

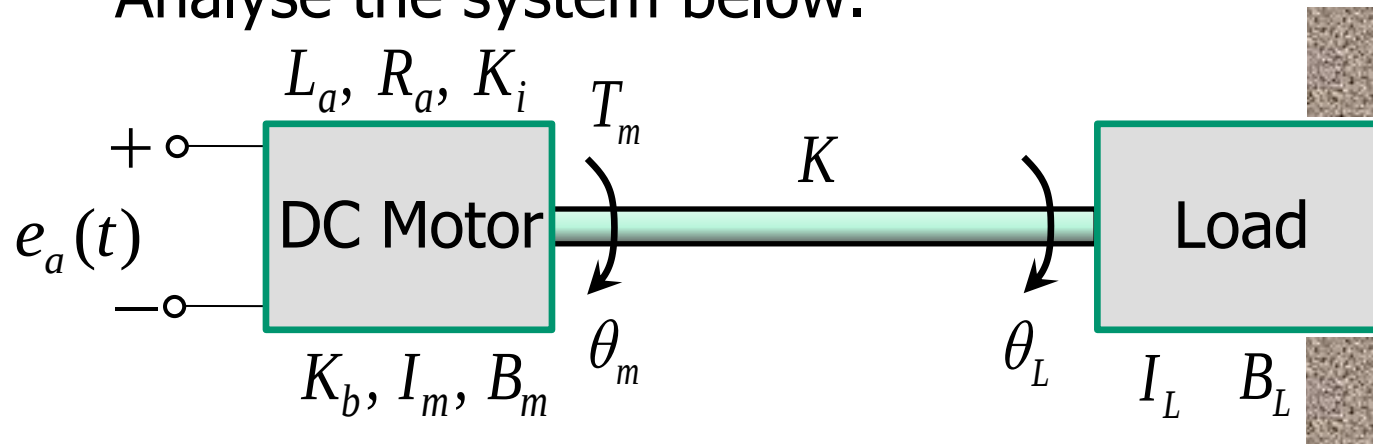
$$T_m(t) = K_i i_a(t) \quad (\text{Motor law})$$

$$K_i = \text{Torque constant [Nm/A]}$$

Tutorial Exercises & Homework

- Tutorial Exercises

- Analyse the system below.



- Homework

- Field-controlled DC motor (Burns, pp. 74–75).

Conclusion

- Electromechanical Systems
 - Principles of Electromechanical Energy Conversion
 - Modelling of a PM DC Motor
- Tutorial Exercises & Homework

Next Attraction! – Miss It & You'll Miss Out!

- Time Domain Analysis (Burns, Chapter 3)

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Thank you!
Any Questions?