TRANSILVANIA University of Braşov
Faculty of Electrical Engineering and Computer Science
Department of Electrical Engineering

CURRICULUM
for the Engineer Degree Diploma Exam 2009 at the subject:
ELECTRICAL ENGINEERING AND CONTROL SYSTEMS
Study programme: Electrical Engineering and Computers (in English)

A1) Electromagnetics

1. Definition of the vector electric polarization in terms of the electric moment of a multipol or an equivalent dipol. The explanatory drawing. Specify the denomination and the unit of measure for each quantity occurring in expression.
2. Relation between the tangential components of the electric field strength when passing from a medium to another. On what is based the derivation of this relation (enunciation without proof), explanatory drawing, unit of measure.
3. Relation between the normal components of the electric induction when passing from a medium to another. On what is based the derivation of this relation (enunciation without proof), explanatory drawing, unit of measure.
4. Biot-Savart-Laplace theorem. Explanatory drawing, denomination and unit of measure of each quantity occurring in formula.
5. Definition of inductances.

BIBLIOGRAPHY:
NICOLAIDE, Andrei: *Electromagnetics*, Transilvania University Press, Braşov. 2003.

A2) Electrical Circuit Theory

1. **Ideal elements of circuit**: The relationship between instantaneous voltage $u_c(t)$ and current $i(t)$ in a capacitor; The energy stored on a capacitor; The inductance of a coil; The relationship between instantaneous voltage $u_L(t)$ and current $i(t)$ in an inductor; The energy stored in a coil.
2. **DC circuits**: Millman's theorem; Thevenin's theorem; Norton's theorem; The maximum power transfer theorem; The power conservation theorem
3. **Transient regime:** The time constant of a series RL circuit; The time constant of a series RC circuit.
4. **AC circuits:** The root-mean-squre (r.m.s.) of an electric current; The root-mean-squre (r.m.s.) of a sinusoidal quantity; The angular frequency; The phasor representation of a sinusoidal quantity; Joubert's theorem; Powers under sinusoidal conditions; Power factor
5. **Three-phase circuits:** The relations between the line and phase values of the currents and voltages in the case of wye and delta connection; Powers absorbed by a three-phase load; Symmetrical components (Fortescue transformation)
6. **Non-sinusoidal regime:** The frequency spectrum; The root-mean-squre (r.m.s.) of a periodic non-sinusoidal quantity; Powers under non-sinusoidal conditions.

Bibliography
Nicolaide, A.: *Lecture notes*, 2005.

Examples of subjects (all subjects require short explanations)**:**

1. Definition of the vector electric polarization in terms of the electric moment of a multipol or an equivalent dipol. The explanatory drawing. Specify the denomination and the unit of measure for each quantity occurring in expression.
2. Relation between the tangential components of the electric field strength when passing from a medium to another. On what is based the derivation of this relation (enunciation without proof), explanatory drawing, unit of measure.
3. Relation between the normal components of the electric induction when passing from a medium to another. On what is based the derivation of this relation (enunciation without proof), explanatory drawing, unit of measure.
4. Biot-Savart-Laplace theorem. Explanatory drawing, denomination and unit of measure of each quantity occurring in formula.
5. Definition of inductances.
6. The energy stored on a capacitor
7. The maximum power transfer theorem
8. The time constant of a series RC circuit
9. The angular frequency
10. Powers under sinusoidal conditions

B1) System theory and Control systems

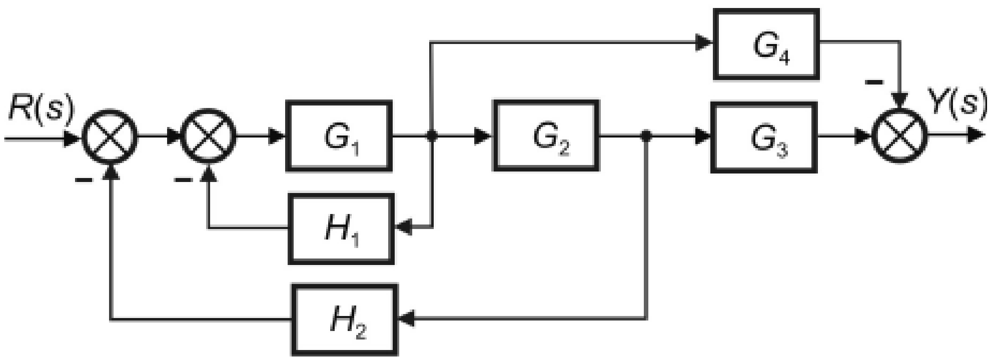
a. **The Fundamentals of the System Theory**: The Laplace Transform. Inverse Laplace Transform, Transfer Function. Block Diagrams
b. **Transient-Response Analysis:** Second-Order Systems, Time response specifications (rise time, peak time, maximum overshoot, settling time), Routh's Stability Criterion
c. **Frequency-Response Analysis:** Bode Diagrams
d. **Root-Locus Analysis:** General Rules For Constructing Root-Loci. Example
e. **Industrial Automatic Controllers:** Effects of Integral and Derivative Control Actions on System Performance, Examples of PI, PID Controllers

BIBLIOGRAPHY:

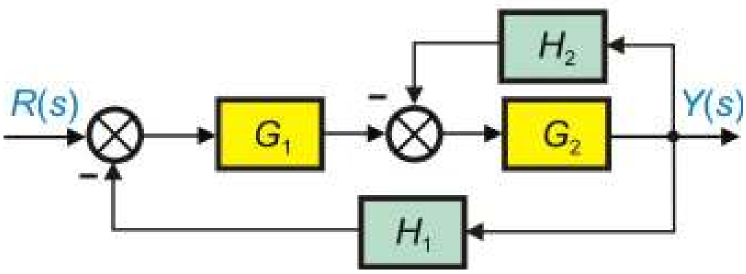
- Comnac, V., Tollet, I., Lahti, S. *Simulation of the Control Systems Used in Electrical Processes*, Formă electronică: http://vlab.unitbv.ro/velab/
- Dumitrache, I., Dumitriu, S., Mihu, I., Munteanu, F., Muscă, Gh., Calcev, C. *Automatizări Electronice* (*Electronic Control Engineering*). Editura Didactică şi Pedagogică, 1993
- Ogata, K. *Modern Control Engineering*. 4th ed., Prentice Hall Englewood Cliffs, N. J., 1990
- Dorf, R. S., Bishop, R. H. *Modern Control Systems*. 9th ed., Prentice Hall, Englewood Cliffs, N. J., 2001
- Suciu, C.: *Lecture notes*, 2006.

Examples of subjects

1. Find time function $f(t)$ for the Laplace transform $F(s) = \frac{s+4}{s^2+4s+13}$.
2. Find time function $f(t)$ for the Laplace transform $F(s) = \frac{s+3}{(s+1)(s^2+4s+8)}$
3. Determine the equivalent transfer function for the system with the block diagram in the following Figure



4. Determine the equivalent transfer function for the system with the block diagram in the Figure.



5. Consider the second order system with transfer function

$$\frac{Y(s)}{R(s)} = \frac{25}{s^2 + 6s + 25},$$

where $\zeta = 0{,}6$ and $\omega_n = 5$ rad/s. Determine damping ratio, ζ, natural undamped frequency, ω_n, the rise time t_r (for 0 -100% definition), the peak time, t_p, and the settling time, t_s (for 2% tolerance band).
6. Consider the unity–feedback system with the open–loop transfer function:

$$G(s) = \frac{K}{(25s+1)(5s+1)(s+1)}.$$

Determine the range of K values for a stable closed–loop system. Assume that $K > 0$.
7. Consider the unity–feedback system with the open–loop transfer function:

$$G(s) = \frac{K}{s(s+7)(s+11)}.$$

Determine the range of K values for a stable closed–loop system. Assume that $K > 0$.
8. Given the system with the open–loop transfer function

$$G(s) = 10\frac{s+10}{s+1}.$$

Draw the approximate log–magnitude and phase curves;
9. Given the system with the open–loop transfer function

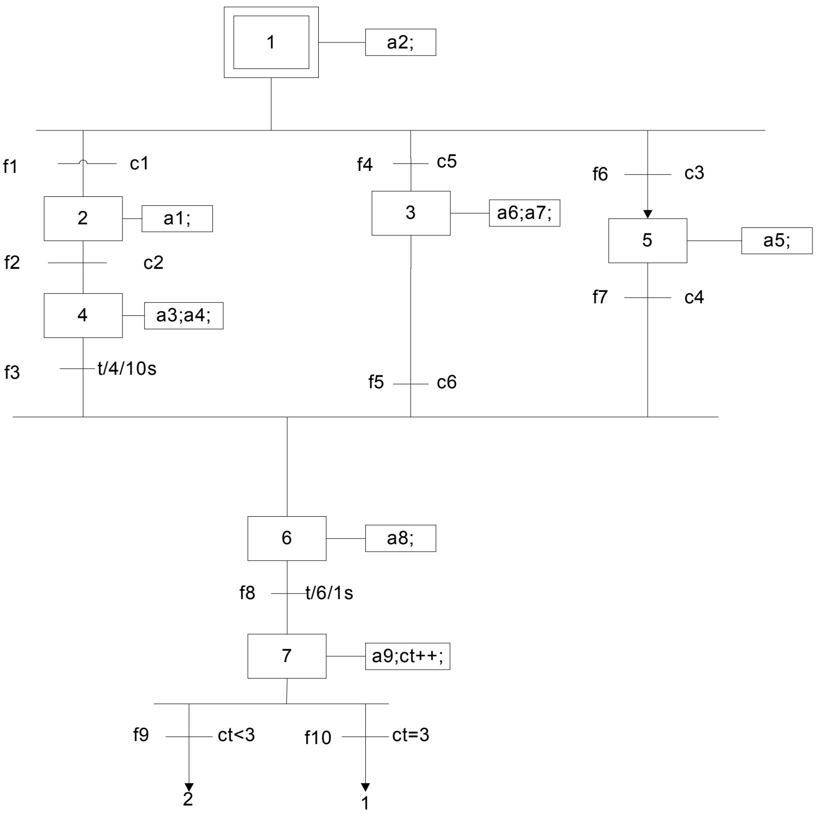
$$G(s) = 5\frac{2s+1}{s}.$$

Draw the approximate log–magnitude and phase curves;
10. Given the system with the open–loop transfer function

$$G(s)H(s) = \frac{3}{s(s+1)(s+2)}.$$

Determine the phase frequency, $\omega_{-\pi}$ and the gain margin m_g.

11. State the rules that govern the relationship between the parent-programs and child-programs according to Grafcet theory(e.g. Isagraf).
12. Describe the 3 execution phases that occurs during and execution cycle of a PLC.
13. Enumerate the areas that compose the memory space of a PLC from S7-200 series.
14. Describe the role of each bit of SMB0 byte from the PLCs of S7-200 series.
15. Describe the role of the special memory byte SMB2 from the PLCs of S7-200 series.
16. Explain when is possible during the execution cycle of a PLC to update the images in the memory of the PLC inputs and outputs.
17. How many types of addressing a variable are available in working with a PLC from S7-200 series. Explain these modes.
18. Explain the difference between a counter and a timer from the point of view of a PLC.
For the given graph



19. Write the expressions of the transition, activation and deactivation functions,
20. Implement the memory map for the transition, activation and deactivation functions, state input and output bits(use the S7-200 notations&memory layout).

<u>B2) Data Acquisition and Processing</u>

a. Analog data quantization and analog-to-digital conversion.
b. Data acquisition boards for PCs.
c. Backplane data acquisition components / systems: SCXI, VXI.
d. Digital communication and specific interfaces in data acquisition systems: CAN, Fieldbus, RS serial family.

Bibliography:

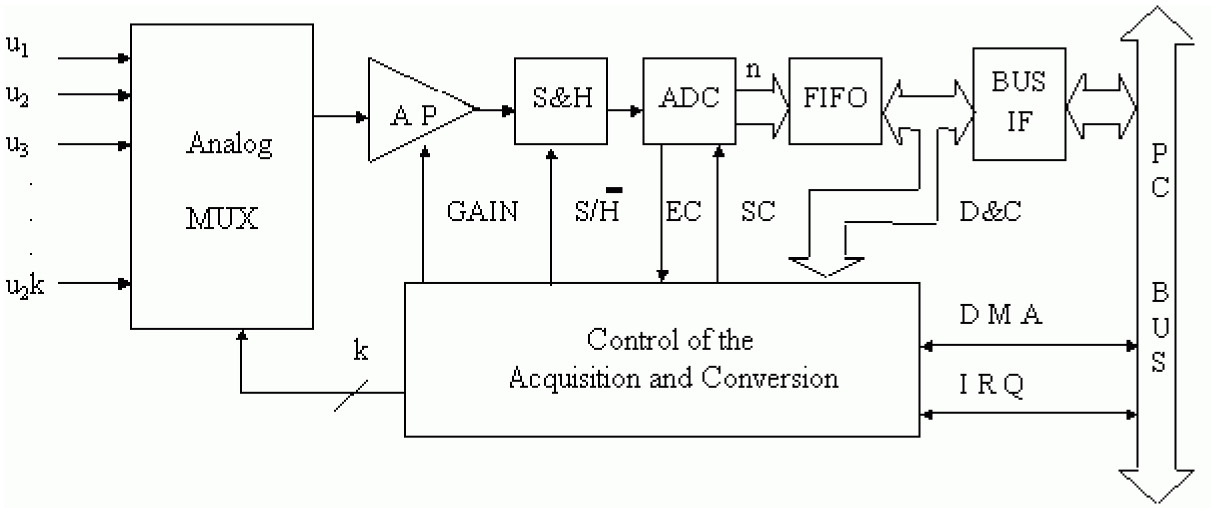
1. *Data acquisition and processing* - Lecture notes of 4th year (prof. I. Szekely)
2. Szekely,I., Szabo,W., Munteanu,R. – Sisteme de achizitie si prelucrare a datelor. Ed. Mediamira, Cluj Napoca, 1997.
3. Szekely,I., Sandu,F. – Circuite electonice de conversie a semnalelor analogice si digitale. Ed. MatrixRom, Bucuresti, 2002.

Examples of subjects

1. The sigma-delta modulation ADC is the highest resolution analog-to-digital converter because:

a) Is has a very high conversion rate ADC (over 1 GSps)
b) Reduces the SNR proportionally with the oversampling factor
c) Drastically increases the SNR by rejecting a great part of the quantisation noise
d) The sampling rate of the signal is much higher as the Nyquist frequency.

2. **The block diagram represents a data acquisition board of following type:**



a) A digital signal extension board for PCs, because it accepts *n* digital inputs
b) An asynchronous DAQ board because contains only one S&H and ADC in the structure, for all the signal channels
c) A multifunctional DAQ board, because there are IRQ and DMA connections with the PC Bus and these connections are bidirectional
d) A synchronous DAQ board, because at the input there is a multiplexer.

3. **The CRC error check technique for data transmission uses:**

a) Division of the message block with a generator polynomial at both sides of the communication chain (transmitter and receiver)
b) Parity bits for each binary word
c) Division of the message block with a generator polynomial at the transmitter side and a multiplication with the same polynomial at the receiver side
d) Parity bits for each lines and columns of the data block.

4. **RS 485 is a digital communication interface which allows:**

a) Handshake communication protocol for the partners
b) A multidrop serial communication with more partners, up to 32
c) A full duplex serial communication for only two partners
d) A cable bus instrumentation communication system, where the data bus has 8 parallel bits.

5. **CAN is considered a CSMA/CD type of digital communication bus, developed initially for automotive applications, because:**

a) The number of active nodes could be maximum 256
b) Is a two - wire serial communication system, one wire being the ground
c) Is a multi-controller area network, one of them being designated as master
d) All nodes receive simultaneously all messages on the bus, can access the bus with equal rights.

6. **Analog input data acquisition boards allow to collect the following number and type of signals in the field:**

a) *n* single ended and *2n* double ended inputs
b) *n* double ended and *2n* single ended inputs
c) *n* single ended and *4n* double ended inputs
d) *n* double ended and *4n* single ended inputs.

B3) Electric Drives

a. Electric drive systems using DC motors supplied by thyristor choppers. The mechanical characteristics of DC motors supplied from a DC-DC converter (chopper). The operation principle of a solid-state breaker.
b. Asynchronous motors equations. Artificial mechanical characteristics.
c. The Ward-Leonard driving system.
d. Step-by-step Motors Variable reluctance step-by-step motors Single-pole motors Two-poles motors. The command methods.
e. Torques classification. The basic motion equation in the case of an electric motor aided drive.

BIBLIOGRAPHY:

1. Henneberger, G. *Electrical Machines II Dynamic Behavior, Converter Supply and Control*, Aachen University, 2004
2. Dănilă, A. *Electrical Drives, Note de curs*, Universitatea Transilvania din Braşov

Examples of subjects

1 Using the Laplace-transformation applied to the differential equations of the separately excited DC machine with constant excitation, compute the step response to set point changes (i.e. the speed variations of the DC machine if the armature voltage changes).

2 Write the voltage equations and the torque equation *in the two-axis rotating system* for the salient-pole synchronous machine. Assume the machine is operating in steady-state operation at mains power supply; translate these equations into the complex plane and then draw the phasor diagram.

3. Select and then prove the relation that matches to the following sentence:

The speed variation to set-point changes of the armature voltage of the separately excited DC machine *is oscillating* if:

a. $D = \sqrt{\frac{T_m}{4 \cdot T_A}} < 1$ **b.** $D = \sqrt{\frac{T_m}{4 \cdot T_A}} > 1$

4. Induction (asynchronous) machine in field oriented coordinate system: field oriented operation; the rotor equations in field oriented coordinates; control strategy diagram; analogy to DC machines structure diagram.

5. **I**. Choose the correct answer:

The torque of some synchronous machines is composed of two components: the synchronous torque and the reluctance torque. The reluctance torque:

a. appears in cylindrical-rotor machines and is depending on the excitation;

b. results from the difference of the permeances on the magnetic axes of the machine;

c. appears both in cylindrical-rotor and salient-pole synchronous machines but doesn't depend on excitation.

a: **b:** **c:**

II. Somewhere into the following sentence some **mistakes** have been filled-in. Locate and then correct them.

The direct and quadrature axis theory approach is as follows:

1. Torque invariant transformation of both three-phase (rotor and stator) to two phase systems;

2. Transformation of the steady rotor winding and rotating rotor winding to an arbitrary system, rotating with angular velocity;

3. Setting up the voltage equations for rotor and stator in the transformed system;

4. Determination of the voltages from balance of power.

6. Step-by-step motors: what are step-by-step motors; definition of a step; structure and control of variable reluctance step-by-step motors; structure and control of PM step-by-step motors; command circuits; the torque formula and operation regimes.

7 Steady-state operation of induction machine using variable frequency and voltage converter: operation with constant stator flux-linkage, operation with constant rotor flux-linkage.

8. EC motors i.e. synchronous motors supplied from three-phase inverters controlled by rotor encoders: the structure and the operation principle; applications; dynamic and steady-state operation; normal operation and field-weakening operation.

9. DC electric drives supplied from a phase-controlled supply. The control system of the DC machine consisting in cascade regulation of the rotational speed and induced current limitation: the dynamic set of equations of the DC machine operating with constant excitation; the cascade control system diagram, operation of the drive at start-up.

10 Electric drive systems using DC motors supplied from GTO thyristor choppers: the structure diagram; the operation principle; applications.