Transilvania University of Brasov
Faculty of Electrical Engineering and Computers

SUBJECT LIST
for the Engineer Degree Diploma Exam 2007 at the subject:
ELECTRICAL ENGINEERING AND CONTROL SYSTEMS
Study programme: Electrical Engineering and Computers (English language)

A. ELECTRICAL ENGINEERING

A1) Electromagnetics

A number of 5 subjects will be arbitrarily selected from the list below:

1. Components of the electric field strength in large sense, with the mention of the cause that produces each of them.
2. Difference between the turn magnetic flux and the flux linked by a coil.
3. 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.
4. The work done by the forces of a potential electric field at the displacement of a point-like electric charge between two points. Explanatory drawing, mathematical expressions, denomination and unit of measure of each quantity occurring in formula.
5. Magnetic circuital law in integral form. Specify:
   a. What represent the lower limits of the integrals (closed curve, open curve, closed surface, open surface, volume)
   b. Explanatory drawing and specify if the directions of travelling along the curve and of the normal to the surface bounded by the curve are adopted arbitrarily or not, and in which manner.
   c. Denomination of each occurring quantity.
6. 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.
7. 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.
8. Relation between the normal components of the magnetic 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.
9. Relation between the tangential component of the magnetic 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.
10. Draw a magnetic hysteresis loop. Precise the characteristic points and their denomination, and fix approximately on the loop the operating point given by H and B in the air gap.
11. Law of electromagnetic induction in concentrated integral form, for media at rest, and in the form with global quantities (without integrals), i.e. the form referred to as *Faraday* form. Explanatory drawing, denomination and unit of measure for each occurring quantity. Precise if the occurring surfaces are closed, open or anyhow.
12. Biot-Savart-Laplace theorem. Explanatory drawing, denomination and unit of measure of each quantity occurring in formula.
13. Unit of measure of the electric field strength. The defining relation, explanatory drawing, denomination of occurring quantities.

14. Unit of measure of the electric tension. Defining relation, explanatory drawing, denomination of occurring quantities.
15. Unit of measure of the magnetic field strength. Defining relation, explanatory drawing, denomination of occurring quantities.
16. Unit of measure of magnetic induction. Defining relation, explanatory drawing, denomination of occurring quantities.
17. Unit of measure of the magnetic flux. Defining relation, explanatory drawing, denomination of occurring quantities.
18. Unit of measure of the intensity of the electric current from the definition of electric current in terms of the passing electric charge quantity. Defining relation, explanatory drawing, denomination of occurring quantities.
19. Lenz rule. Explanatory figure. Enunciation.
20. Eddy currents in a metallic plate at rest in a variable magnetic field. Explanations without proof.
21. What is an electrostatic screen? Explanatory drawing. Does this screen act in both direction with respect to external charges and internal charges or not?
22. Definition of inductances.
23. Example of positive and negative inductances considering coils wound about the same toroidal core (without proof). Meaning of the dot introduced at one end of the coil.
24. Hopkinson law for magnetic circuits.
25. Definition of capacitance. What does it mean a capacitor?

Bibliography

Nicolaide, A.: *Electromagnetics,* Transilvania University Press, Braşov, 2003.

A2) Electric Circuits

A number of 5 subjects will be arbitrarily selected from the list below:

1. The relationship between instantaneous voltage $u_C(t)$ and current $i(t)$ in a capacitor.
2. The energy stored on a capacitor
3. The inductance of a coil
4. The relationship between instantaneous voltage $u_L(t)$ and current $i(t)$ in an inductor
5. The energy stored in an inductor
6. Millman's theorem
7. Thevenin's theorem
8. Norton's theorem
9. The maximum power transfer theorem
10. The power conservation theorem
11. The time constant of a series RL circuit
12. The time constant of a series RC circuit
13. The root-mean-squre (r.m.s.) of an electric current
14. The root-mean-squre (r.m.s.) of a sinusoidal quantity
15. The angular frequency
16. The phasor representation of a sinusoidal quantity
17. Joubert's theorem
18. Powers under sinusoidal conditions
19. Power factor
20. The relations between the line and phase values of the currents and voltages in the case of wye and delta connection
21. Powers absorbed by a three-phase load
22. Symmetrical components (Fortescue transformation)
23. The frequency spectrum

24. The root-mean-squre (r.m.s.) of a periodic non-sinusoidal quantity
25. Powers under non-sinusoidal conditions

Bibliography

Nicolaide, A.: *Lecture notes*, 2004.

B. CONTROL SYSTEMS

B1) Electrical machines

A number of 2 subjects will be arbitrarily selected from the list below:

1. Single-phase non-ideal transformer. Theory of operation based on equations.
2. Single-phase non-ideal transformer. To express the turn ratio, voltage regulation and the maximum efficiency criterion.
3. Single-phase non-ideal transformer. Equivalent diagrams for open circuit and short circuit tests to determine its parameters.
4. Three-phase transformer. Theory and diagrams of basic connections schemes.
5. Direct Current machine: explanatory figure for magnetization characteristic of a DC machine.
6. The expressions of developed torque and of losses structure for a DC motor.
7. To express relations of power and torque for an induction motor.
8. The equivalent circuit of an induction motor. The significance of parameters.
9. Induction motor, torque - speed characteristics. Explanatory diagrams.
10. Field orientated control of induction motor: Principle, Clarke and Park diagrams.

Bibliography

1. Guru, Bhag S. and Hiziroglu.R.H.: Electric Machinery and Transformers, 3-rd edition, Hardback, 720 pages, July 2000, ISBN 13 9780195138900, OXFORD University Press
2. Ilea, D: ***Lecture Notes***, 2005.

B2) Electrical drives

A number of 2 subjects will be arbitrarily selected from the list below:

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.

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

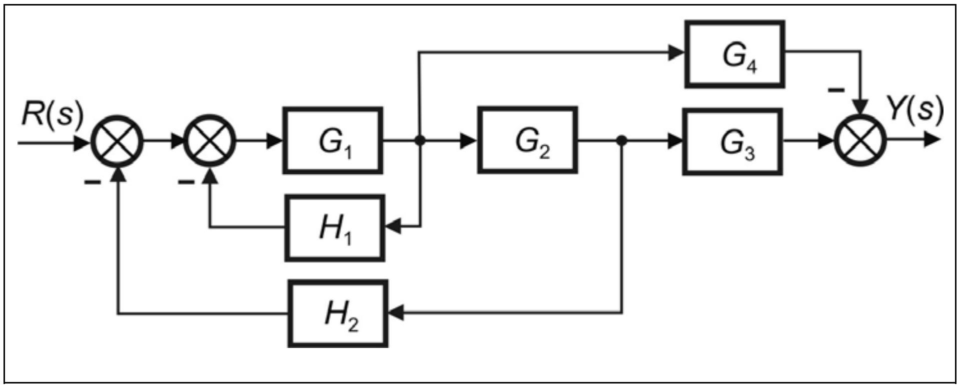
B3) System Theory

A number of 2 subjects will be arbitrarily selected from the list below:

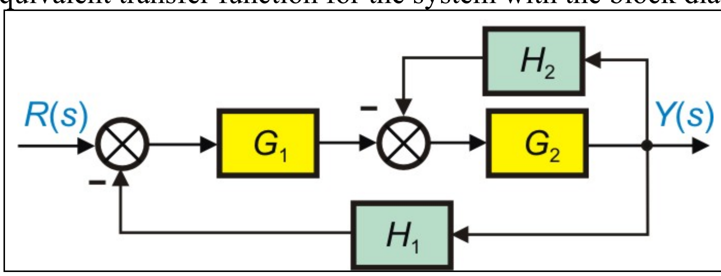
1. Find time function $f(t)$ for the Laplace transform $F(s) = \frac{s+4}{s^2+4s+13}$.

2. Find time function $f(t)$ for the Laplace transform $F(s) = \dfrac{s+3}{(s+1)(s^2+4s+8)}$

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 $\dfrac{Y(s)}{R(s)} = \dfrac{25}{s^2+6s+25}$, where ζ = 0,6 and ω_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: $G(s) = \dfrac{K}{(25s+1)(5s+1)(s+1)}$. 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: $G(s) = \dfrac{K}{s(s+7)(s+11)}$. 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 $G(s) = 10\dfrac{s+10}{s+1}$. 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.

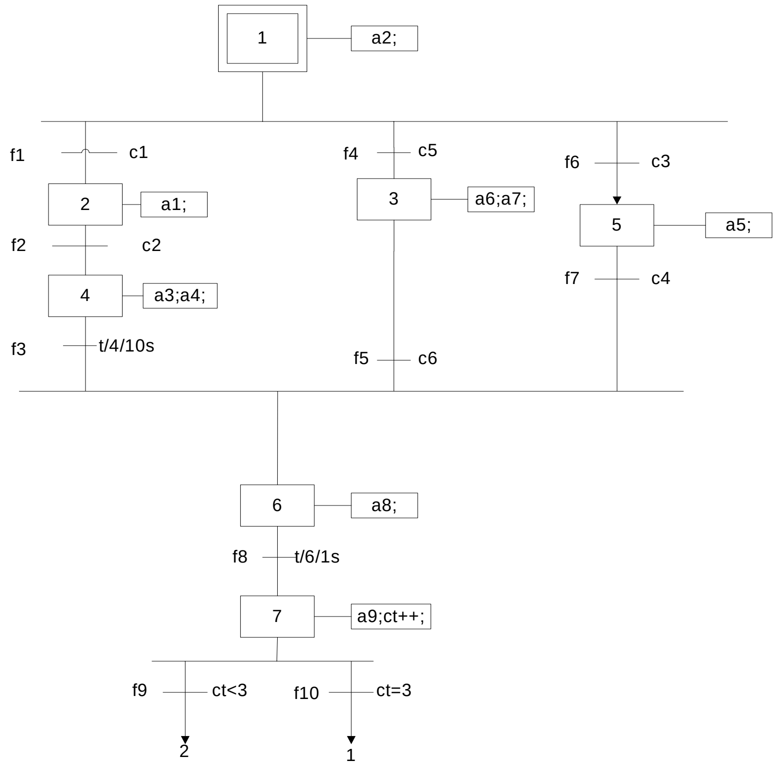
BIBLIOGRAPHY

Comnac, V., Tollet, I., Lahti, S. "*System Theory–Analysis, Modelling and Simulation of Electrical Processes*", Editura Lux Libris, 2004, 160 pag., ISBN 973-9458-28-9.

B4) Control System

A number of 2 subjects will be arbitrarily selected from the list below:

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



9. Write the expressions of the transition, activation and deactivation functions,

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

Bibliography

Suciu, C.: *Lecture notes*, 2006.

B5) Data acquisition

A number of 2 subjects will be arbitrarily selected from the list below:

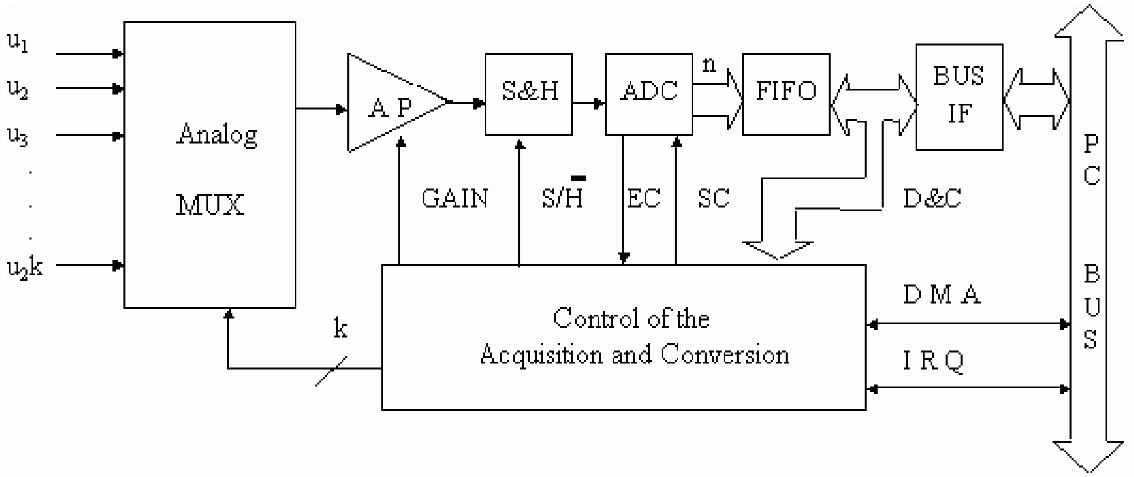
1. **The sigma-delta modulation ADC is the highest resolution analog-to-digital converter because:**

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. **Insulation amplifiers are often used in data acquisition systems because:**

a) Has a large bandwidth (cutoff frequency over 100 MHz)
b) Assures a very high common mode rejection of the input signals (CMRR > 130 dB)
c) Has a very accurate and adjustable gain, as a general negative feedback technique is used
d) The input impedance of the amplifier is low enough to assure an impedance adaptation with coaxial cables (characteristic impedance of 50 Ω or 75 Ω.

3. **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.

4. 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.

5. 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.

6. The GPIB (IEEE 488) instrumentation bus system has one of the following features:

a) Is a cable bus communication system, which accepts a maximum number of 256 devices (talkers, listeners and controllers)
b) The handshake protocol is performed via a 3 line control bus
c) A handshake protocol for commanders and servants is applied, where commanders have all the rights over the configuration and communication registers of the slaves
d) Is a serial multidrop communication system with maximum 15 devices (talkers, listeners and controllers).

7. 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.

8. 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.

9. Strain gauges are sensors which perform a primary conversion of a non-electrical signal into an electrical signal of the following type:

a) Temperature into a variation of electrical resistance
b) Mechanical stress into electrical charge
c) Mechanical stress into a variation of electrical resistance
d) Temperature into a voltage.

10. For a DAC the following statement is valid:

a) Converts an analog voltage into a digital code
b) Converts digital data into a continuously variable level voltage or current
c) Amplifies an input voltage to a higher level voltage
d) Performs an adaptation of impedance between the analog and digital stages of a data acquisition system.

Bibliography:

1. *Data acquisition and processing* - Lecture notes of 4^{th} 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.