basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

EXEMPLAR 2014

MARKS: 200

TIME: 3 hours

This question paper consists of 11 pages and a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of SEVEN questions.
2. Answer ALL the questions.
3. Sketches and diagrams must be large, neat and fully labelled.
4. Show ALL calculations and round off correctly to TWO decimal places.
5. Number the answers correctly according to the numbering system used in this question paper.
6. You may use a non-programmable calculator.
7. Show the units for all answers of calculations.
8. A formula sheet is provided at the end of this question paper.
9. Write neatly and legibly.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Name ONE unsafe act that may cause a learner an electric shock when working in an electrical technology workshop. (1)

1.2 State ONE unsafe condition in an electrical technology workshop. (1)

1.3 State ONE procedure that must be followed in the event of a medical emergency in an electrical technology workshop. (1)

1.4 Describe how a person's human rights may be compromised if an electrical technology workshop has no wheel chair access. (2)

1.5 Describe why it is unethical to use drugs when working in an electrical technology workshop. (2)

1.6 Explain why doing a risk analysis will improve housekeeping in an electrical technology workshop. (3)
[10]

QUESTION 2: THREE-PHASE AC GENERATION

2.1 State the function of a kilowatt-hour meter. (2)

2.2 State TWO advantages of a three-phase distribution system over a single-phase distribution system. (2)

2.3 Draw a phasor diagram that represents the currents of a three-phase star-connected supply. (3)

2.4 In a three-phase supply system, the two wattmeter method is used to measure the power delivered to a load.

The values indicated on the instruments are 4 kW and 17,5 kW respectively. The line voltage is 380 V and the power factor is 0,8.

Given:

W_1 = 4 kW
W_2 = 17,5 kW
V_{Supply} = 380 V
Cos θ = 0,8

Calculate the:

2.4.1 Total power drawn from the supply (3)

2.4.2 Line current (3)

2.5 An 11 kW balanced load connected in star draws a current of 25 A. Assume the apparent power of the load is 20 kVA.

Calculate the:

2.5.1 Line voltage (3)

2.5.2 Phase voltage (3)

2.6 Recommend ONE method of improving the power factor of a resistive inductive load. (1)

[20]

QUESTION 3: THREE-PHASE TRANSFORMERS

3.1 State the principle of operation of a transformer. (1)

3.2 List THREE factors that may cause excessive heating in a transformer. (3)

3.3 Name the internal protective device that will protect a transformer if the oil in the transformer overheats. (1)

3.4 State the purpose of a breather in a transformer. (2)

3.5 State the causes of the following losses in a transformer:

3.5.1 Copper losses (2)

3.5.2 Iron losses (2)

3.6 A 200 kVA three-phase transformer supplies power to floodlights in a soccer stadium. The transformer is connected in delta-star. The input line voltage is 11 kV and the output line voltage is 380 V at a lagging power factor of 0,85.

Given:

$S = 200$ kVA
$V_L = 380$ V
$\cos\theta = 0{,}85$ lagging

Calculate the:

3.6.1 Secondary phase voltage (3)

3.6.2 Power delivered at full load to the soccer stadium (3)

3.6.3 Current drawn from the supply by the transformer at full load (3)

[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1 Name THREE parts of a three-phase squirrel-cage induction motor. (3)

4.2 State ONE disadvantage of a direct-on-line starter when used to start a motor. (1)

4.3 The speed of the rotating magnetic field of an induction motor depends upon TWO factors. State these TWO factors. (2)

4.4 List THREE mechanical inspections that should be completed on a motor after installation and before energising. (3)

4.5 Describe the function of a three-phase motor starter. (2)

4.6 Refer to the circuit diagram in FIGURE 4.1.

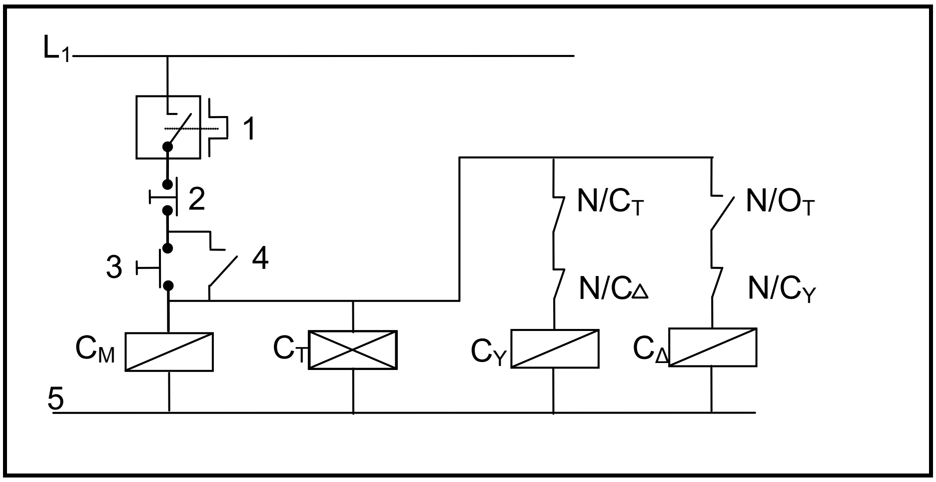

FIGURE 4.1: CONTROL CIRCUIT OF A STAR-DELTA STARTER

4.6.1 Write down the numbers 1–5 in your ANSWER BOOK and then the correct labels for the diagram next to the corresponding numbers. (5)

4.6.2 Describe the function of the contact labelled 1. (3)

4.6.3 Describe how a star-delta starter reduces the starting current of a motor at start-up. (4)

4.6.4 Explain the starting sequence of the starter. (10)

4.7 Describe the principle of operation of a three-phase squirrel-cage induction motor. (7)

[40]

QUESTION 5: RLC

5.1 Define the term *impedance*. (3)

5.2 An incandescent lamp is connected in series with an inductor across an alternating voltage supply. Explain what will happen to the brightness of the lamp if the frequency of the supply is increased. (3)

5.3 Define the term *Q-factor* with reference to a series RLC circuit. (2)

5.4 Draw the characteristic curve of current against frequency in a series RLC circuit. (3)

5.5 Refer to the circuit diagram in FIGURE 5.1.

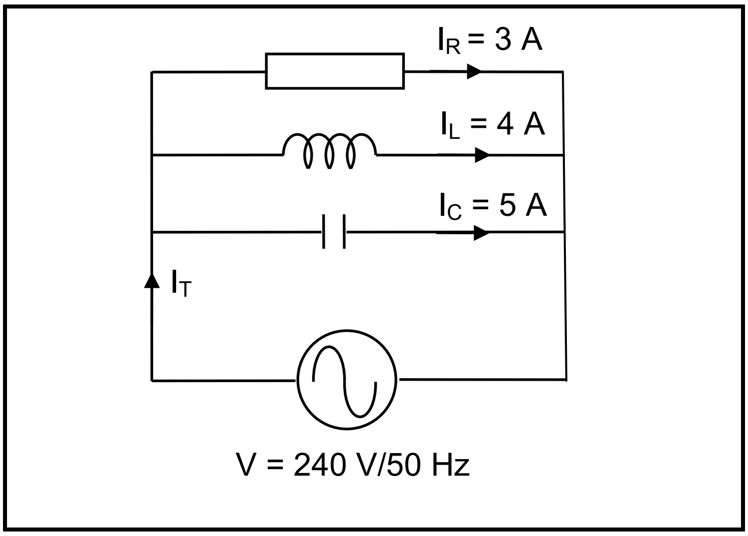

FIGURE 5.1: PARALLEL RLC CIRCUIT

5.5.1 Calculate the total current of the circuit. (3)

5.5.2 Draw the phasor diagram that represents the circuit. (6)

[20]

QUESTION 6: LOGIC

6.1 A PLC is a solid-state device used to automate machines in industry.

6.1.1 Write the abbreviation *PLC* out in words. (1)

6.1.2 Draw a block diagram to illustrate a typical PLC system. (4)

6.1.3 Name a control system that has been improved by the use of PLCs. (1)

6.1.4 State THREE advantages of PLC logic control over other electrical control systems. (3)

6.1.5 Name ONE component that is used by a PLC to switch power systems on or off. (1)

6.1.6 Name THREE types of programmable languages/methods used to instruct the operation of a PLC. (3)

6.2 Refer to the circuit in FIGURE 6.1.

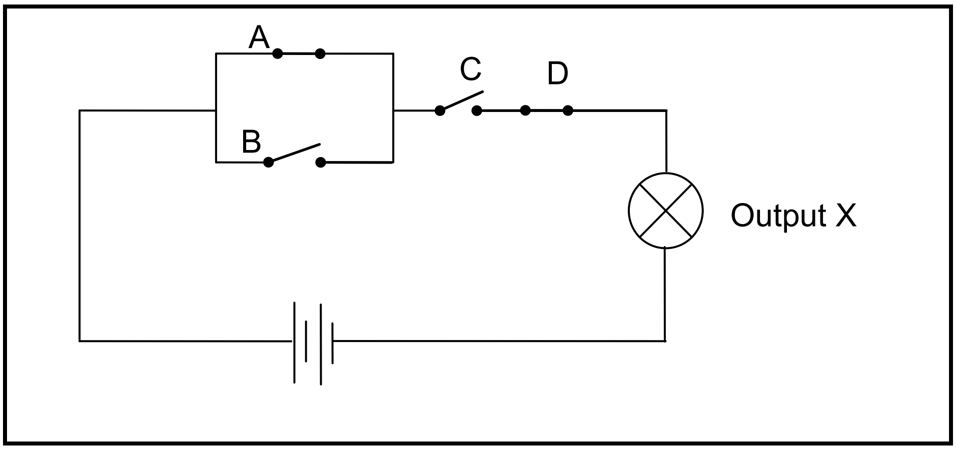

FIGURE 6.1: CIRCUIT DIAGRAM

6.2.1 Write down the equivalent Boolean equation for the circuit in FIGURE 6.1. (5)

6.2.2 Design an equivalent ladder diagram of the circuit in FIGURE 6.1. (5)

6.3 Refer to the circuit in FIGURE 6.2.

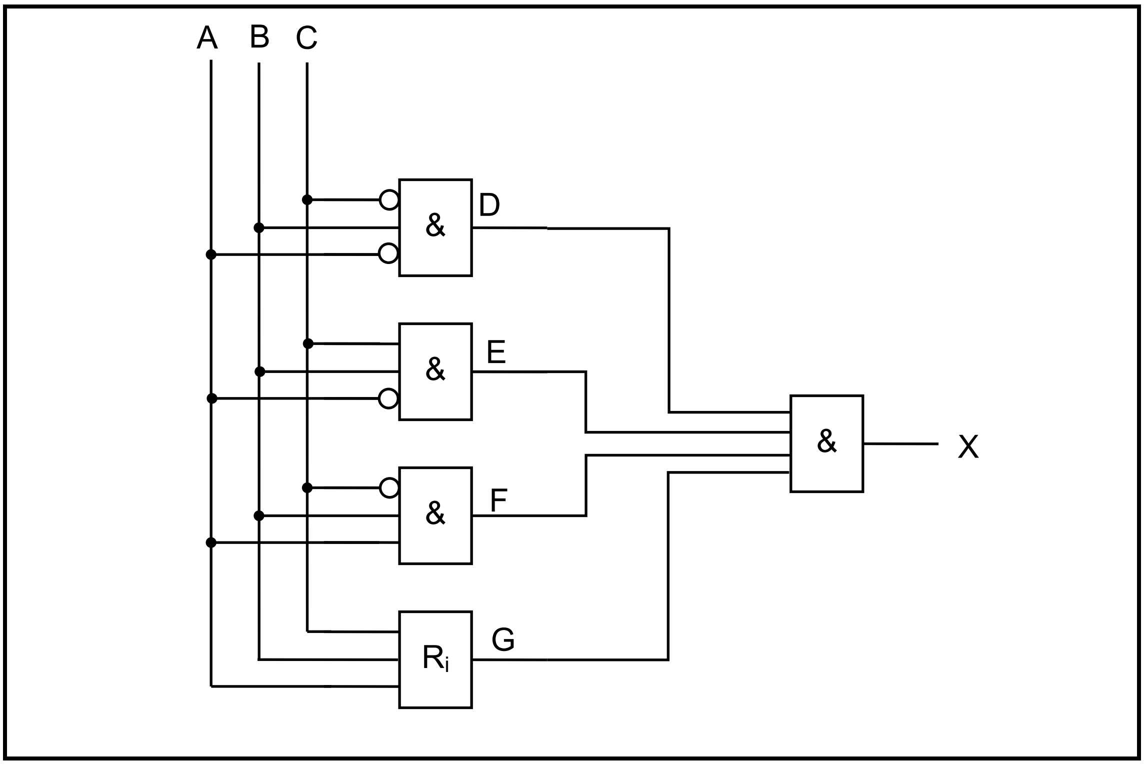

FIGURE 6.2: LOGIC CIRCUIT

Write down the Boolean equations at the following points:

6.3.1 D (1)

6.3.2 E (1)

6.3.3 F (1)

6.3.4 G (1)

6.3.5 Output X (2)

6.4 Use the Karnaugh map method to simplify output X in FIGURE 6.2. (8)

6.5 When designing a set of instructions for a PLC, give ONE example where a timer function could be used. (3)

[40]

QUESTION 7: AMPLIFIERS

7.1 State TWO characteristics of an ideal operational amplifier (op amp). (2)

7.2 Describe the function of the dual DC power supply (split PSU). (4)

7.3 Describe the term *negative feedback*. (3)

7.4 State TWO advantages of using negative feedback in an op-amp circuit. (2)

7.5 Describe the term *bandwidth* in relation to amplifiers. (2)

7.6 Draw and label the circuit symbol of an op amp. (6)

7.7 Refer to FIGURE 7.1 to answer the questions that follow.

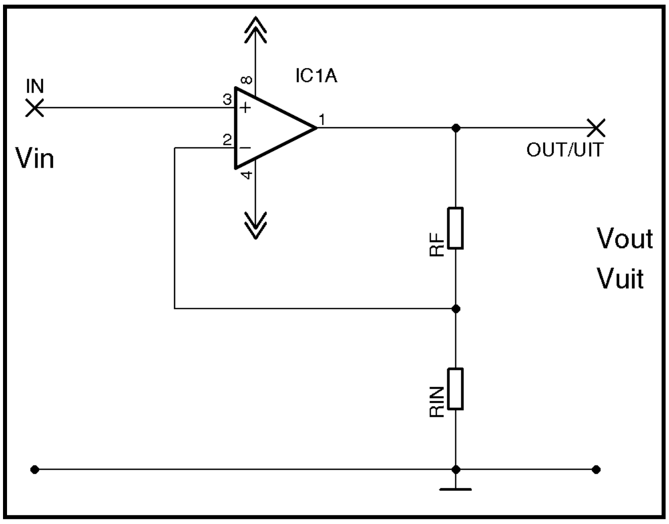

FIGURE 7.1: OP AMP

7.7.1 Name the op amp. (1)

7.7.2 Draw the output signal. (1)

7.7.3 Indicate what would occur to the voltage gain of the amplified signal if the value of the feedback resistor was increased. (3)

7.7.4 Explain why the gain of the amplifier changes when the feedback resistor is increased. (3)

7.8 Refer to FIGURE 7.2 to answer the questions that follow.

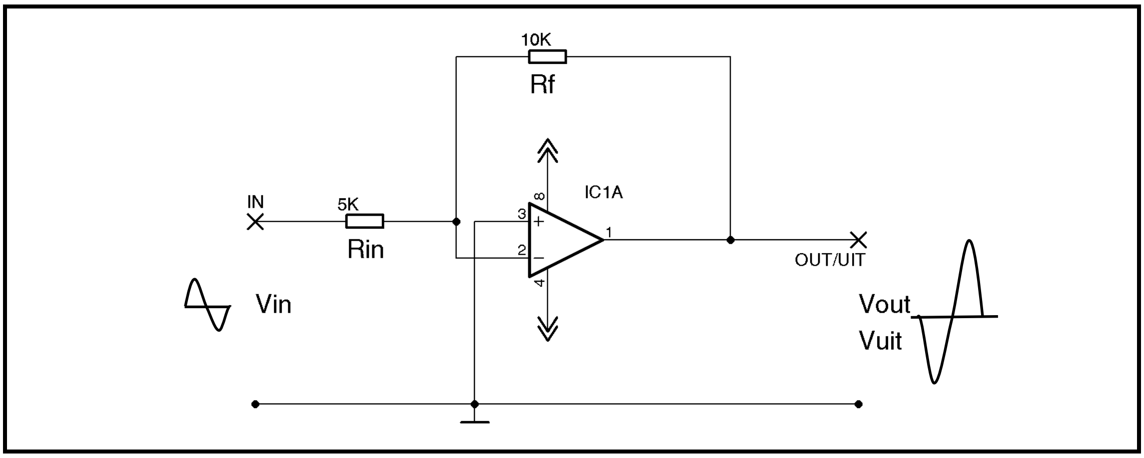

FIGURE 7.2: OP-AMP CIRCUIT

Calculate:

7.8.1 The voltage gain if the feedback resistor has a resistance of 10 kΩ and the input resistor has a value of 5 kΩ (3)

7.8.2 The output voltage if an input signal of 1 V is applied to the op amp (3)

7.9 Refer to FIGURE 7.3 to answer the questions that follow.

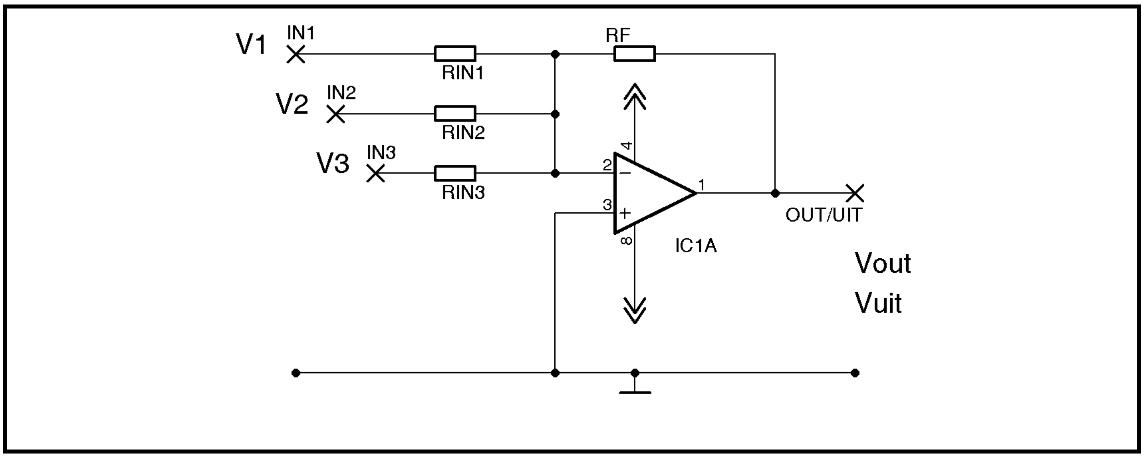

FIGURE 7.3: OP-AMP CIRCUIT

7.9.1 Identify the op-amp circuit in FIGURE 7.3. (1)

7.9.2 Describe ONE practical application of this type of op amp. (3)

7.9.3 If the values of the input resistors and the feedback resistor are the same, calculate the voltage output of the op amp if the input voltage is as follows:

V_1 = 2 V
V_2 = -1 V
V_3 = 3 V (3)

7.10 The circuit diagram in FIGURE 7.4 is an op amp connected to a bi-stable multivibrator configuration.

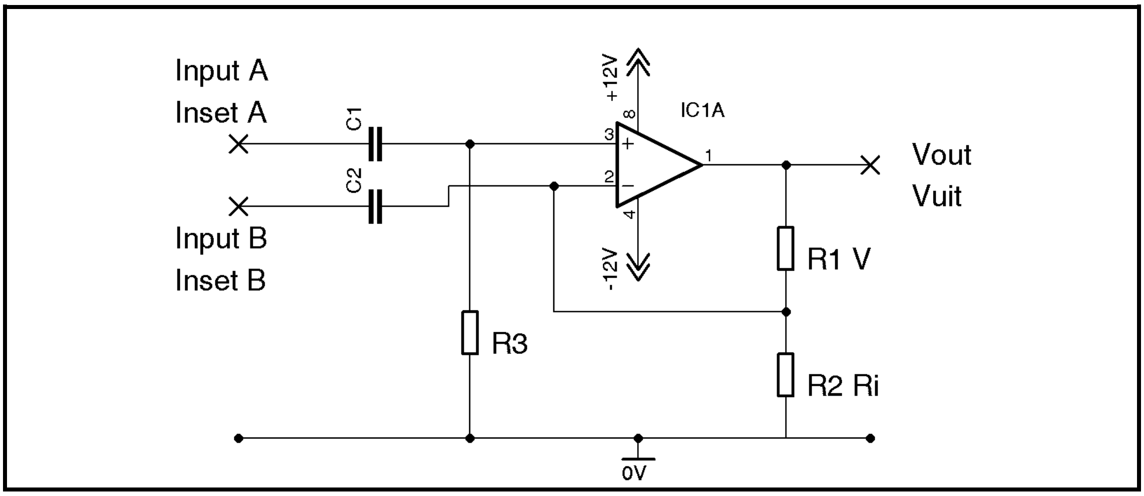

FIGURE 7.4: BI-STABLE MULTIVIBRATOR

7.10.1 State the functions of R_1 and R_2 respectively. (3)

7.10.2 State the purpose of the input capacitors, C1 and C2. (4)

7.10.3 Explain what type of output is produced by a bi-stable multivibrator. (3)
[50]

TOTAL: 200

FORMULA SHEET

THREE-PHASE AC GENERATION

STAR

$V_L = \sqrt{3}\, V_{PH}$

$I_L = I_{PH}$

DELTA

$I_L = \sqrt{3}\, I_{PH}$

$V_L = V_{PH}$

$S = \sqrt{3}\, V_L\ I_L$

$Q = \sqrt{3}\, V_L I_L \text{ Sin}\,\theta$

$\text{Cos}\theta = \frac{P}{S}$

TWO WATTMETER METHOD

$P = P_1 + P_2$

THREE-PHASE TRANSFORMERS

STAR

$V_L = \sqrt{3}\, V_{PH}$

$I_L = I_{PH}$

DELTA

$I_L = \sqrt{3}\, I_{PH}$

$V_L = V_{PH}$

$P = \sqrt{3}\, V_L\ I_L \text{ Cos}\,\theta$

$S = \sqrt{3}\, V_L\ I_L$

$Q = \sqrt{3}\, V_L\ I_L \text{ Sin}\,\theta$

$\text{Cos}\theta = \frac{P}{S}$

$\frac{V_{ph(p)}}{V_{ph(s)}} = \frac{N_p}{N_s} = \frac{I_{ph(s)}}{I_{ph(p)}}$

RLC CIRCUIT

$X_L = 2\pi f L$

$X_c = \frac{1}{2\pi f c}$

SERIES

$I_T = I_R = I_C = I_L$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$V_L = I\, X_L$

$V_C = I\, X_C$

$V_T = I\, Z$

$V_T = \sqrt{V_R^{\,2} + (V_L - V_C)^2}$

$I_T = \frac{V_T}{Z}$

$\text{Cos}\theta = \frac{R}{Z}$

$\text{Cos}\theta = \frac{V_R}{V_T}$

PARALLEL

$V_T = V_R = V_C = V_L$

$I_R = \frac{V_R}{R}$

$I_C = \frac{V_C}{X_C}$

$I_L = \frac{V_L}{X_L}$

$I_T = \sqrt{I_R^{\,2} + (I_L - I_C)^2}$

$\text{Cos}\theta = \frac{I_R}{I_T}$

THREE-PHASE MOTORS AND STARTERS	AMPLIFIERS
STAR $V_L = \sqrt{3}\, V_{PH}$ $I_L = I_{PH}$ **DELTA** $I_L = \sqrt{3}\, I_{PH}$ $V_L = V_{PH}$ **POWER** $P = \sqrt{3}\, V_L\, I_L\, \cos\theta$ $S = \sqrt{3}\, V_L\, I_L$ $Q = \sqrt{3}\, V_L\, I_L\, \sin\theta$ $\text{Efficiency}\,(\eta) = \frac{P_{in}\ \text{- losses}}{P_{in}}$ **SPEED** $n_s = \frac{60 \times f}{p}$ $\text{Slip} = \frac{n_s - n_r}{n_s}$	$\text{Gain}\ A_V = -\frac{V_{out}}{V_{in}} = -\left(\frac{R_f}{R_{in}}\right)$ $\text{Gain}\ A_V = \frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_{in}}$ $f_r = \frac{1}{2\pi\sqrt{LC}}$ $f = \frac{1}{2\pi\sqrt{6RC}}$