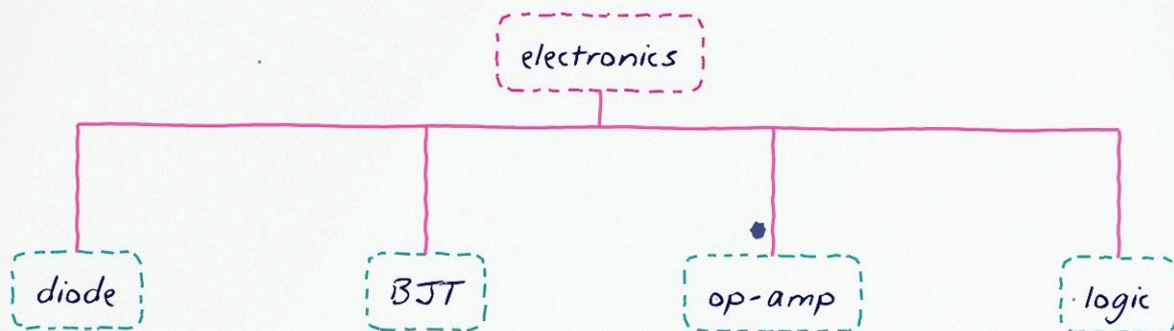


GATE EC HANDWRITTEN NOTES

ANALOG AND DIGITAL ELECTRONICS

Topics :-

- analog amplifiers
- op-amps, filters and oscillators
- combinational digital logic
- sequential logic and data conversion



Keep in mind :-

Understand the idea before learning the equation. Write units with every value and check the final sign.

First formula :-

$$A_v = v_o / v_i$$

First check :-

Verify the assumed transistor region after solving the bias point.

- say the meaning once without looking
- write the formula again from memory

Analog Amplifiers

Meaning :-

An amplifier uses a biased nonlinear device for locally linear gain.

Main idea :-

Bias, gain, input/output resistance, frequency response and feedback determine performance.

$$A_v = v_o/v_i$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Verify the assumed transistor region after solving the bias point.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Op-Amps, Filters and Oscillators. An operational amplifier realizes high-gain feedback circuits.

Quick test :-

Can I explain analog amplifiers without looking at the formula? Then can I state when the formula is valid?

Analog Amplifiers : IMPORTANT POINTS

In one line :-

An amplifier uses a biased nonlinear device for locally linear gain.

What is happening :-

Bias, gain, input/output resistance, frequency response and feedback determine performance.

$$A_v = v_o/v_i$$

How I remember it :-

Write the meaning first. The formula is much easier to recall after that.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Verify the assumed transistor region after solving the bias point.

Compare :-

Do not mix this with op-amps, filters and oscillators. Virtual short is a consequence of negative feedback; filters shape spectra and oscillators require loop conditions.

Analog Amplifiers : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$A_v = v_o / v_i$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Verify the assumed transistor region after solving the bias point.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Op-Amps, Filters and Oscillators: An operational amplifier realizes high-gain feedback circuits.

Analog Amplifiers : QUICK PRACTICE

Try without looking :-

1. Define analog amplifiers in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Bias, gain, input/output resistance, frequency response and feedback determine performance.
4. Why is this warning important: Verify the assumed transistor region after solving the bias point.
5. State one difference between analog amplifiers and op-amps, filters and oscillators.

Hints :-

An amplifier uses a biased nonlinear device for locally linear gain.

$$A_v = v_o / v_i$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Verify the assumed transistor region after solving the bias point.

Op-Amps, Filters and Oscillators

Meaning :-

An operational amplifier realizes high-gain feedback circuits.

Main idea :-

Virtual short is a consequence of negative feedback; filters shape spectra and oscillators require loop conditions.

$$\text{closed-loop gain} = 1 + R_f/R_g$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Virtual ground is not a universal op-amp rule.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Combinational Digital Logic. Combinational outputs depend only on present inputs.

Quick test :-

Can I explain op-amps, filters and oscillators without looking at the formula? Then can I state when the formula is valid?

Op-Amps, Filters and Oscillators : IMPORTANT POINTS

In one line :-

An operational amplifier realizes high-gain feedback circuits.

What is happening :-

Virtual short is a consequence of negative feedback; filters shape spectra and oscillators require loop conditions.

$$\text{closed-loop gain} = 1 + R_F/R_g$$

How I remember it :-

Keep the sketch beside the formula. It prevents sign and direction mistakes.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Virtual ground is not a universal op-amp rule.

Compare :-

Do not mix this with combinational digital logic. Boolean algebra, K-maps, arithmetic circuits, multiplexers and CMOS gates convert logic specifications into hardware.

Op-Amps, Filters and Oscillators : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$\text{closed-loop gain} = 1 + R_f/R_g$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Virtual ground is not a universal op-amp rule.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Combinational Digital Logic: Combinational outputs depend only on present inputs.

Op-Amps, Filters and Oscillators : QUICK PRACTICE

Try without looking :-

1. Define op-amps, filters and oscillators in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Virtual short is a consequence of negative feedback; filters shape spectra and oscillators require loop conditions.
4. Why is this warning important: Virtual ground is not a universal op-amp rule.
5. State one difference between op-amps, filters and oscillators and combinational digital logic.

Hints :-

An operational amplifier realizes high-gain feedback circuits.

$$\text{closed-loop gain} = 1 + R_F/R_g$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Virtual ground is not a universal op-amp rule.

Combinational Digital Logic

Meaning :-

Combinational outputs depend only on present inputs.

Main idea :-

Boolean algebra, K-maps, arithmetic circuits, multiplexers and CMOS gates convert logic specifications into hardware.

$$A + A'B = A + B$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Include don't-care terms only when they improve the implementation.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Sequential Logic and Data Conversion. Sequential circuits retain state through feedback and storage.

Quick test :-

Can I explain combinational digital logic without looking at the formula? Then can I state when the formula is valid?

Combinational Digital Logic : IMPORTANT POINTS

In one line :-

Combinational outputs depend only on present inputs.

What is happening :-

Boolean algebra, K-maps, arithmetic circuits, multiplexers and CMOS gates convert logic specifications into hardware.

$$A + A'B = A + B$$

How I remember it :-

Circle the final unit. A wrong unit usually means one step was missed.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Include don't-care terms only when they improve the implementation.

Compare :-

Do not mix this with sequential logic and data conversion. Flip-flops, counters, finite-state machines, ADCs, DACs and memory introduce timing and quantization constraints.

Combinational Digital Logic : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$A + A'B = A + B$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Include don't-care terms only when they improve the implementation.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Sequential Logic and Data Conversion: Sequential circuits retain state through feedback and storage.

Combinational Digital Logic : QUICK PRACTICE

Try without looking :-

1. Define combinational digital logic in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Boolean algebra, K-maps, arithmetic circuits, multiplexers and CMOS gates convert logic specifications into hardware.
4. Why is this warning important: Include don't-care terms only when they improve the implementation.
5. State one difference between combinational digital logic and sequential logic and data conversion.

Hints :-

Combinational outputs depend only on present inputs.

$$A + A'B = A + B$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :-

Include don't-care terms only when they improve the implementation.

Sequential Logic and Data Conversion

Meaning :-

Sequential circuits retain state through feedback and storage.

Main idea :-

Flip-flops, counters, finite-state machines, ADCs, DACs and memory introduce timing and quantization constraints.

$$\text{quantization step} = \text{full-scale range} / \text{levels}$$

Why it matters :-

Most questions become simple once the definition, assumptions and required quantity are written clearly.

Remember :-

Check setup, hold and propagation delays.

- write symbols before putting numbers
- keep the sign convention on the page
- check the unit of the final answer

Related idea :-

Next: Analog Amplifiers. An amplifier uses a biased nonlinear device for locally linear gain.

Quick test :-

Can I explain sequential logic and data conversion without looking at the formula? Then can I state when the formula is valid?

Sequential Logic and Data Conversion : IMPORTANT POINTS

In one line :-

Sequential circuits retain state through feedback and storage.

What is happening :-

Flip-flops, counters, finite-state machines, ADCs, DACs and memory introduce timing and quantization constraints.

$$\text{quantization step} = \text{full-scale range} / \text{levels}$$

How I remember it :-

Read the assumptions once more before using the short formula.

Conditions :-

Use the relation only for the model stated in the question. Start from the general law if one condition changes.

- mark all known values with their units
- draw the figure when direction matters
- do not round values in the middle

Quick check :-

Check setup, hold and propagation delays.

Compare :-

Do not mix this with analog amplifiers. Bias, gain, input/output resistance, frequency response and feedback determine performance.

Sequential Logic and Data Conversion : WORKING

Given in the question :-

Write every known value in one place. Put its unit beside it and underline the quantity to be found.

Formula :-

$$\text{quantization step} = \text{full-scale range} / \text{levels}$$

Steps :-

- convert all values to one unit system
- rearrange the equation before substitution
- put values carefully with brackets
- round only the final answer

Final check :-

Check setup, hold and propagation delays.

Small thought :-

Change one quantity mentally and read the equation again. The answer should follow the same physical or mathematical trend.

Also revise :-

Analog Amplifiers: An amplifier uses a biased nonlinear device for locally linear gain.

Sequential Logic and Data Conversion : QUICK PRACTICE

Try without looking :-

1. Define sequential logic and data conversion in one clear sentence.
2. Write the main formula and name every quantity.
3. Explain this idea: Flip-flops, counters, finite-state machines, ADCs, DACs and memory introduce timing and quantization constraints.
4. Why is this warning important: Check setup, hold and propagation delays.
5. State one difference between sequential logic and data conversion and analog amplifiers.

Hints :-

Sequential circuits retain state through feedback and storage.

$$\text{quantization step} = \text{full-scale range} / \text{levels}$$

Before moving on :-

- definition recalled without help
- formula written with correct symbols
- units and limiting case checked

One last reminder :- *

Check setup, hold and propagation delays.

FORMULAS I MUST REMEMBER

Analog Amplifiers :-

$$A_v = v_o/v_i$$

An amplifier uses a biased nonlinear device for locally linear gain.

Op-Amps, Filters and Oscillators :-

$$\text{closed-loop gain} = 1 + R_f/R_g$$

An operational amplifier realizes high-gain feedback circuits.

Combinational Digital Logic :-

$$A + A'B = A + B$$

Combinational outputs depend only on present inputs.

Sequential Logic and Data Conversion :-

$$\text{quantization step} = \text{full-scale range} / \text{levels}$$

Sequential circuits retain state through feedback and storage.

While using them :-

- write the condition beside each formula
- keep units consistent from the first line
- check the sign and final magnitude

COMMON MISTAKES

Do not forget :-

Analog Amplifiers: Verify the assumed transistor region after solving the bias point.

Op-Amps, Filters and Oscillators: Virtual ground is not a universal op-amp rule.

Combinational Digital Logic: Include don't-care terms only when they improve the implementation.

Sequential Logic and Data Conversion: Check setup, hold and propagation delays.

My usual checks :-

- read the exact quantity asked
- copy every value with its unit
- write the sign convention before working
- use brackets during substitution
- round only after the final step

Before submitting :-

Read the answer once as a sentence. The value, unit and direction should all make sense together.

Good habit :-

Keep one clean line between the given data, formula, substitution and final answer. It makes rechecking much faster.

MIXED PRACTICE

Short questions :-

1. Write the meaning and main formula for analog amplifiers.
2. Write the meaning and main formula for op-amps, filters and oscillators.
3. Write the meaning and main formula for combinational digital logic.
4. Write the meaning and main formula for sequential logic and data conversion.

Think a little :-

5. Compare analog amplifiers with combinational digital logic.
6. Which condition is most important in op-amps, filters and oscillators?
7. Draw a small figure or flow sketch for sequential logic and data conversion.

Answer reminders :-

- Verify the assumed transistor region after solving the bias point.
- Virtual ground is not a universal op-amp rule.
- Include don't-care terms only when they improve the implementation.
- Check setup, hold and propagation delays.

Final line :-

If an option has the wrong unit, sign or physical trend, reject it before doing a long calculation.