SNS COLLEGE OF TECHNOLOGY

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COIMBATORE-641 035, TAMIL NADU

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Course Name: 23ECT203 LINEAR INTEGRATED CIRCUITS

II YEAR/VI SEMESTER

UNIT I –BASICS OF OPERATIONAL AMPLIFIERS

Topic :Frequency response of OP-AMP

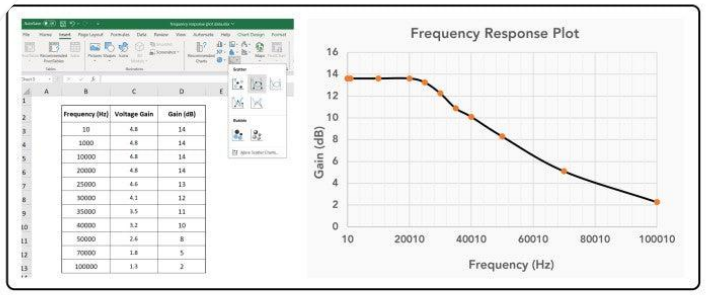
Introduction to Frequency Response

ⓘ What is Frequency Response?

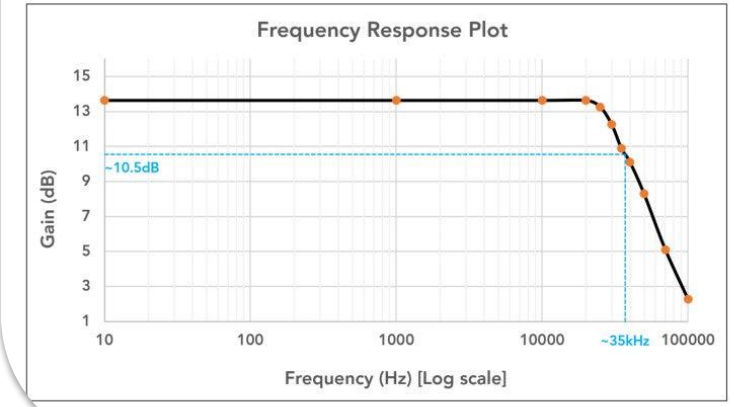
- Describes how op-amp **gain varies with frequency**
- Characterized by **bandwidth** and **gain-bandwidth product**

! Why is it important?

- Real op-amps have **frequency limitations**
- Gain **decreases** at higher frequencies
- Affects **signal integrity** and **stability**
- Critical for **filter design** and **signal processing**



Gain in Linear Scale



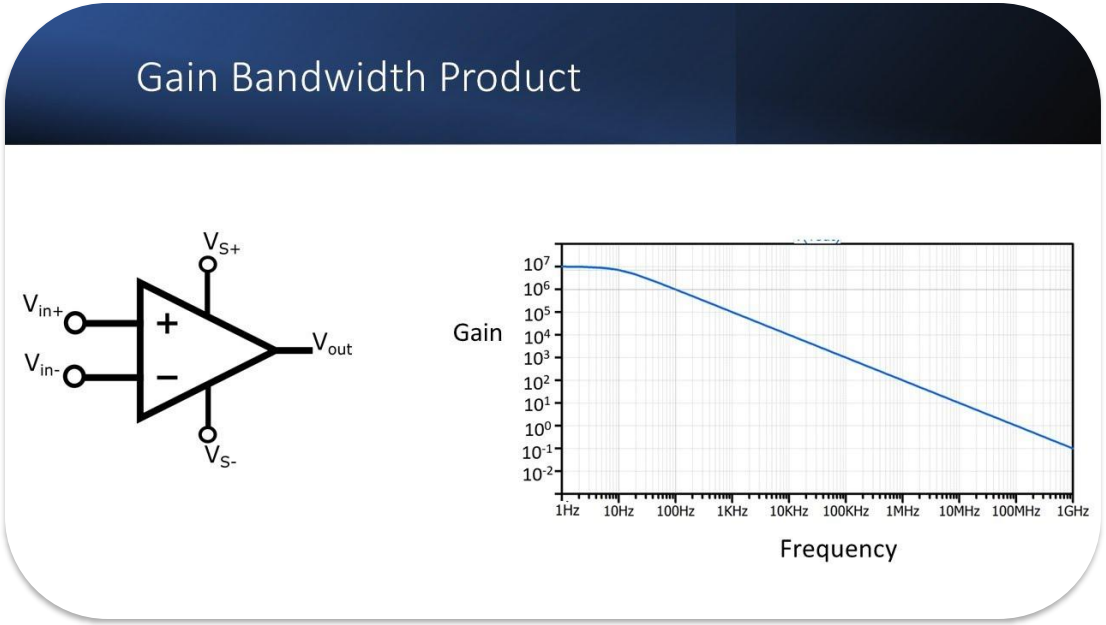
Gain in Log Scale

Stage 1: Empathize

Understanding challenges in analyzing frequency response

Student Challenges

- **Abstract concepts** like gain-bandwidth product
- **Complex mathematics** involved in Bode plot analysis
- **Difficulty visualizing** frequency-dependent behavior
- **Confusion between** open-loop and closed-loop response



Stage 2: Define

Defining requirements for understanding frequency response

Learning Goals

- Define key parameters: **Bandwidth**, **Gain-Bandwidth Product**, **Bode Plot**
- Understand **frequency-dependent behavior** of op-amps
- Learn to **analyze Bode plots** and interpret results
- Calculate **gain-bandwidth product** and bandwidth limitations

Bandwidth

Frequency range where gain is within 3dB of DC gain

Gain-Bandwidth Product

Constant for a given op-amp: GBW = A_DC × f_3dB

Bode Plot

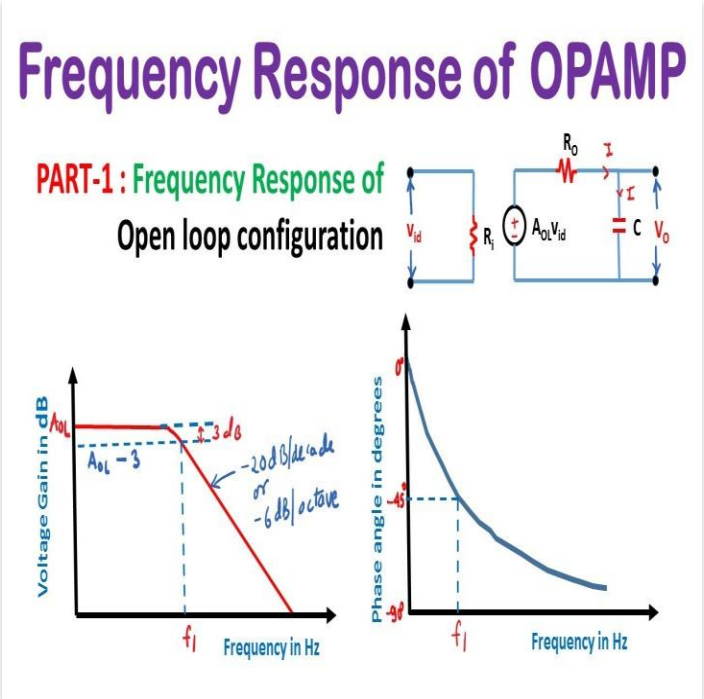
Graphical representation of frequency response

Stage 3: Ideate

Brainstorming approaches to analyze frequency response

Approaches

- Perform **Bode plot analysis** to visualize frequency response
- Calculate **gain-bandwidth product** for different configurations
- Determine **cutoff frequency** and bandwidth limitations
- Use **simulation tools** to verify frequency response

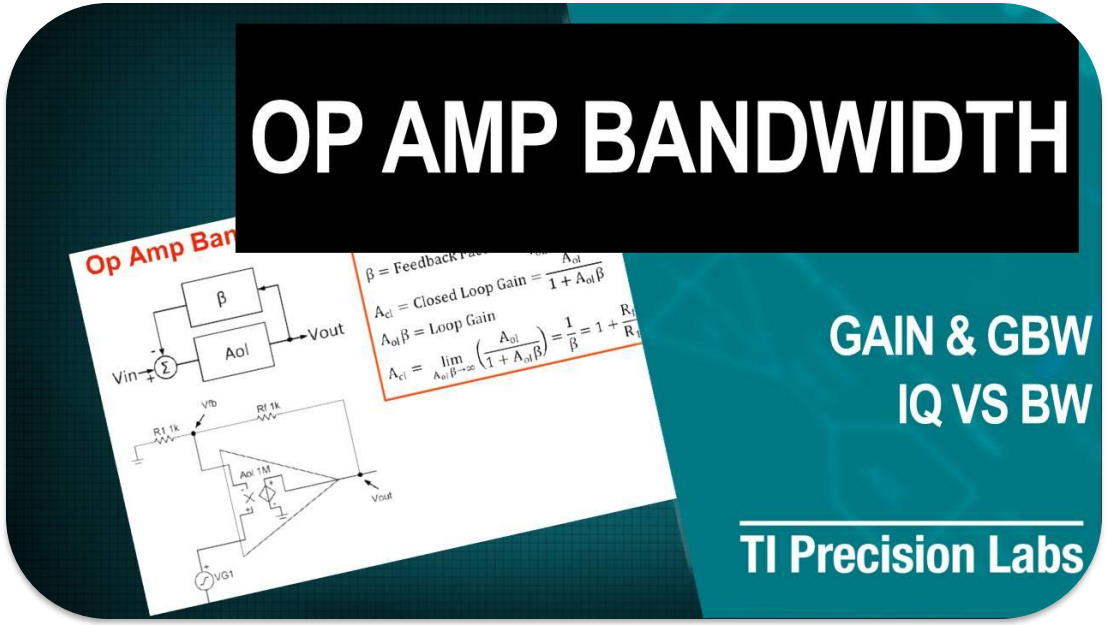


Stage 4: Prototype

Creating a frequency response model of an op-amp

The Model

1. Start with **ideal op-amp symbol**
2. Add **frequency-dependent elements** (capacitance)
3. Include **poles and zeros** to model frequency response
4. Model helps **predict frequency behavior** and bandwidth

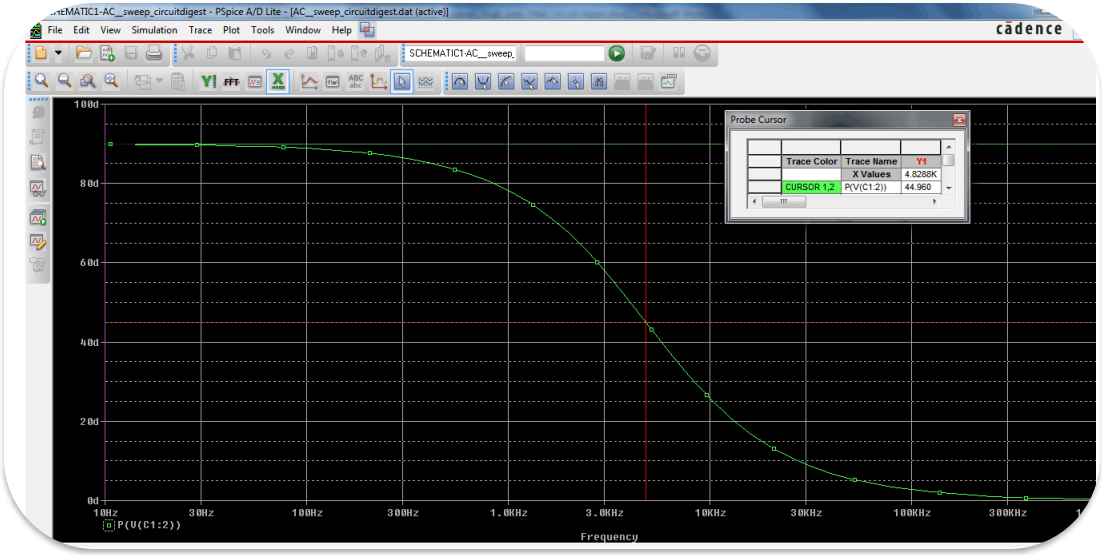


Stage 5: Test

Testing and evaluating frequency response calculations

Testing Method

1. Select a **test circuit** (e.g., inverting amplifier)
2. Measure **frequency response** using network analyzer
3. Create **Bode plot** to visualize gain and phase
4. Compare measured results with **theoretical predictions**



Bandwidth and Gain-Bandwidth Product

Bandwidth

Definition: Frequency range where gain is within 3dB of DC gain

Cutoff frequency: Point where gain drops by 3dB

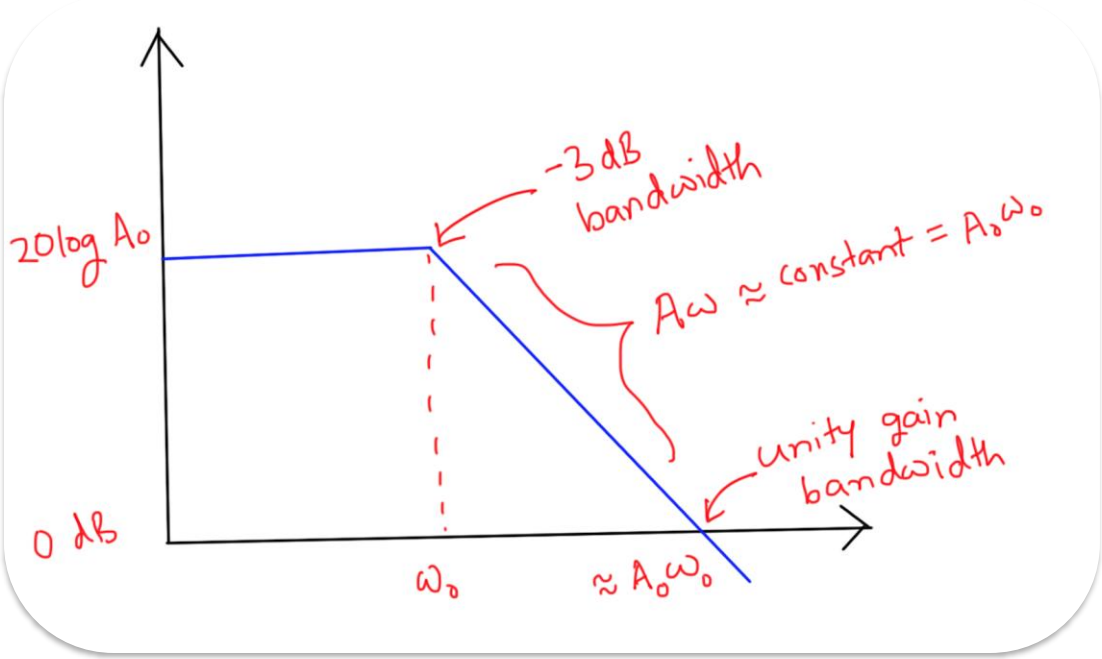
Trade-off: Higher gain reduces bandwidth

Gain-Bandwidth Product

Formula: GBW = A_DC × f_3dB

Constant for a given op-amp

Design tool for comparing op-amps



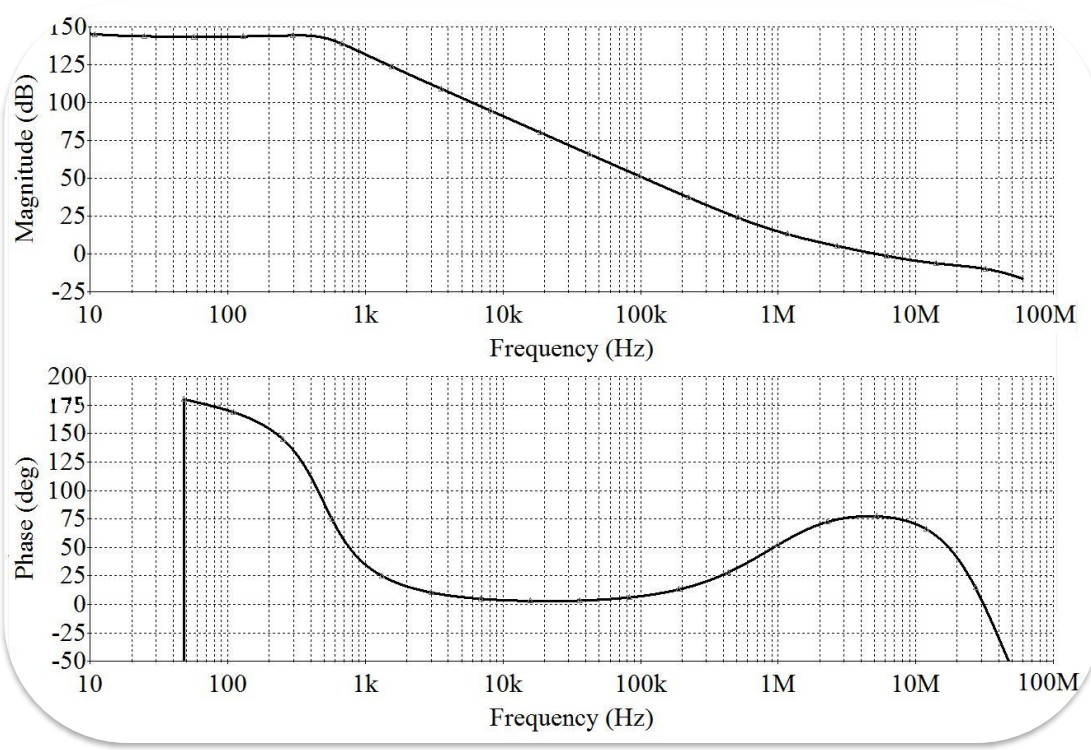
Bode Plots

Key Components

- **Magnitude plot**: Gain vs frequency (log scale)
- **Phase plot**: Phase shift vs frequency
- **Roll-off rate**: -20 dB/decade for single pole
- **Breakpoints**: Poles and zeros locations

Interpretation

- **Flat region**: Constant gain (0 dB/decade)
- **Transition region**: -20 dB/decade slope
- **Crossover frequency**: Where magnitude crosses 0 dB



Activity: THINK-PAIR-SHARE

THINK (2 min)

An op-amp has a **gain-bandwidth product** of 1 MHz. What is the maximum gain for a bandwidth of 100 kHz?

PAIR (3 min)

Discuss your calculation and method with a partner

SHARE (5 min)

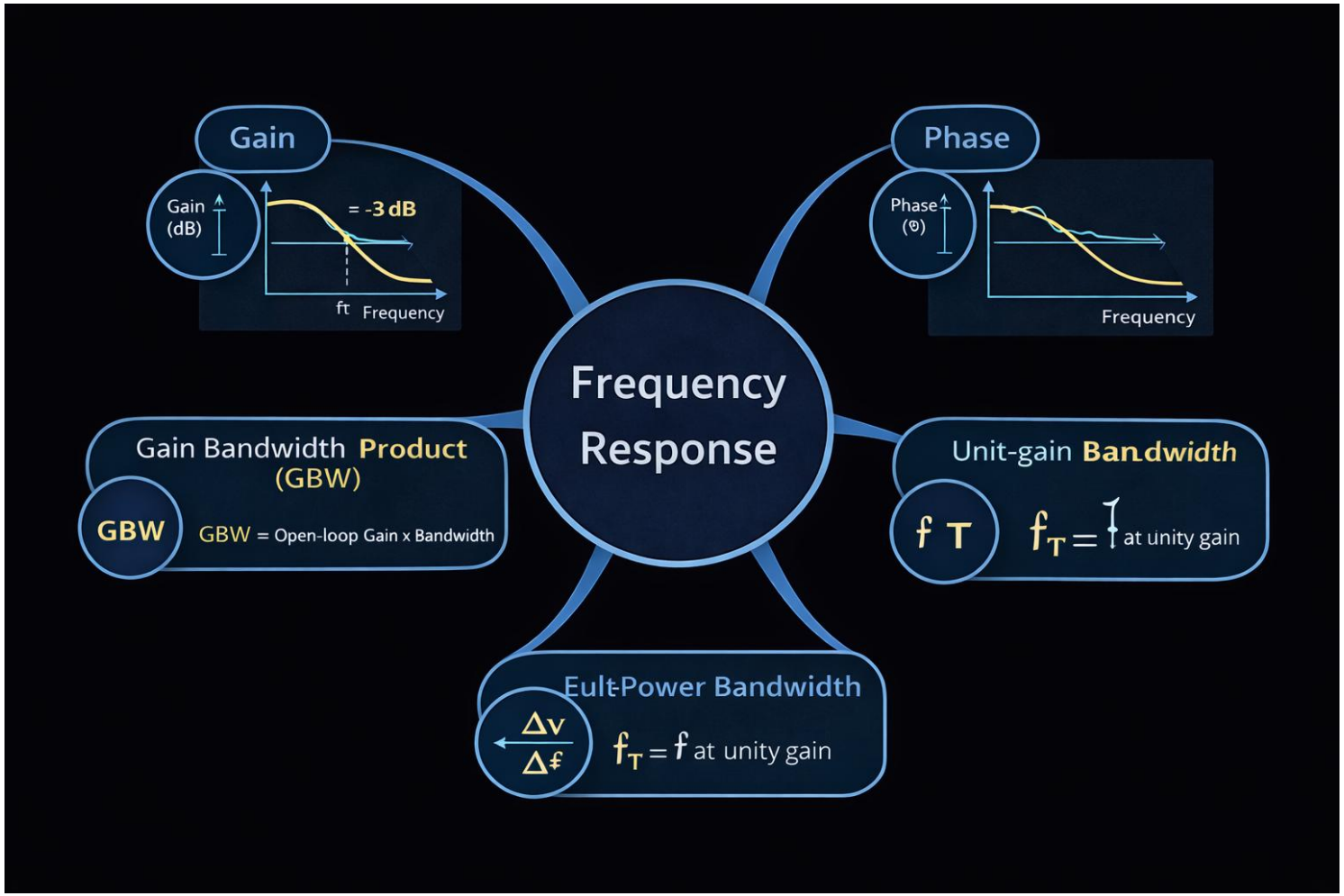
Be ready to share your answer and formula you used

Individual Thinking

Partner Discussion

Group Sharing

Mind Map Activity



Assessment

Exam-Oriented Questions

1. Define **bandwidth** and explain its significance in op-amp circuits.

2. Explain the relationship between **gain and bandwidth** in op-amp circuits.

3. Draw a **Bode plot** for an op-amp with a single pole at 10 kHz.

4. Calculate the maximum gain for an op-amp with a gain-bandwidth product of 5 MHz and required bandwidth of 100 kHz.

References

Textbooks

D.Roy Choudhry, Shail Jain, **"Linear Integrated Circuits"**, New Age International, 5th edition, 2018. (Unit I, Section 1.5)

Sergio Franco, **"Design with Operational Amplifiers and Analog Integrated Circuits"**, 4th Edition, Tata Mc Graw-Hill, 2014. (Chapter 3)

Online Resource

Texas Instruments, **"Op-amp Frequency Response and Bandwidth"**, [Link to TI E2E or technical document]

Textbooks

Online Resources

Thank You!