# 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 II –APPLICATIONS OF OPERATIONAL AMPLIFIERS**

**Topic :Logarithmic and Antilogarithmic Amplifier**

# Ideate

www.snsgroups.com

## Basic Principle

Output voltage is proportional to the natural logarithm of input voltage

### PN Junction

Exponential I-V characteristic

### Diode Equation

$I = I_s \cdot \exp(V/V_T)$

### VT

Thermal voltage (~26mV at 27°C)

### Is

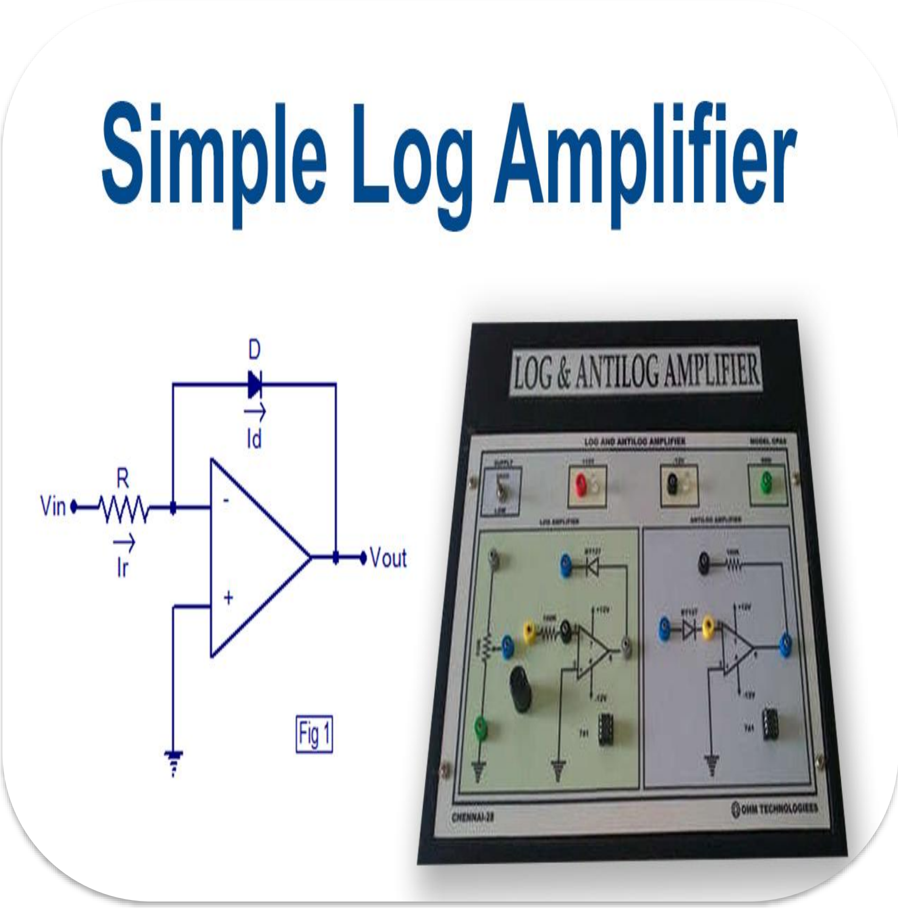
Saturation current

### Linearization

Sensor response linearization

**Key Concept:** Log amplifiers compress wide dynamic range, useful for sensors with exponential response

# Prototype




## Circuit Components

### Op-Amp
Operational amplifier (IC)

### Input Resistor
Rin controls input current

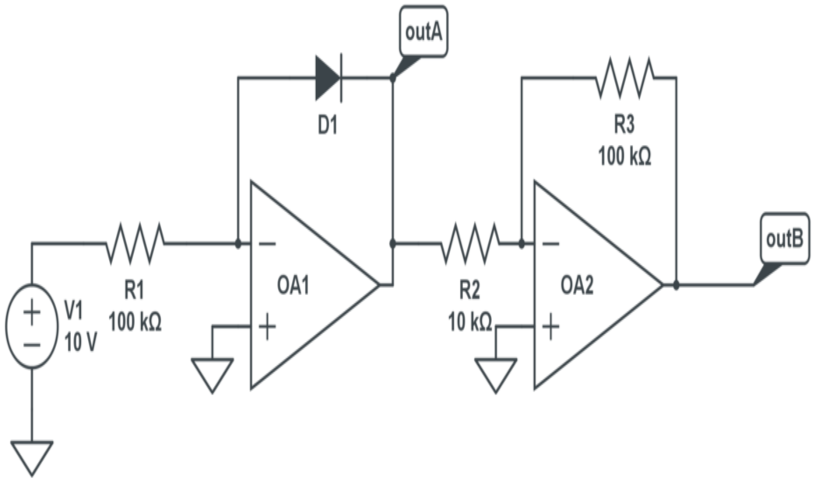
### Feedback Element
Diode or transistor

### Power Supply
Dual voltage rails

### Circuit Operation
Input voltage applied through Rin to inverting terminal, feedback through diode provides logarithmic output

- Inverting configuration
- Virtual ground at inverting input
- Requires positive Vin

# Test




Σ Output Formula

$$V_{out} = -(V_T/R_{in})\ln(V_{in}/I_s)$$

**VT**

Thermal voltage

**≈ 26 mV at 27°C**

**Is**

Saturation current

**Device parameter**

**Input Range**

Positive Vin only

**Step 1**

I = Vin/Rin

**Step 2**

Vout = -VT·ln(I/Is)

**Operating Condition:** Vin must be positive and forward bias the diode properly

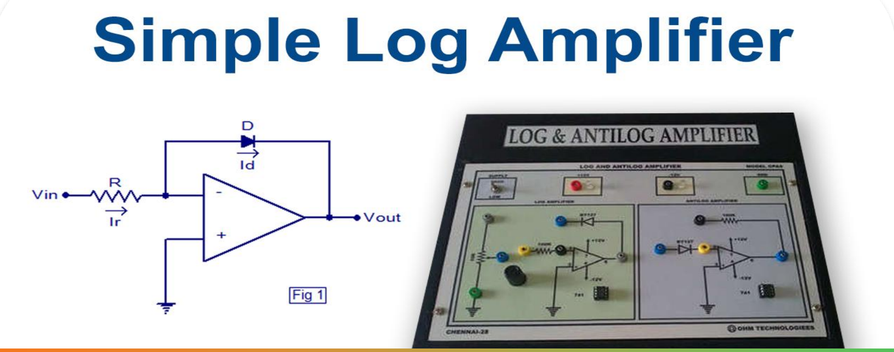
# Logarithmic Amplifier Applications & Characteristics

### Dynamic Range Compression

Compresses wide input range to manageable output

**40-60 dB**

Effective Range




### Sensor Linearization

- Photodiodes
- Thermistors
- Exponential transducers

### Analog Computation

- Logarithmic scaling
- Multiplication via addition
- Signal processing

### Advantages

- Wide input range
- Simple circuit
- Low component count

### Limitations

- Temperature sensitive
- Non-ideal diode
- Limited accuracy

**Practical Applications:** Optical power measurement, Audio compressors, Industrial instrumentation, Data acquisition systems

# Ideate

## Inverse Operation

Performs exponential operation, inverse of logarithmic amplifier

### Output Characteristic

Exponential response $V_{out} \propto \exp(V_{in})$

### Log-Antilog Pair

Complementary circuits for computation

### Input Path

Diode in input stage

### Base Function

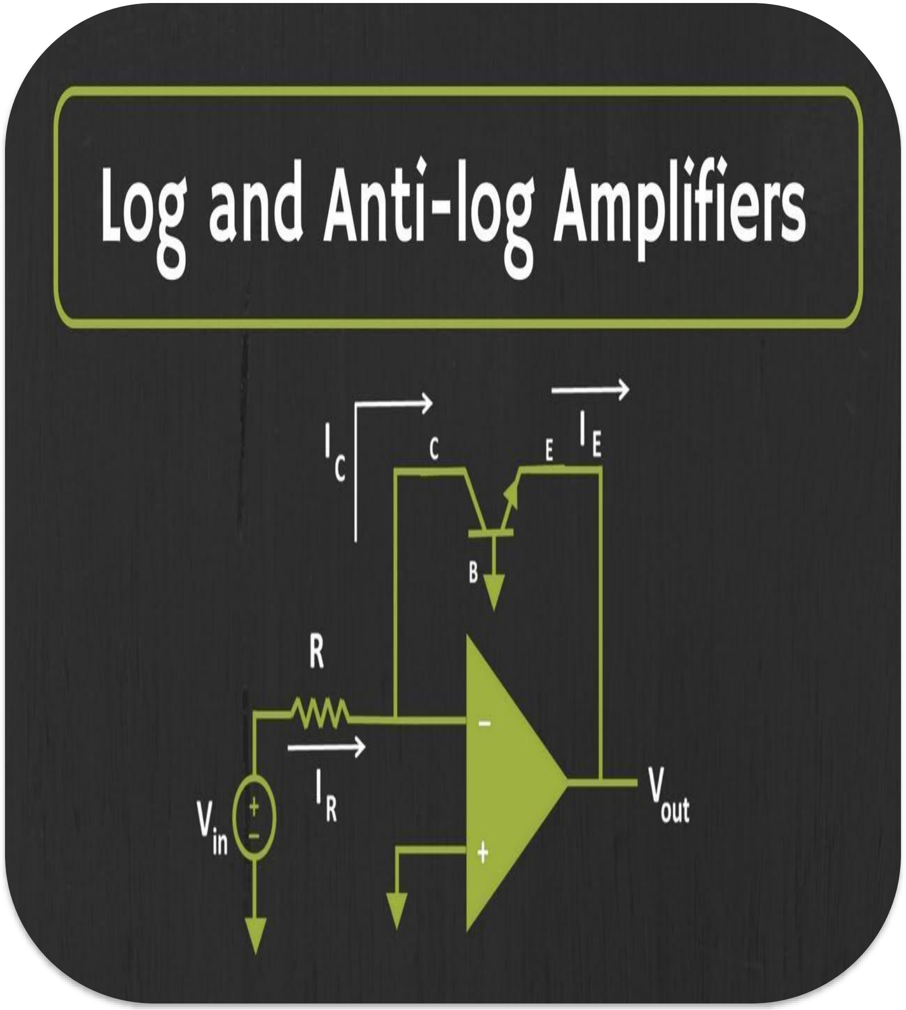
Exponential operation

### Reversibility

Undo log operation

**Key Concept:** Antilog amplifiers expand compressed logarithmic signals back to original range

# Prototype




## Circuit Components

### Op-Amp
Operational amplifier

### Input Element
Diode or transistor

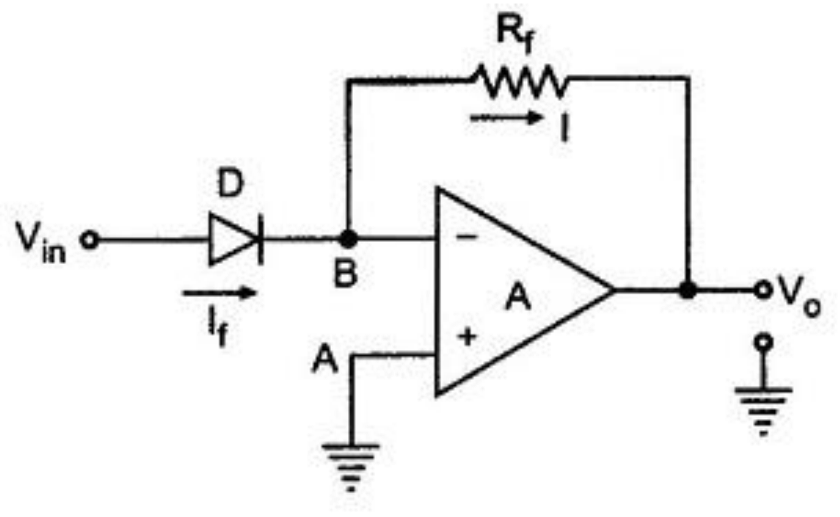
### Feedback Resistor
Rf controls output gain

### Reference Current
Iref from bias circuit

### Circuit Operation
Input voltage applied through diode to inverting terminal, exponential current converted to voltage by Rf

- Inverting configuration
- Current-driven input
- Voltage conversion

# Test




### Output Formula

## Vout = -Rf·Iref·exp(Vin/VT)

### Exp(Vin/VT)

Exponential function

**Increases rapidly**

### Iref

Reference current

**Sets output scale**

### Inverse of Log

Reverses logarithmic operation

### Step 1

I = Iref·exp(Vin/VT)

### Step 2

Vout = -I·Rf

**Operating Condition:** Vin applied to diode base, exponential current flows through feedback resistor

# Antilogarithmic Amplifier Applications & Characteristics

### Exponential Response

Rapidly expanding output

$$V_{out} \propto \exp(V_{in})$$

Output Characteristic

### Analog Multiplication

- Log + Antilog cascade
- $V1 \times V2 = \exp(\ln V1 + \ln V2)$
- High precision computation

### Power Functions

- V^x operations
- Non-linear transformations
- Signal processing

### Advantages

- Inverse of log amp
- Wide output range
- Versatile computation

### Limitations

- Temperature sensitive
- Component matching
- Power consumption

**Practical Applications:** Analog computers, Multiplier circuits, Signal expansion, Control systems, Frequency synthesis

# Comparison: Log vs Antilog Amplifiers

## Logarithmic

**Function: Logarithmic**

Compresses wide range

**Formula**

$V_{out} = -(V_T/R_{in})\ln(V_{in}/I_s)$

**Applications**

Linearization • Compression • Sensor interfacing

**Advantage**

Wide dynamic range compression (40-60 dB)

## Antilogarithmic

**Function: Exponential**

Expands compressed range

**Formula**

$V_{out} = -R_f \cdot I_{ref} \cdot \exp(V_{in}/V_T)$

**Applications**

Multiplication • Division • Power functions

**Advantage**

Inverse of log, versatile computation

# Practical Circuit Applications

### Sensor Linearization

- Photodiodes
- Thermistors
- Exponential transducers

### Analog Multipliers

- Log + Antilog cascade
- $V1 \times V2 = \exp(\ln V1 + \ln V2)$
- High precision

### Signal Compressors

- Audio compressors
- Industrial instrumentation
- Dynamic range reduction

### Signal Processing

- Range compression
- Noise reduction
- Pre-processing

# Activity: THINK • PAIR • SHARE

## 1 THINK

### Individual Reflection

- Compare advantages and disadvantages of log and antilog amplifiers
- Consider temperature sensitivity and component requirements
- Evaluate dynamic range limitations

## 2 PAIR

### Partner Discussion

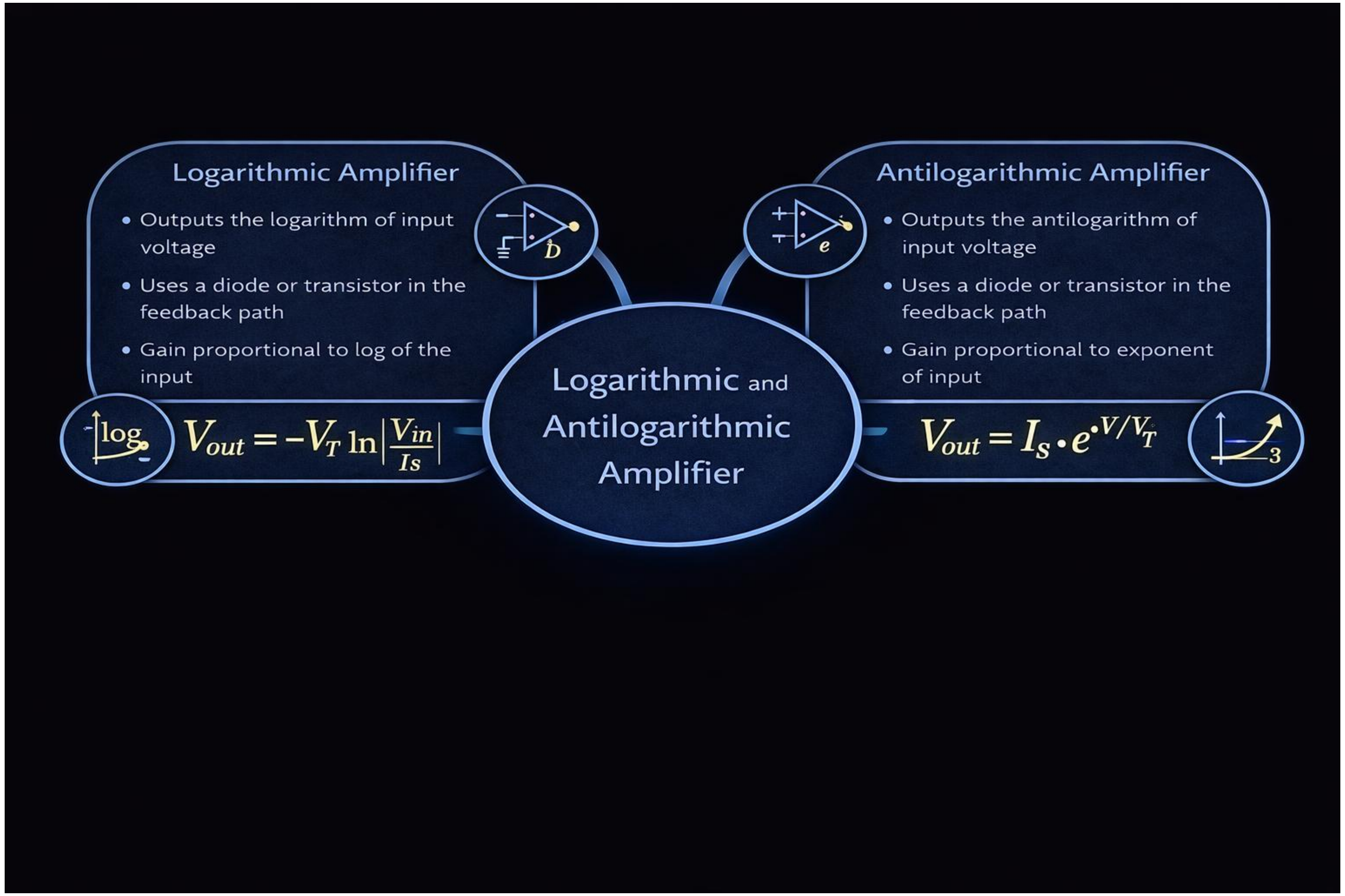
- When to use log vs antilog amplifiers
- Sensor linearization applications
- Analog computation requirements

## 3 SHARE

### Group Discussion

- Present findings on circuit selection
- Justify choice for specific applications
- Design examples and practical considerations

# Mind Map - Logarithmic & Antilogarithmic Amplifiers



# Assessment & Review

## Logarithmic Amplifier

**Derive Output Formula**

$V_{out} = -(V_T/R_{in})\ln(V_{in}/I_s)$

**Explain Key Parameters**

- VT: Thermal voltage (~26mV at 27°C)
- Is: Saturation current
- Operating: Positive Vin required

**Advantages & Disadvantages**

| | |
|---|---|
| + Wide range compression | - Limited accuracy |

## Antilogarithmic Amplifier

**Derive Output Formula**

$V_{out} = -R_f \cdot I_{ref} \cdot \exp(V_{in}/V_T)$

**Explain Exponential Operation**

- exp(Vin/VT) provides rapid increase
- Iref sets output scale
- Requires component matching

**Advantages & Disadvantages**

| | |
|---|---|
| + Versatile computation | - Temperature sensitive |

# References & Further Reading

## Textbooks


1. **Sergio Franco**
   "Design with Operational Amplifiers and Analog Integrated Circuits"
2. **D. Roy Choudhry & Shail Jain**
   "Linear Integrated Circuits"
3. **Ramakant A. Gayakwad**
   "OP-AMP and Linear ICs"


## Online Resources


**Texas Instruments**
MT-077: Log Amp Basics Tutorial

**Analog Devices**
Op-Amp Applications Handbook

**Application Notes**
Design guides and specifications

# Thank You