

# 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 :Comparators and Schmitt Trigger**

## ↔ Basic Principle Compares Two Voltages

### ⊘ No Feedback

Open-loop operation

### ⇨ Saturation Output

High/Low binary states

**Key Difference from Amplifiers:** No feedback, output saturates, switches between two voltage levels

### ADC

Analog-to-digital conversion

### Zero Crossing

AC signal detection

### ⚡ Level Detection

Signal threshold monitoring

## Open-Loop Op-Amp

### No Feedback

#### Non-Inverting (+)

Reference voltage input

#### Inverting (-)

Signal input

#### Direct Output

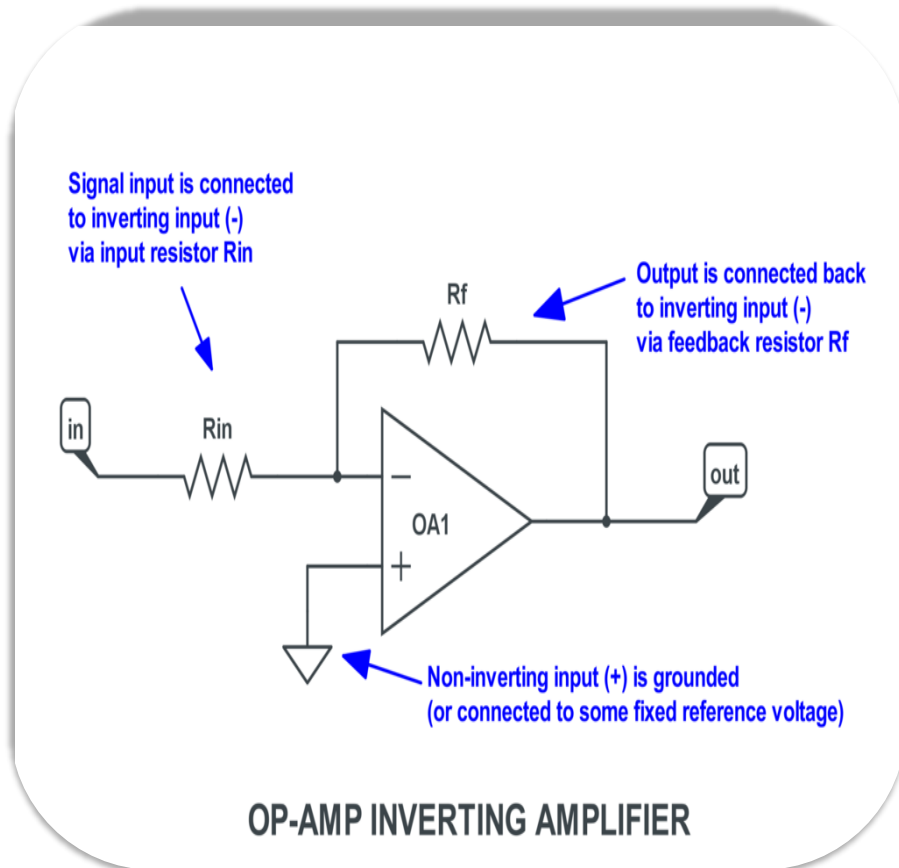
Connected to saturation output

#### Power Supply

Dual voltage rails  $\pm V$

#### Comparison Logic

$V_{in} > V_{ref} \rightarrow V_{sat+}$



↕ Switching Condition

$V_{in} > V_{ref}$  OR  $V_{in} < V_{ref}$

⊘ No Feedback

Open-loop operation

🔄 Response Time

Propagation delay

↑ Positive Sat

$V_{sat+} \approx +V_{CC}$

↓ Negative Sat

$V_{sat-} \approx -V_{EE}$

**Transfer Characteristic:** Stepped response with single threshold, output saturates at supply rails

# Inverting vs Non-inverting Comparators



## Inverting

- $V_{in}$  at inverting input
- $V_{ref}$  at non-inverting

### Output Logic

$$V_{in} > V_{ref} \rightarrow -V_{sat}$$

$$V_{in} < V_{ref} \rightarrow +V_{sat}$$



## Non-inverting

- $V_{in}$  at non-inverting
- $V_{ref}$  at inverting

### Output Logic

$$V_{in} > V_{ref} \rightarrow +V_{sat}$$

$$V_{in} < V_{ref} \rightarrow -V_{sat}$$

- Regenerative comparator
- With positive feedback
- Creates hysteresis

## ⚠ Why Hysteresis?

### Two Switching Thresholds

#### 🛡 Noise Immunity

Rejects small noise

#### 🚫 Chatter Elimination

Prevents multiple switching

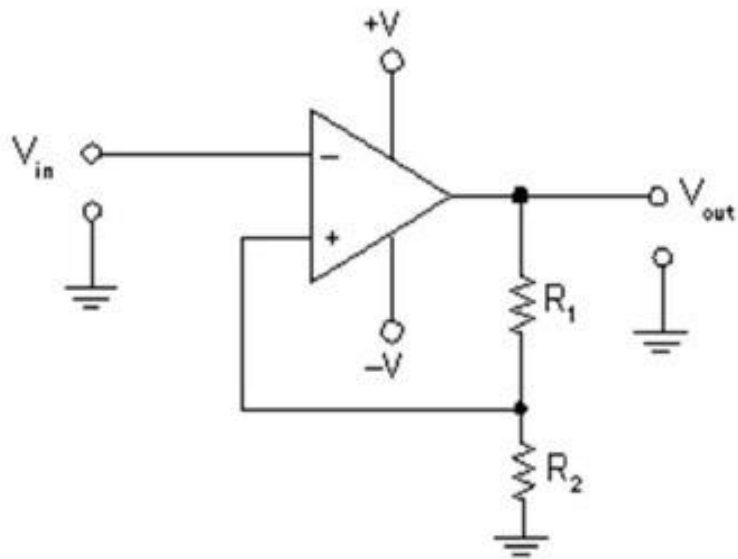
#### 🔄 Positive Feedback

Creates memory effect

#### 🔘 Bistable Output

Two stable states

**Key Advantage:** Clean switching, no noise sensitivity, precise threshold control compared to simple comparators



## Inverting Configuration Positive Feedback Network

### ↑ Upper Threshold

$$V_{UT} = (R1+R2/R1)V_{ref}$$

### ↓ Lower Threshold

$$V_{LT} = (R2/R1)V_{ref}$$

### ↔ Inverting Input

Signal at (-) terminal

### ⚡ Reference Vref

Sets threshold levels

### ⚡ R1, R2 Values

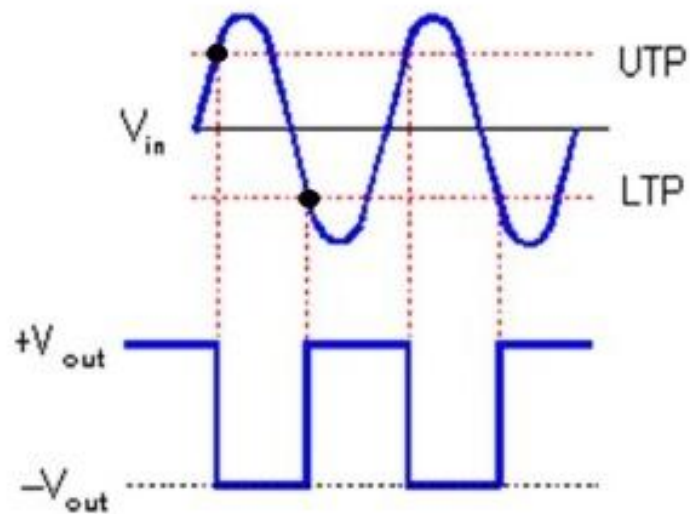
Determine hysteresis width

### ✓ Hysteresis Width

$$V_{UT} - V_{LT}$$

### ⚡ Dual Supply

±VCC operation



## Hysteresis Concept

### Two Switching Thresholds

#### ↑ Upper Threshold

$$V_{UT} = (R1+R2/R1)V_{ref}$$

#### ↓ Lower Threshold

$$V_{LT} = (R2/R1)V_{ref}$$

#### 🛡️ Noise Immunity

Prevents false triggering

#### 🕒 Memory Effect

Hysteresis loop

#### 🔘 Bistable

Two stable output states

#### ↔ Transfer Characteristic

Square hysteresis loop

#### 🏎️ Switching Speed

Fast response time

## →← Comparator Applications

### Zero Crossing Detector

AC signal detection

### ↗ Peak Detector

Maximum/minimum tracking

### ⬇ Window Comparator

Range detection

### A/D Converter

Analog-to-digital conversion

### PWM Generator

Pulse width modulation

## ↔ Schmitt Trigger Applications

### 🔇 Noise Elimination

Chatter prevention

### 🔘 Switch Debouncing

Clean contact signals

### ◻ Pulse Shaping

Edge enhancement

### • Sine-to-Square

AC to DC conversion

### ■ Square Generator

Clock signal generation

## ↔ Comparator

- ✓ Single Threshold
- ✗ No Hysteresis
- 🔒 Open-Loop Operation
- 📄 Fast Response
- ⚠ Susceptible to Noise

### ↘ Disadvantage

Multiple switching near threshold (chatter)

## ↔ Schmitt Trigger

- ✓ Two Thresholds
- 🔄 With Hysteresis
- 🔄 Positive Feedback
- 🛡 Noise Immune
- 🕒 Regenerative Action

### ↗ Advantage

Clean switching, prevents chatter

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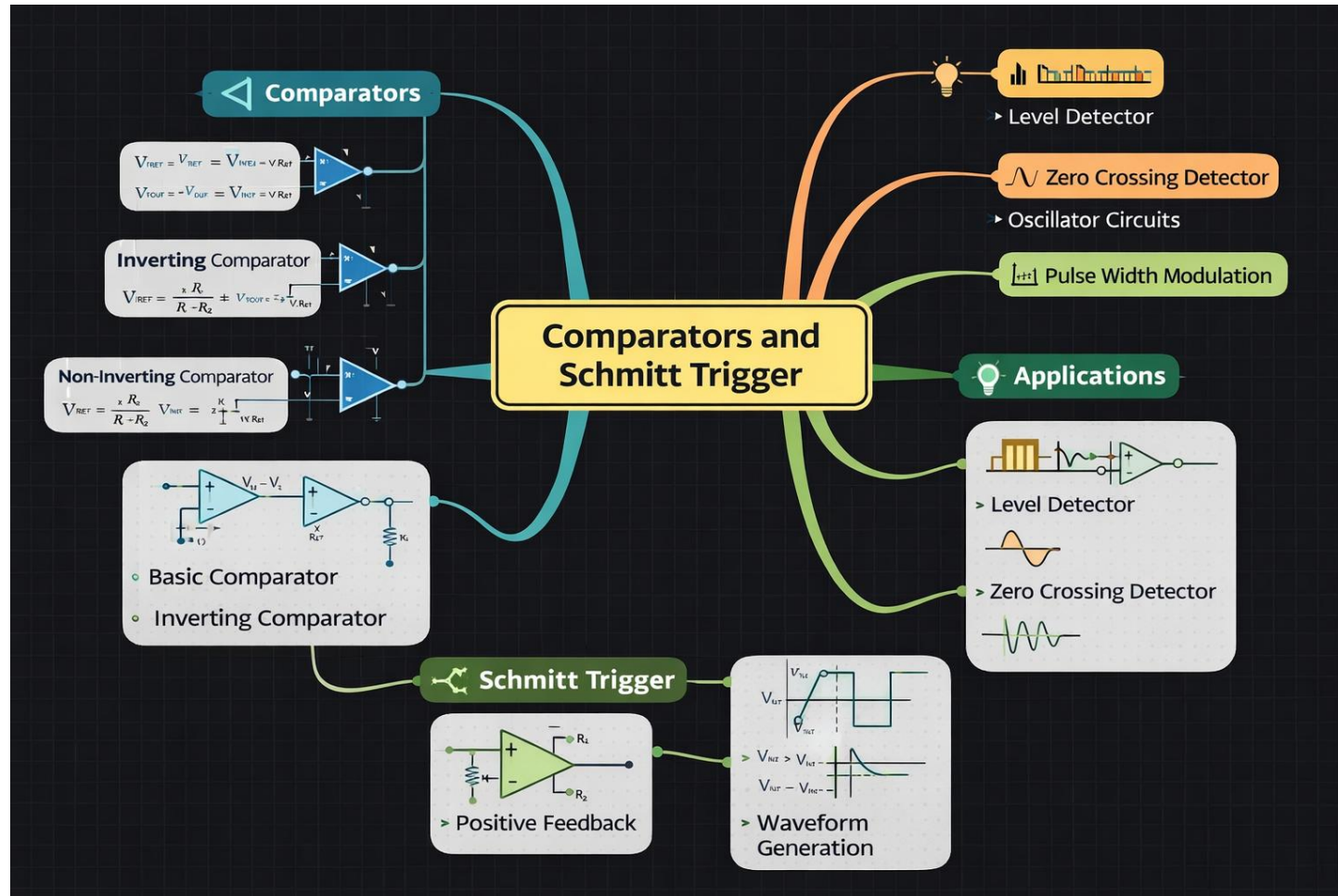
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### Group Discussion

- Best circuit for specific applications
- Justify circuit choice
- Design recommendations

# Mind Map - Comparators & Schmitt Trigger



## ↔ Comparator

### Q1: Derive Switching Condition

$V_{in} > V_{ref}$  OR  $V_{in} < V_{ref}$

### Q2: Explain Open-Loop Operation

No feedback, output saturates at  $V_{sat\pm}$

### Q3: Noise Sensitivity Issue

Multiple switching near threshold (chatter)

## ↔ Schmitt Trigger

### Q4: Derive Threshold Formulas

$V_{UT} = (R1+R2/R1)V_{ref}$ ,  $V_{LT} = (R2/R1)V_{ref}$

### Q5: Explain Hysteresis

Two threshold levels create memory effect, noise immunity

### Q6: Calculate Hysteresis Width

## 📋 Design Problem

**Q7:** Design a Schmitt trigger for sine-to-square conversion with 5V supply, switching thresholds at 3V and 2V. Calculate R1/R2 ratio.

**Q8:** Design a window comparator to detect voltage range 4V-6V. Draw circuit and explain operation.

## 💡 Key Concepts

**Hysteresis:**  $\Delta V = V_{UT} - V_{LT}$

**Regenerative:** Positive feedback action

**Bistable:** Two stable output states

**Noise Immunity:** Schmitt > Comparator

## 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

Comparator Applications  
Handbook



### Analog Devices

Schmitt Trigger Design Guide



### Electronics Tutorials

Comparator and Schmitt Trigger  
Applications



### Application Notes

Design guides and specifications



# Thank You

