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COIMBATORE-641 035, TAMIL NADU

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

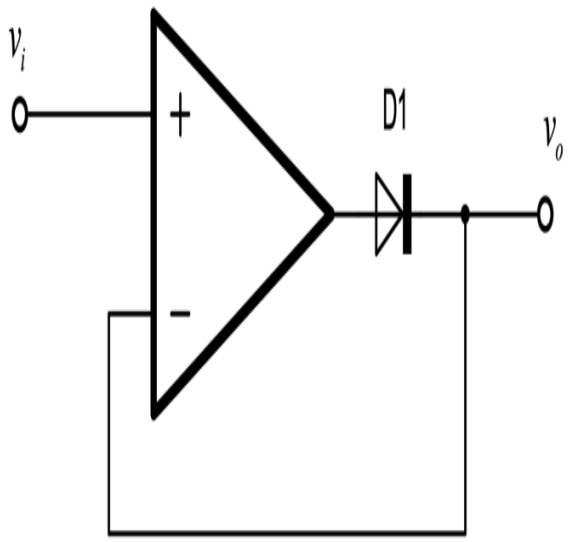
Course Name: 23ECT203 LINEAR INTEGRATED CIRCUITS

II YEAR/VI SEMESTER

UNIT II –APPLICATIONS OF OPERATIONAL AMPLIFIERS

Topic : Precision Rectifier and Peak Detector

Introduction to Precision Rectifier



What is Precision Rectifier?

Eliminates Diode Drop

Op-amp feedback removes Vf

High Accuracy

Precise absolute value output

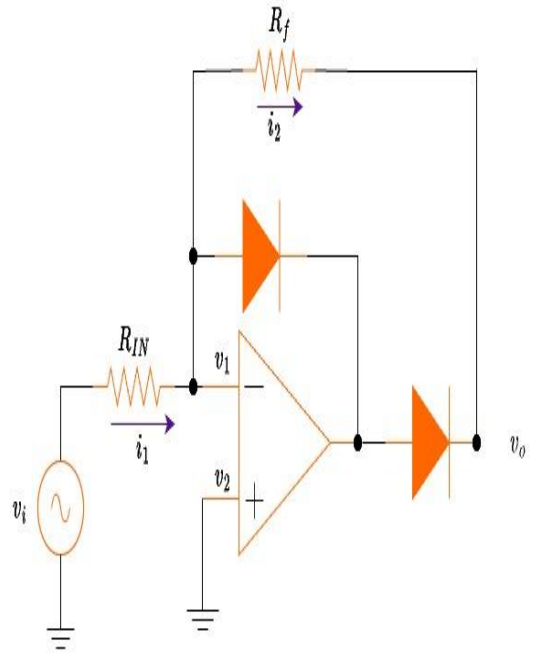
Vs. Conventional

- Conventional: Vout = Vin - Vf
- Precision: Vout = |Vin| (no Vf)
- Better for measurement systems

Basic Principle

Op-amp in feedback loop with diode creates ideal rectifier

Define



Σ Output Formula

Vout = |Vin|

No Diode Drop

Op-amp eliminates Vf in feedback

High Accuracy

Output equals absolute input value

Input

AC signal at inverting terminal

Feedback

Diode rectifies output

Output

DC = |AC| (rectified)

Key Characteristic: Output magnitude equals input magnitude, eliminates diode forward voltage drop through op-amp feedback loop

Ideate

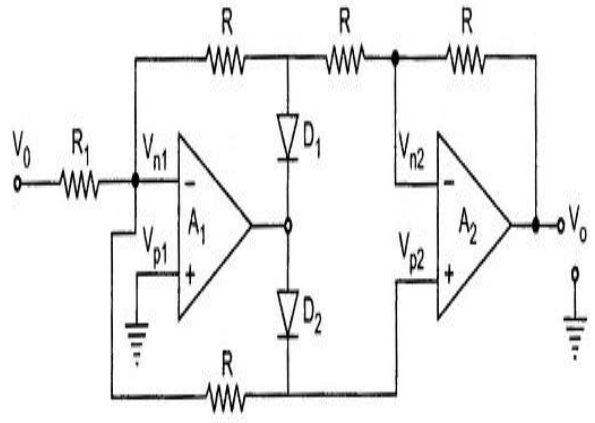


Fig. 2.63 Full wave rectifier

Full-Wave Rectification

Both Half-Cycles

Two Op-Amps

Dual configuration for full-wave output

Bridge Config

Using precision diodes

High Efficiency

Better than half-wave (100% vs 50%)

Precision

Eliminates diode Vf completely

Positive Cycle

Rectified by first half

Negative Cycle

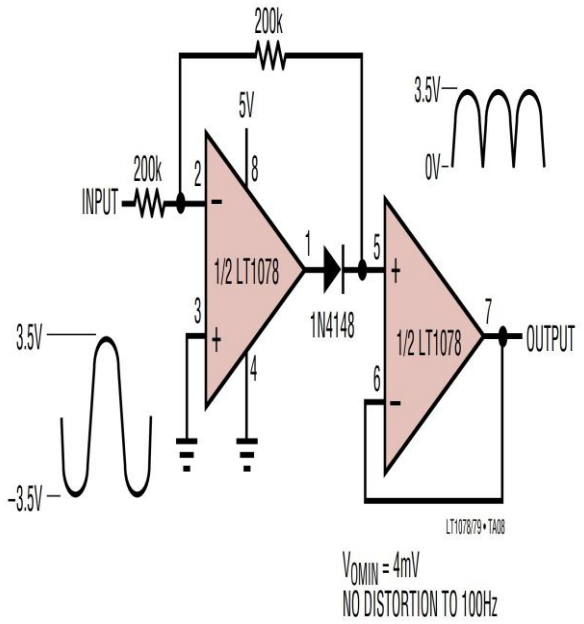
Rectified by second half

DC Output

Smooth rectified DC

Advantage: Double output frequency, smoother DC, higher efficiency compared to half-wave configuration

Prototype & Testing



How It Works

Op-amp in feedback with diode eliminates Vf

Output Formula

|Vin|

Fast Response

Low propagation delay

High Accuracy

Eliminates diode drop

Low Distortion

Clean DC output

Input

AC signal applied

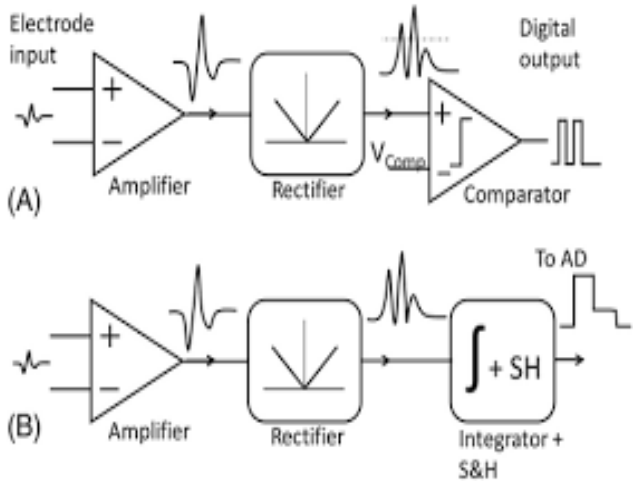
Output

|Vin| absolute value

Freq Response

Wide bandwidth

Applications of Precision Rectifier



RMS Measurement

Calculate root mean square value

AC Voltmeter

Accurate AC without diode drop

Signal Processing

Absolute value detection

Mathematical

Absolute value computation

Analog Computing

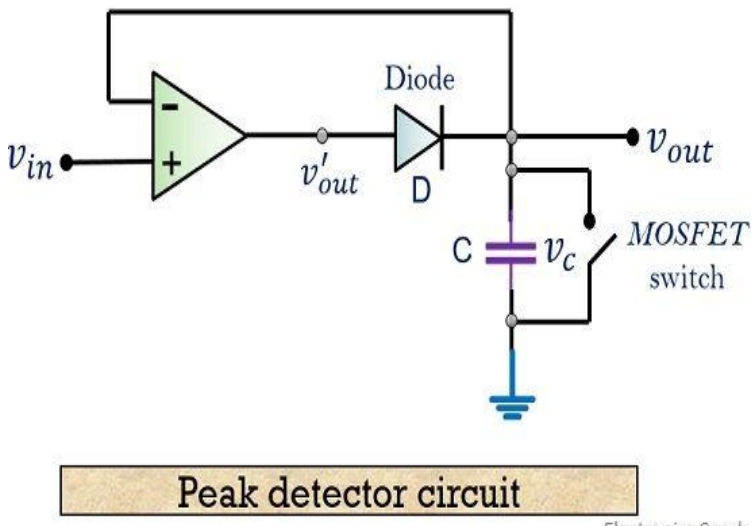
Precision analog operations

Instrumentation

Measurement systems

Key Advantage: Precision rectifiers provide accurate |Vin| output without diode voltage drop, essential for instrumentation and measurement systems

Introduction to Peak Detector



Peak detector circuit

Electronics Coach

What is Peak Detector?

Captures Maximum Voltage

Peak Capture

Holds maximum value of input signal

Envelope Detection

Follows amplitude variations

Capacitor Holds

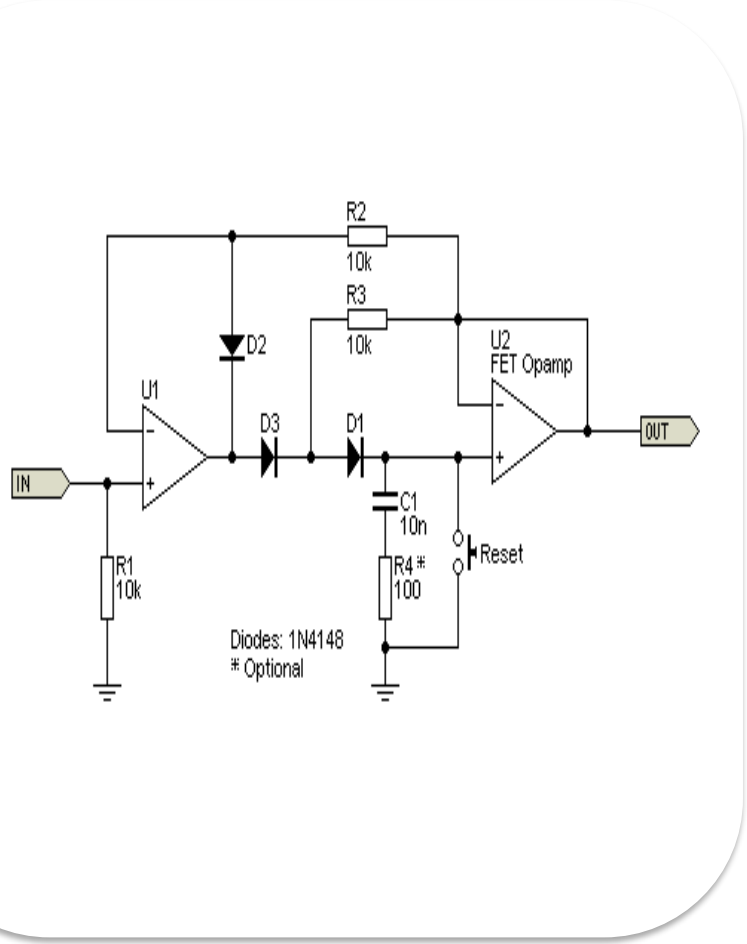
Stores peak voltage

Diode Rectifies

Prevents discharge

Basic Principle: Input signal charges capacitor through diode to peak value; output follows input peaks; capacitor voltage represents peak value

Ideate



Circuit Components

Op-Amp
Active element

Diode
Rectification

Capacitor
Holds peak voltage

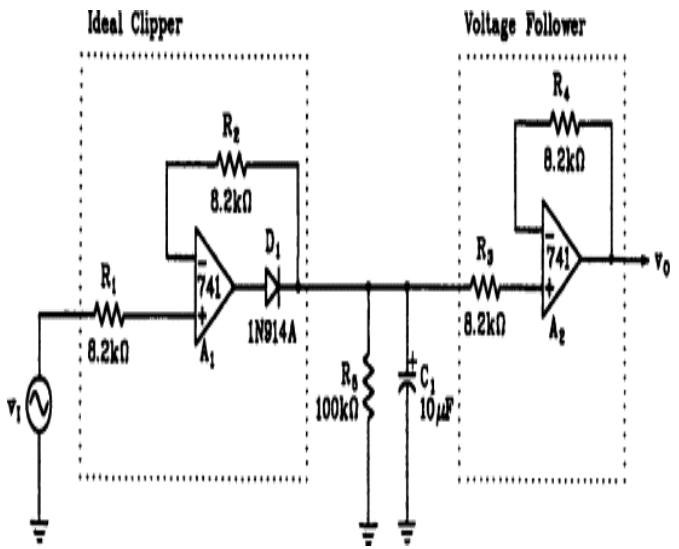
Input Signal
Applied to non-inverting

Output Peak
Maximum input voltage

Reset Path
Resistor discharges C

Operation: Diode charges capacitor to peak when input rises; capacitor holds voltage when input falls

Prototype



Charging Phase

Input rises → Capacitor charges to peak

Rise Phase

Diode conducts, capacitor charges to peak voltage

Fall Phase

Diode blocks, capacitor holds voltage

Holding

Capacitor stores peak value

Discharge

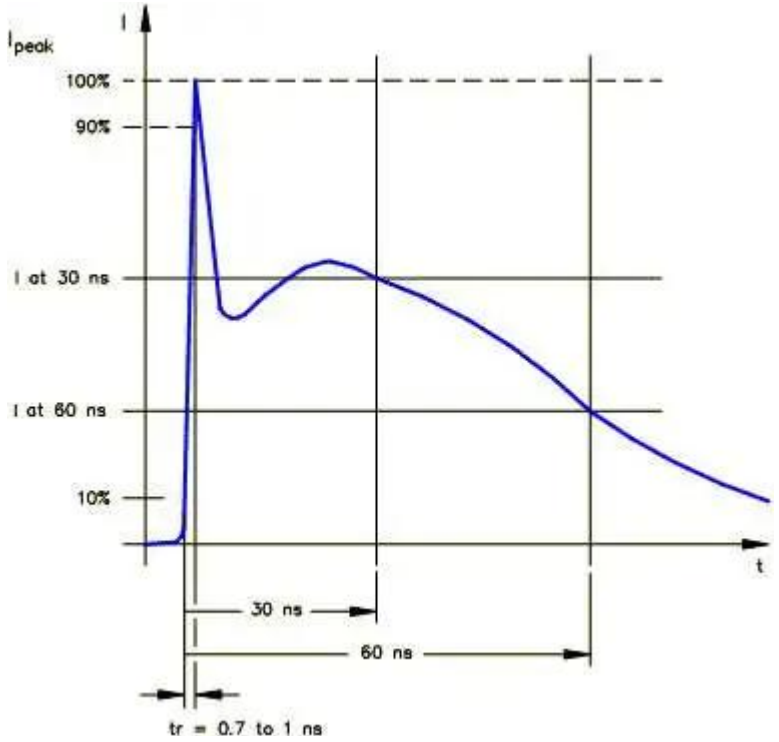
RC time constant

Reset

Follows new peak

Output follows input peaks - capacitor holds voltage between peaks, providing peak detection with memory effect

Testing



Key Parameters

Response Time

Depends on RC time constant

Accuracy

Capacitor value selection critical

Droop Rate

Discharge through resistor

Peak Capture

Maximum input voltage

Advantages

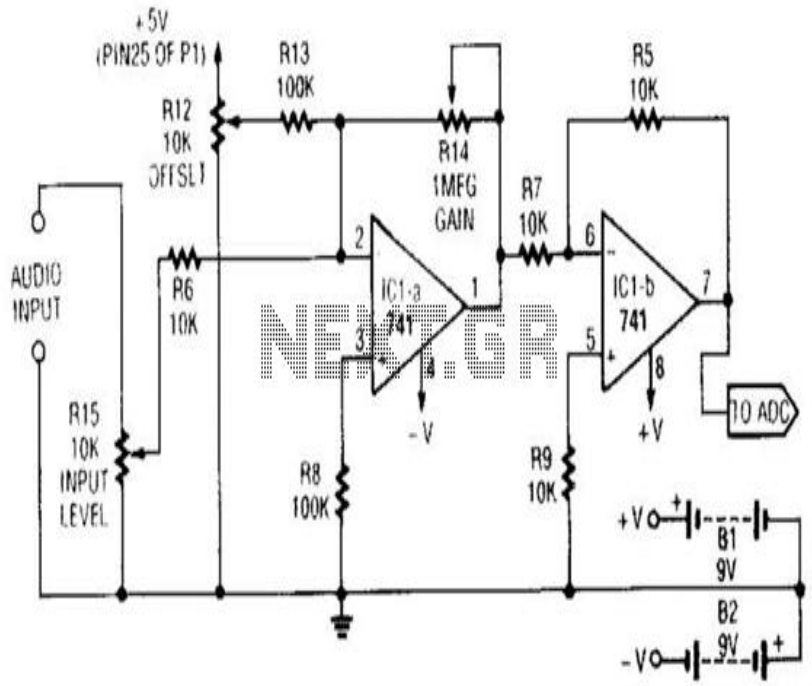
- Simple circuit
- Accurate peak measurement

Disadvantages

- Response time limited
- Droop affects measurement

Performance Note: RC time constant determines speed and accuracy trade-off; smaller C = faster response, larger C = slower droop

Applications of Peak Detector



Real-World Applications

AM Demodulation

Envelope detection for amplitude modulation

Peak Measurement

Instrumentation and measurement systems

Audio Processing

Amplitude tracking and analysis

Signal Analysis

Pulse detection and waveform analysis

Sensor Readings

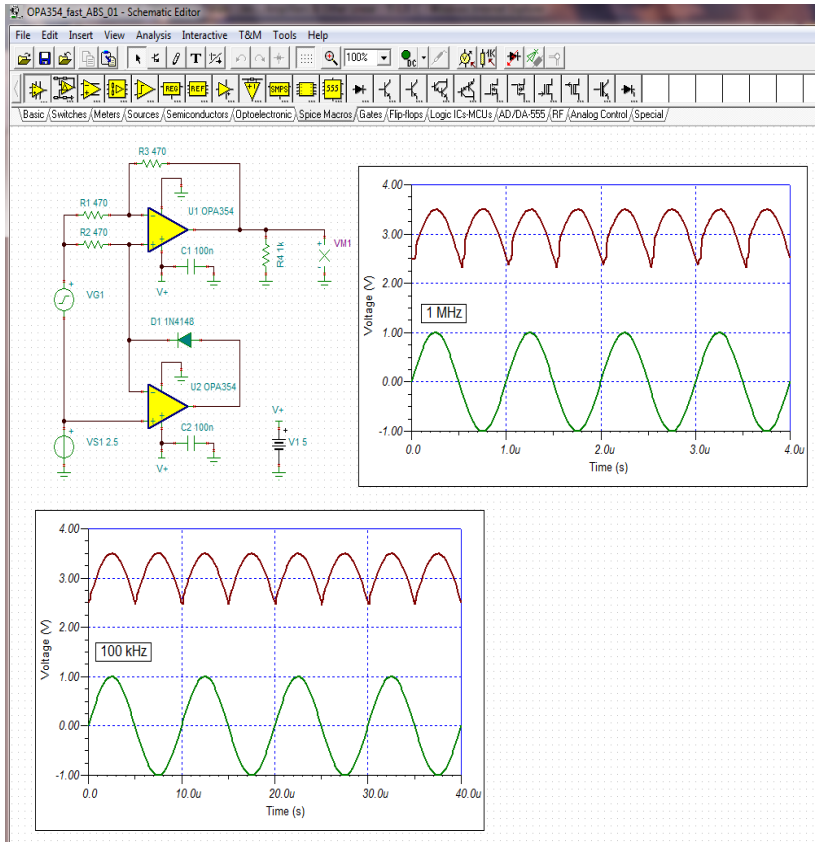
Peak value acquisition from sensors

Oscilloscope

Trigger and envelope detection

Key Feature: Peak detectors capture and hold maximum voltage values for real-time amplitude monitoring and signal envelope extraction

Comparison & Design Considerations



Precision Rectifier vs Peak Detector

Precision Rectifier

- Absolute value output |Vin|
- Instant response time
- No memory effect

Peak Detector

- Holds peak value Vmax
- Slower RC response
- Memory effect

When to Use Precision Rectifier

- Need absolute value
- Fast response required
- Signal processing

When to Use Peak Detector

- Peak measurement needed
- Envelope detection
- AM demodulation

Design Tip: For precision rectifier, use high-speed op-amp; For peak detector, select C based on RC time constant and signal frequency

Activity: THINK • PAIR • SHARE

1 THINK

Individual Reflection

- Compare precision rectifier and peak detector circuits
- Analyze output characteristics
- Consider design requirements

2 PAIR

Partner Discussion

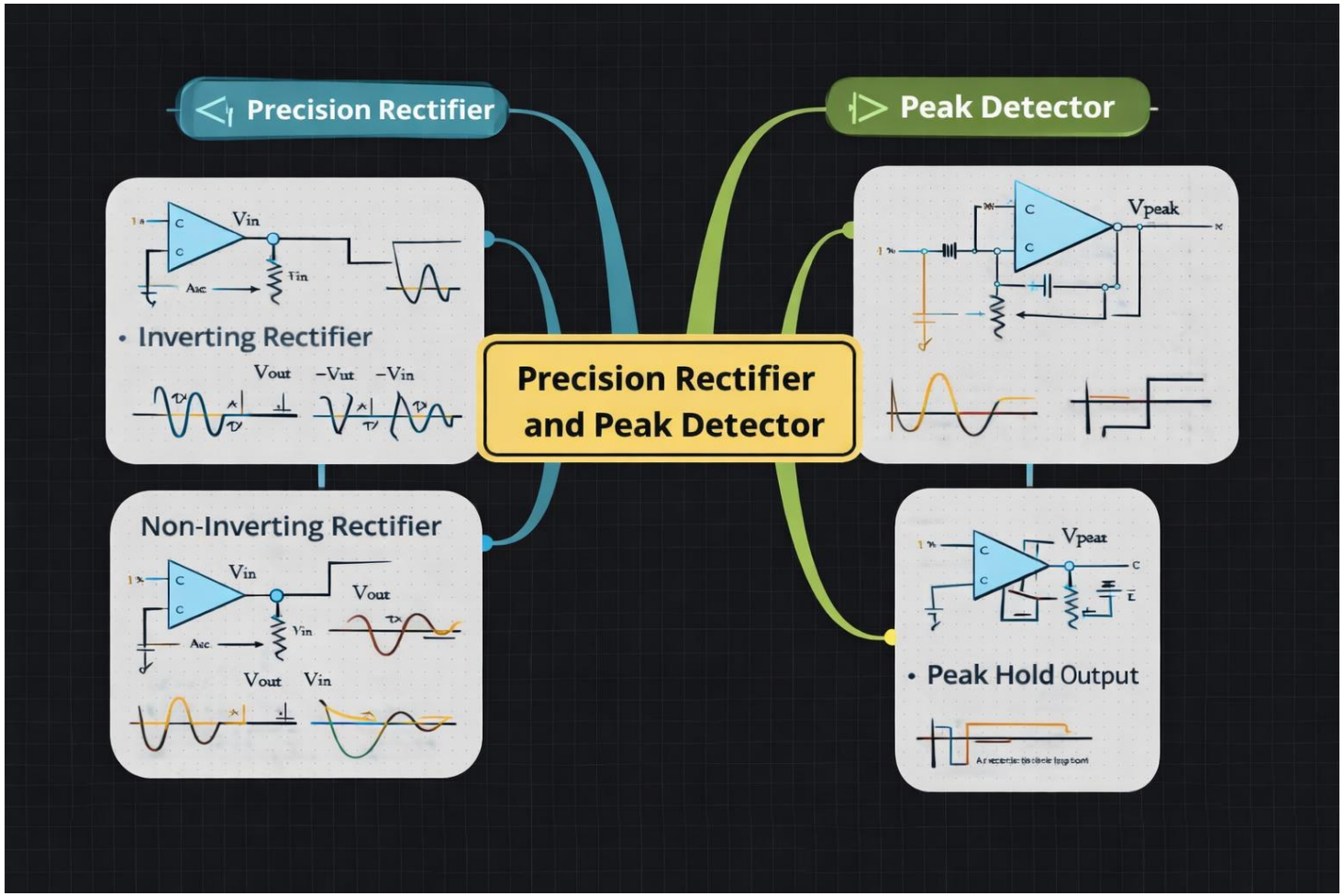
- Discuss applications of each circuit
- Compare design considerations
- Evaluate performance trade-offs

3 SHARE

Group Presentation

- Present circuit selection rationale
- Explain best circuit for specific applications
- Justify design choices

Mind Map - Precision Rectifier and Peak Detector



Assessment & Review

Precision Rectifier

Q1: Derive Output Formula

Vout = |Vin|

Q2: Explain Diode Drop Elimination

Op-amp in feedback eliminates Vf

Q3: Compare Half-Wave vs Full-Wave

Half-wave: 50% efficiency
Full-wave: 100% efficiency

Peak Detector

Q4: Explain Working Principle

Diode charges capacitor to peak value

Q5: Derive Capacitor Charging Equation

Vc(t) = Vpeak(1-e^(-t/RC))

Q6: Calculate RC Time Constant

RC = R×C determines response time

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

Precision Rectifier Applications - Technical Literature

Analog Devices

Peak Detector Design Guide - Application Notes

Electronics Tutorials

Rectifier and Detector Circuit Design

NPTEL

Linear Integrated Circuits - Video Lectures

Thank You

Understanding Precision Rectifiers and Peak Detectors is essential for measurement systems, signal processing, and instrumentation applications.

Precision Rectifiers

Provide absolute value output |Vin| without diode voltage drop

Peak Detectors

Capture and hold peak voltage values using capacitors

Measurement Systems

Accurate measurement and signal analysis for instrumentation