Design of application-specific amplifiers with OpAmps

Structured design approach

- Benefits
  - First time right
  - Predictable results
  - Manageble design process
  - Guaranteed by design
  - Knowledge building

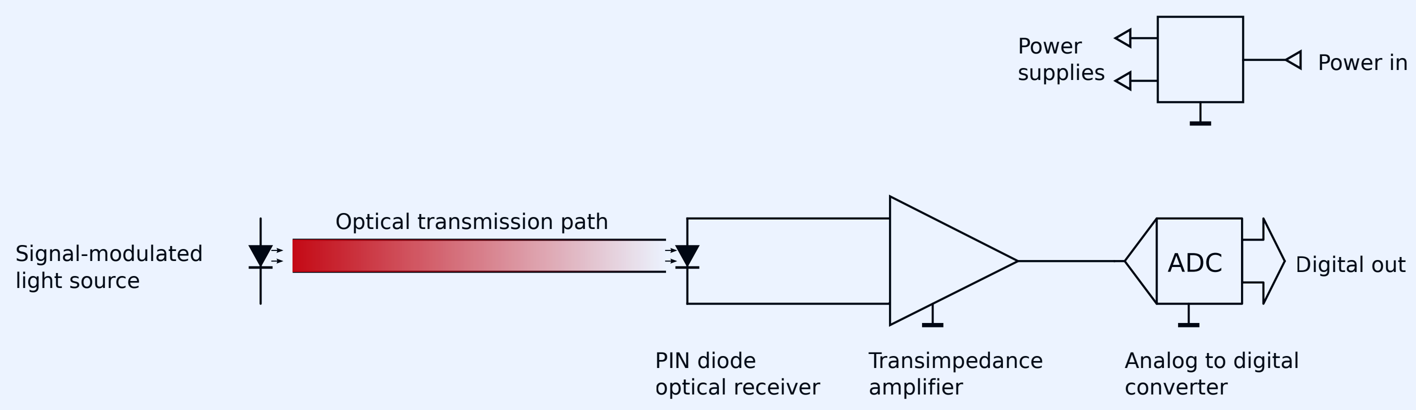
- Features
  - Clear distinction between concepts and implementation
  - SLiCAP: MATLAB based integrated design and HTML documentation tool
  - Use dedicated models for specific performance aspects during various stages of the design

- Practical approach:
  1. Specification of performance, environment and costs
  2. Concept development
  3. Implementation study (technology and components)
  4. Circuit engineering
  5. Design verification (simulation, prototype, ...)
  6. Design documentation (design, production, test, ...)

- Clear theoretical basis:
  - Physics
  - Signal processing
  - Control theory
  - Network theory
  - Systems engineering

Performance Specification

Optical receiver
Application context diagram



Object:
- Amplifier

Application description:
- Application-specific information

Life cycle description:
- Life cycle process specific information that may be relevant during design:
  - Marketing
  - Development and design
  - Production
  - Test and qualification
  - Transportation
  - Sales
  - Usage
  - Service and maintenance
  - Collection and demolishment

Function:
- Amplification

Signal source:
- Best info reproducing electrical quantity
- Source impedance
- Relation information - electrical quantity
- Impedance to ground

Signal load:
- Best info reproducing electrical quantity
- Load impedance
- Relation information - electrical quantity
- Impedance to ground

Performance parameters:
- Noise
- Frequency characteristics - pulse response
- Voltage/current handling capability
- Linearity
- Temperature stability
- Power consumption - power efficiency
- EMI - CMRR - PSRR
- ...

Resources for operation:
- Space (dimensions)
- Electrical power
- Weight
- Material
- Operational costs

Design resources:
- Design tools
- Device simulation models
- Design time - costs

Production resources:
- SMT
- PCB
- Lead time - costs

Test resources:
- Test methods and tools
- Time and costs

...

Operating environment:
- Temperature range
- Power supply range(s)
- Interference signals
- ESD
- Shock and vibrations
- Humidity
- ...

Production environment:
- Temperature range
- ESD
- ...

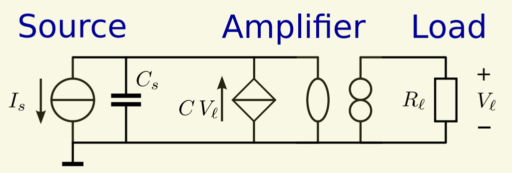
Transport environment:
- Temperature range
- Shock and vibrations
- Humidity
- Space

...

Concept development

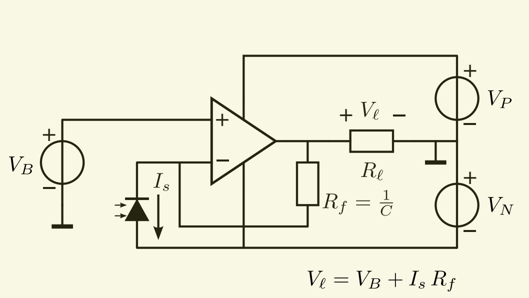
Transimpedance amplifier
- Zero input impedance
- Zero output impedance
- Transmission-1 parameters:

$A = 0,\ B = 0,\ C = \frac{I_s}{V_\ell},\ D = 0$

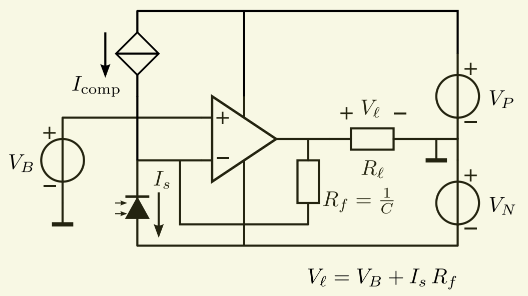


Implementation study

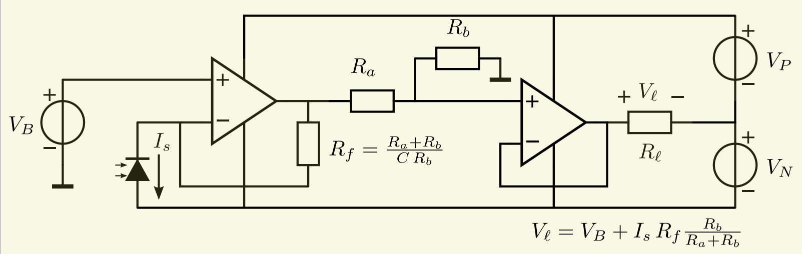
Transimpedance with OpAmp



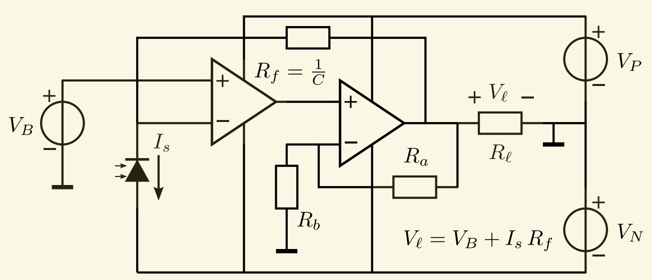
Dark current compensation



Reduction influence noise R_f



Relax requirement GB product OpAmp



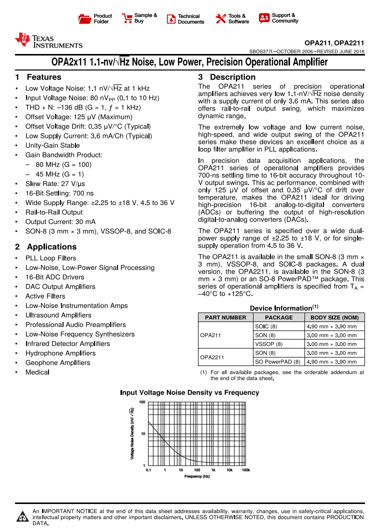
Application data:
- Max. optical power 30uW
- Max. rate of change: 150W/s
- PIN diode conversion gain: 0.35A/W
- PIN diode capacitance: 8pF
- Max. PIN diode dark current: 200nA
- PIN diode bias voltage: 5V
- Min. load resistance: 20kOhm
- Load voltage swing: 4V@30uW
- Bandwidth: 0.25MHz
- Max RMS output noise: 100uV
- Zero-signal load voltage: 0.1...0.5V

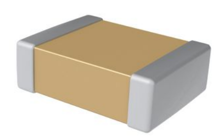
Circuit engineering

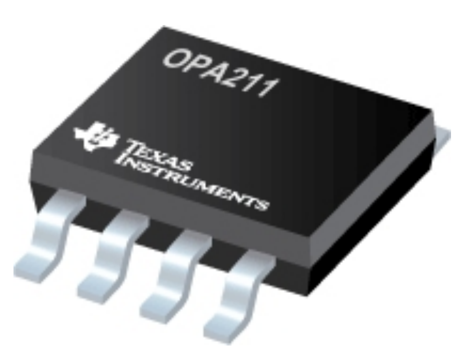
Find design equations for OpAmp parameters:
- Equivalent input noise sources
- GB product
- Input capacitance
- Output impedance
- Input bias/offset current
- Input offset voltage
- Input common-mode voltage range
- Output voltage slew rate
- Output current drive capability
- Output voltage drive capability
- Temperature range

Select operational amplifiers:
- Satistfy design equations
- Preferred components/suppliers
- Costs
- Footprints

Select passive devices:
- Satistfy design equations
- Preferred components/suppliers
- Costs
- Footprints
- Tolerances







Determine power supply requirements:
- Voltage and current drive capability
- Voltage tolerances
- Noise