Linear OPAMP Characterization: Power Supply Rejection Ratio

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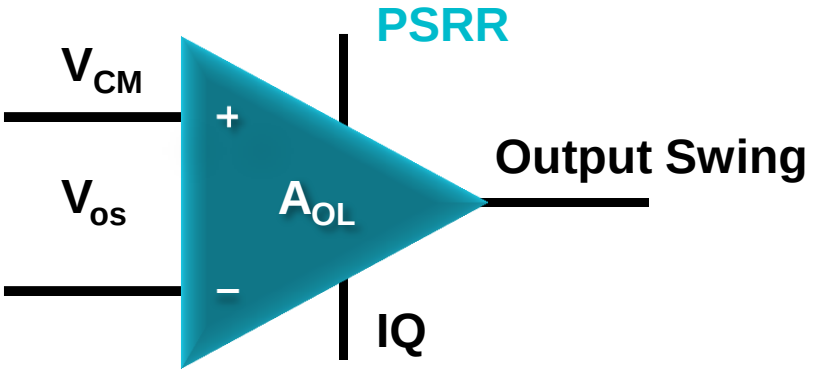
OPAMP verification

OPAMP Electrical Characterization:

- Characterizing the electrical behavior of an integrated circuit is critical during application troubleshooting
  - Non-conformances can be identified by comprehending device level characteristics in addition to system performance
- OPAMP electrical characterization series will review following topics:
  - Voltage offset (V_{OS})
  - V_{CM} / Common mode rejection ratio (CMRR)
  - **Power supply rejection ratio (PSRR)**
  - Output swing
  - Quiescent current
  - Open loop gain (A_{OL})



Prerequisites

Electrical characterization: PSRR

- Power supply rejection ratio measurements methods are reviewed
- Following prerequisites are recommended prior to proceeding though the handbook

Prerequisites:

TI-Precision Labs (TIPL) courses:

PSRR: TIPL - Op Amps: Power Supply Rejection

ti.com/training-power-supply-rejection

Pocket Reference:

Training: Analog Engineer's Pocket Reference

ti.com/analogrefguide

Application handbook:

A-B-A: Board Level Troubleshooting

ti.com/board-level-troubleshooting

Simulation tools:

Simulations are presented within the handbook. It is recommended to install TINA-TI

TINA-TI can be downloaded for free on ti.com: http://www.ti.com/tool/tina-ti

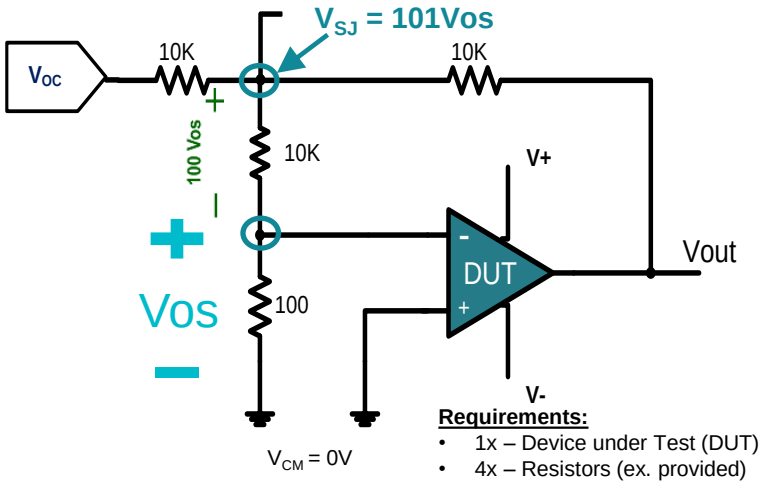
OPAMP test loops

Overview:

- Analyzing datasheet parameters may appear a challenging task!
- Multiple parameters can be derived easily from offset (V_{OS}).
  - PSRR, CMRR, and AOL can be calculated by monitoring shifts

False Summing Junction (FSJ):

- Accurate VOS measurements can be obtained through test loops
  - **Benefits:**
    - Simplistic
    - Stable
    - Small
  - **Disadvantages:**
    - Feedback resistor load in parallel with other added loads
    - Loop drive function of DUT V_{OS}
- Majority of **DC** parameters determined with 4 resistors!



Requirements:
- 1x – Device under Test (DUT)
- 4x – Resistors (ex. provided)
  - Resistor values can be varied depending on device

Measuring VOS:

- **VOS:** differential input voltage required to force output to mid-supply
  - best measured at the summing junction **(V_{SJ})**
- **Output control voltage (VOC):** Calibrate the out voltage to zero volts
  - Know as offset correction factor (derived from Kirchhoff's Voltage Law):

$$V_{OC} = -\left(V_{OUT} + VOS(302)\right) + 2VCM$$

Example:

- V+ = +10V
- V- = -10V
- V_{OUT} = 0V
- V_{OC} = 0V (ideal opamp)

Results:

- V_{SJ}= 1.01mV
- 1.01mV = (101)Vos = **V_{SJ}**
  10µV = Vos

Power supply rejection ratio – OPA192

Bench setup and measurements:

- **PSRR:** Change in V_{OS} divided by the change in V_{Supply}
  - Consider the transition region for rail to rail amps
  - The nMos active region remains constant as supply delta varies
- Refer to data sheet for PSRR test conditions versus supply range

$$PSRR\left(\frac{V}{V}\right) = \left(\left|\frac{\Delta VOS}{\Delta V_{Supply}}\right|\right)$$
$$PSRR(dB) = -20 \times LOG\left(PSRR\left(\frac{V}{V}\right)\right)$$

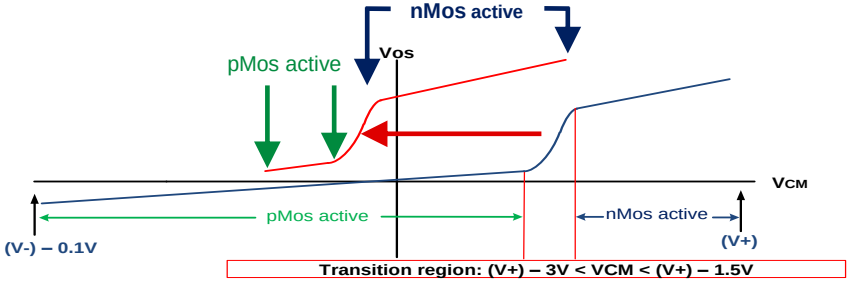


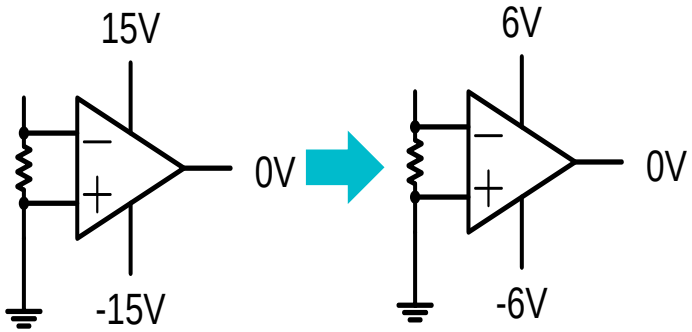
Figure: representative V_{CM} versus V_{OS} graph. The red line represents the common voltage range of a decreased supply voltage

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
PSRR	Power-supply rejection ratio	T_A = –40°C to +125°C		±0.3	±1.0	µV/V

http://www.ti.com/lit/ds/symlink/opa192.pdf

Power supply rejection ratio

Bench Setup and Measurements:



Offset Voltage (1):

- DUT: OPA192IDGK
- V+ = +15V
- V- = -15V
- V_{OUT1} = 0V

Offset Voltage (2):

- DUT: OPA192IDGK
- V+ = +6V
- V- = -6V
- V_{OUT2} = 0V

Use the offset correction factor equation to accurately set Vout