Linear OPAMP Characterization: Output Swing

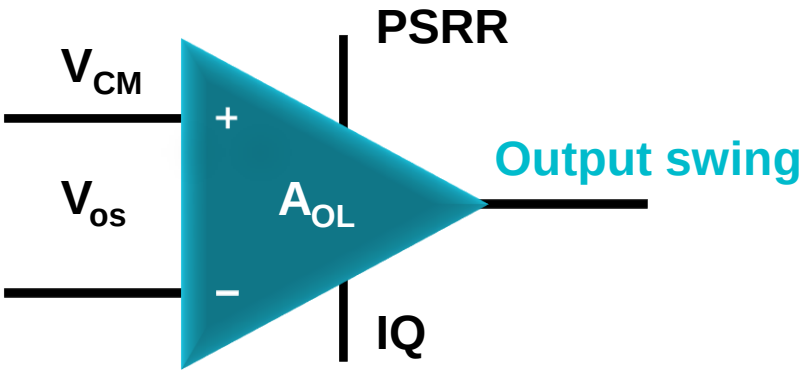
Presented by: Joseph Serritella

Prepared by: Joseph Serritella, Daryl Hiser, Ray Ochotorena

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 the following topics:
  - Voltage offset (V_{OS})
  - V_{CM} / Common Mode Rejection Ratio (CMRR)
  - Power Supply Rejection ratio (PSRR)
  - **Output swing**
  - Output swing
  - Quiescent current
  - Open loop gain (A_{OL})



Prerequisites

Electrical characterization: Output Swing / Slam

- Output swing and slam measurement methods are reviewed
- Following prerequisites are recommended prior to proceeding though the handbook

Prerequisites:

TI-Precision Labs (TIPL) courses:

Op Amps: Input and Output Limitations

TI.com/output-limitations

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: TI.com/tina-ti

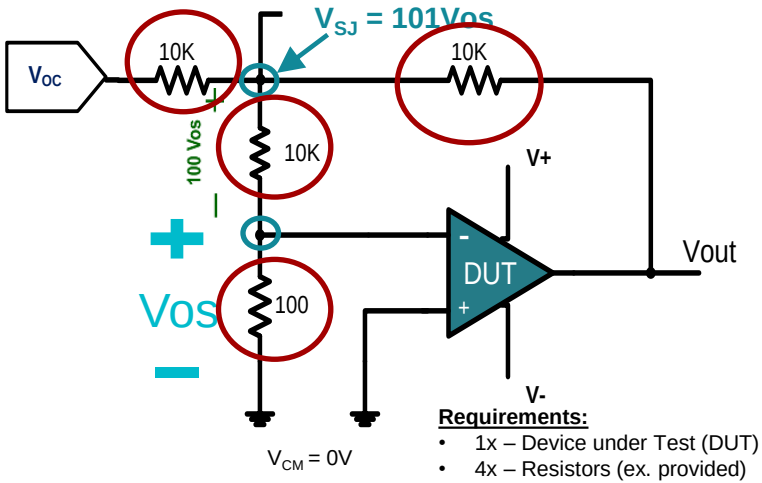
OPAMP test loops

Overview:

- Analyzing datasheet parameters may appear a daunting task!
- Multiple datasheet parameters can be derived using various circuits.

False Summing Junction (FSJ):

- Commonly used circuit to measure offset voltage of an amplifier
  - **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 opamp specifications:

- **VOS:** differential input voltage required to force output to mid-supply
- **Output swing:** can also be measured by using VOC to force the output voltage near the positive or negative supple
- **Output control voltage (VOC):** Calibrate the out voltage to zero volts

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

Example:

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

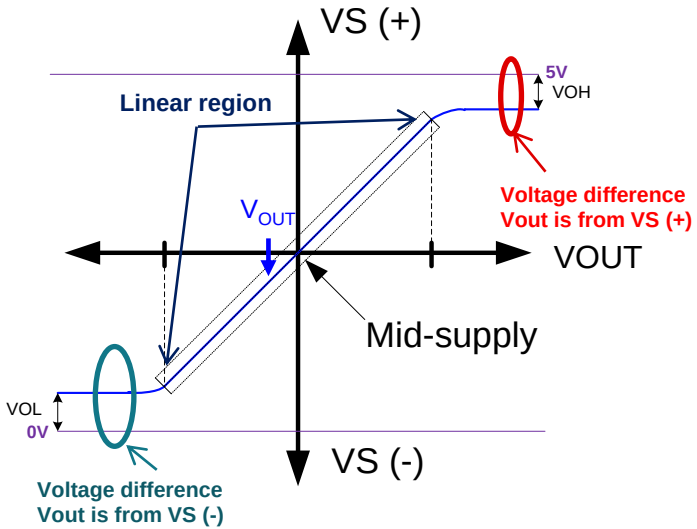
Results:

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

Output swing - OPA192

Measurement preparation:

- Output swing and output slam are **not the same** as offset voltage (VOS)!
  - Offset voltage is defined when V_{OUT} = V_{CM}= Mid-supply
- **Output swing**: How close the output voltage of the opamp can reach the positive or negative supply voltage
  - Therefore V_{OUT} =/= Mid-supply, thus VOS is not defined
  - V_{OL} (output low) and V_{OH} (output high) denote a similar spec
- Review data sheet test conditions prior to evaluating **output swing**
  - Confirm supply voltage, input common mode voltage and output load conditions



6.7 Electrical Characteristics: V_S = ±4 V to ±18 V (V_S = +8 V to +36 V)

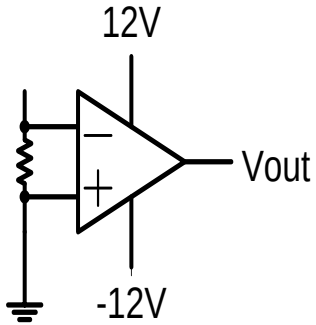
At T_A = +25°C, V_{CM} = V_{OUT} = V_S / 2, and R_{LOAD} = 10 kΩ connected to V_S / 2, unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_O	Voltage output swing from rail	Positive rail	No load		5	15	mV
			R_{LOAD} = 10 kΩ		95	110	
			R_{LOAD} = 2 kΩ		430	500	
		Negative rail	No load		5	15	
			R_{LOAD} = 10 kΩ		95	110	
			R_{LOAD} = 2 kΩ		430	500	

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

Output swing

Bench setup and measurements:



Output swing positive rail:

- **DUT:** OPA192IDGK
- V+ = +12V
- V- = -12V
- V_{force} = 12V
- R_{load} = no load
- Measure V_{OUT}

Use the offset correction factor (VOC) to Vout