

CMRR

TIPL 1231

TI Precision Labs – Op Amps

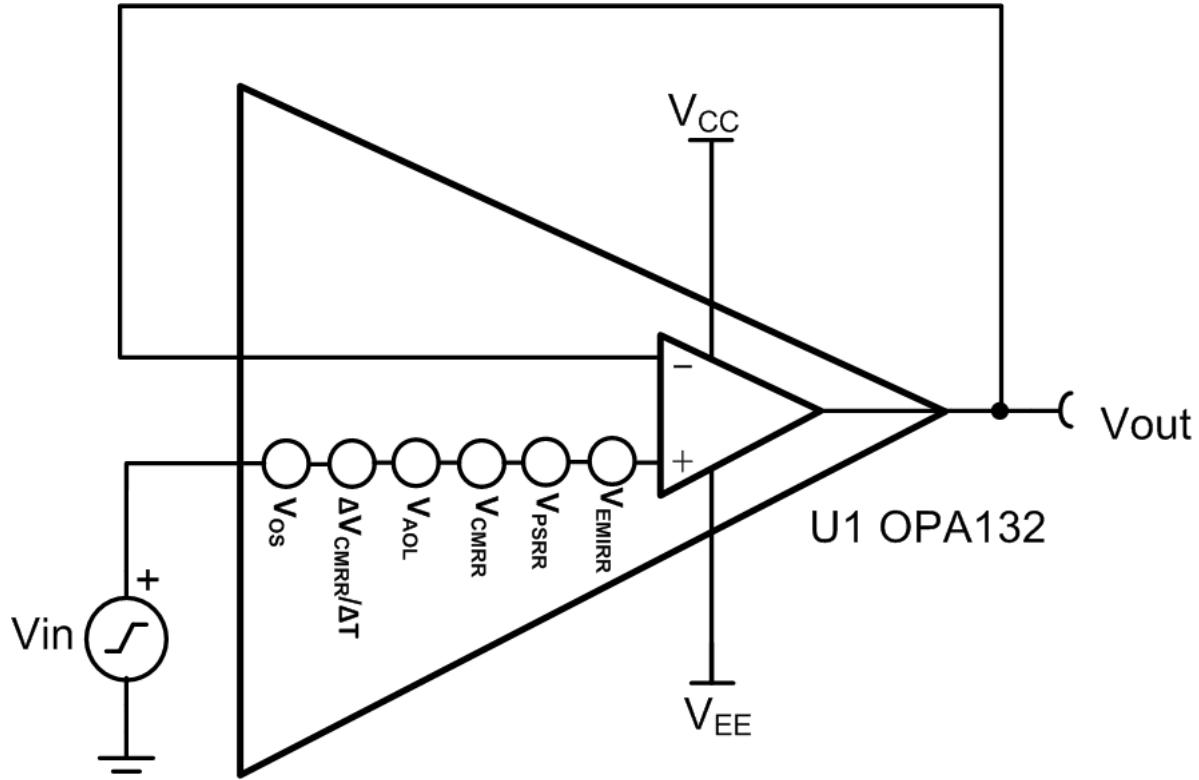
Presented by Collin Wells

Prepared by Collin Wells, Art Kay, Ian Williams, and Tim Green

Prerequisites: Op Amp Bandwidth 1 – 3

(TIPL1221 – TIPL1223)

Referring Error to Input (RTI)



CMRR and A_{OL} Combined

	Typical	Unit
A_{OL}	136	dB
CMRR	134	dB

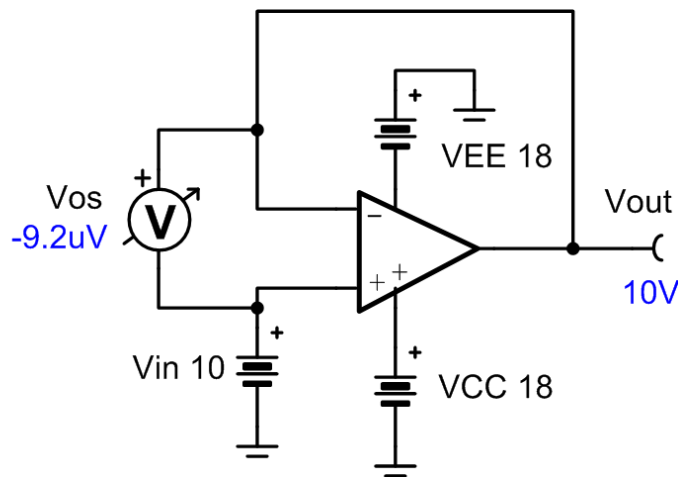
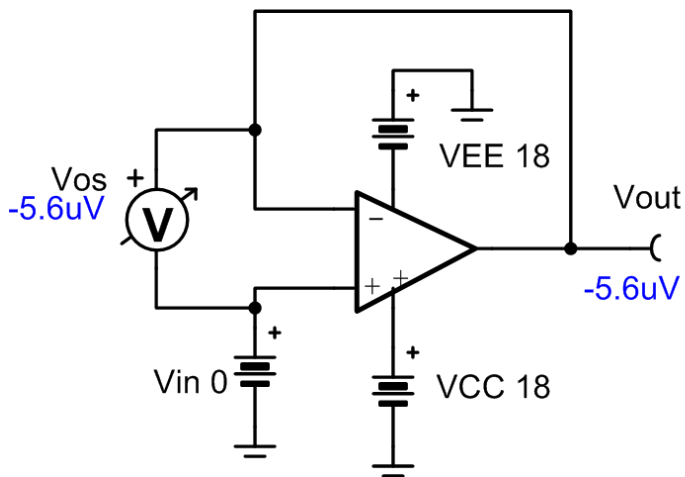
Combined Effects of A_{OL} and CMRR

$$V_{OS_{A_{OL}}} = \frac{\Delta V_{OUT}}{A_{OL}} = \frac{10V}{10^{\frac{136}{20}}} = 1.6\mu V$$

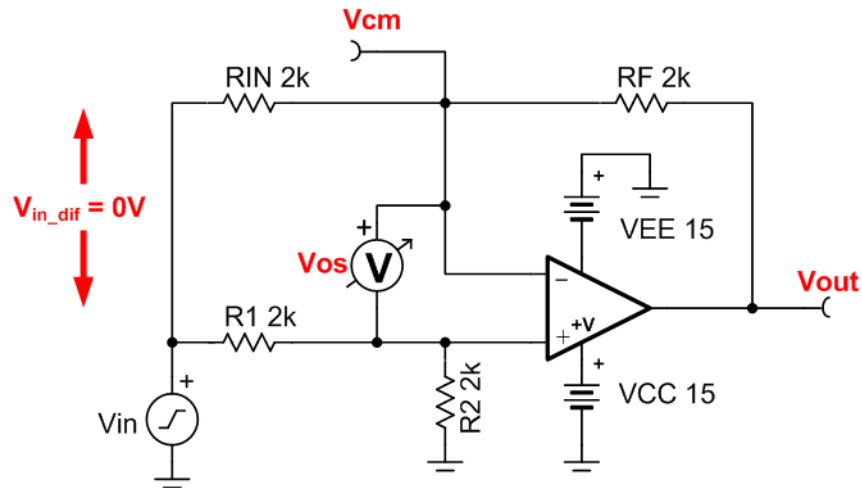
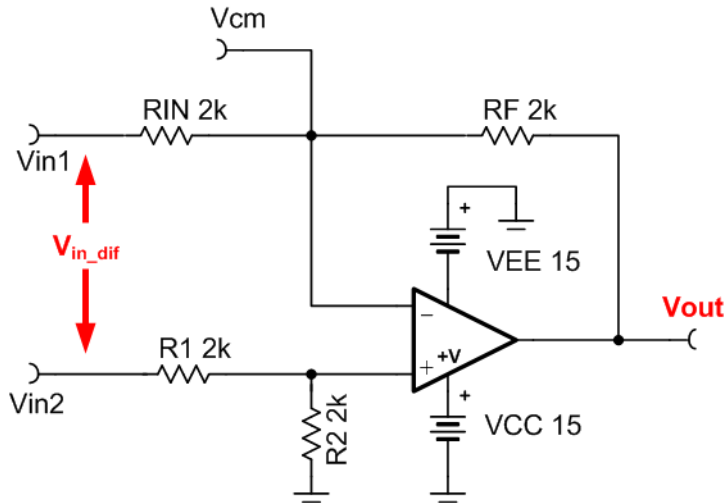
$$V_{OS_{CMRR}} = \frac{\Delta V_{OUT}}{CMRR} = \frac{10V}{10^{\frac{134}{20}}} = 2\mu V$$

$$\Delta V_{OS_{Total}} = V_{OS_{A_{OL}}} + V_{OS_{CMRR}} = 3.6\mu V$$

$$\Delta V_{OS_{Sim}} = V_{OS_{10V}} - V_{OS_{0V}} = 3.6\mu V$$



Introducing the Dif Amp for testing CMRR



Gain of a Dif-Amp

$$R_f = R_2 \text{ and } R_{in} = R_1$$

$$G_{\text{dif}} = \frac{R_F}{R_{IN}} = 1 \text{ V/V}$$

$$V_{\text{out}} = G_{\text{dif}} \cdot V_{\text{in_dif}}$$

CMRR of a Dif-Amp

$$V_{\text{out}} = (0\text{V}) \cdot (1 \text{ V/V}) = 0\text{V}$$

$$V_{\text{cm}} = V_{\text{in}} \cdot \left(\frac{R_2}{R_1 + R_2} \right) = \frac{V_{\text{in}}}{2}$$

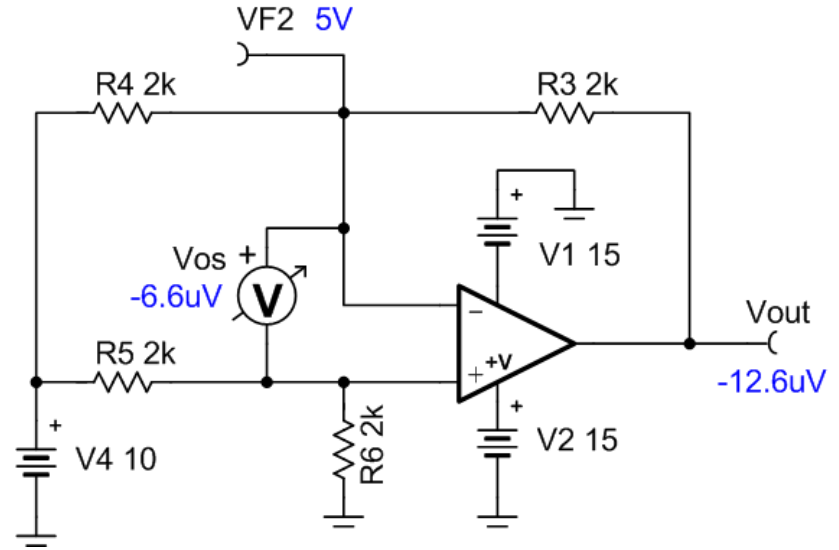
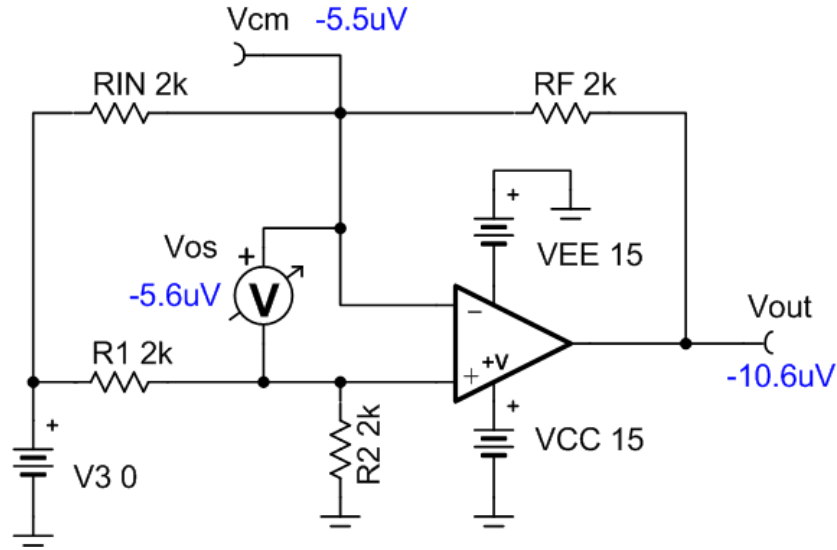
$$\text{CMRR}(\text{V/V}) = \frac{\Delta V_{\text{os}}}{\Delta V_{\text{cm}}}$$

Ideal output.

Common Mode Voltage

Common Mode Rejection

DC CMRR Test

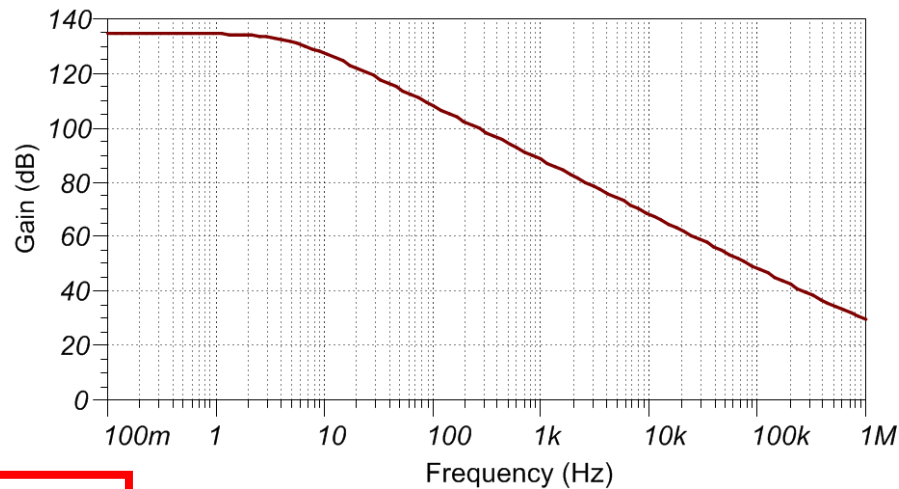
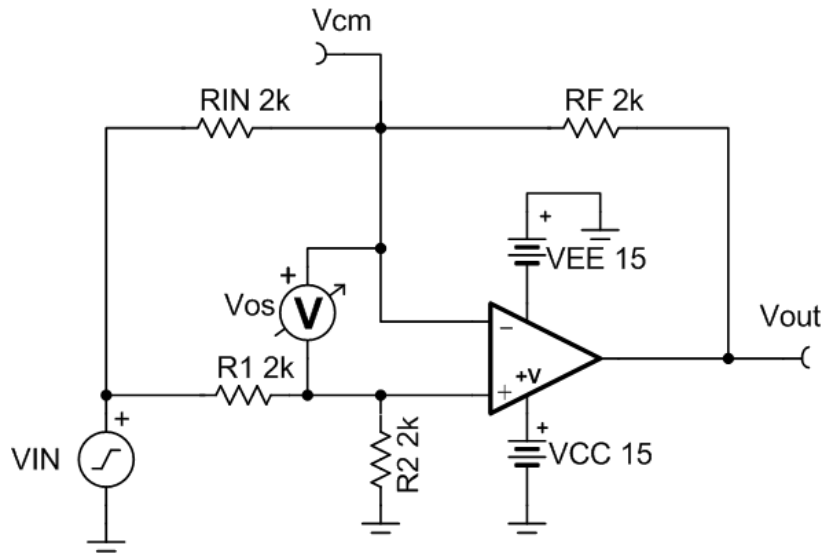


CMRR of a Dif-Amp

$$\text{CMRR(V/V)} = \frac{\Delta V_{os}}{\Delta V_{cm}} = \frac{|-6.6\mu\text{V} - (-5.6\mu\text{V})|}{|5\text{V} - 0\text{V}|} = 0.2 \cdot 10^{-6} \text{ V/V}$$

$$\text{CMRR(dB)} = -20 \cdot \log[\text{CMRR(V/V)}] = 134\text{dB}$$

AC CMRR Test

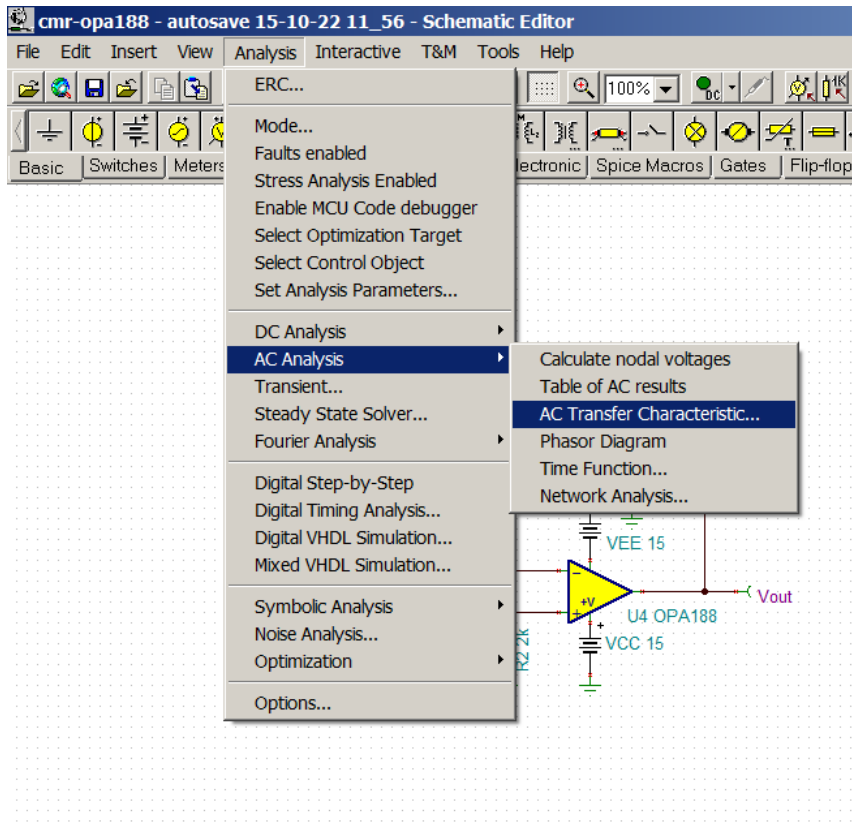


CMRR of a Dif-Amp

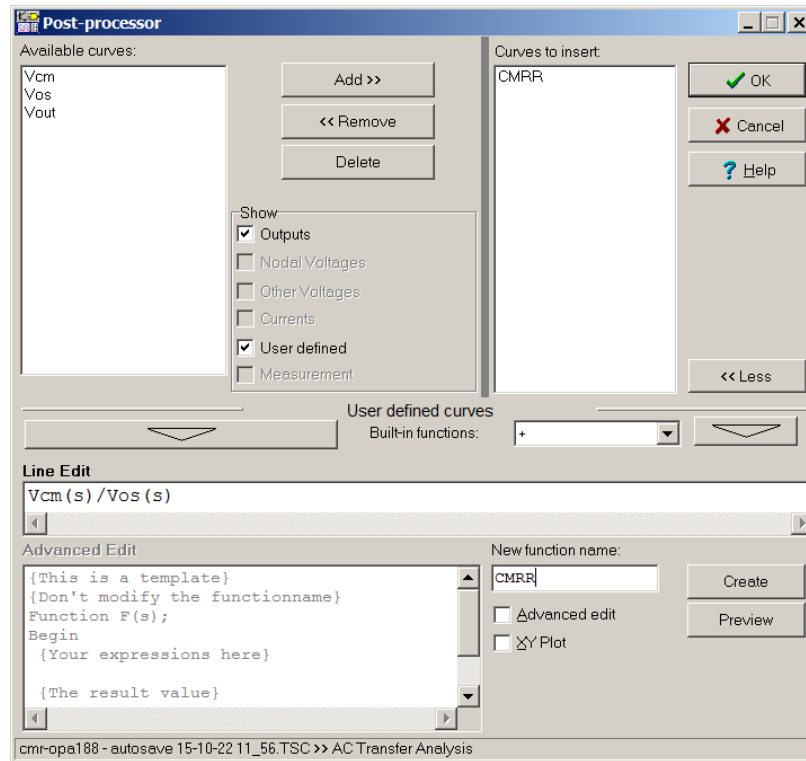
$$\text{CMRR(V/V)} = \frac{\Delta V_{os}}{\Delta V_{cm}}$$

$$\text{CMRR(dB)} = -20 \cdot \log[\text{CMRR(V/V)}]$$

Post Processor – Generating the Curve in Tina



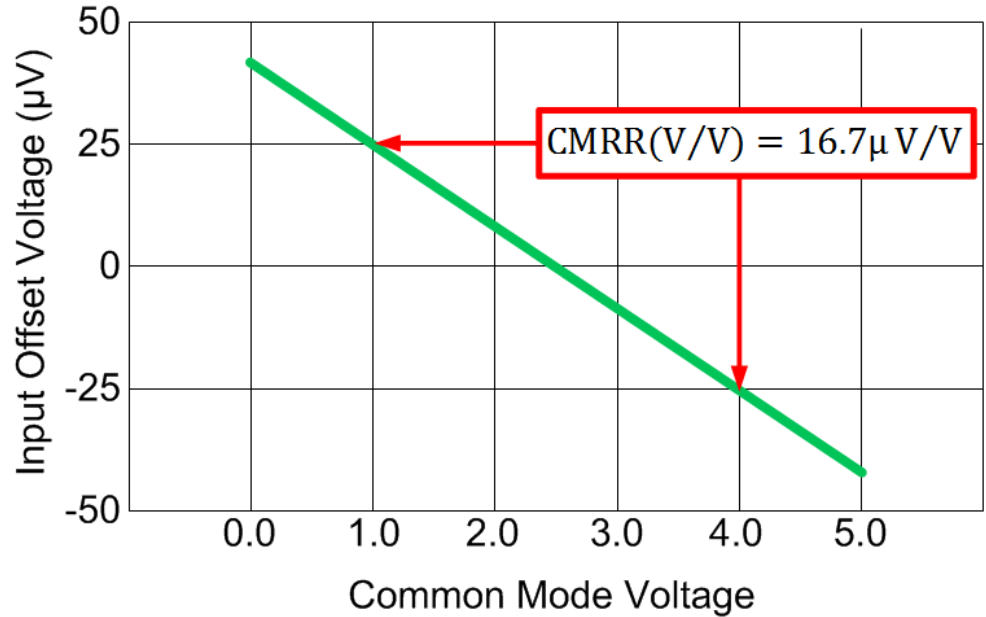
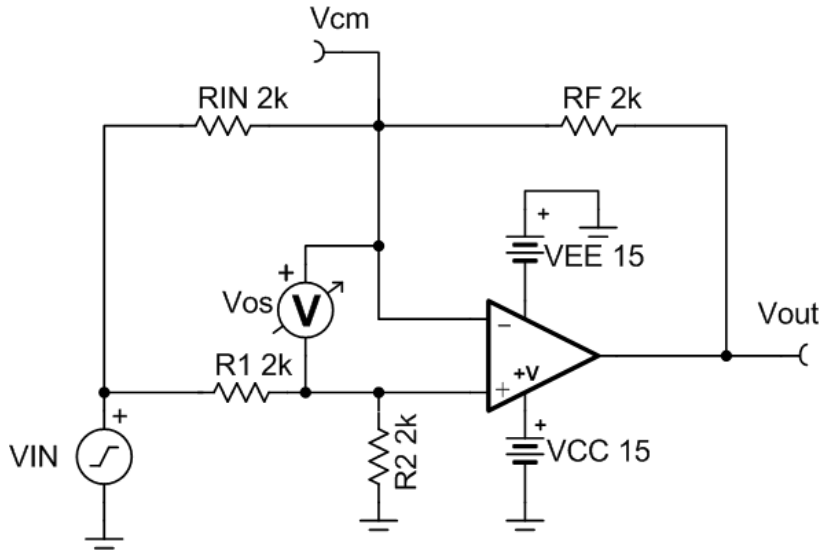
The screenshot shows the Schematic Editor interface for a circuit containing an OPA188 op-amp. The circuit includes a feedback resistor labeled 'R2 2k', a non-inverting input connected to 'VEE 15', and a common-mode input connected to 'VCC 15'. The output is labeled 'Vout'. The 'Analysis' menu is open, and the path 'AC Analysis' > 'AC Transfer Characteristic...' is highlighted.



The Post-processor dialog box is shown with the following settings:

- Available curves:** Vcm, Vos, Vout
- Curves to insert:** CMRR
- Show:** Outputs, Nodal Voltages, Other Voltages, Currents, User defined, Measurement
- User defined curves:** Built-in functions: +
- Line Edit:** Vcm (s) / Vos (s)
- Advanced Edit:** New function name: CMRR, Advanced edit, XY Plot

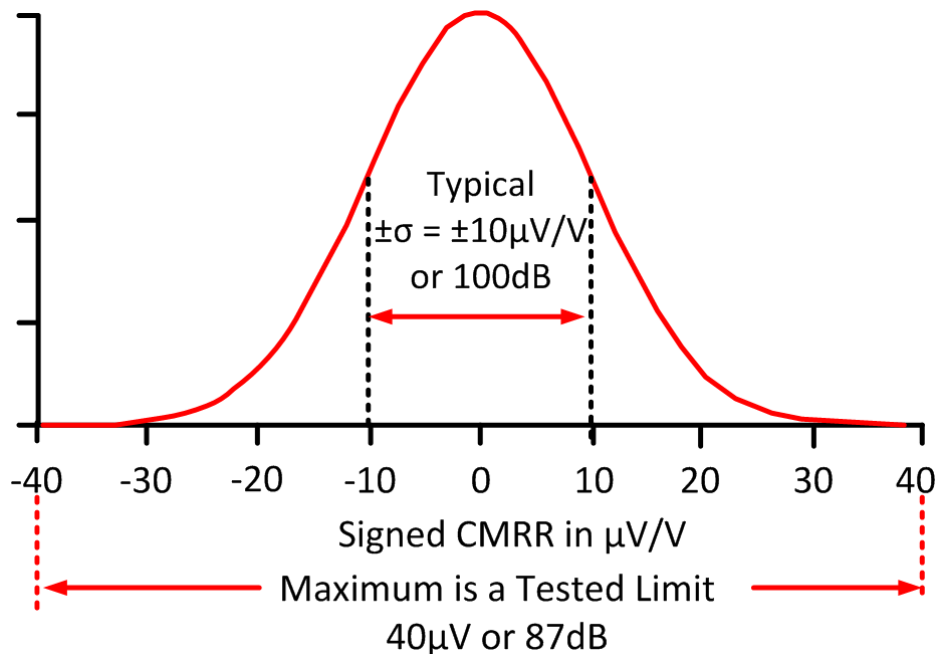
Offset (V_{os}) vs. Common Mode Voltage (V_{cm})



$$CMRR(V/V) = \frac{\Delta V_{os}}{\Delta V_{cm}} = \frac{|25\mu V - (-25\mu V)|}{|1V - 4V|} = 16.7 \cdot 10^{-6} V/V$$
$$CMRR(dB) = -20 \cdot \log[CMRR(V/V)] = 96dB$$

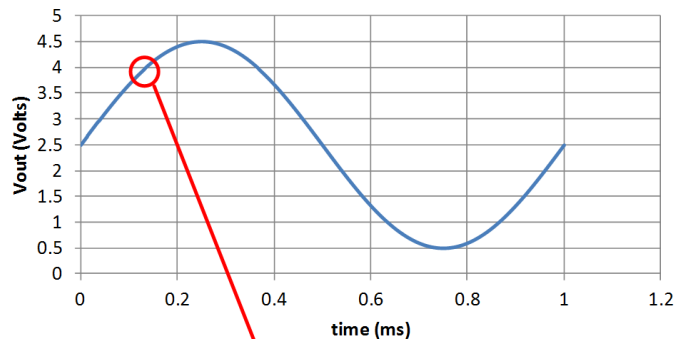
Distribution of CMRR

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Common-Mode Rejection	$V_{CM} = -12.5V$ to $12.5V$	87	100		dB

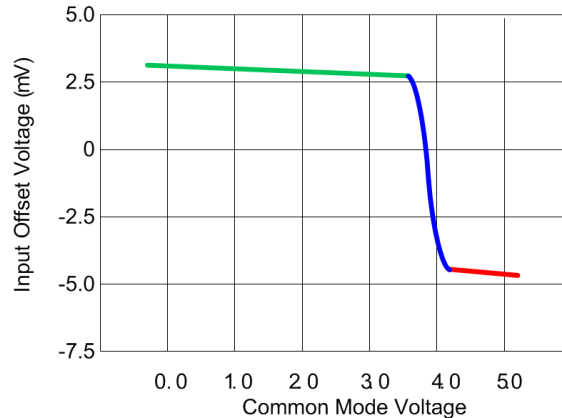
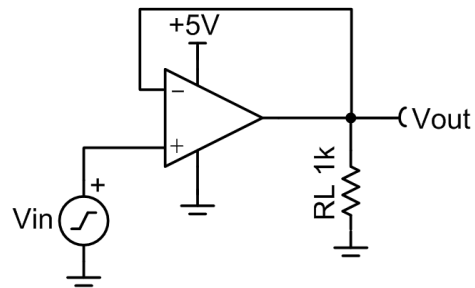
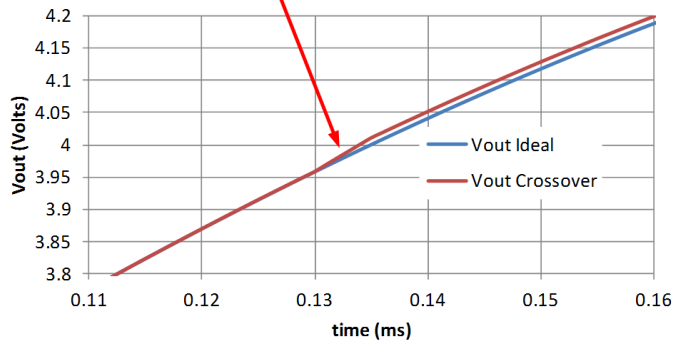


Crossover Distortion Caused by CMRR

Vout vs. Time (Crossover Distortion)

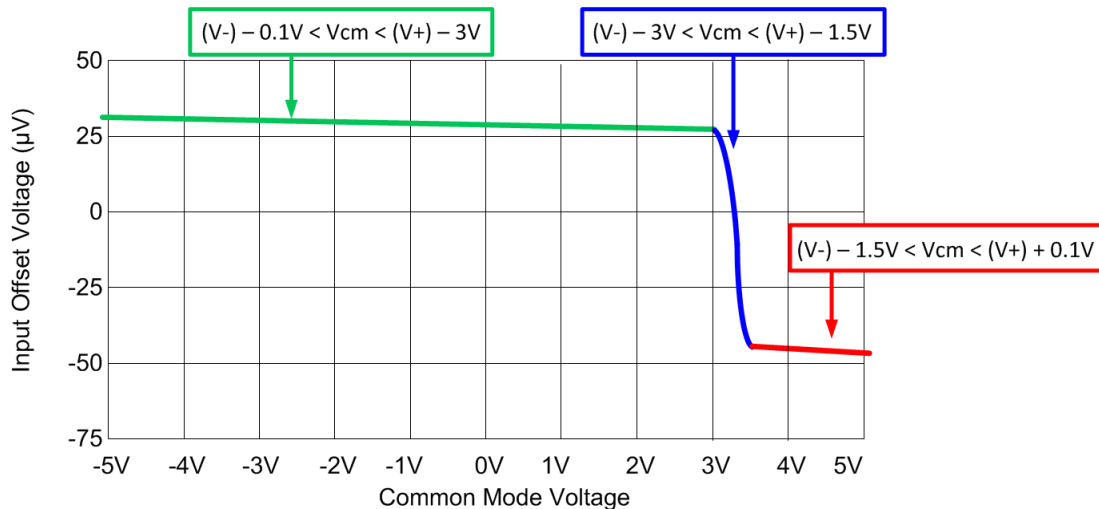
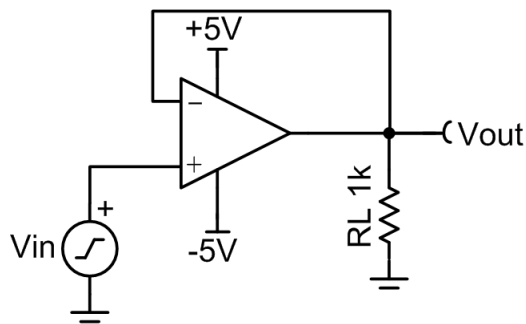


Zoom in on Crossover Distortion

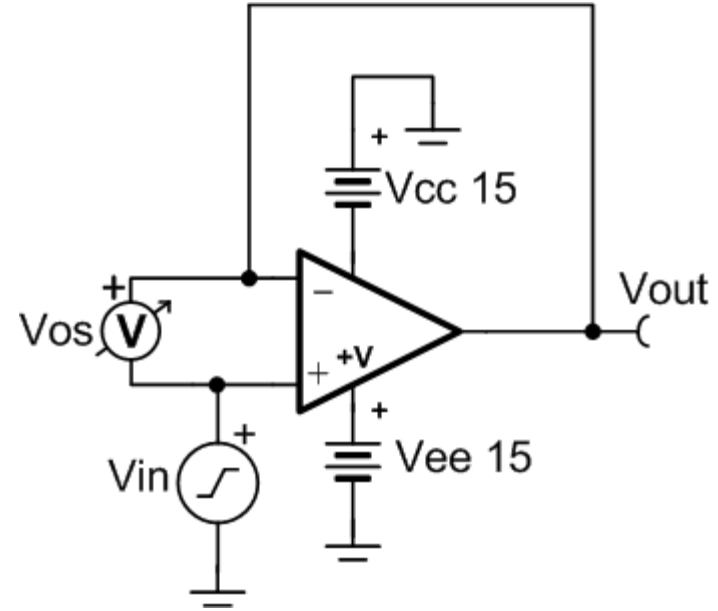
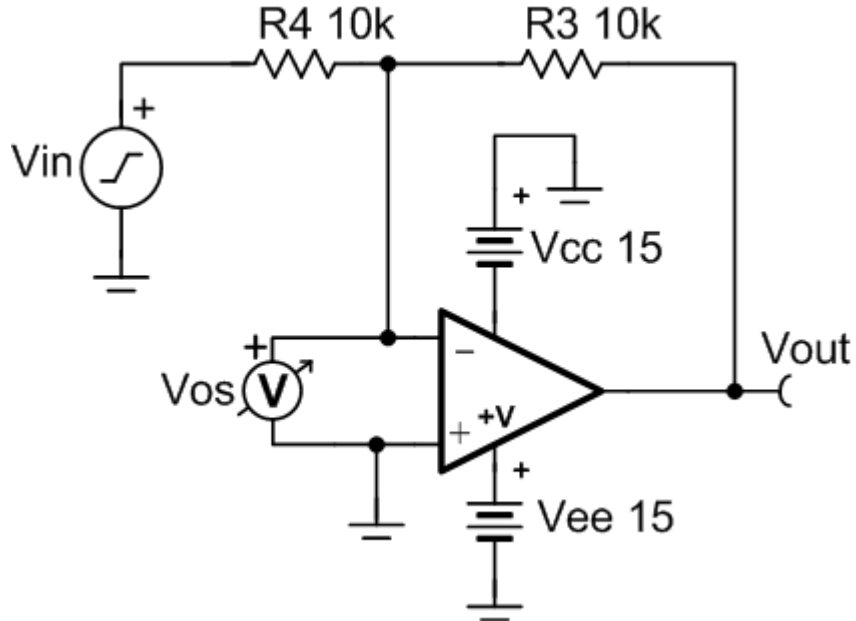


CMRR for Amplifiers with Crossover Distortion

PARAMETER	TEST CONDITIONS	OPA192			UNIT
		MIN	TYP	MAX	
CMRR Common-mode rejection ratio	$(V-) - 0.1\text{V} < V_{CM} < (V+) - 3\text{V}$	120	140		dB
	$(V+) - 3\text{V} < V_{CM} < (V+) - 1.5\text{V}$	See Typical Characteristics			
	$(V+) - 1.5\text{V} < V_{CM} < (V+) + 0.1\text{V}$	100	120		dB



Inverting vs. Non-inverting (Impact on CMRR)



**Thanks for your time!
Please try the quiz.**