CMRR

TIPL 1231
TI Precision Labs – Op Amps

Presented by Collin Wells

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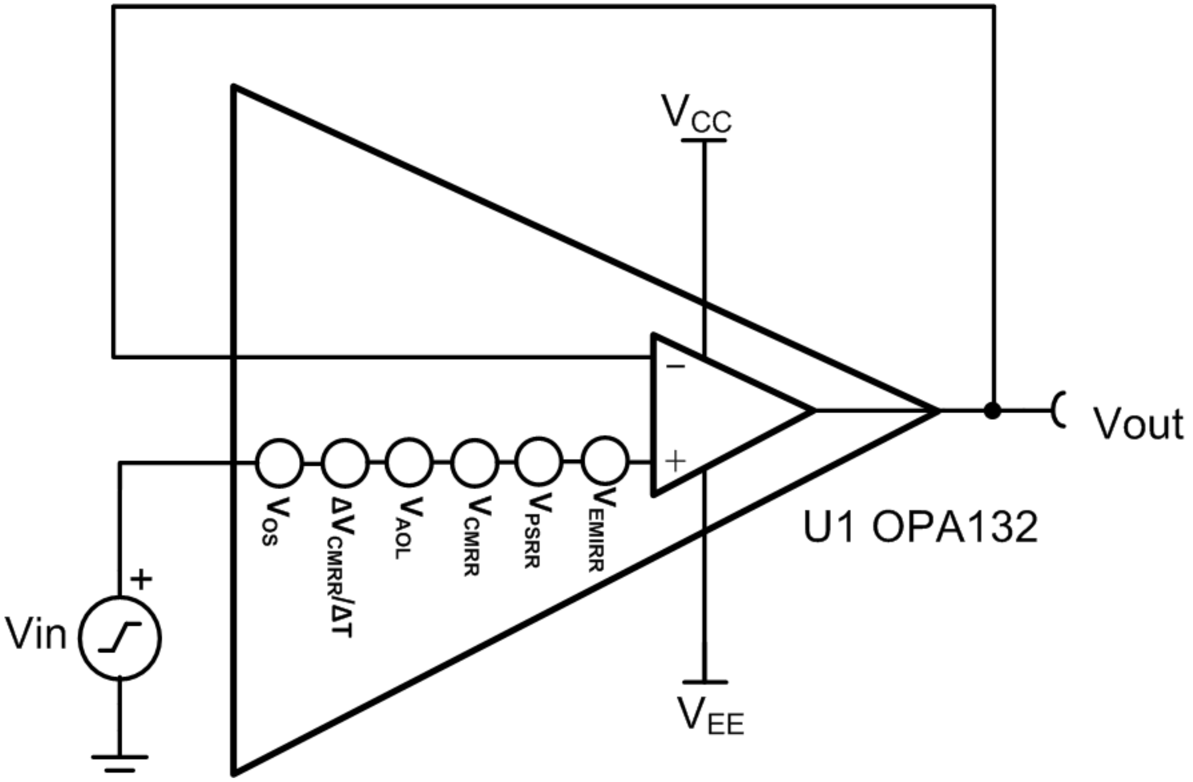
Prerequisites: Op Amp Bandwidth 1 – 3
(TIPL1221 – TIPL1223)

Referring Error to Input (RTI)



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CMRR and A_{OL} Combined

	Typical	Unit
A_{OL}	136	dB
CMRR	134	dB

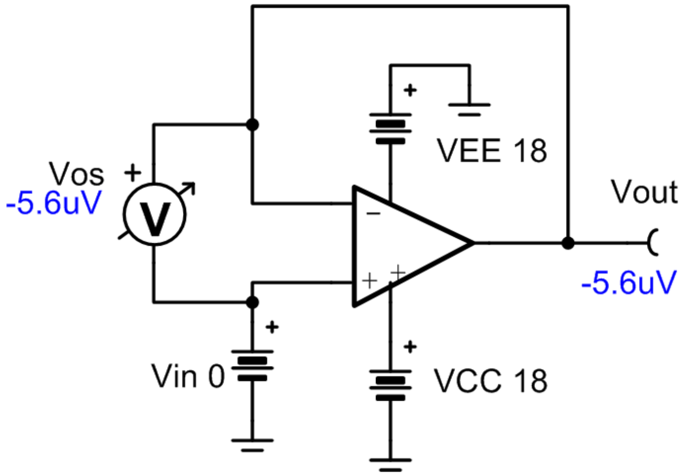
Combined Effects of A_{OL} and CMRR

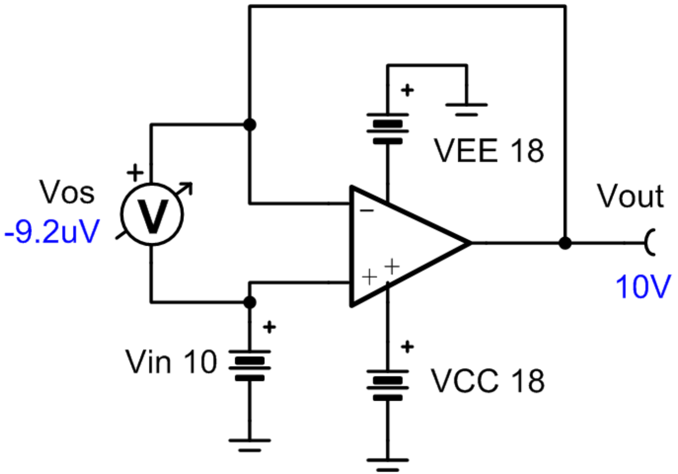
$$V_{os_{Aol}} = \frac{\Delta V_{OUT}}{A_{OL}} = \frac{10V}{10^{\frac{136}{20}}} = 1.6\mu V$$

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

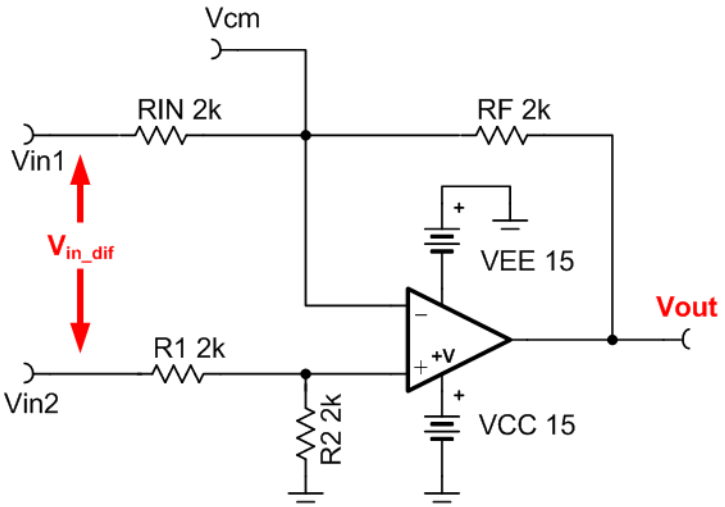
$$\Delta V_{os_{Total}} = V_{os_{Aol}} + V_{os_{CMRR}} = 3.6\mu V$$

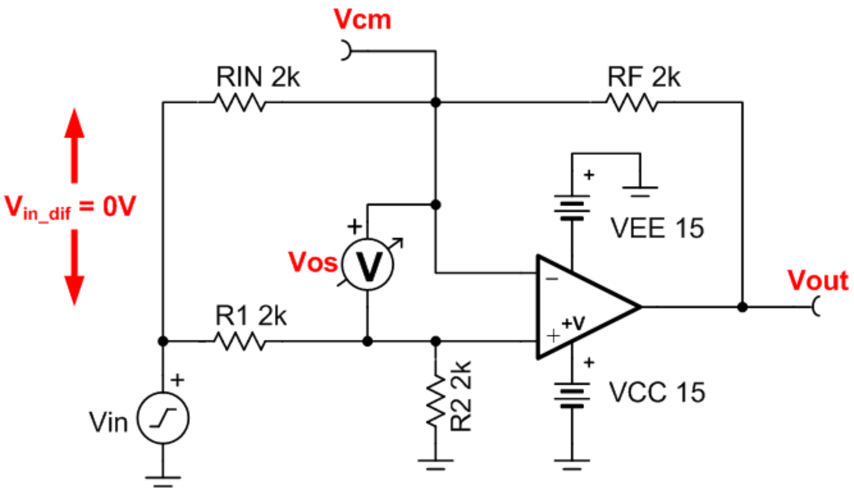
$$\Delta V_{os_{Sim}} = V_{os_{10V}} - V_{os_{0V}} = 3.6\mu V$$





Introducing the Dif Amp for testing CMRR





Gain of a Dif-Amp

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

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

$$V_{out} = G_{dif} \cdot V_{in\_dif}$$

CMRR of a Dif-Amp

$V_{out} = (0V) \cdot (1\,V/V) = 0V$ — Ideal output.

$V_{cm} = V_{in} \cdot \left(\frac{R_2}{R_1 + R_2}\right) = \frac{V_{in}}{2}$ — Common Mode Voltage

$CMRR(V/V) = \frac{\Delta V_{os}}{\Delta V_{cm}}$ — Common Mode Rejection

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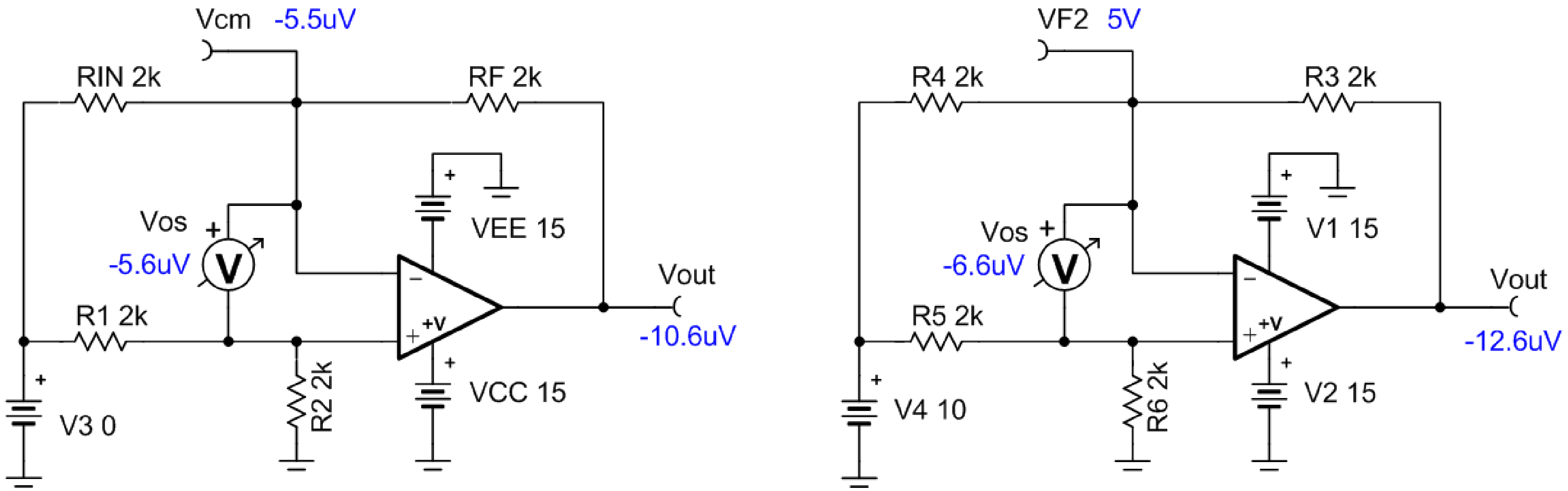
DC CMRR Test



CMRR of a Dif-Amp

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

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

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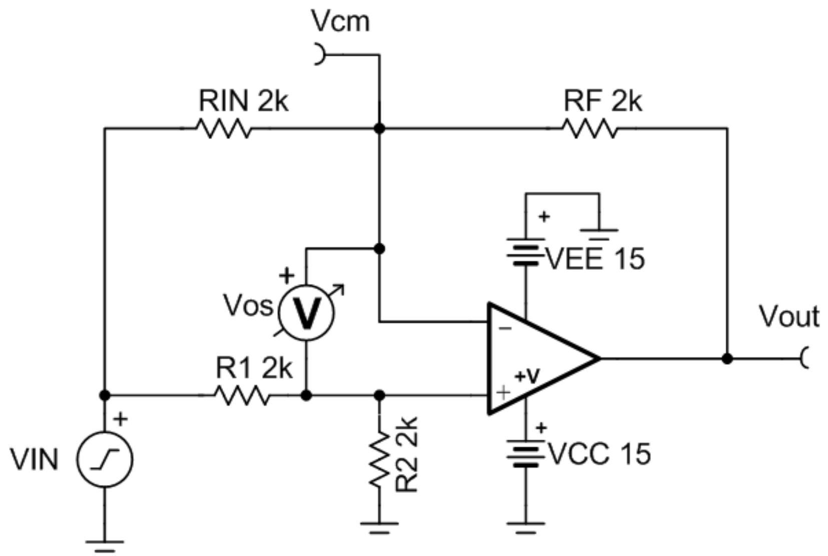
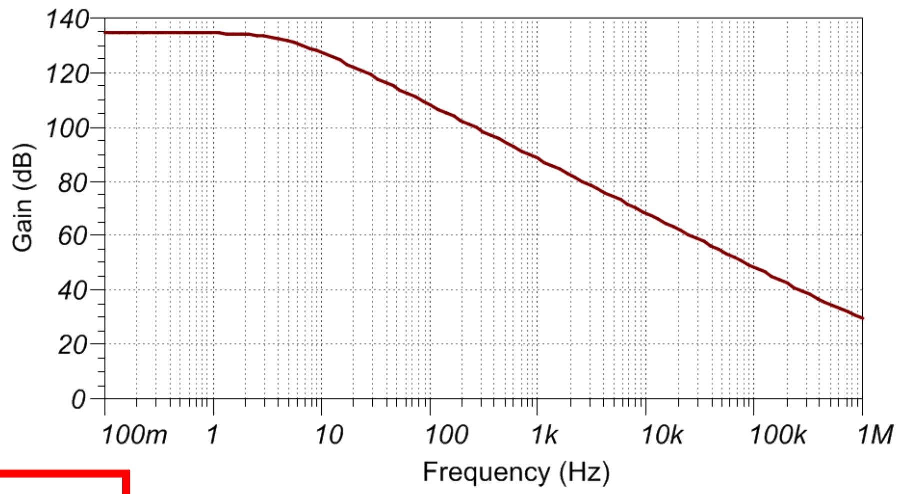
AC CMRR Test



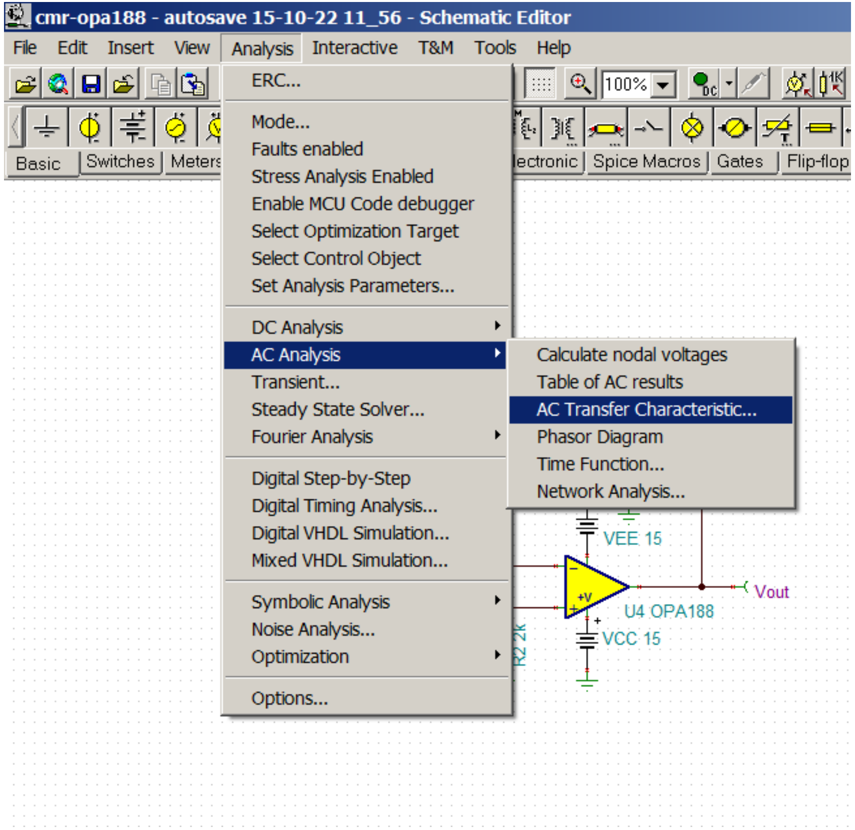


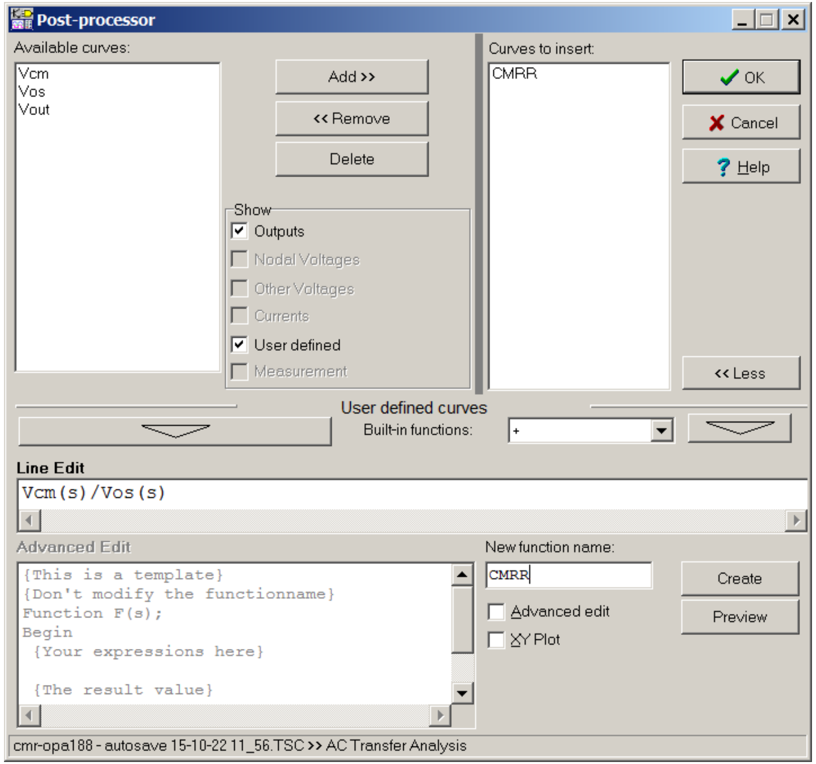
CMRR of a Dif-Amp

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

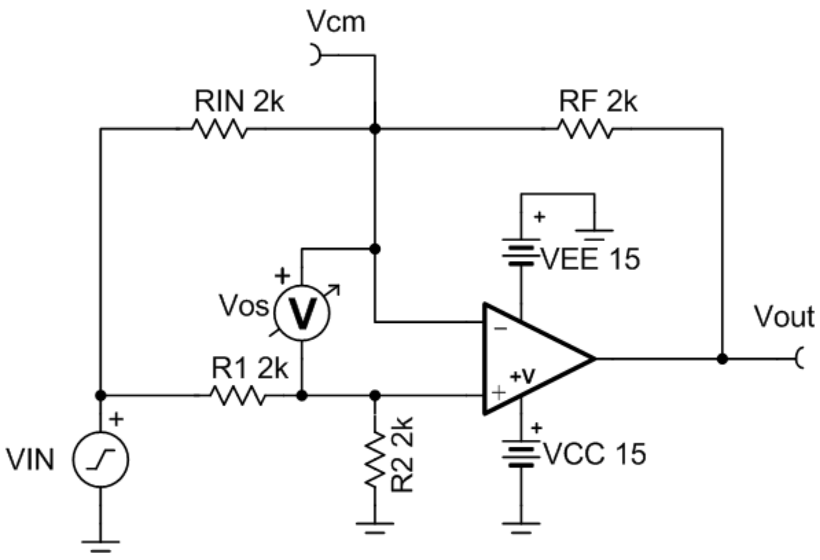
$$\mathrm{CMRR(dB)} = -20 \cdot \log[\mathrm{CMRR(V/V)}]$$

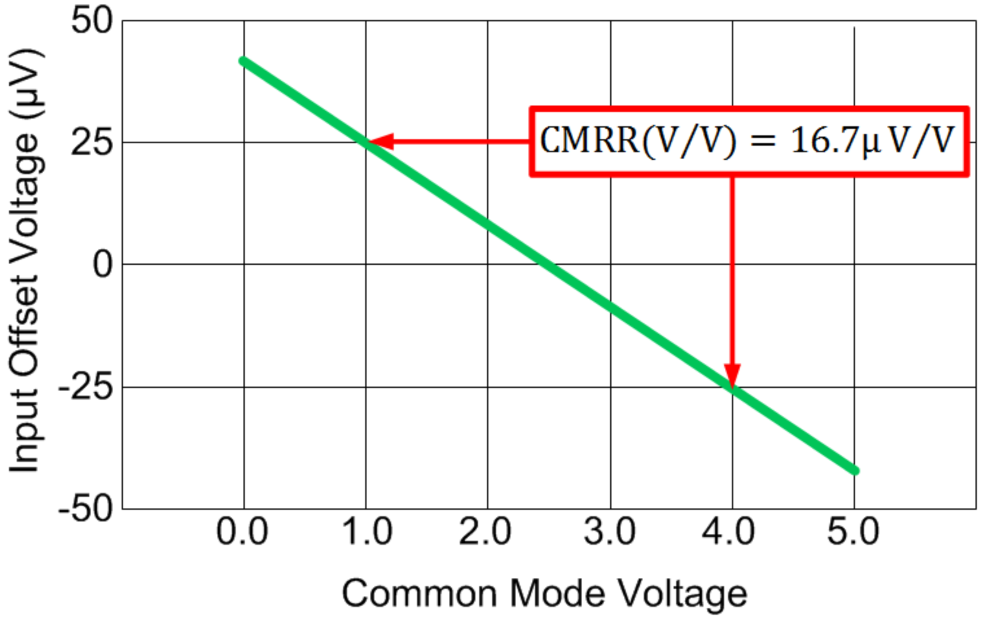
Post Processor – Generating the Curve in Tina





Offset (Vos) vs. Common Mode Voltage (Vcm)





$$\mathrm{CMRR(V/V)} = \frac{\Delta V_{os}}{\Delta V_{cm}} = \frac{|25\mu V - (-25\mu V)|}{|1V - 4V|} = 16.7 \cdot 10^{-6}\ \mathrm{V/V}$$

$$\mathrm{CMRR(dB)} = -20 \cdot \log[\mathrm{CMRR(V/V)}] = 96\mathrm{dB}$$

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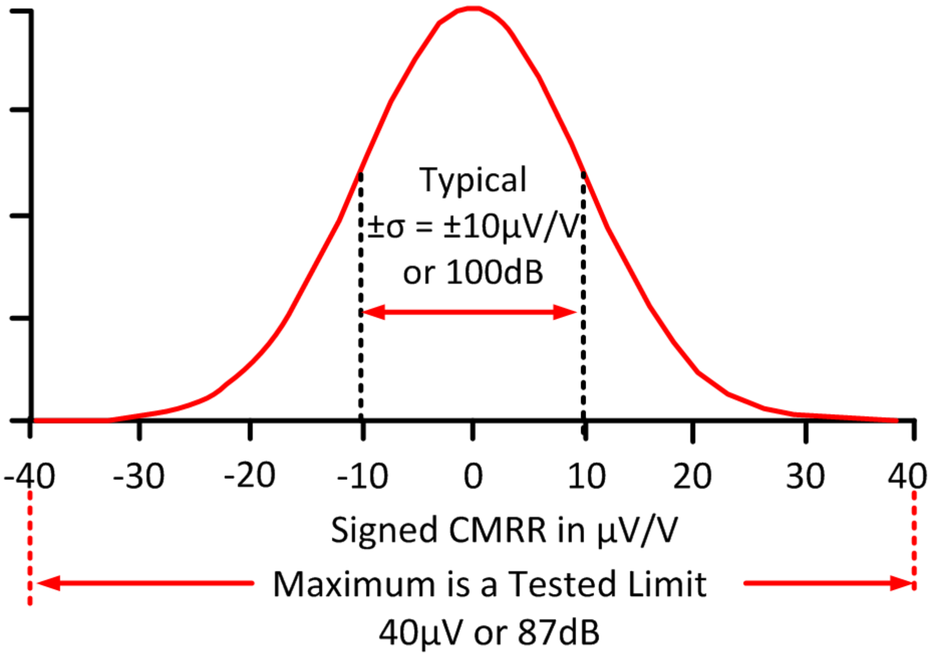
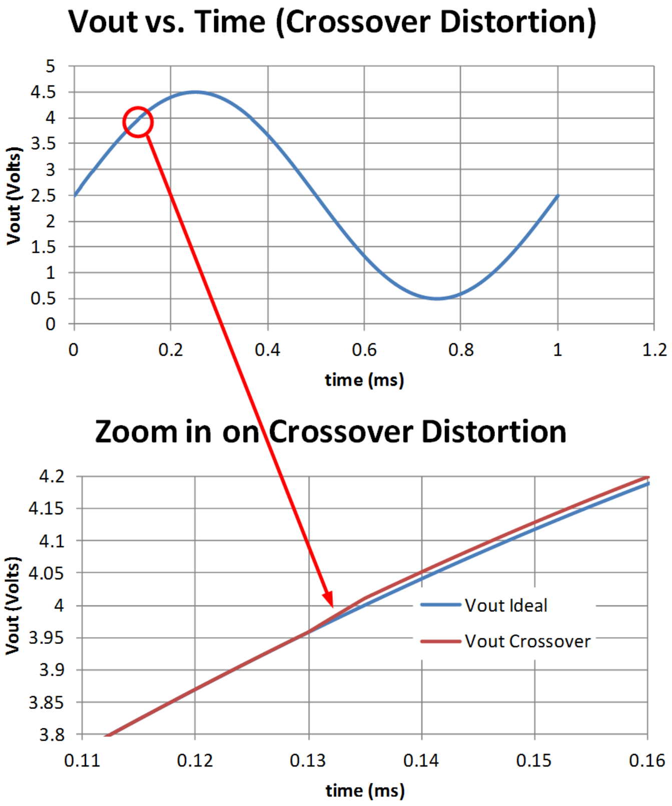
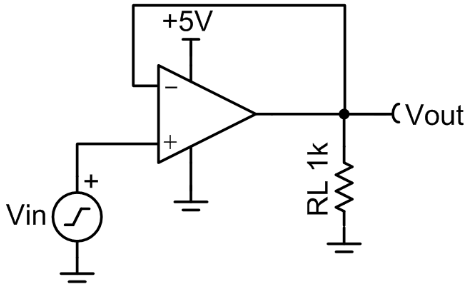
Distribution of CMRR

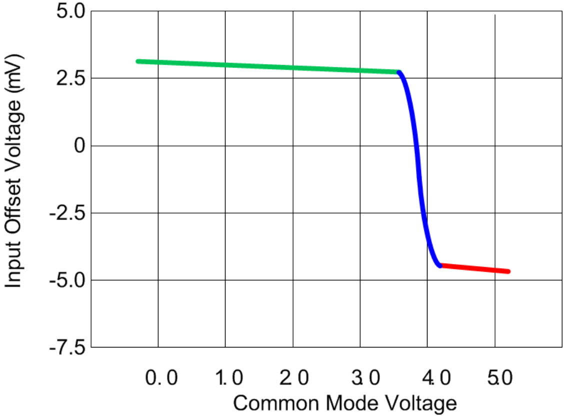
PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Common-Mode Rejection	V_{CM} = -12.5V to 12.5V	87	100		dB



Crossover Distortion Caused by CMRR

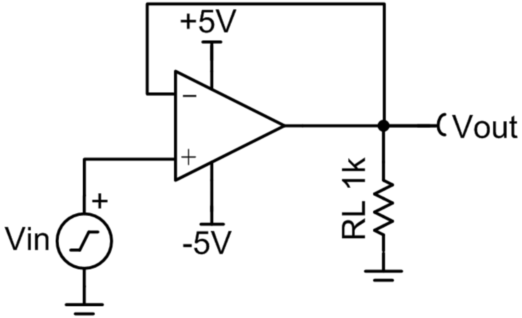


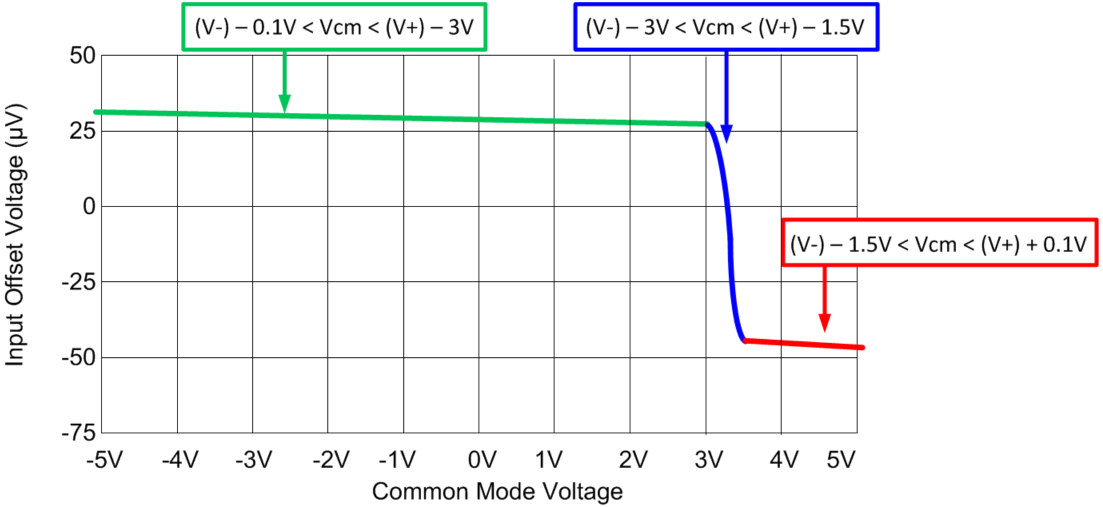




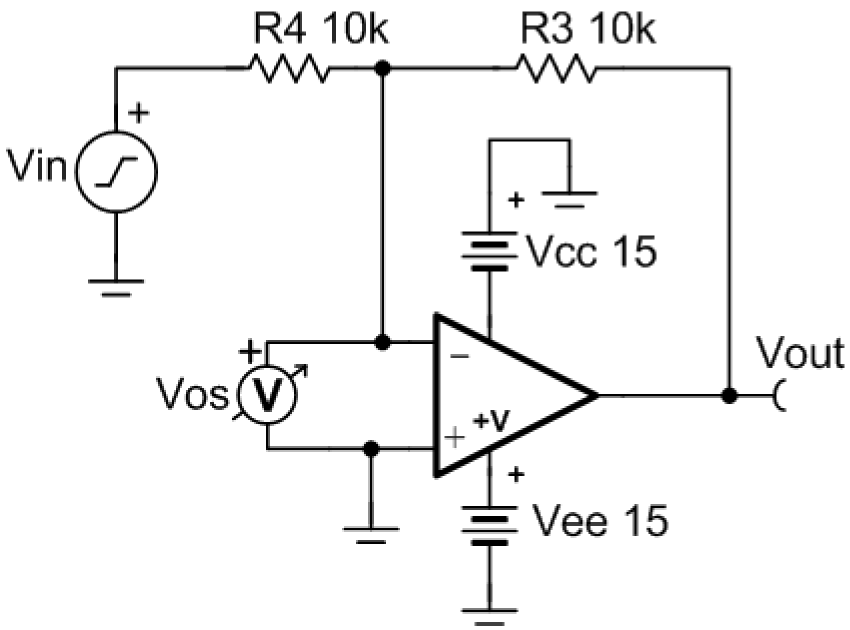
CMRR for Amplifiers with Crossover Distortion

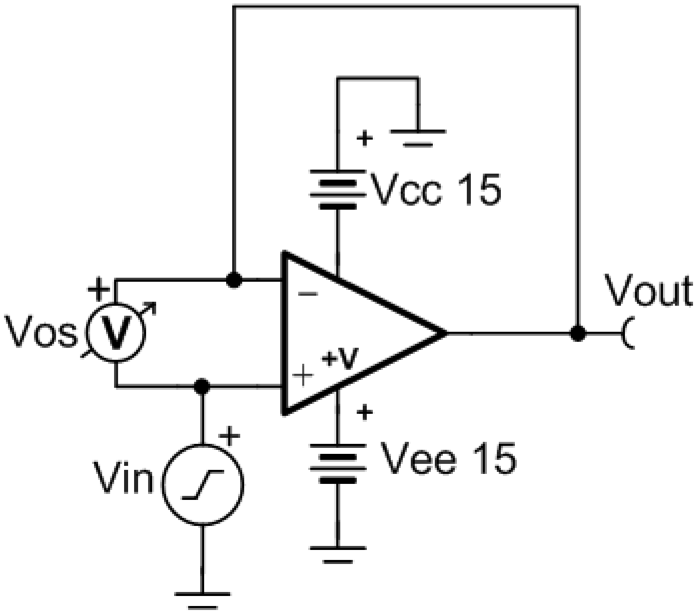
PARAMETER		TEST CONDITIONS		OPA192 MIN	OPA192 TYP	OPA192 MAX	UNIT
CMRR	Common-mode rejection ratio		(V–) – 0.1 V < V_{CM} < (V+) – 3 V	120	140		dB
			(V+) – 3 V < V_{CM} < (V+) - 1.5 V	See Typical Characteristics			
			(V+) – 1.5 V < V_{CM} < (V+) + 0.1 V	100	120		dB





Inverting vs. Non-inverting (Impact on CMRR)





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Thanks for your time!
Please try the quiz.