PSRR

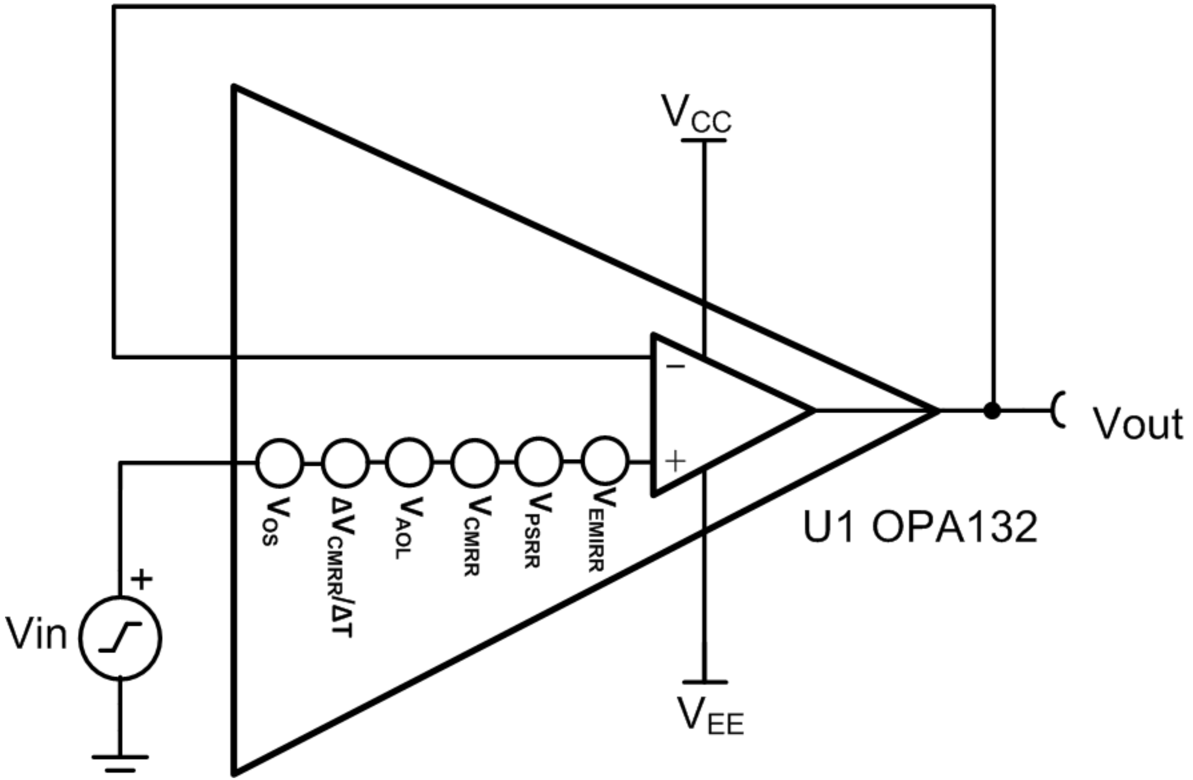
TIPL 1232
TI Precision Labs – Op Amps

Presented by Collin Wells

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

Prerequisites: Input and Output Limitations 1 – 3
(TIPL1130 – TIPL1132)

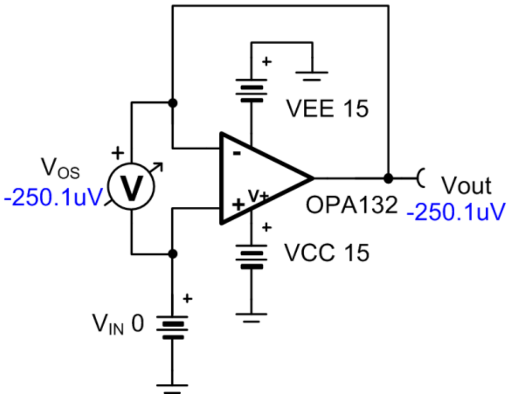
Referring Error to Input (RTI)

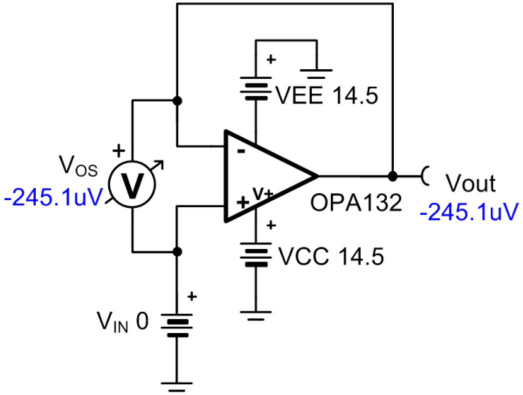


DC PSRR

At T_A = +25°C, V_S = ±15V, unless otherwise noted.

PARAMETER	CONDITION	OPA132P, U OPA2132P, U			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE					
Input Offset Voltage			±0.25	±0.5	mV
vs Temperature[(1)]	Operating Temperature Range		±2	±10	µV/°C
vs Power Supply	V_S = ±2.5V to ±18V		5	15	µV/V
Channel Separation (dual and quad)	R_L = 2kΩ		0.2		µV/V





Power Supply Rejection Example

$$\Delta V_{os} = 250.1\mu V - 245.1\mu V = 5\mu V$$

$$\Delta V_{Supply} = 30V - 29V = 1V$$

$$PSRR(\mu V/V) = \frac{\Delta V_{os}}{\Delta V_{Supply}} = \frac{5\mu V}{1V} = 5\,\mu V/V$$

$$PSRR(dB) = -20\log\left(\frac{5\mu V}{1V}\right) = 106dB$$

Power Supply Rejection Definitions

$$\Delta V_{os} = V_{os1} - V_{os2}$$

Vos measured at two different supply voltages

$$\Delta V_{Supply} = V_{s1} - V_{s1}$$

The difference in the supply voltages

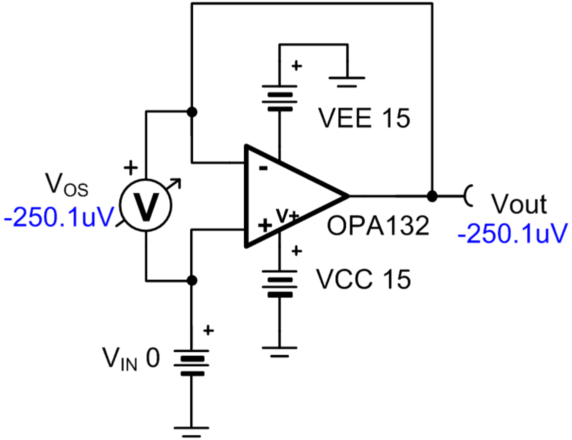
$$PSRR(V/V) = \frac{\Delta V_{os}}{\Delta V_{Supply}}$$

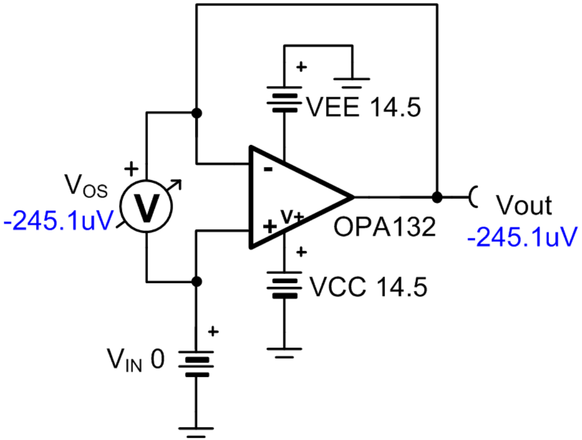
Power supply rejection ratio in µV/V

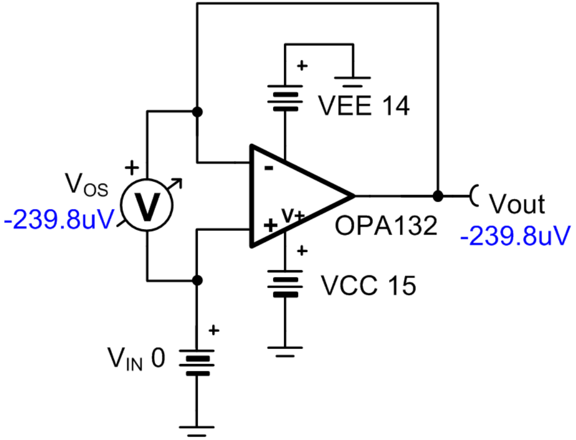
$$PSRR(dB) = -20\log\left(\frac{\Delta V_{os}}{\Delta V_{Supply}}\right)$$

Power supply rejection ratio in dB

PSRR & CMRR Combined Effects: Supply Symmetry







$$\frac{V_{CC}+V_{EE}}{2}=\frac{15V+(-15V)}{2}=0V$$

$V_{CM}=0V$

V_{OS} *is defined at* $V_{CM}=\frac{V_{CC}+V_{EE}}{2}$

If supplies shift such that $V_{CM}\neq\frac{V_{CC}+V_{EE}}{2}$

than this is an effective shift in V_{CM}

$$\frac{V_{CC}+V_{EE}}{2}=\frac{14.5V+(-14.5V)}{2}=0V$$

$V_{CM}=0V$

Thus $\Delta V_{CM}=0V$

The shift in V_{os} *is from PSRR*

$$\frac{V_{CC}+V_{EE}}{2}=\frac{15V+(-14V)}{2}=0.5V$$

$V_{CM}=0V$

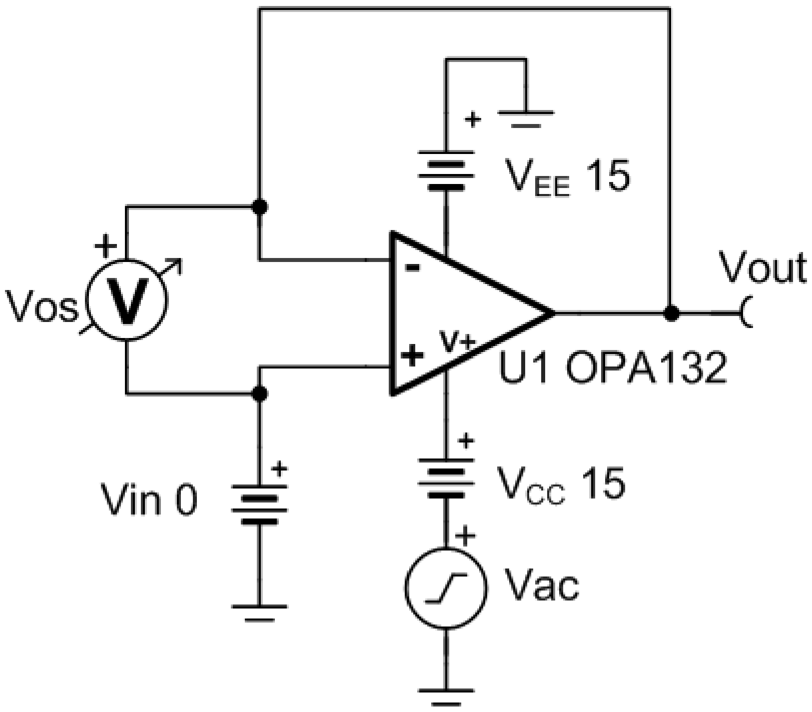
Thus $\Delta V_{CM}=0.5V$ *relative to supplies*

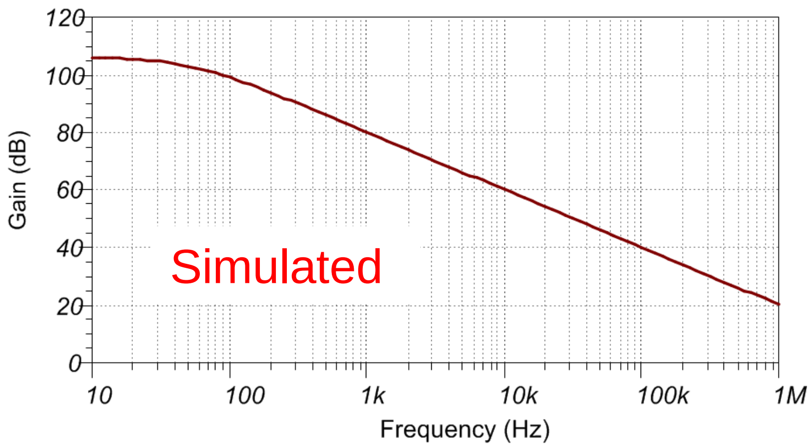
The shift in V_{os} *is from CMRR & PSRR*

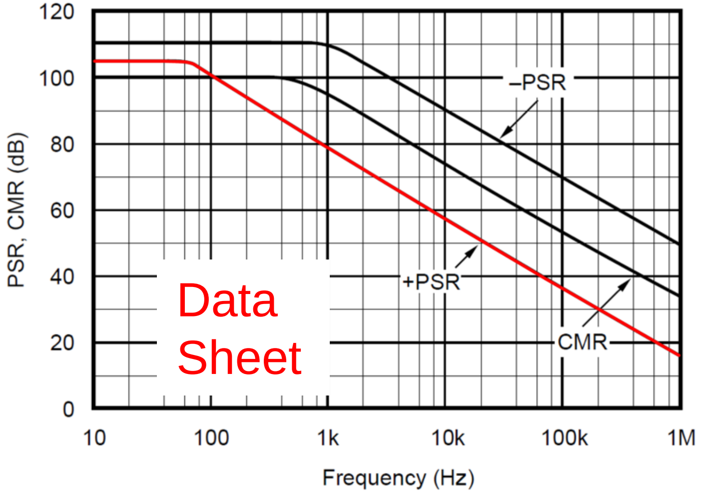
Translating µV/V to dB and Vice Versa

Useful Formulas for PSR	
$\log\left(\frac{y}{x}\right) = -\log\left(\frac{x}{y}\right)$	(1) Law of Logarithms
$\mathrm{PSRR(dB)} = -20\log\left(\frac{\Delta V_{os}}{\Delta V_{Supply}}\right) = 20\log\left(\frac{\Delta V_{Supply}}{\Delta V_{os}}\right)$	(2) Using (1) to show alternative definition
$\mathrm{PSRR(V/V)} = \frac{\Delta V_{os}}{\Delta V_{Supply}}$	(3) PSRR definition in V/V
$\mathrm{PSRR(dB)} = -20\log\left(\mathrm{PSRR(V/V)}\right)$	(4) Substitute (3) into (2)
$\mathrm{PSRR(V/V)} = 10^{\left(\frac{-\mathrm{PSRR(dB)}}{20}\right)}$	(5) Translating dB to V/V
$\mathrm{PSRR(\mu V/V)} = 10^{6} \cdot \mathrm{PSRR(V/V)}$	(6) Translating V/V into µV/V

AC PSRR

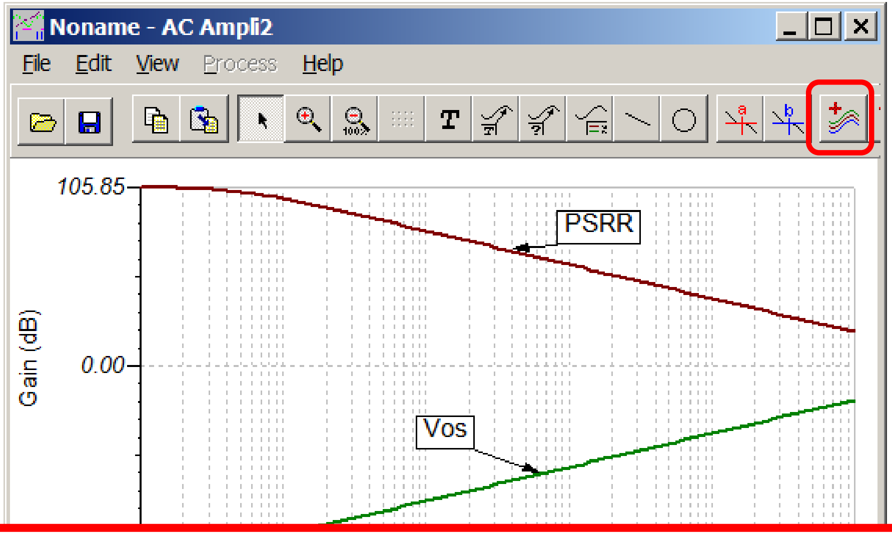


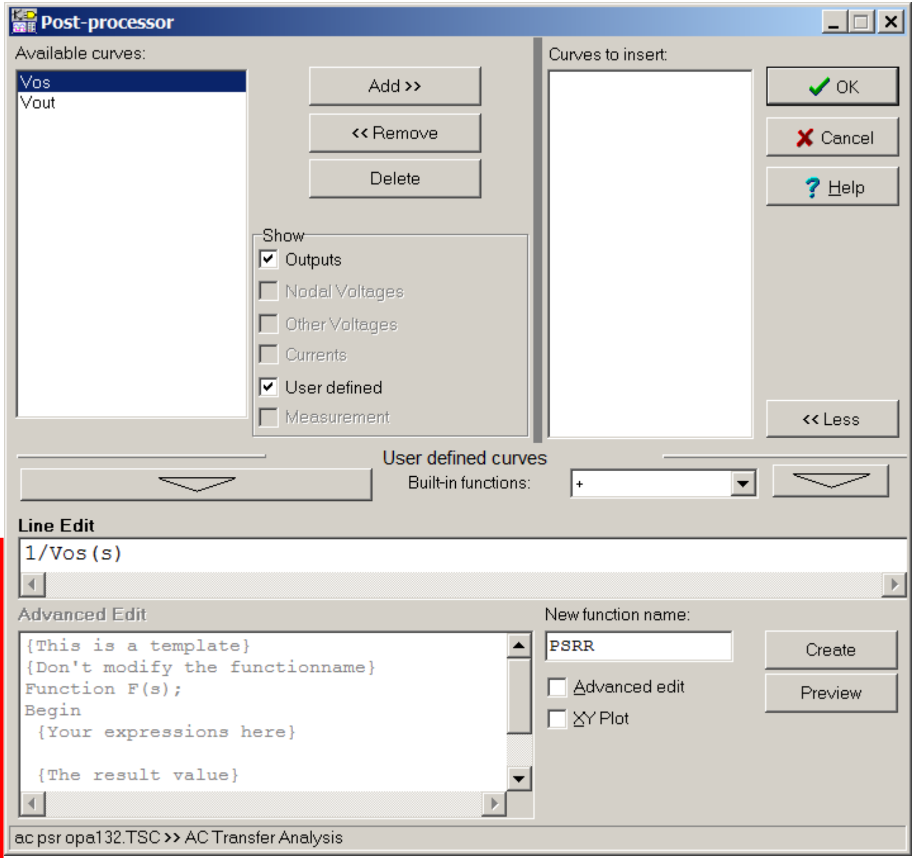




TEXAS INSTRUMENTS

Tina: Use Post Processor





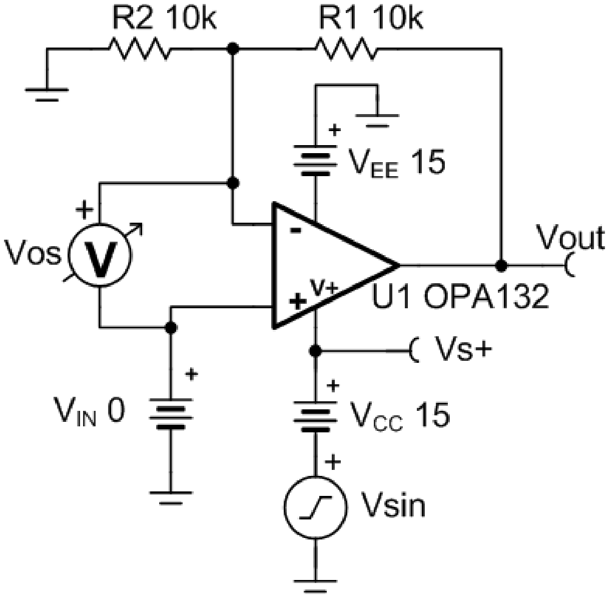
$$PSRR(V/V) = \frac{\Delta V_{OS}}{\Delta V_{supply}}$$

$$PSRR(dB) = 20 \cdot \log\left(\frac{\Delta V_{supply}}{\Delta V_{OS}}\right)$$

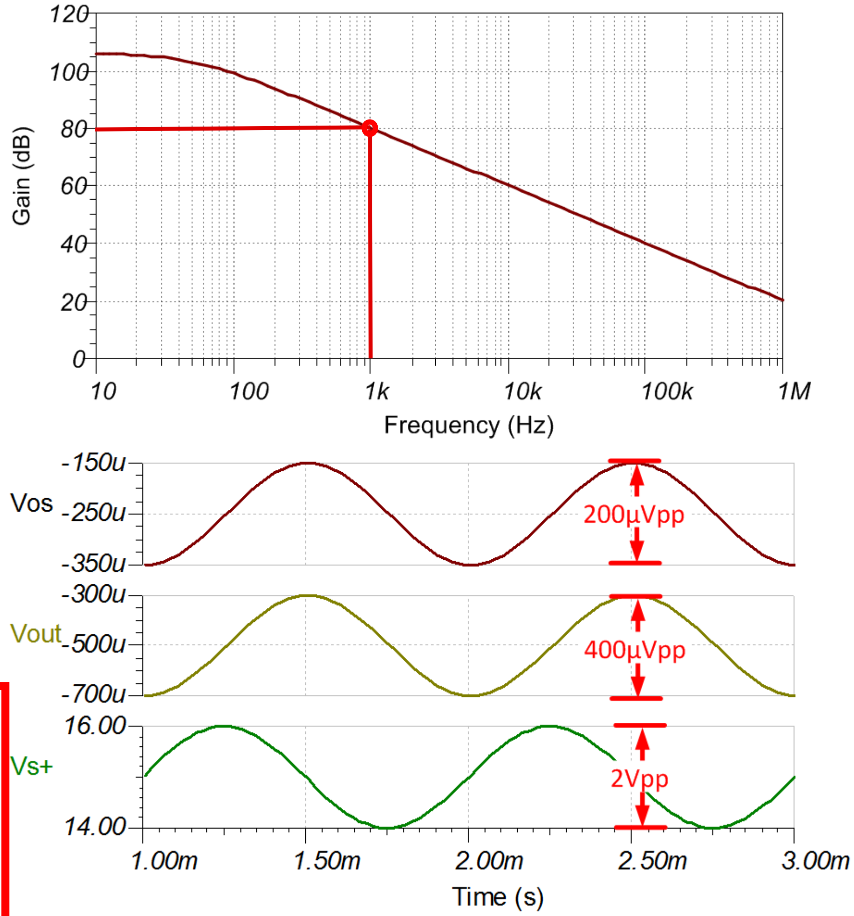
But $\Delta V_{supply} = 1$ and Tina automatically displays in dB, so $1/V_{OS}$ displays PSRR in dB for Tina Spice

Texas Instruments

AC PSRR Example

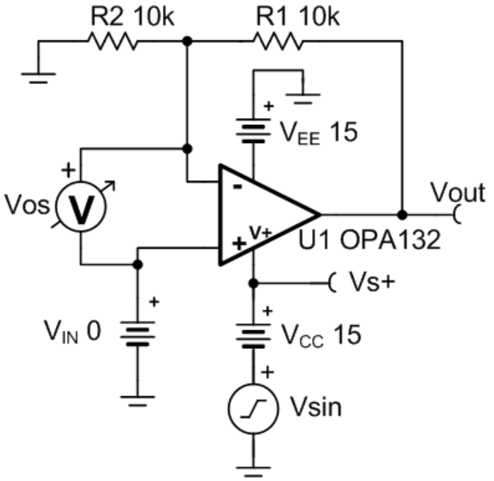


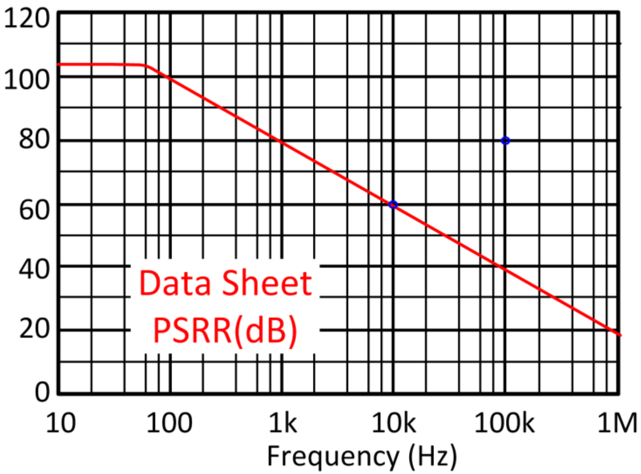
$$PSRR(V/V) = 10^{\left(\frac{-80dB}{20}\right)} = 100\mu V/V$$
$$V_{os} = V_{ac} \cdot PSRR(V/V) = 200\mu V$$
$$V_{out} = V_{os} \cdot G = (200\mu V) \cdot (2\,V/V) = 400\mu V$$

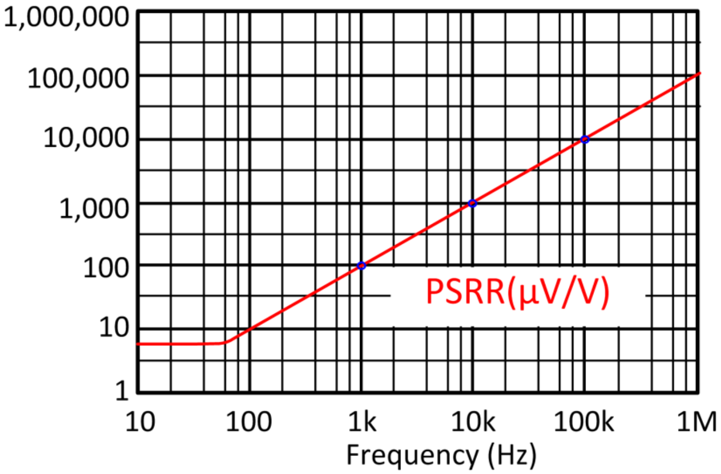


Texas Instruments

PSRR Acts Like a High Pass Filter



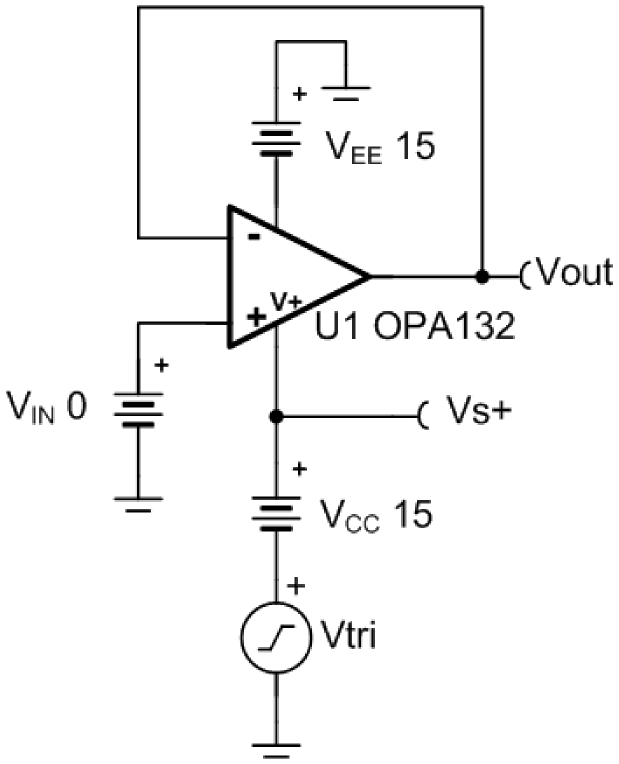


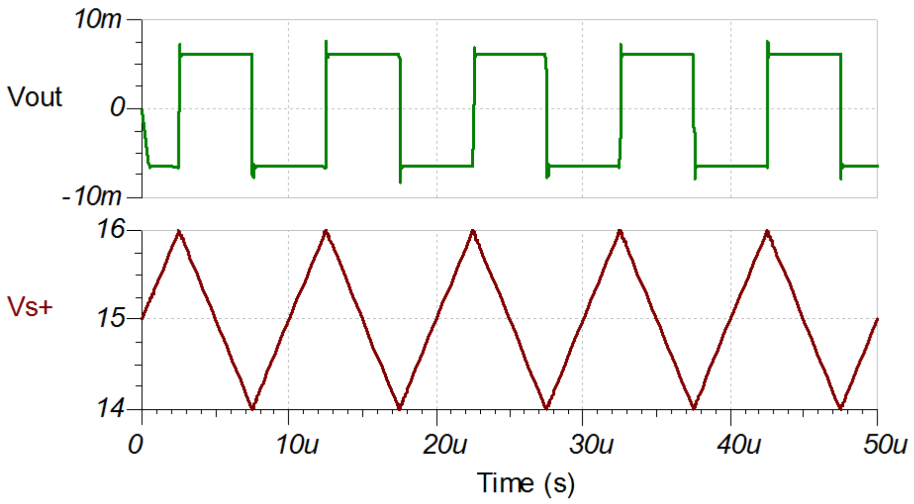


Vac	PSRR(dB)	PSRR(µV/V)	Vos	Vout
1Vpk, 1kHz	80	100	100µVpk	200µVpk
1Vpk, 10kHz	60	1,000	1mVpk	2mVpk
1Vpk, 100kHz	40	10,000	10mVpk	20mVpk

Texas Instruments

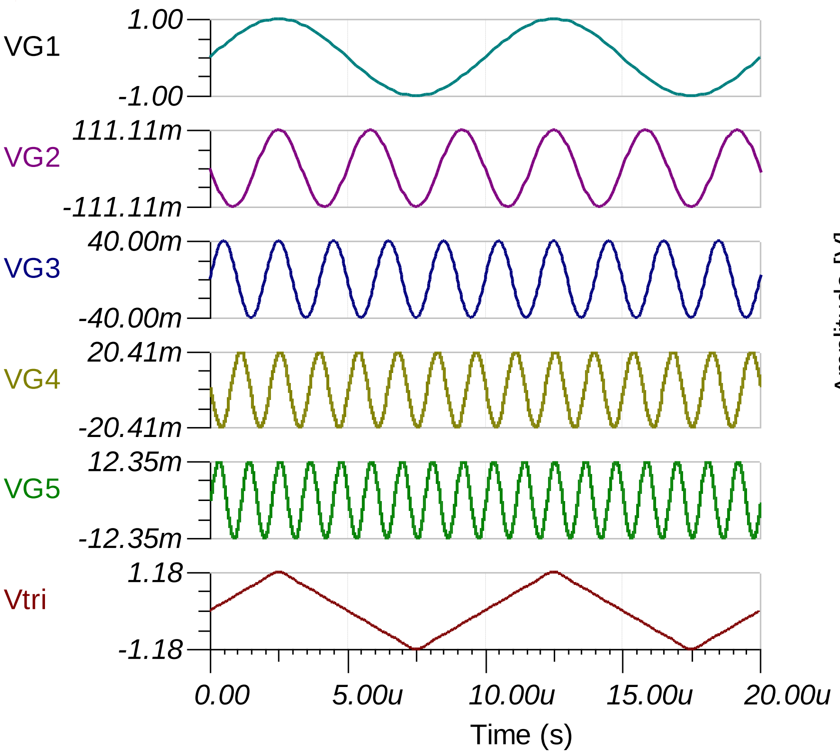
AC PSRR – Time Domain

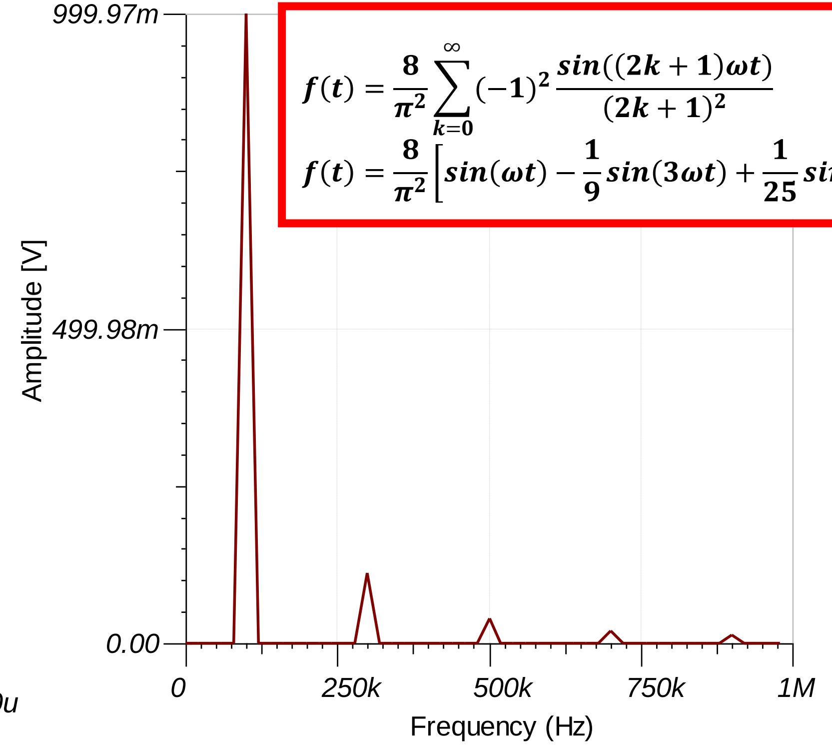




Texas Instruments

Infinite Series for a Triangle Wave



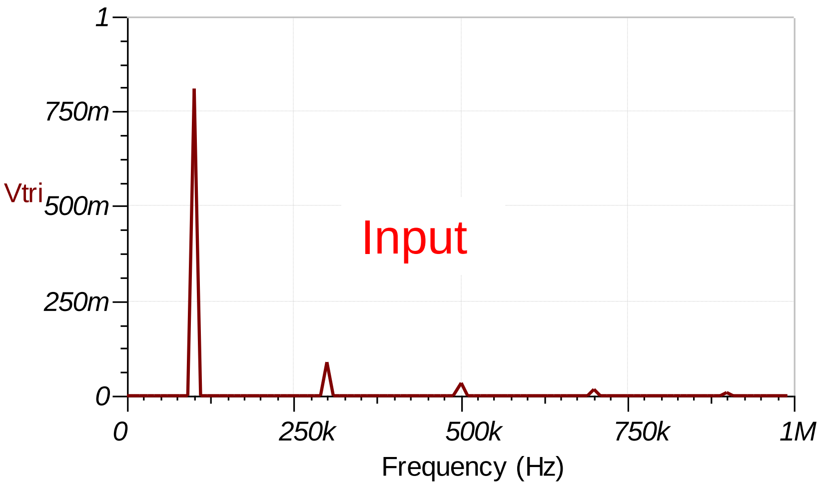


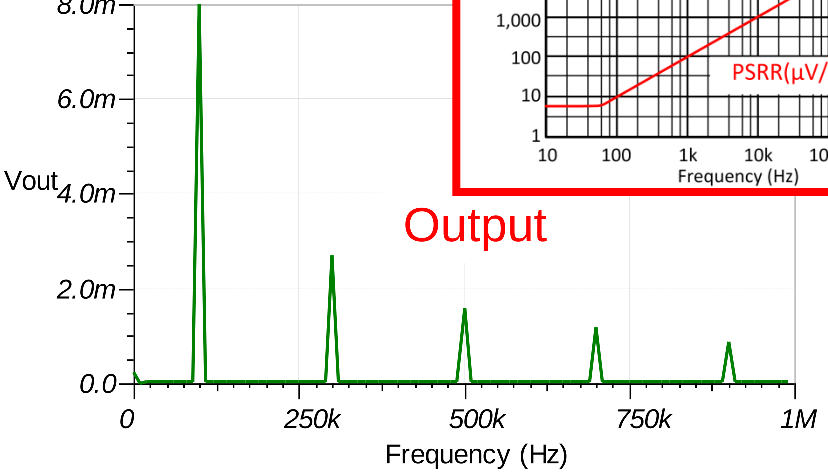
$$f(t) = \frac{8}{\pi^2} \sum_{k=0}^{\infty} (-1)^2 \frac{sin((2k+1)\omega t)}{(2k+1)^2}$$

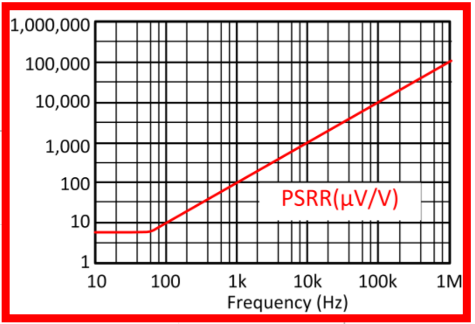
$$f(t) = \frac{8}{\pi^2} \left[sin(\omega t) - \frac{1}{9} sin(3\omega t) + \frac{1}{25} sin(5\omega t) - \cdots \right]$$

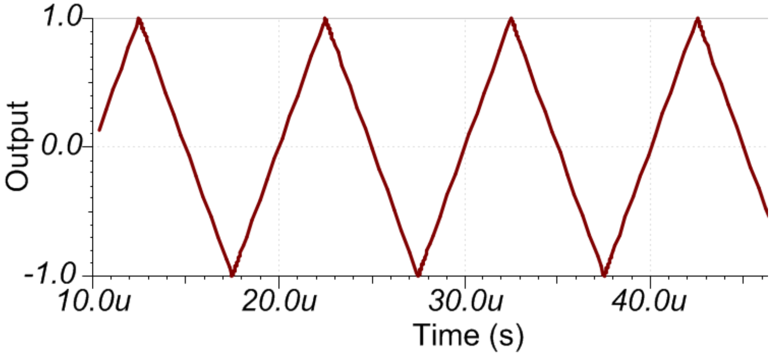
Texas Instruments

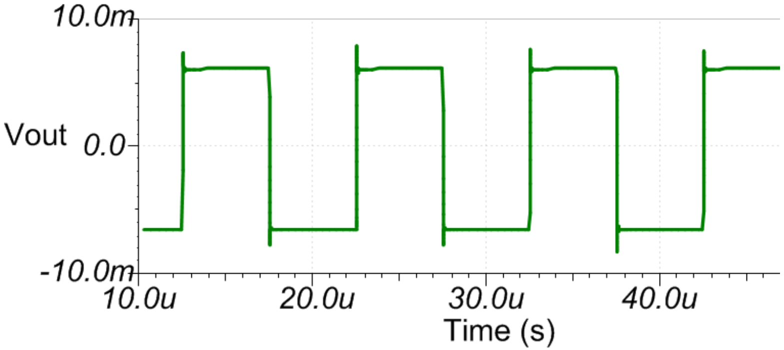
Input Spectrum vs. Output Spectrum



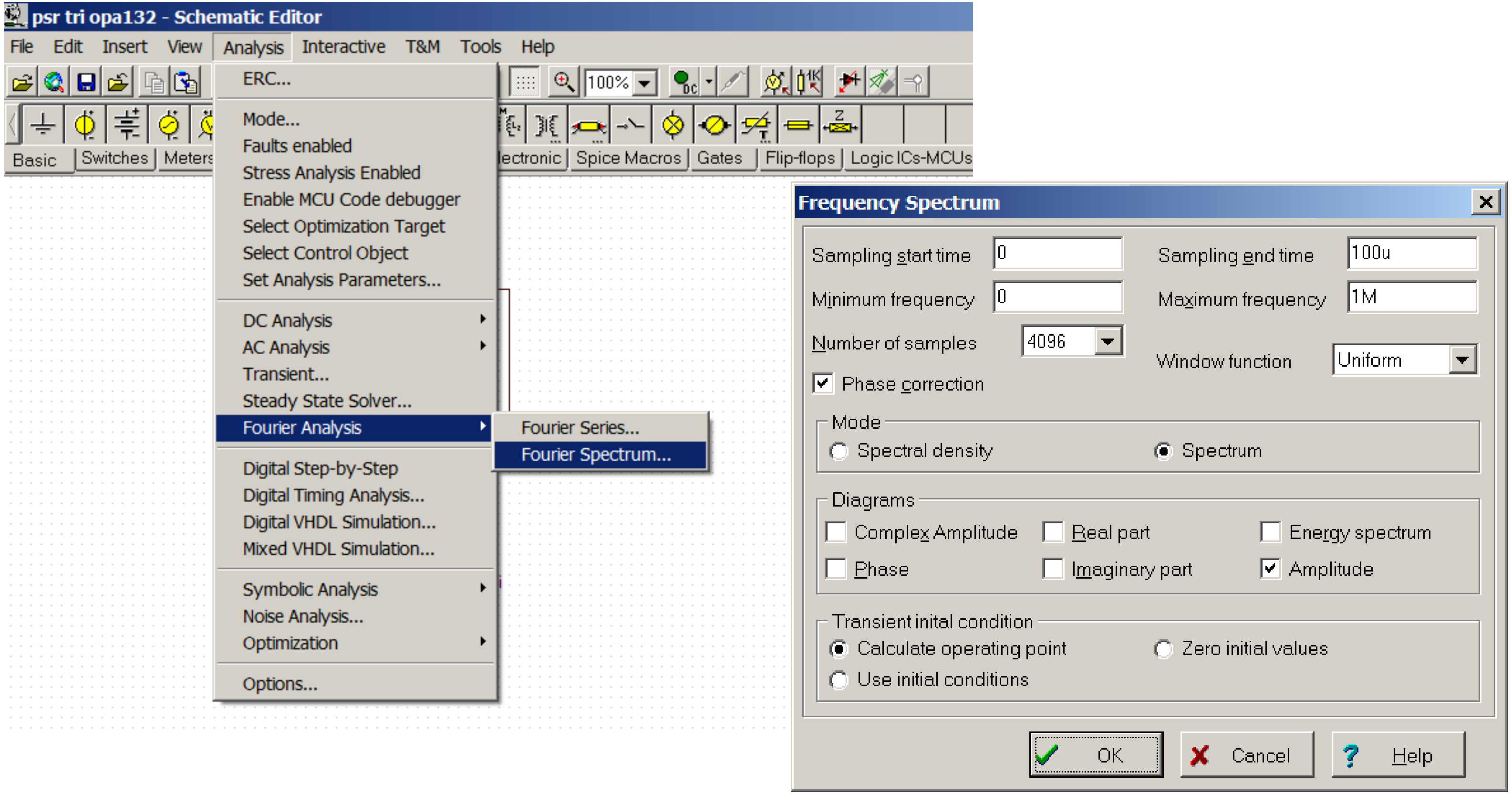








How to Generate the Fourier Spectrum in Tina



Thanks for your time! Please try the quiz.