

Input & Output Limitations – 2

TIPL 1131

TI Precision Labs – Op Amps

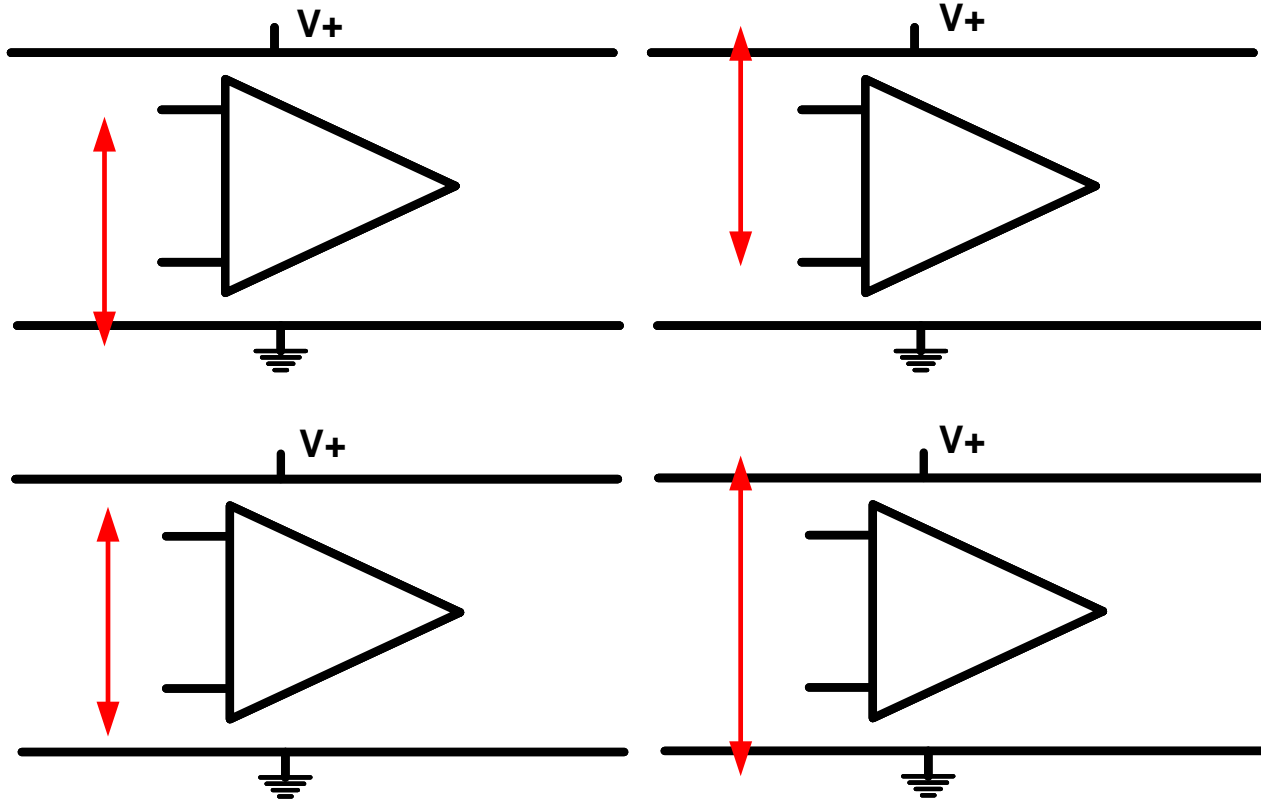
Presented by Ian Williams

Prepared by Art Kay and Ian Williams

Prerequisite: Input & Output Limitations

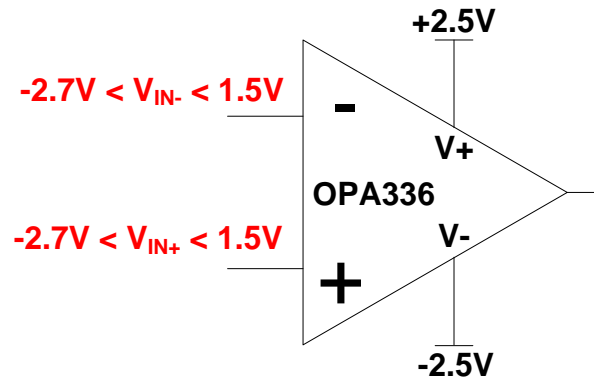
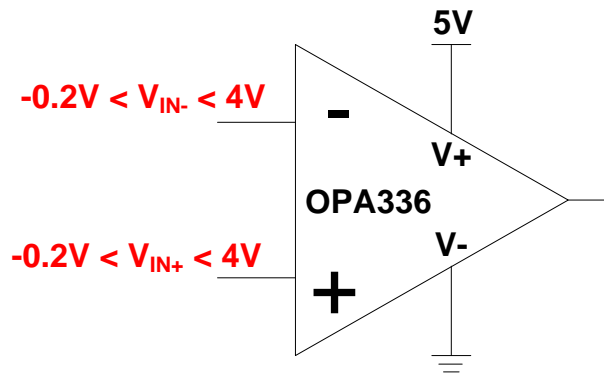
(TIPL 1130)

Real World V_{CM} Range

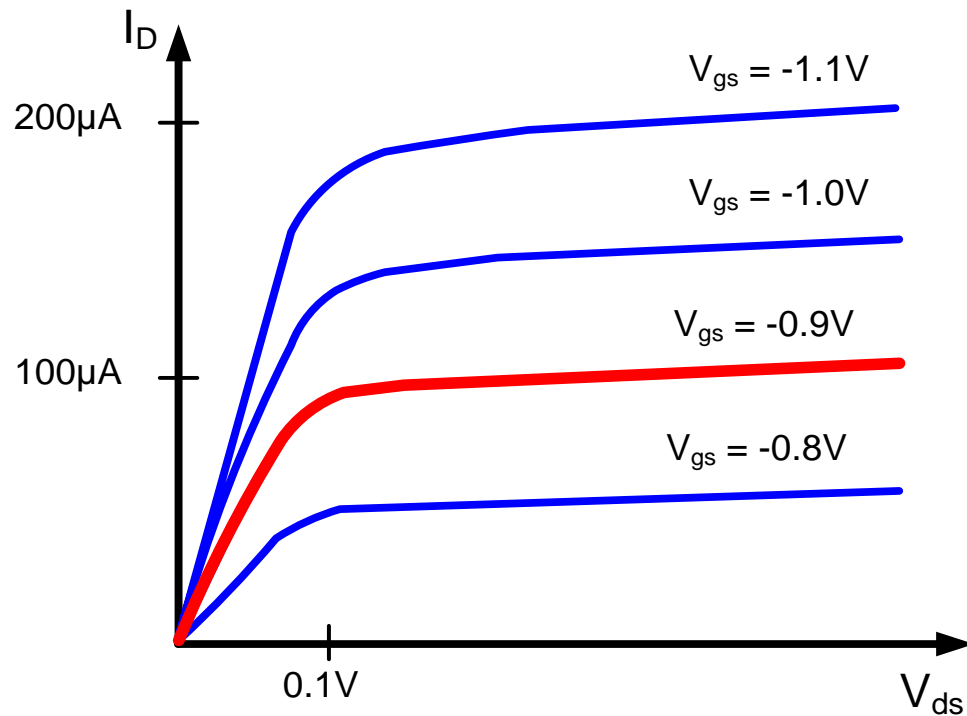
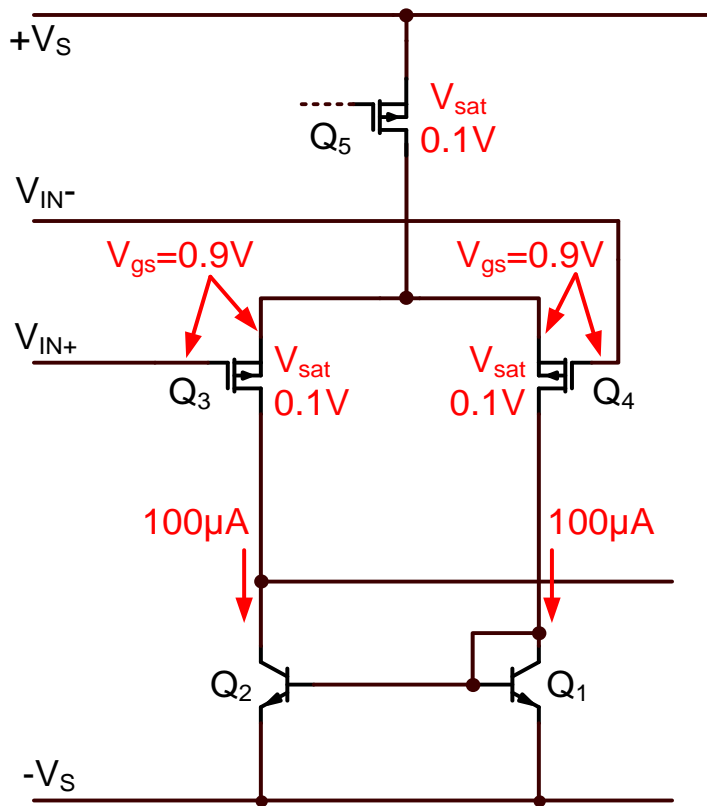


Simple MOSFET Input – V_{CM} to Negative Rail

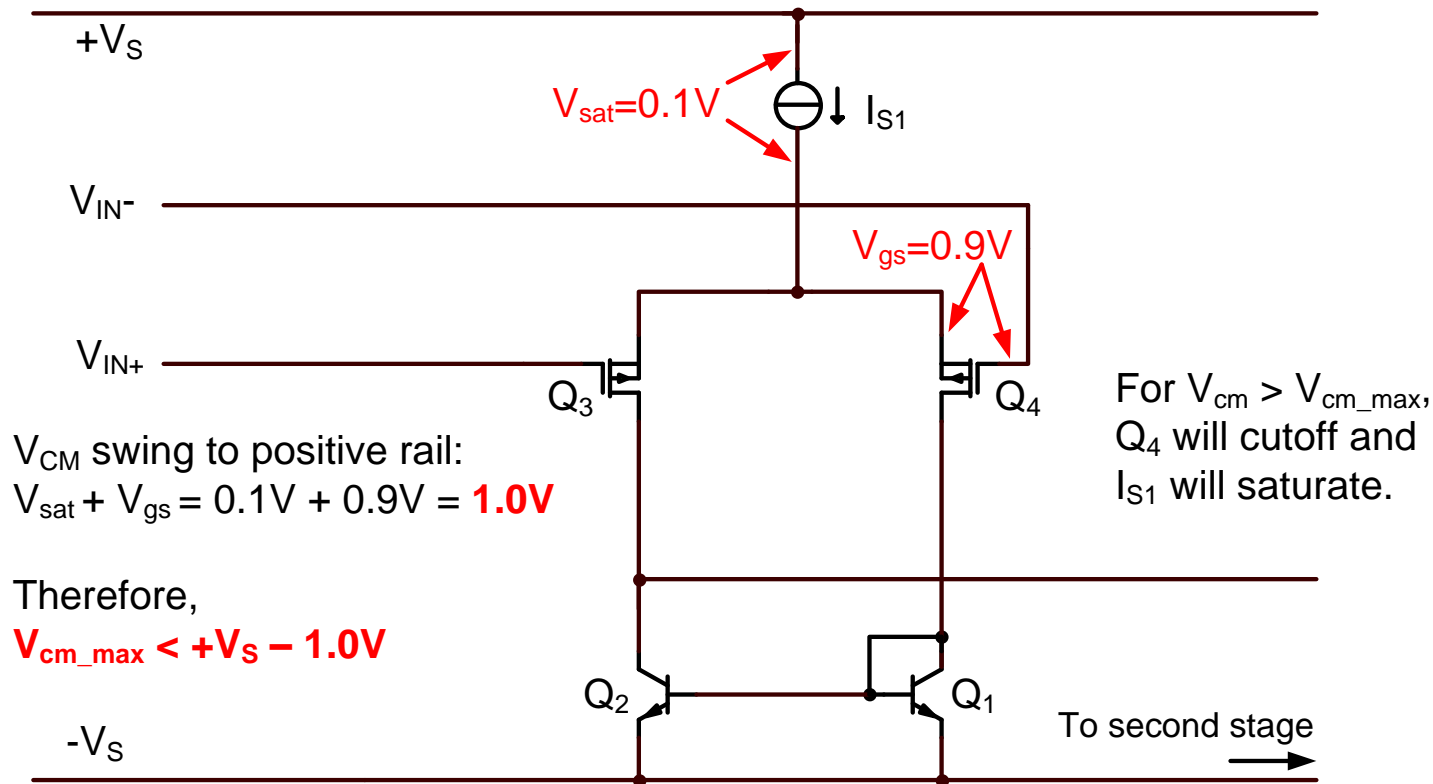
PARAMETER	CONDITION	OPA336N, U OPA2336E, P, U		
		MIN	TYP ⁽¹⁾	MAX
INPUT VOLTAGE RANGE				
Common-Mode Voltage Range	V_{CM}	-0.2		$(V+) - 1$
Common-Mode Rejection Ratio		80	90	
Over Temperature		76		



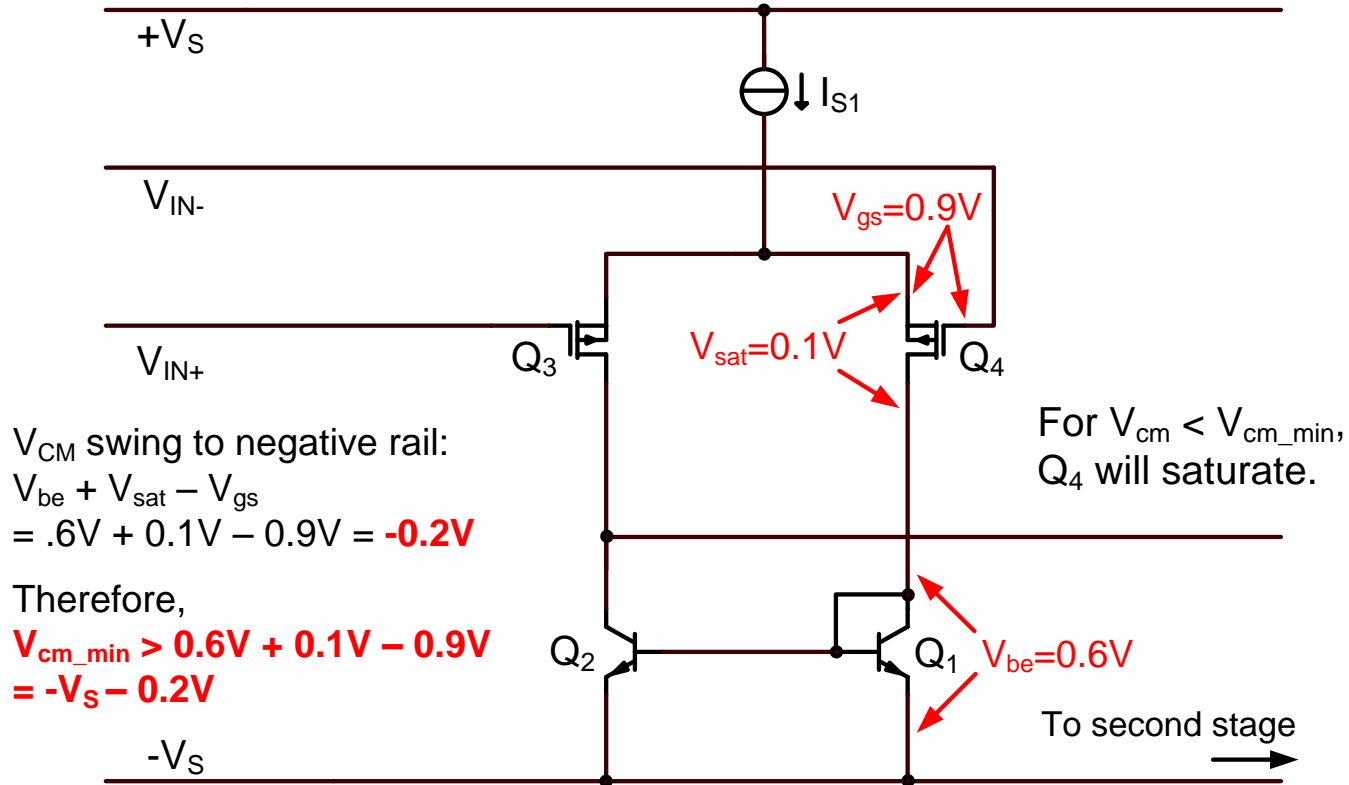
Input Pair Biasing



OPA336 Input Stage – Maximum V_{CM}

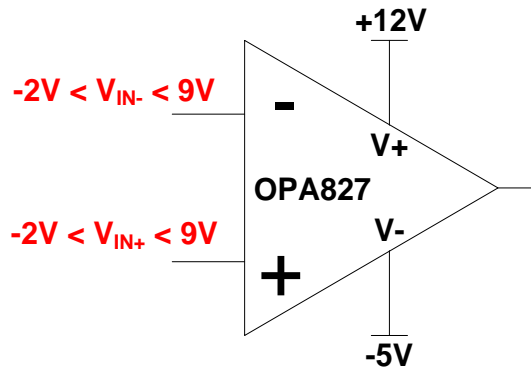


OPA336 Input Stage – Minimum V_{CM}

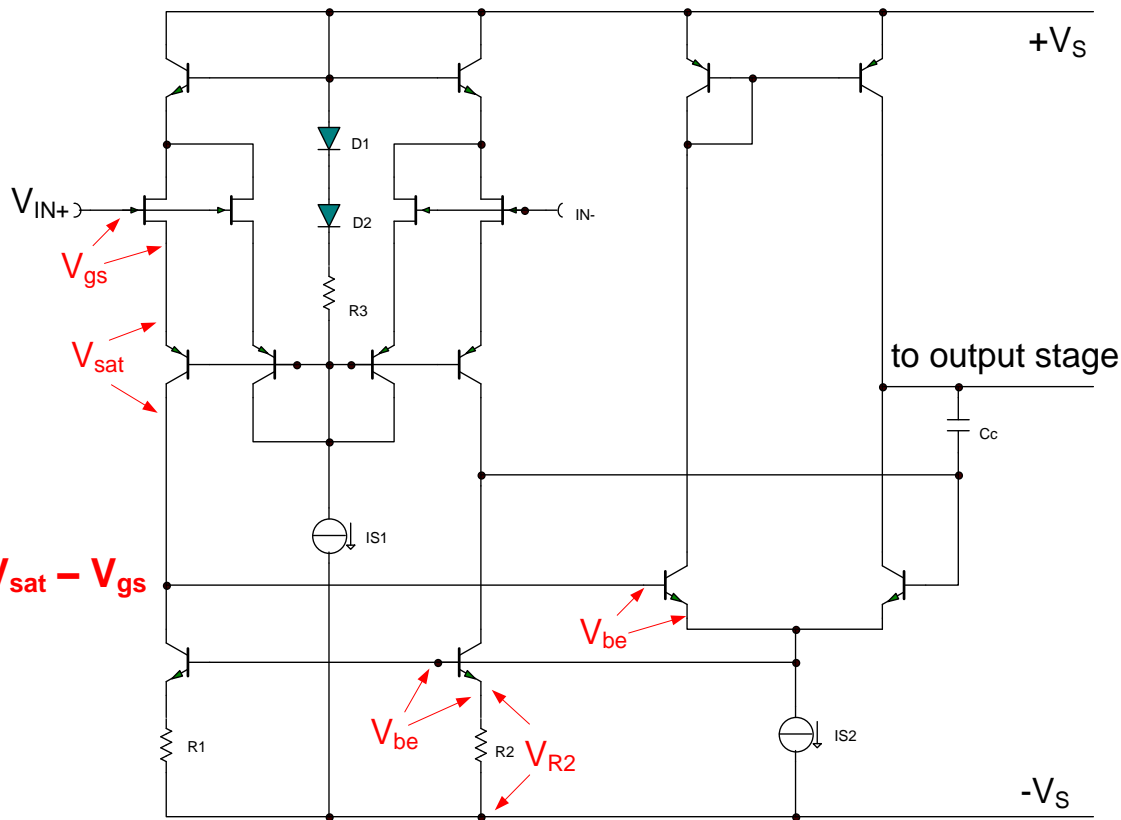


Typical Bipolar or JFET Input – Not Rail-to-Rail

PARAMETER	CONDITIONS	STANDARD GRADE OPA827AI		
		MIN	TYP	MAX
INPUT VOLTAGE RANGE				
Common-Mode Voltage Range	V_{CM}	$(V-)+3$		$(V+)-3$
Common-Mode Rejection Ratio	$(V-)+3V \leq V_{CM} \leq (V+)-3V, V_S < 10V$	104	114	
	$(V-)+3V \leq V_{CM} \leq (V+)-3V, V_S \geq 10V$	114	126	
Over Temperature	$(V-)+3V \leq V_{CM} \leq (V+)-3V, V_S < 10V$	100		
	$(V-)+3V \leq V_{CM} \leq (V+)-3V, V_S \geq 10V$	110		



OPA827 Input Stage – Minimum V_{CM}



V_{CM} swing to negative rail:

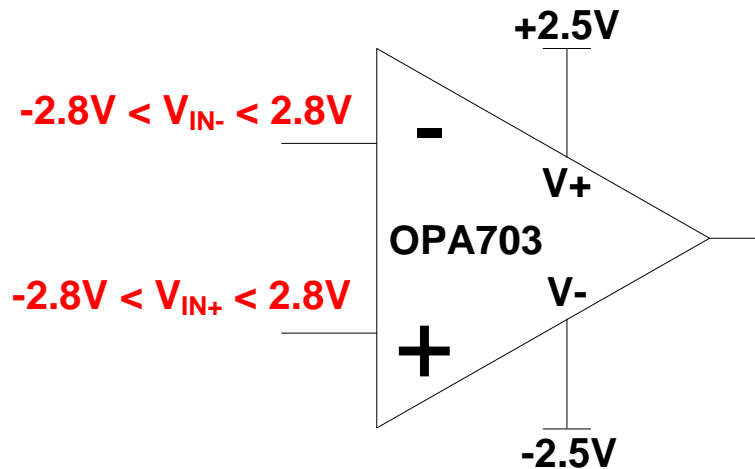
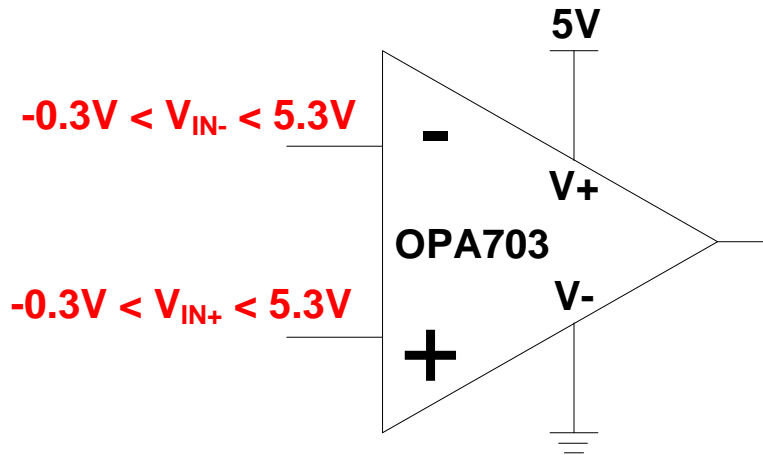
$$V_{CM} > -V_S + V_{R2} + 2V_{be} + V_{sat} - V_{gs}$$

Therefore,

$$-V_S + 3V < V_{CM} < +V_S - 3V$$

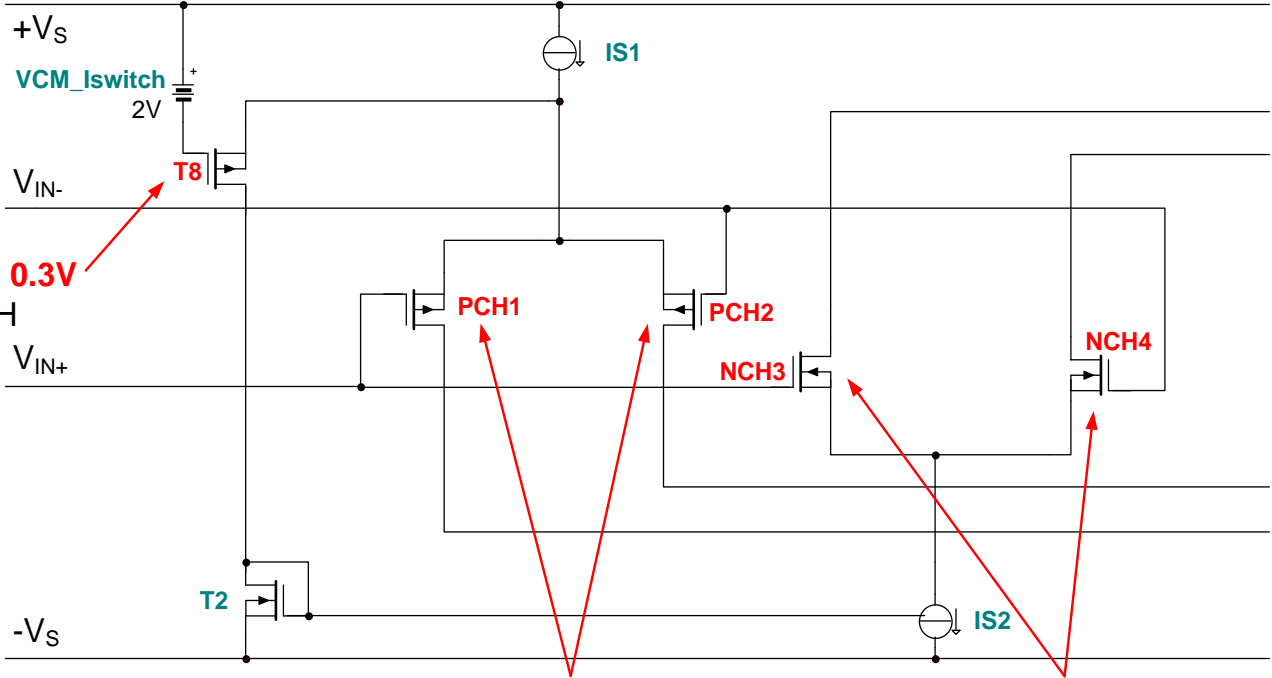
MOSFET Complementary N-P-FET – Rail-to-Rail

PARAMETER	CONDITION	OPA703NA, UA, PA OPA2703EA, UA, PA OPA4703EA, UA			UNITS
		MIN	TYP	MAX	
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$(V-) - 0.3$		$(V+) + 0.3$	V
Common-Mode Rejection Ratio over Temperature	CMRR	$V_S = \pm 5V, (V-) - 0.3V < V_{CM} < (V+) + 0.3V$ $V_S = \pm 5V, (V-) < V_{CM} < (V+)$	70 68	90	dB dB
over Temperature		$V_S = \pm 5V, (V-) - 0.3V < V_{CM} < (V+) - 2V$ $V_S = \pm 5V, (V-) < V_{CM} < (V+) - 2V$	80 74	96	dB dB



OPA703 Input Stage – Simplified Schematic

Turns on when
 $+V_S - 2V < V_{CM} < +V_S + 0.3V$
 Steals current from PCH

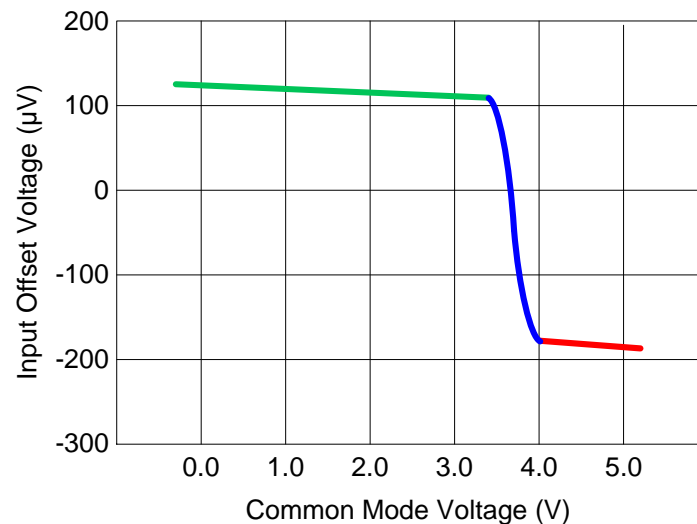
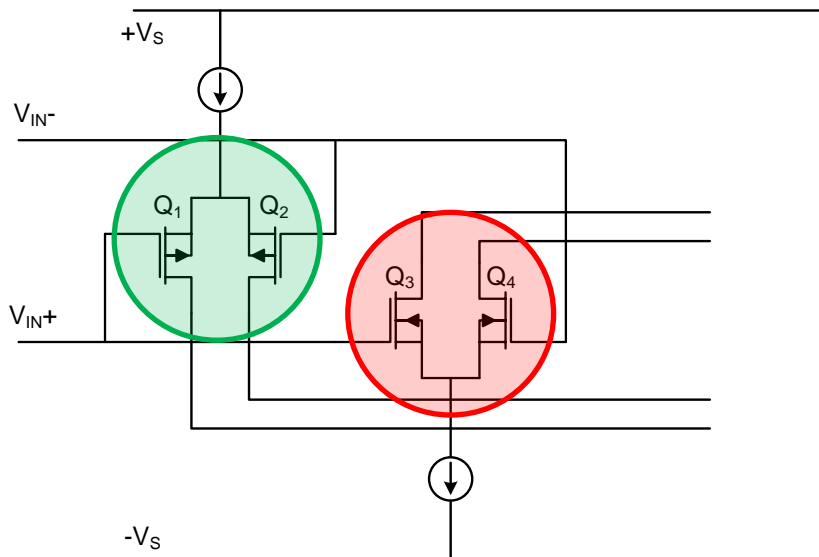


PCH input pair active for:
 $-V_S - 0.3V < V_{CM} < +V_S - 2V$

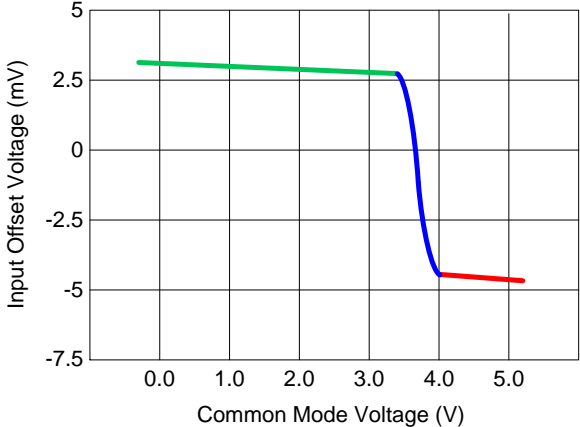
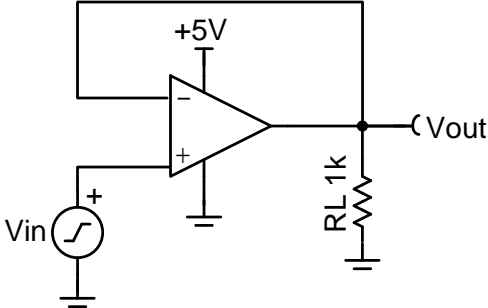
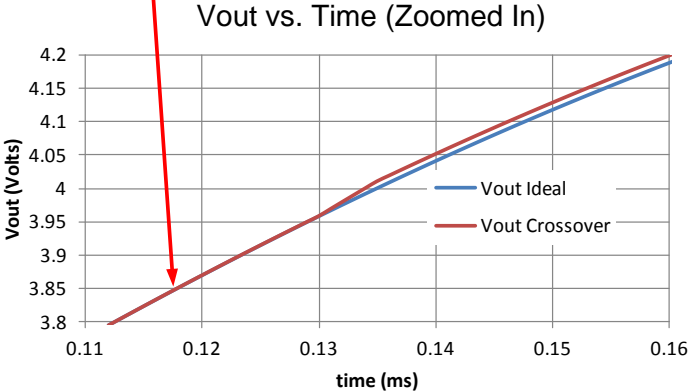
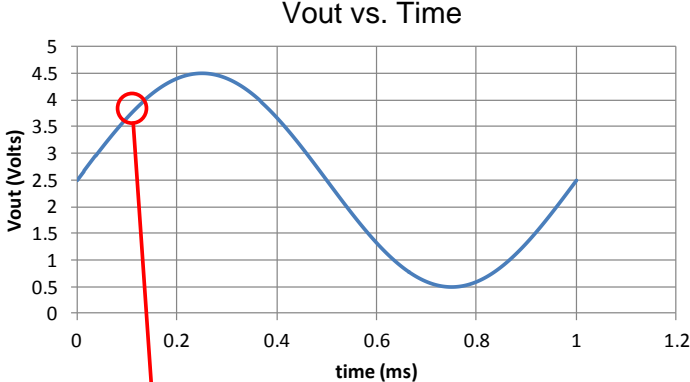
NCH input pair active for:
 $+V_S - 2V < V_{CM} < +V_S + 0.3V$

OPA703 Complementary CMOS – Rail-to-Rail

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$(V-) - 0.3$		$(V+) + 0.3$	V
Common-Mode Rejection Ratio	$CMRR$	$V_S = \pm 5V, (V-) - 0.3V < V_{CM} < (V+) + 0.3V$	70	90	dB
over Temperature		$V_S = \pm 5V, (V-) < V_{CM} < (V+)$	68		dB
		$V_S = \pm 5V, (V-) - 0.3V < V_{CM} < (V+) - 2V$	80	96	dB
over Temperature		$V_S = \pm 5V, (V-) < V_{CM} < (V+) - 2V$	74		dB

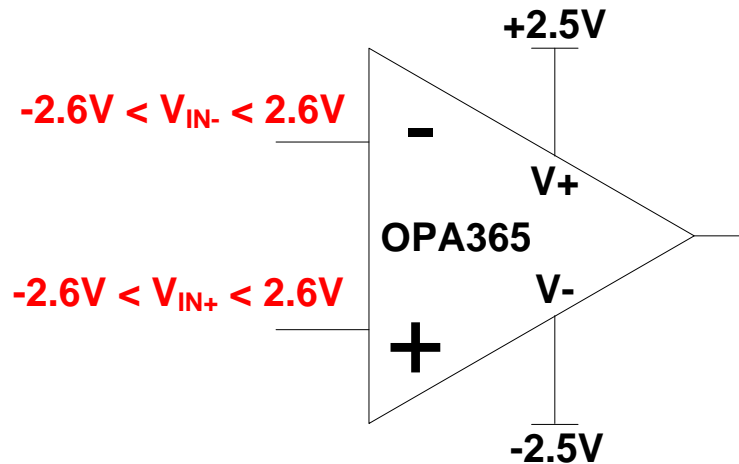
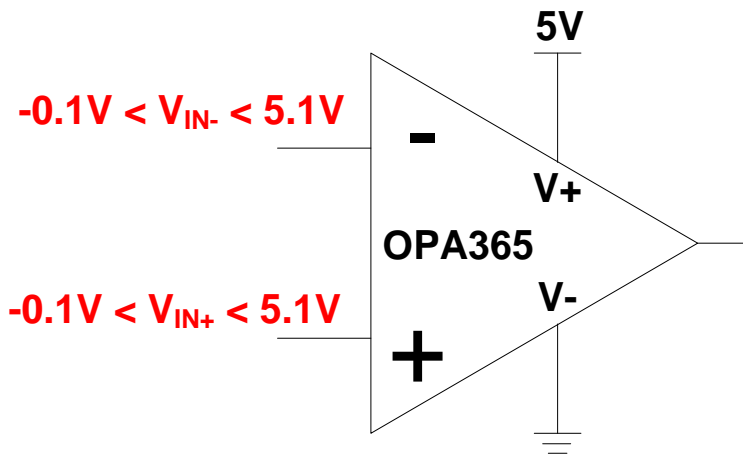


Crossover Distortion

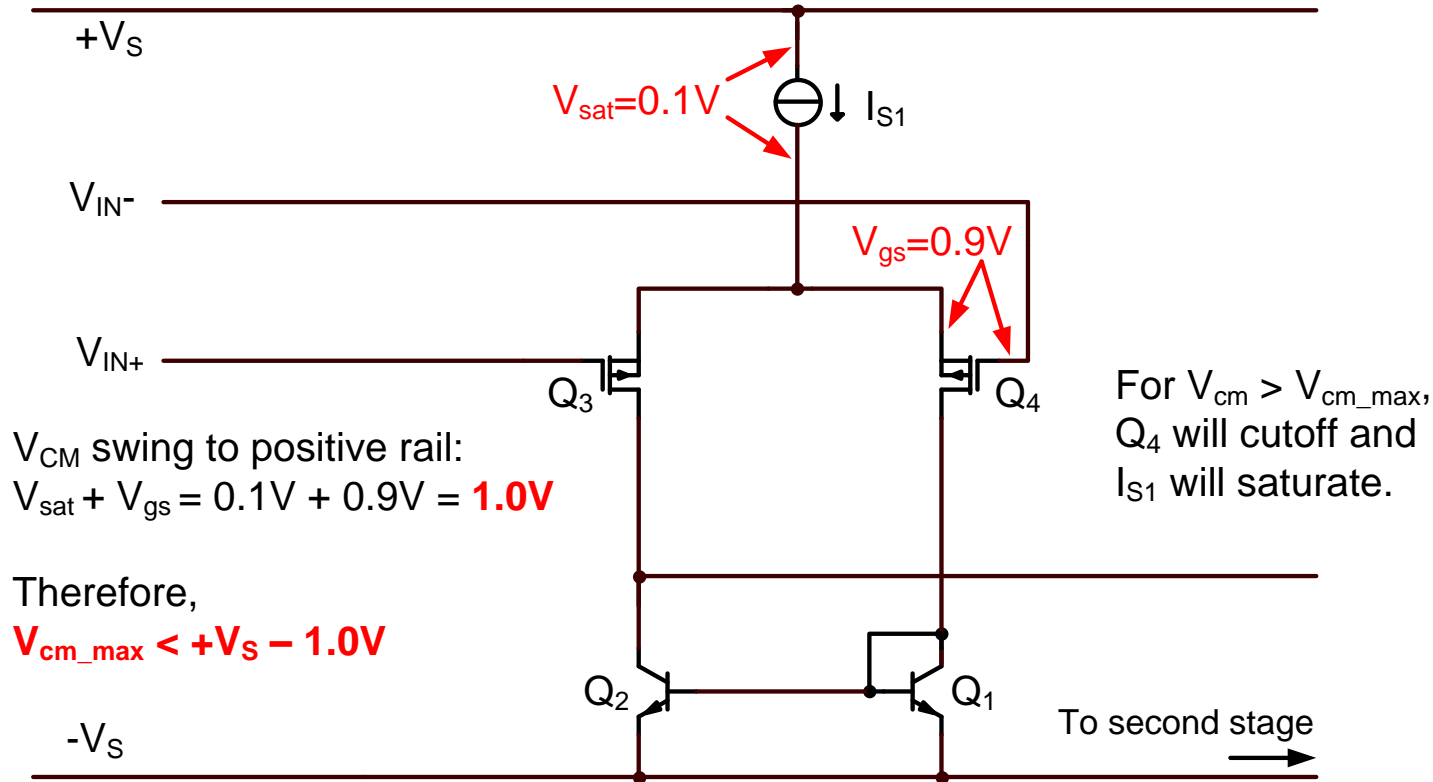


MOSFET Charge Pump – Rail-to-Rail

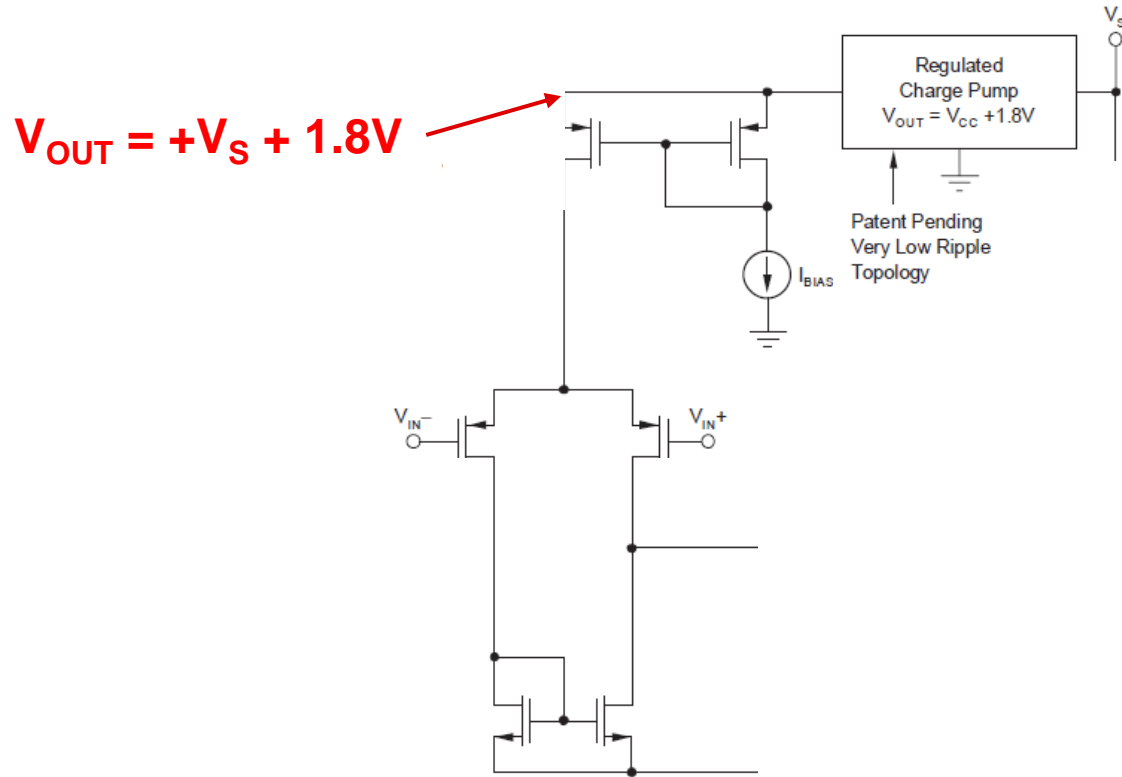
PARAMETER	TEST CONDITIONS	OPAx365			UNIT
		MIN	TYP	MAX	
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$(V-) - 0.1$		$(V+) + 0.1$	V
Common-Mode Rejection Ratio	$(V-) - 0.1V \leq V_{CM} \leq (V+) + 0.1V$	100	120		dB



Remember from Earlier in the Presentation...

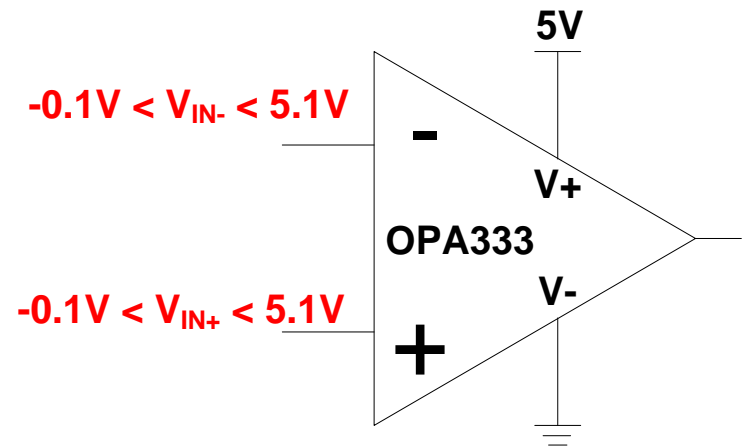
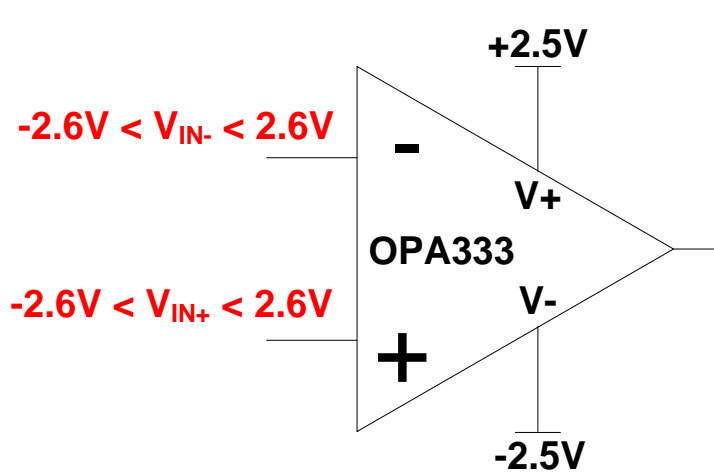


OPA365 MOSFET Charge Pump – Rail-to-Rail

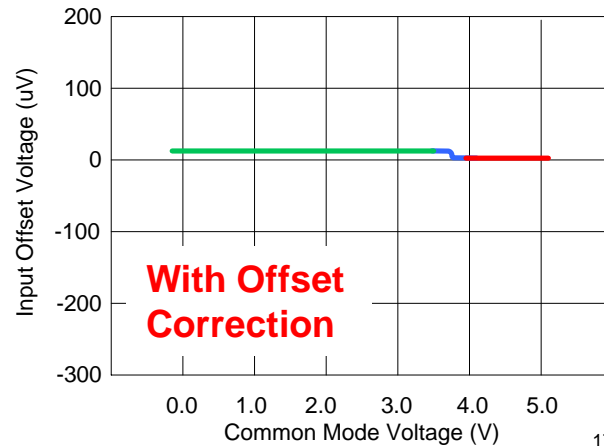
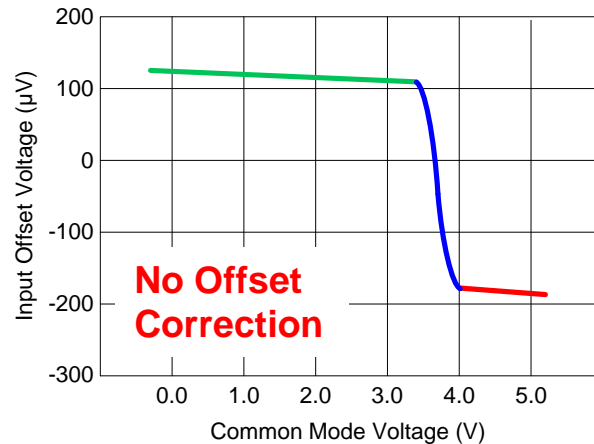
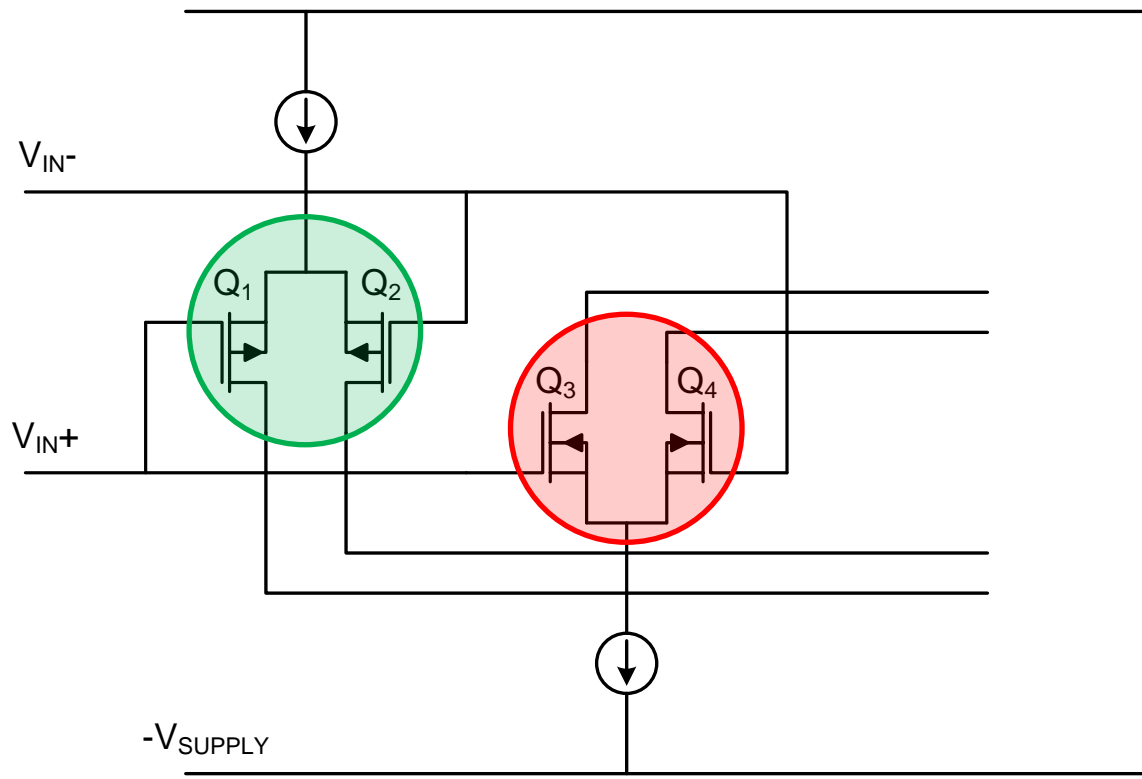


Zero Drift MOSFET – Rail-to-Rail

PARAMETER	TEST CONDITIONS	OPA333, OPA2333			UNIT
		MIN	TYP	MAX	
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$(V-) - 0.1$		$(V+) + 0.1$	V
Common-Mode Rejection Ratio	$CMRR$	$(V-) - 0.1V < V_{CM} < (V+) + 0.1V$	106	130	dB



Zero Drift MOSFET – Rail-to-Rail



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

Input & Output Limitations – 2

Multiple Choice Quiz

TI Precision Labs – Op Amps

Quiz: Input & Output Limitations – 2

1. Single supply amplifiers have _____.
 - a. Common mode range that extends to the negative supply.
 - b. Common mode range that extends to the positive supply.
2. (T/F) Single supply amplifiers can be used in a dual supply configuration.
 - a. True
 - b. False
3. (T/F) The common mode range of an amplifier is limited by the saturation and cutoff voltages of transistors in the input stage.
 - a. True
 - b. False
4. (T/F) Most rail-to-rail amplifiers use bipolar transistors.
 - a. True
 - b. False

Quiz: Input & Output Limitations – 2

5. What is a potential issue associated with using a charge pump to power the input stage on an op amp?
 - a. The charge pump can create crossover distortion.
 - b. The charge pump will cause a significant increase in the device quiescent current.
 - c. The charge pump requires external components.
 - d. Charge pump switching noise can introduce errors.

6. Consider the CMRR specification below. Does this device have crossover distortion?
 - a. Yes.
 - b. No.

ELECTRICAL CHARACTERISTICS: $V_S = +1.8\text{ V}$ to $+5.5\text{ V}$

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT VOLTAGE					
V_{CM} Common-mode voltage range		$(V-) - 0.1$		$(V+) + 0.1$	V
CMRR Common-mode rejection ratio	$(V-) - 0.1\text{ V} < V_{CM} < (V+) + 0.1\text{ V}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	106	130		dB

Quiz: Input & Output Limitations – 2

7. Which of the following will **NOT** minimize crossover distortion on rail to rail amplifiers?
 - a. Use an internal charge pump to boost the supply on the input stage
 - b. Use external TVS diodes to minimize the distortion.
 - c. Use a zero drift amplifier to minimize the overall offset so that the offset shift is small.

8. Consider the CMRR specification below. Does this device have crossover distortion?
 - a. Yes.
 - b. No.

PARAMETER	CONDITION	OPA343NA, UA OPA2343EA, UA OPA4343EA, UA, NA			UNITS
		MIN	TYP ⁽¹⁾	MAX	
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	-0.3		(V+) + 0.3	V
Common-Mode Rejection Ratio	CMRR	74	92		dB
	$V_S = 5V, -0.3V < V_{CM} < 5.3V$	60	75		dB
	$V_S = 2.7V, -0.3V < V_{CM} < 3V$	54	70		dB

Input & Output Limitations – 2

Multiple Choice Quiz: Solutions
TI Precision Labs – Op Amps

Solutions: Input & Output Limitations – 2

1. Single supply amplifiers have _____.
 - a. **Common mode range that extends to the negative supply.**
 - b. Common mode range that extends to the positive supply.

2. (T/F) Single supply amplifiers can be used in a dual supply configuration.
 - a. **True**
 - b. False

3. (T/F) The common mode range of an amplifier is limited by the saturation and cutoff voltages of transistors in the input stage.
 - a. **True**
 - b. False

4. (T/F) Most rail-to-rail amplifiers use bipolar transistors.
 - a. True
 - b. **False**

Solutions: Input & Output Limitations – 2

5. What is a potential issue associated with using a charge pump to power the input stage on an op amp?
 - a. The charge pump can create crossover distortion.
 - b. The charge pump will cause a significant increase in the device quiescent current.
 - c. The charge pump requires external components.
 - d. **Charge pump switching noise can introduce errors.**

6. Consider the CMRR specification below. Does this device have crossover distortion?
 - a. Yes.
 - b. **No.**

ELECTRICAL CHARACTERISTICS: $V_S = +1.8\text{ V}$ to $+5.5\text{ V}$

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT VOLTAGE					
V_{CM} Common-mode voltage range		$(V-) - 0.1$		$(V+) + 0.1$	V
CMRR Common-mode rejection ratio	$(V-) - 0.1\text{ V} < V_{CM} < (V+) + 0.1\text{ V}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	106	130		dB

Solutions: Input & Output Limitations – 2

7. Which of the following will **NOT** minimize crossover distortion on rail to rail amplifiers?
- Use an internal charge pump to boost the supply on the input stage
 - Use external TVS diodes to minimize the distortion.**
 - Use a zero drift amplifier to minimize the overall offset so that the offset shift is small.
8. Consider the CMRR specification below. Does this device have crossover distortion?
- Yes.**
 - No.

PARAMETER	CONDITION	OPA343NA, UA OPA2343EA, UA OPA4343EA, UA, NA			UNITS
		MIN	TYP ⁽¹⁾	MAX	
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	-0.3		(V+) + 0.3	V
Common-Mode Rejection Ratio	CMRR	$-0.3V < V_{CM} < (V+) - 1.8V$	74	92	dB
		$V_S = 5V, -0.3V < V_{CM} < 5.3V$	60	75	dB
		$V_S = 2.7V, -0.3V < V_{CM} < 3V$	54	70	dB