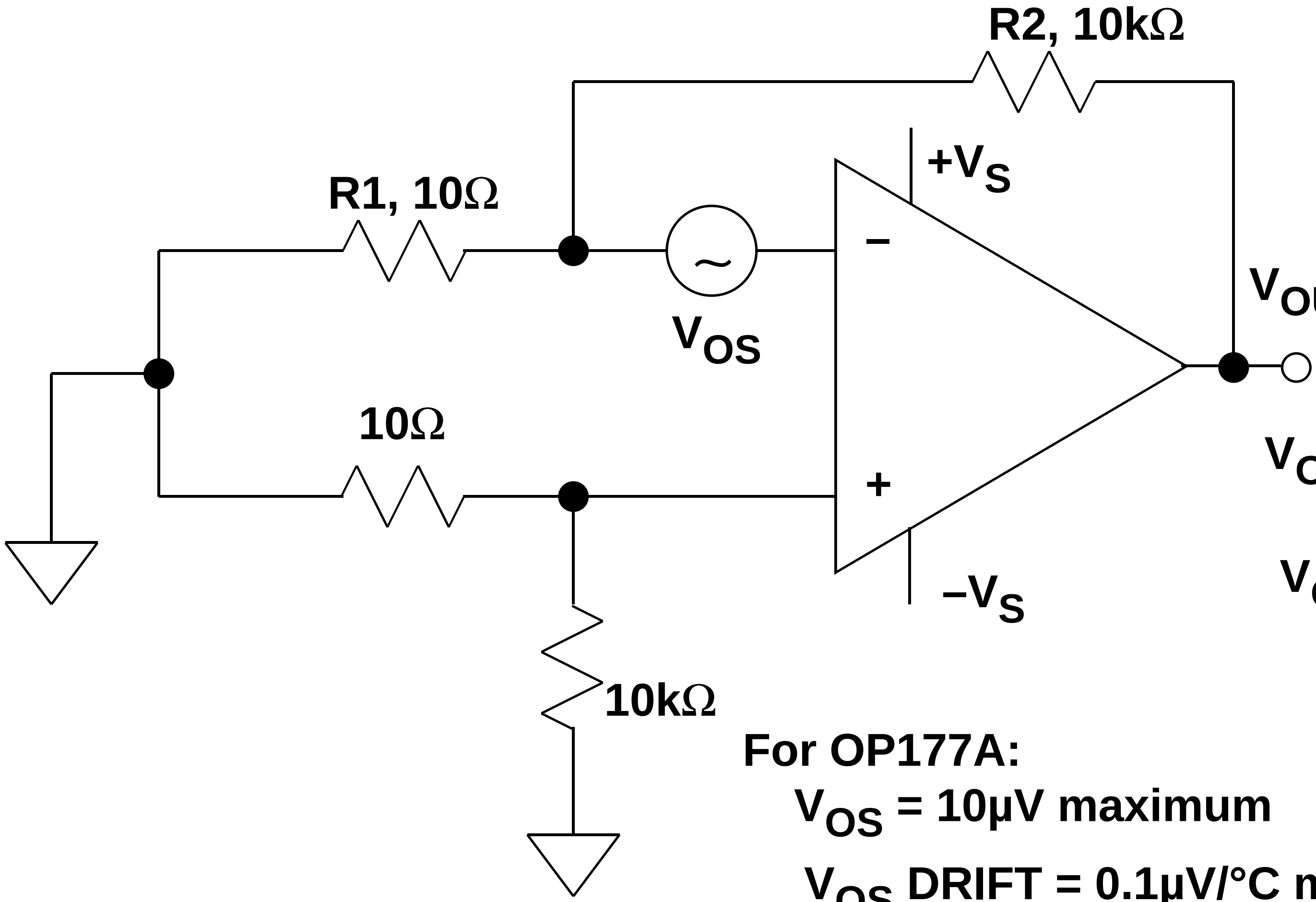
PRACTICAL DESIGN TECHNIQUES FOR SENSOR SIGNAL CONDITIONING

AMPLIFIERS FOR SIGNAL CONDITIONING

- Input Offset Voltage — <100µV
- Input Offset Voltage Drift — <1µV/°C
- Input Bias Current — <2nA
- Input Offset Current — <2nA
- DC Open Loop Gain — >1,000,000
- Unity Gain Bandwidth Product, f_u — 500kHz - 5MHz
- Always Check Open Loop Gain at Signal Frequency!
- 1/f (0.1Hz to 10Hz) Noise — <1µV p-p
- Wideband Noise — <10nV/√Hz
- CMR, PSR — >100dB

  - Single Supply Operation
  - Power Dissipation

MEASURING INPUT OFFSET VOLTAGE



$$V_{OUT} = \left[1 + \frac{R2}{R1}\right] V_{OS}$$

$$V_{OUT} = 1001 \bullet V_{OS}$$

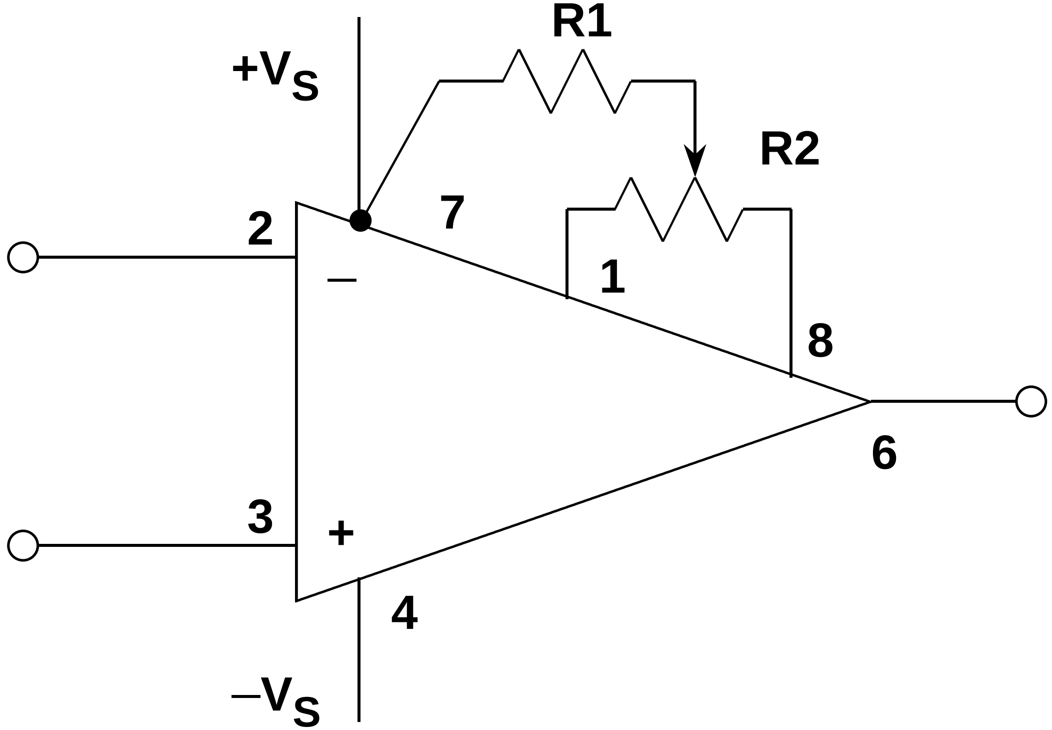
$$V_{OS} = \frac{V_{OUT}}{1001}$$

For OP177A:

- V_{OS} = 10µV maximum
- V_{OS} DRIFT = 0.1µV/°C maximum
- V_{OS} STABILITY = 0.2µV/month typical

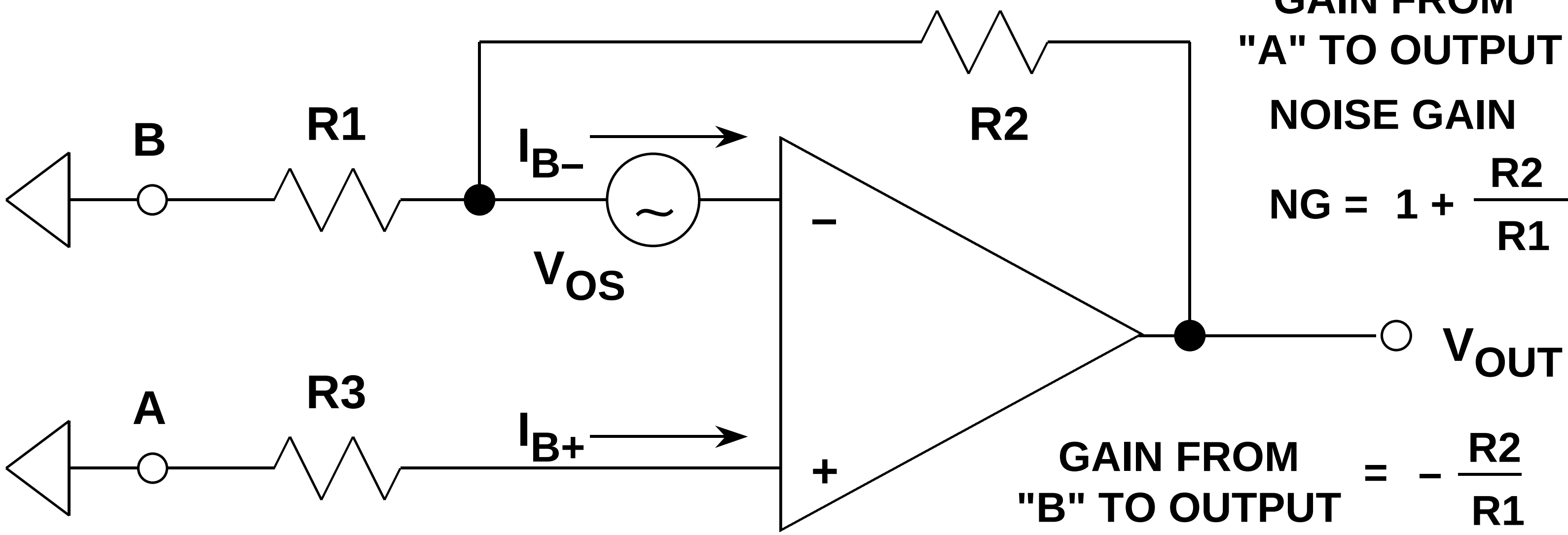
a

OP177/AD707 OFFSET ADJUSTMENT PINS



- R1 = 10kΩ, R2 = 2kΩ , OFFSET ADJUST RANGE = 200µV
- R1 = 0, R1 = 20kΩ , OFFSET ADJUST RANGE = 3mV

OP AMP TOTAL OFFSET VOLTAGE MODEL



GAIN FROM "A" TO OUTPUT = NOISE GAIN = $NG = 1 + \frac{R2}{R1}$

GAIN FROM "B" TO OUTPUT $= -\frac{R2}{R1}$

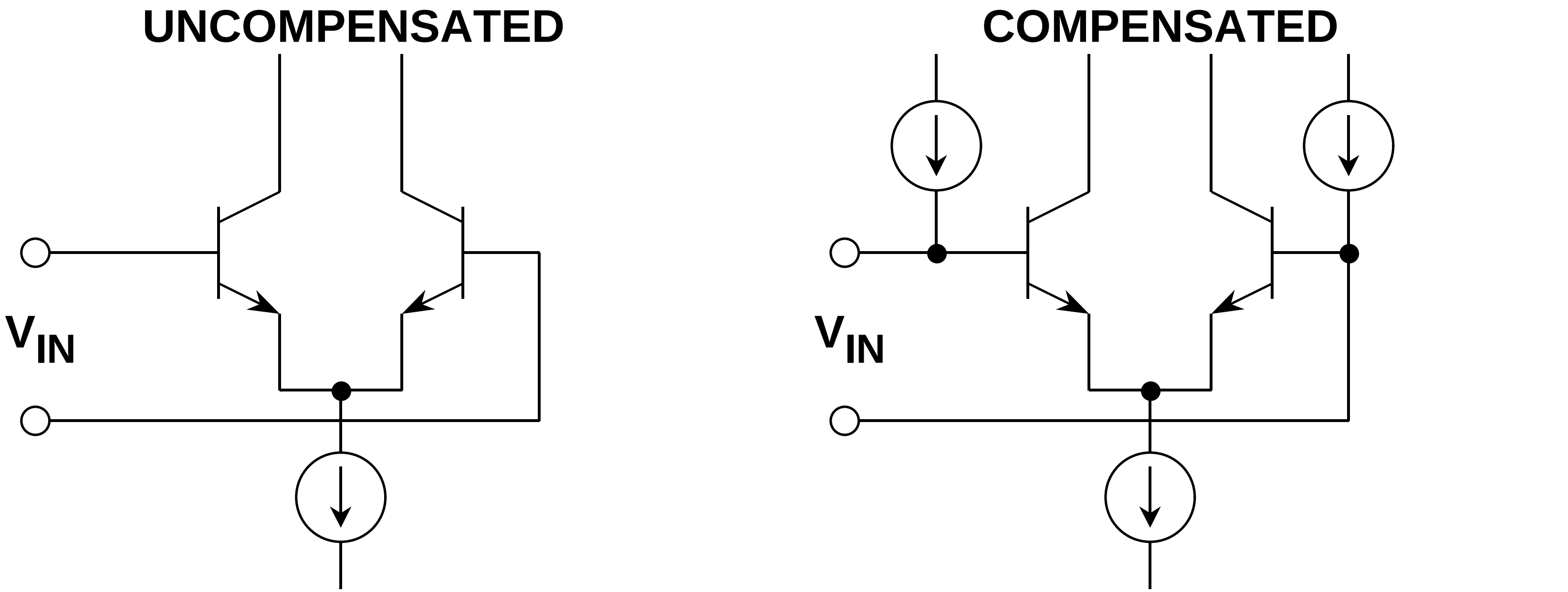
- $\text{OFFSET (RTO)} = V_{OS}\left[1 + \frac{R2}{R1}\right] + I_{B+} \cdot R3 \left[1 + \frac{R2}{R1}\right] - I_{B-} \cdot R2$

- $\text{OFFSET (RTI)} = V_{OS} + I_{B+} \cdot R3 - I_{B-}\left[\frac{R1 \cdot R2}{R1 + R2}\right]$

FOR BIAS CURRENT CANCELLATION:

$\text{OFFSET (RTI)} = V_{OS} \quad \text{IF } I_{B+} = I_{B-} \text{ AND } R3 = \frac{R1 \cdot R2}{R1 + R2}$

INPUT BIAS CURRENT COMPENSATED OP AMPS



- MATCHED BIAS CURRENTS
- SAME SIGN
- 50nA - 10µA
- 50pA - 5nA (Super Beta)
- $I_{OFFSET} << I_{BIAS}$

- LOW, UNMATCHED BIAS CURRENTS
- CAN HAVE DIFFERENT SIGNS
- 0.5nA - 10nA
- HIGHER CURRENT NOISE
- $I_{OFFSET} \approx I_{BIAS}$

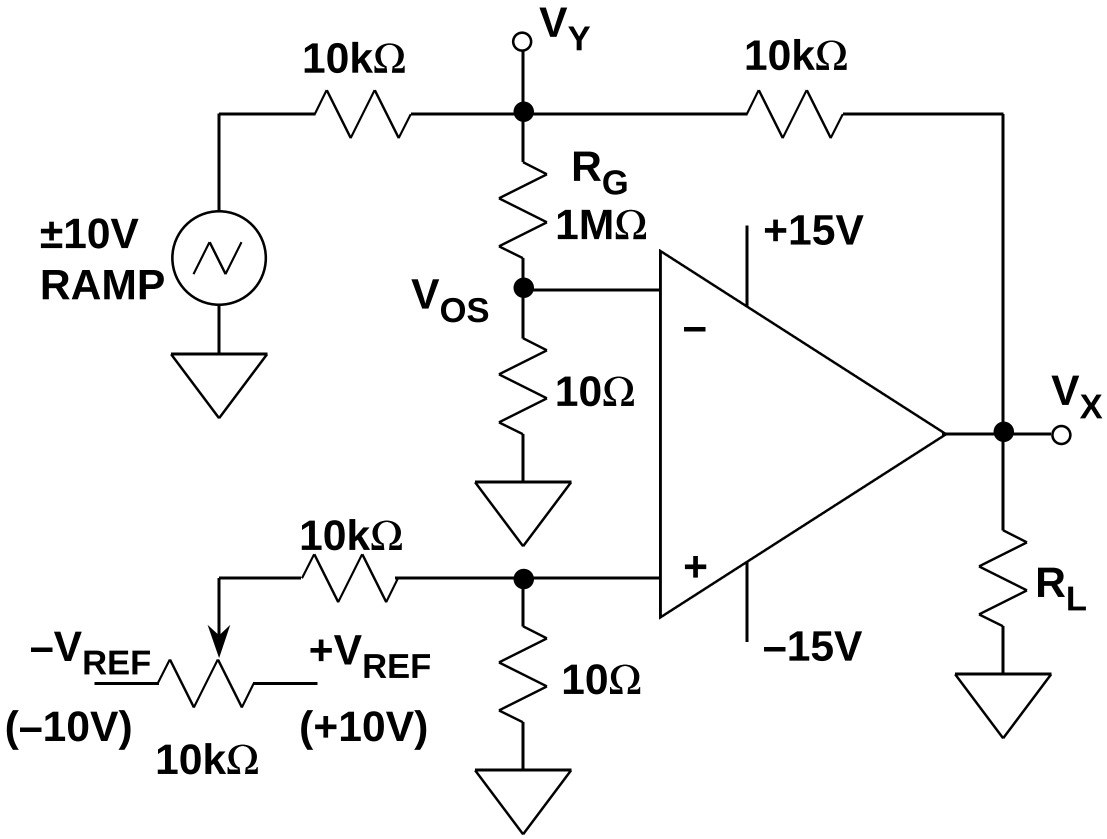
CHANGES IN DC OPEN LOOP GAIN CAUSE CLOSED LOOP GAIN UNCERTAINTY

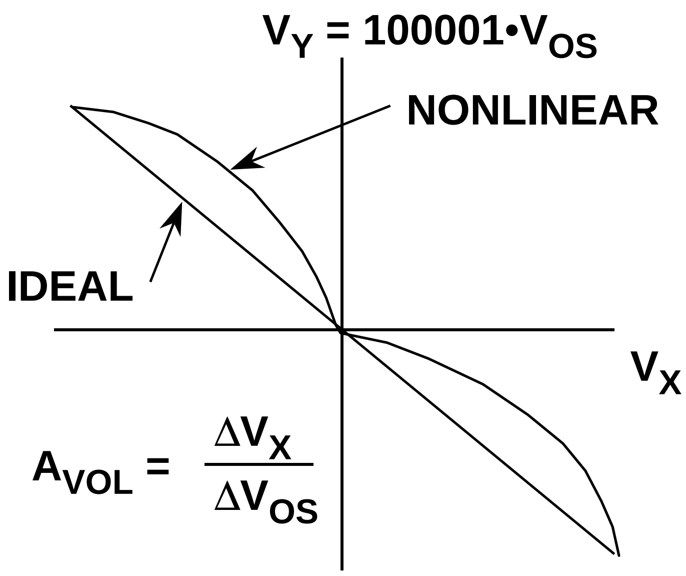
- "IDEAL" CLOSED LOOP GAIN = NOISE GAIN = NG
- ACTUAL CLOSED LOOP GAIN = $\dfrac{NG}{1+\dfrac{NG}{A_{VOL}}}$
- % CLOSED LOOP GAIN ERROR = $\dfrac{NG}{1+A_{VOL}} \times 100\%$

- Assume A_{VOL} = 2,000,000, NG = 1,000
  %GAIN ERROR ≈ 0.05%
- Assume A_{VOL} Drops to 300,000
  %GAIN ERROR ≈ 0.33%
- CLOSED LOOP GAIN UNCERTAINTY
  = 0.33% – 0.05% = 0.28%

a

CIRCUIT MEASURES OPEN LOOP GAIN NONLINEARITY





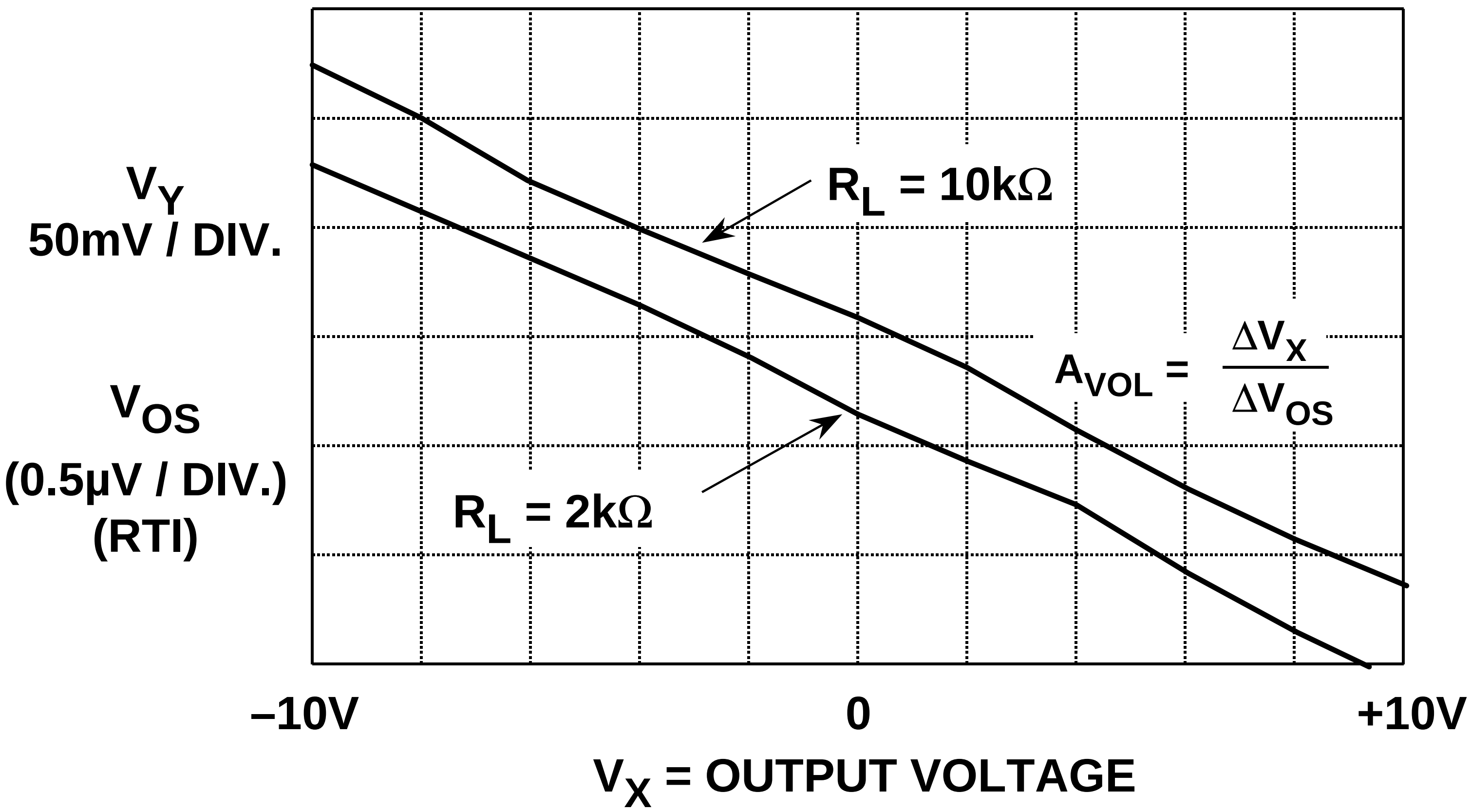
OFFSET ADJUST
(Multi-Turn Film-Type)

CLOSED LOOP GAIN NONLINEARITY

$$\approx NG \bullet \left[\text{OPEN LOOP GAIN NONLINEARITY}\right]$$

$$\approx NG \bullet \left[\frac{1}{A_{VOL,MIN}} - \frac{1}{A_{VOL,MAX}}\right]$$

OP177 GAIN NONLINEARITY



A_{VOL} (AVERAGE) ≈ 8 million

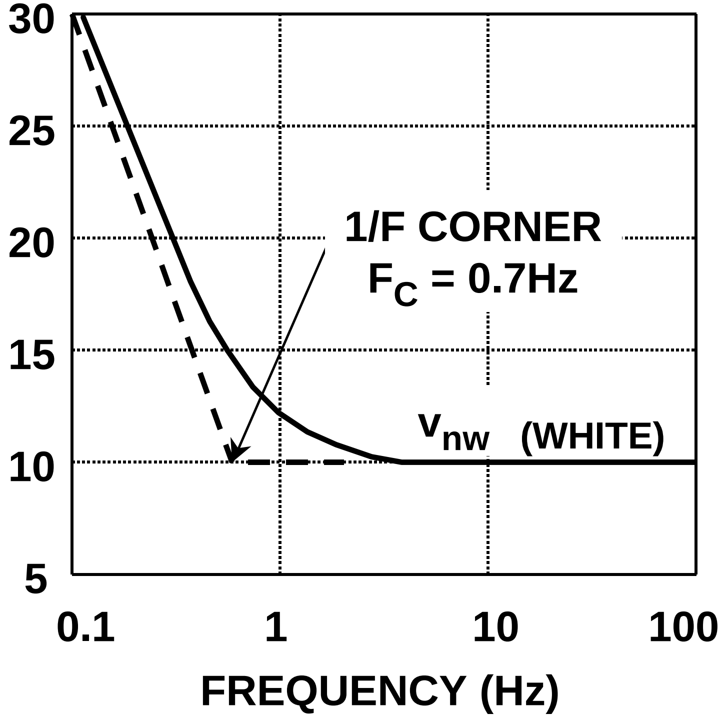
$A_{VOL,MAX}$ ≈ 9.1 million, $A_{VOL,MIN}$ ≈ 5.7million

OPEN LOOP GAIN NONLINEARITY ≈ 0.07ppm

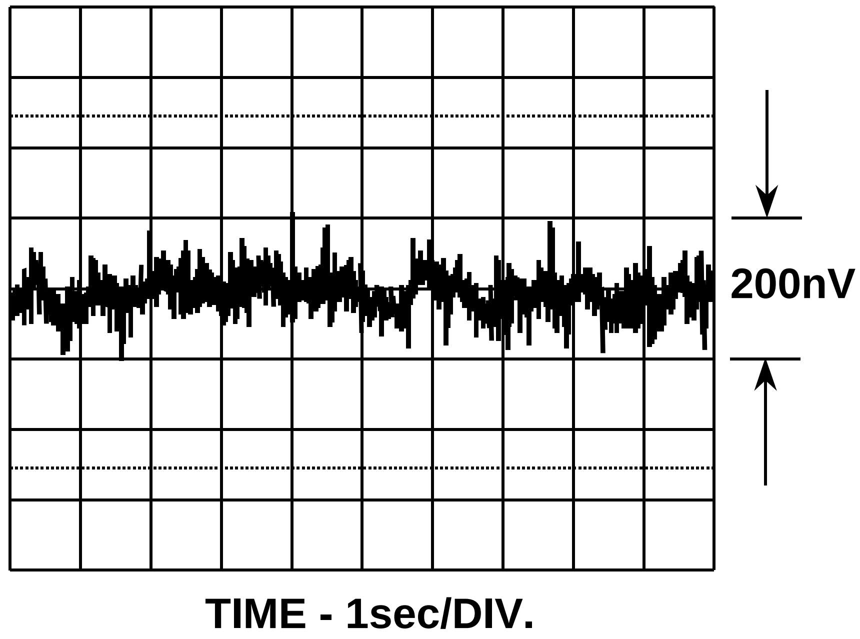
CLOSED LOOP GAIN NONLINEARITY ≈ NG×0.07ppm

INPUT VOLTAGE NOISE FOR OP177/AD707

INPUT VOLTAGE NOISE, nV / √Hz

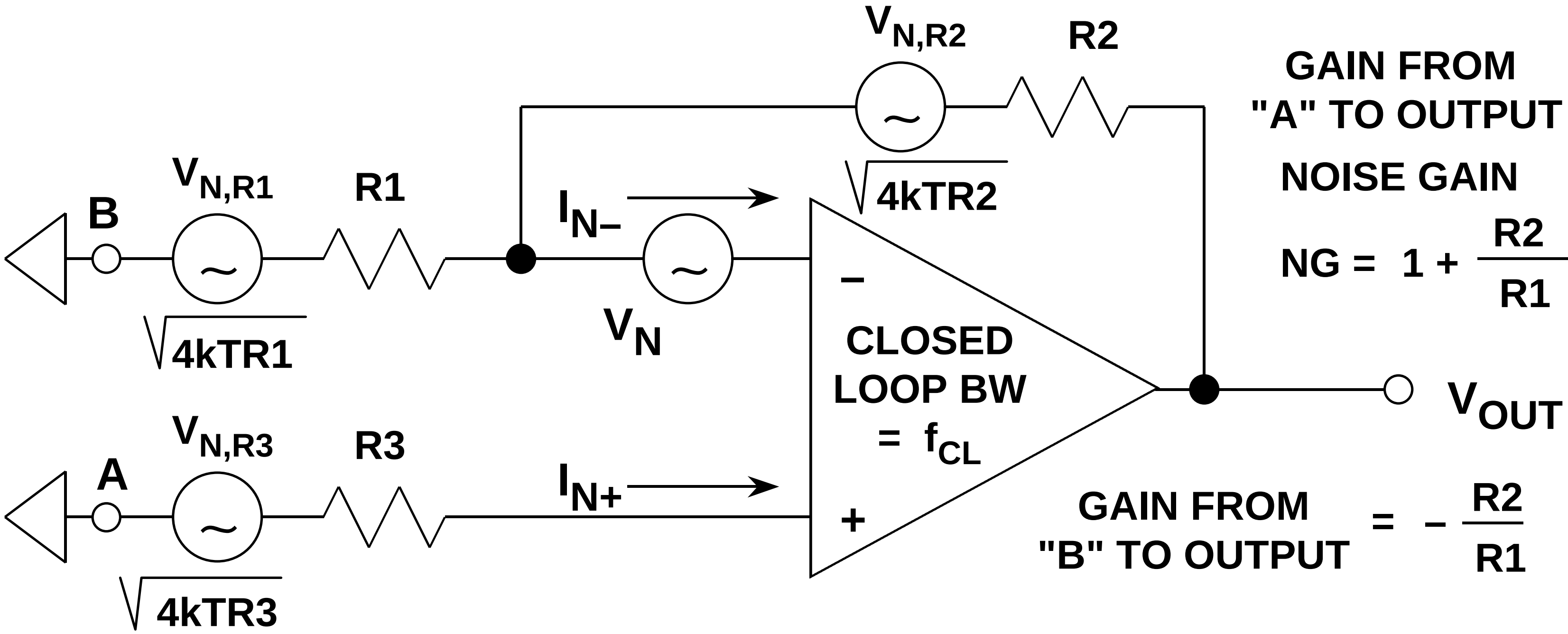


0.1Hz to 10Hz VOLTAGE NOISE



- $V_{n,rms}(F_H, F_L) = v_{nw}\sqrt{F_C \ln\left[\frac{F_H}{F_L}\right] + (F_H - F_L)}$
- For F_L = 0.1Hz, F_H = 10Hz, v_{nw} = 10nV/ √Hz, F_C = 0.7Hz:
  - $V_{n,rms}$ = 36nV
  - $V_{n,pp}$ = 6.6 × 36nV = 238nV

OP AMP NOISE MODEL



GAIN FROM "A" TO OUTPUT = NOISE GAIN =

$$NG = 1 + \frac{R2}{R1}$$

GAIN FROM "B" TO OUTPUT $= -\frac{R2}{R1}$

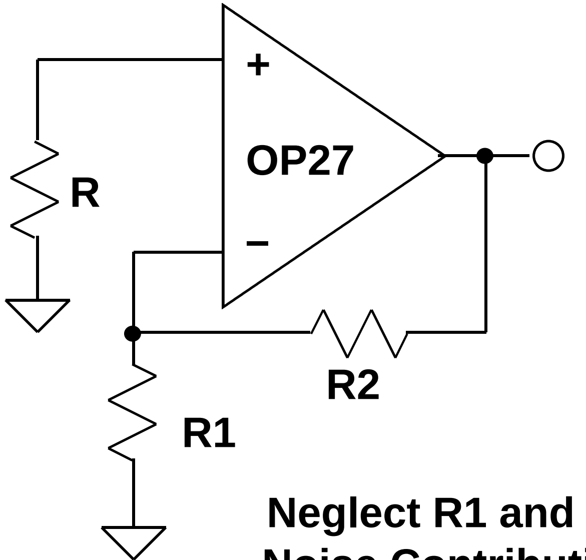
- RTI NOISE = $\sqrt{BW} \bullet \sqrt{V_N^{\,2} + 4kTR3 + 4kTR1\left[\frac{R2}{R1+R2}\right]^2 + I_{N+}^{\,2}R3^2 + I_{N-}^{\,2}\left[\frac{R1 \bullet R2}{R1+R2}\right]^2 + 4kTR2\left[\frac{R1}{R1+R2}\right]^2}$

- RTO NOISE = NG • RTI NOISE
- BW = 1.57 f_{CL}

a

DIFFERENT NOISE SOURCES DOMINATE AT DIFFERENT SOURCE IMPEDANCES

EXAMPLE: OP27
Voltage Noise = 3nV / √ Hz
Current Noise = 1pA / √ Hz
T = 25°C



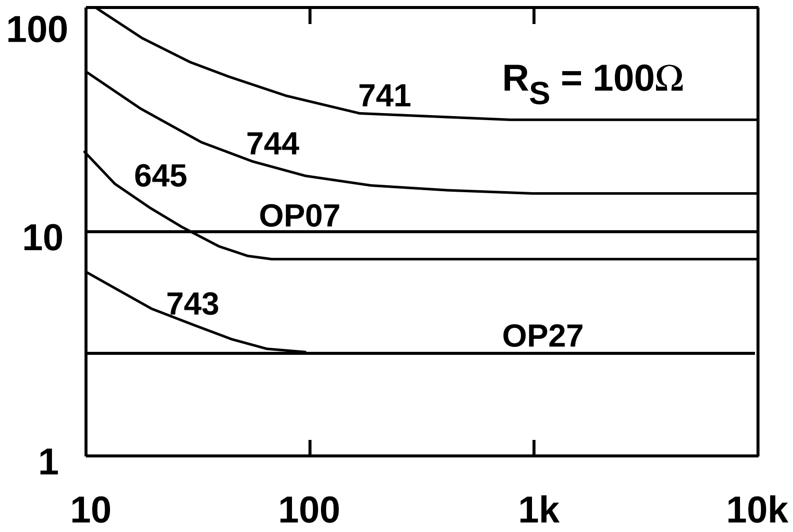
Neglect R1 and R2 Noise Contribution

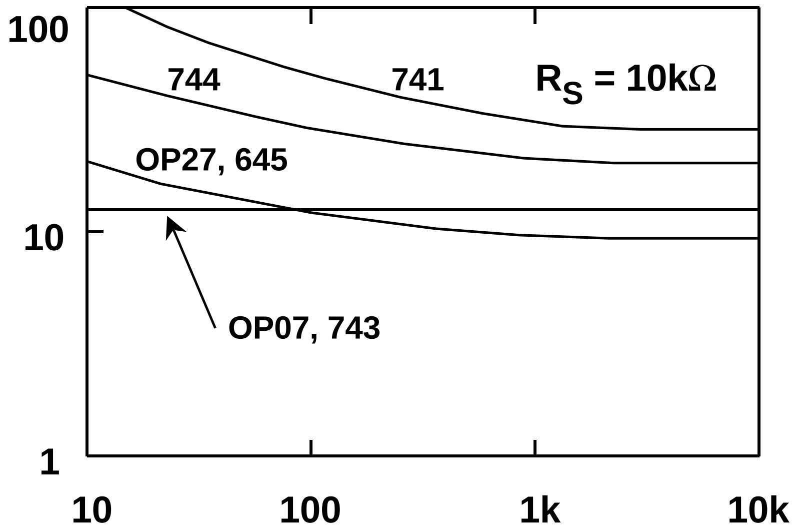
CONTRIBUTION FROM	VALUES OF R		
	0	3kΩ	300kΩ
AMPLIFIER VOLTAGE NOISE	**3**	3	3
AMPLIFIER CURRENT NOISE FLOWING IN R	0	3	**300**
JOHNSON NOISE OF R	0	**7**	70

RTI NOISE (nV / √ Hz)

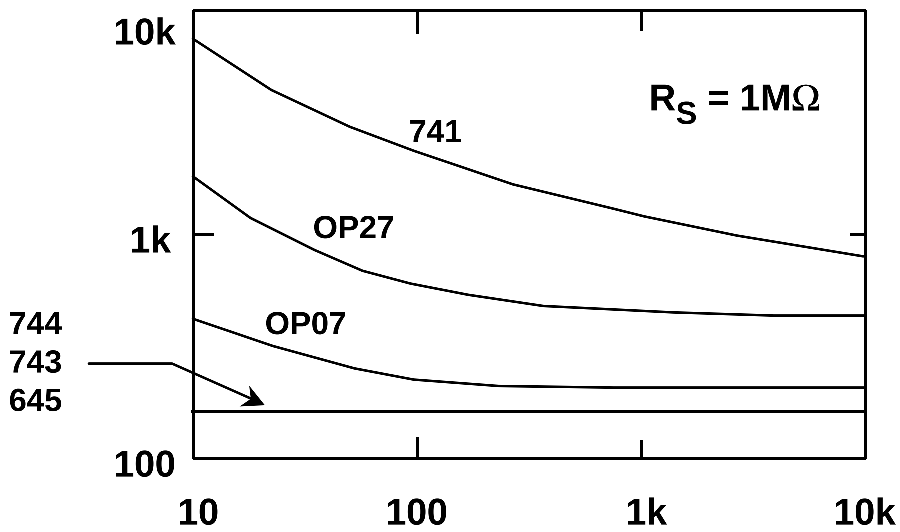
Dominant Noise Source is Highlighted

DIFFERENT AMPLIFIERS ARE BEST AT DIFFERENT SOURCE IMEPDANCE LEVELS





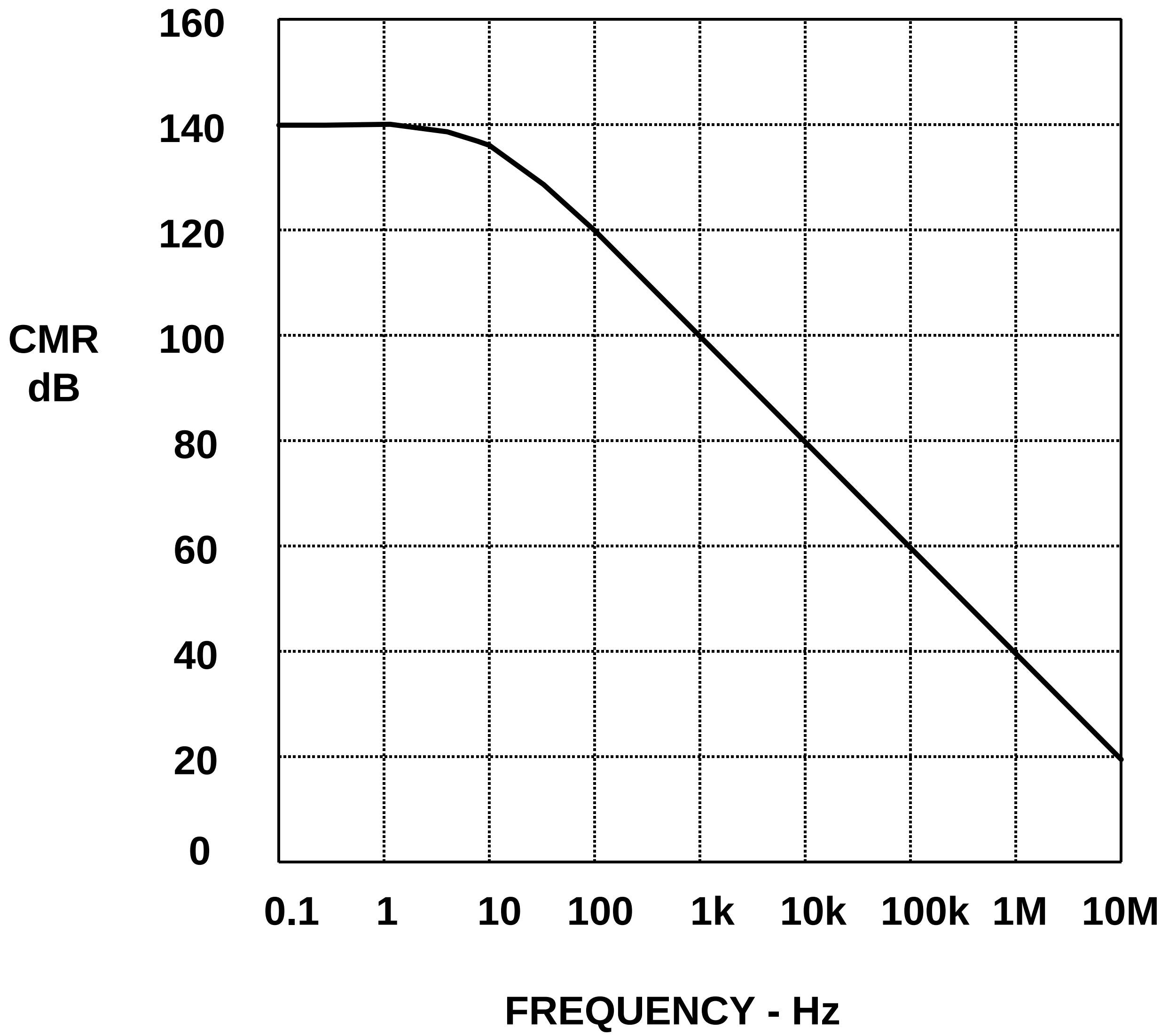
All Vertical Scales
nV /√ Hz



All Horizontal Scales
Hz

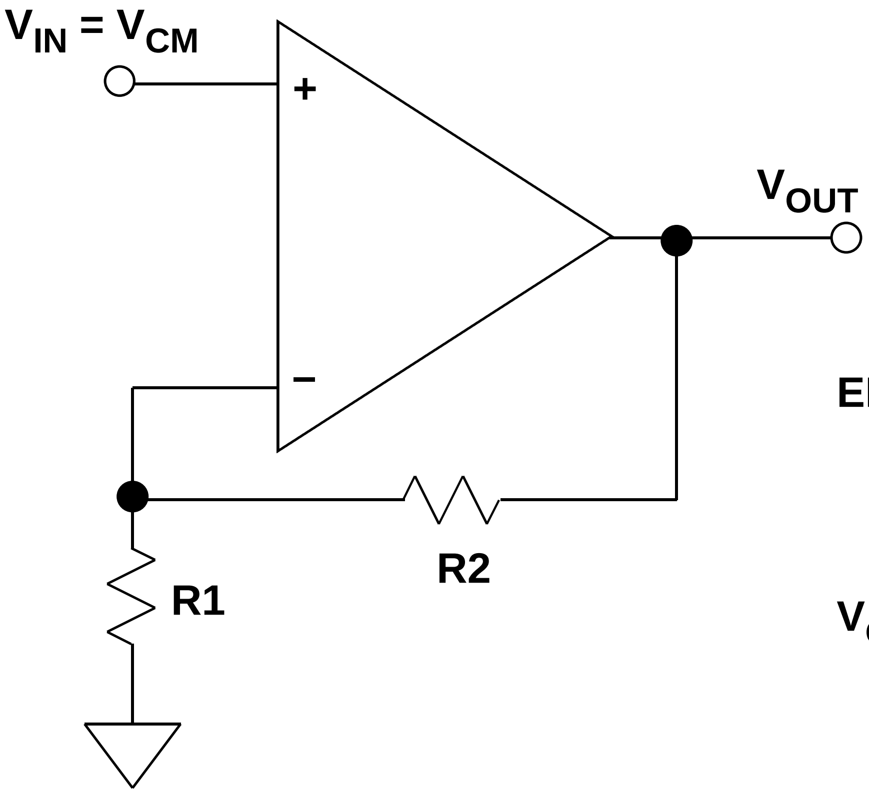
a

OP177/AD707 COMMON MODE REJECTION (CMR)



CMR =
20 $\log_{10}$ CMRR

CALCULATING OFFSET ERROR
DUE TO COMMON MODE REJECTION RATIO (CMRR)



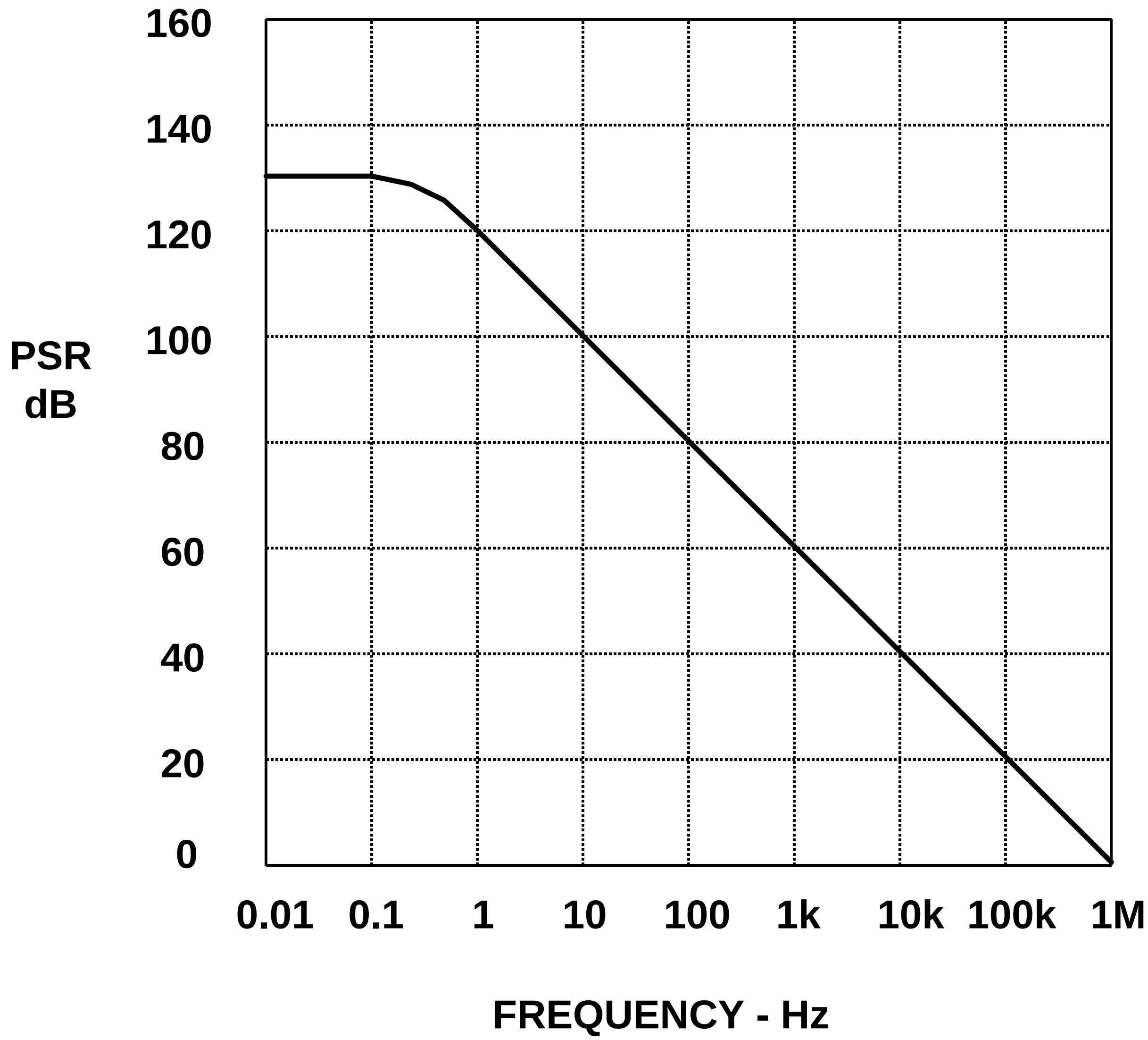
$$\text{ERROR (RTI)} = \frac{V_{CM}}{\text{CMRR}} = \frac{V_{IN}}{\text{CMRR}}$$

$$V_{OUT} = \left[1 + \frac{R2}{R1}\right]\left[V_{IN} + \frac{V_{IN}}{\text{CMRR}}\right]$$

$$\text{ERROR (RTO)} = \left[1 + \frac{R2}{R1}\right]\left[\frac{V_{IN}}{\text{CMRR}}\right]$$

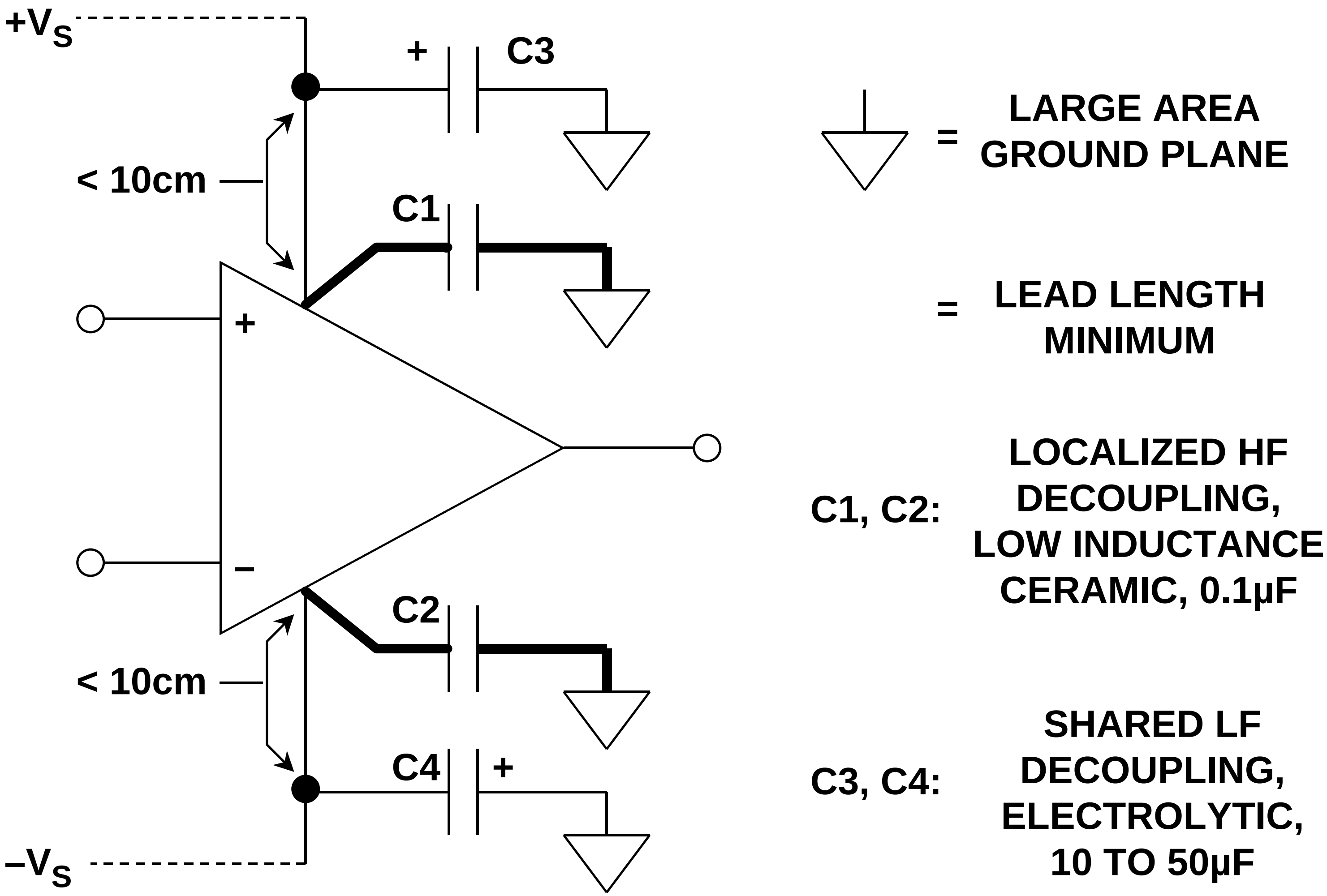
a

OP177/AD707 POWER SUPPLY REJECTION (PSR)

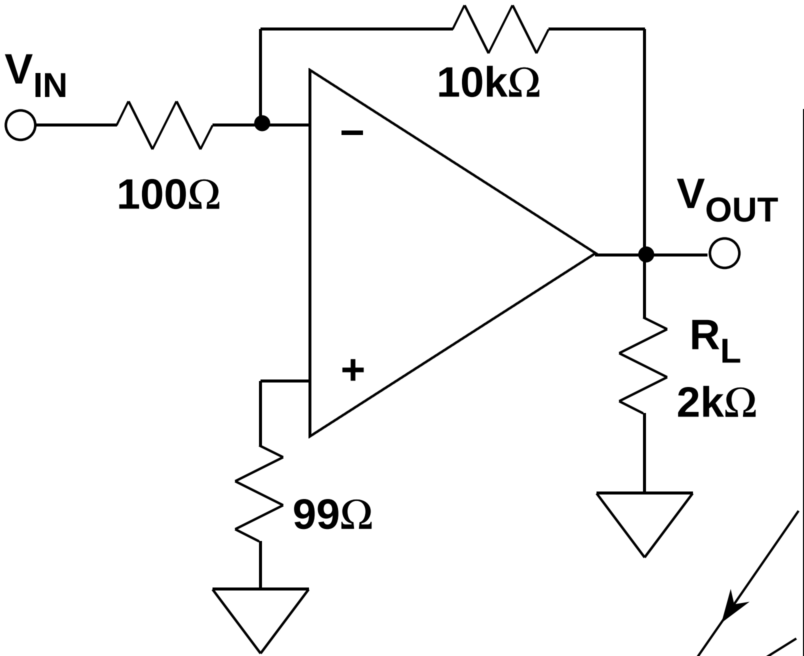


PSR =
20 $\log_{10}$ PSRR

PROPER LOW AND HIGH-FREQUENCY DECOUPLING TECHNIQUES FOR OP AMPS



PRECISION OP AMP (OP177A) DC ERROR BUDGET



MAXIMUM ERROR CONTRIBUTION, + 25°C

FULLSCALE: V_{IN}=100mV, V_{OUT} = 10V

V_{OS}	10µV ÷ 100mV	100ppm
I_{OS}	100Ω × 1nA ÷ 100mV	1ppm
A_{VOL}	$(100/\ 5\times10^6) \times 100mV$	20ppm
A_{VOL} Nonlinearity	100 × 0.07ppm	7ppm
0.1Hz to 10Hz 1/f Noise	200nV ÷ 100mV	2ppm
Total Unadjusted Error	≈ 13 Bits Accurate	130ppm
Resolution Error	≈ 17 Bits Accurate	9ppm

SPECS @ +25°C:

V_{OS} = 10µV max

I_{OS} = 1nA max

A_{VOL} = 5×10^6 min

A_{VOL} Nonlinearity = 0.07ppm

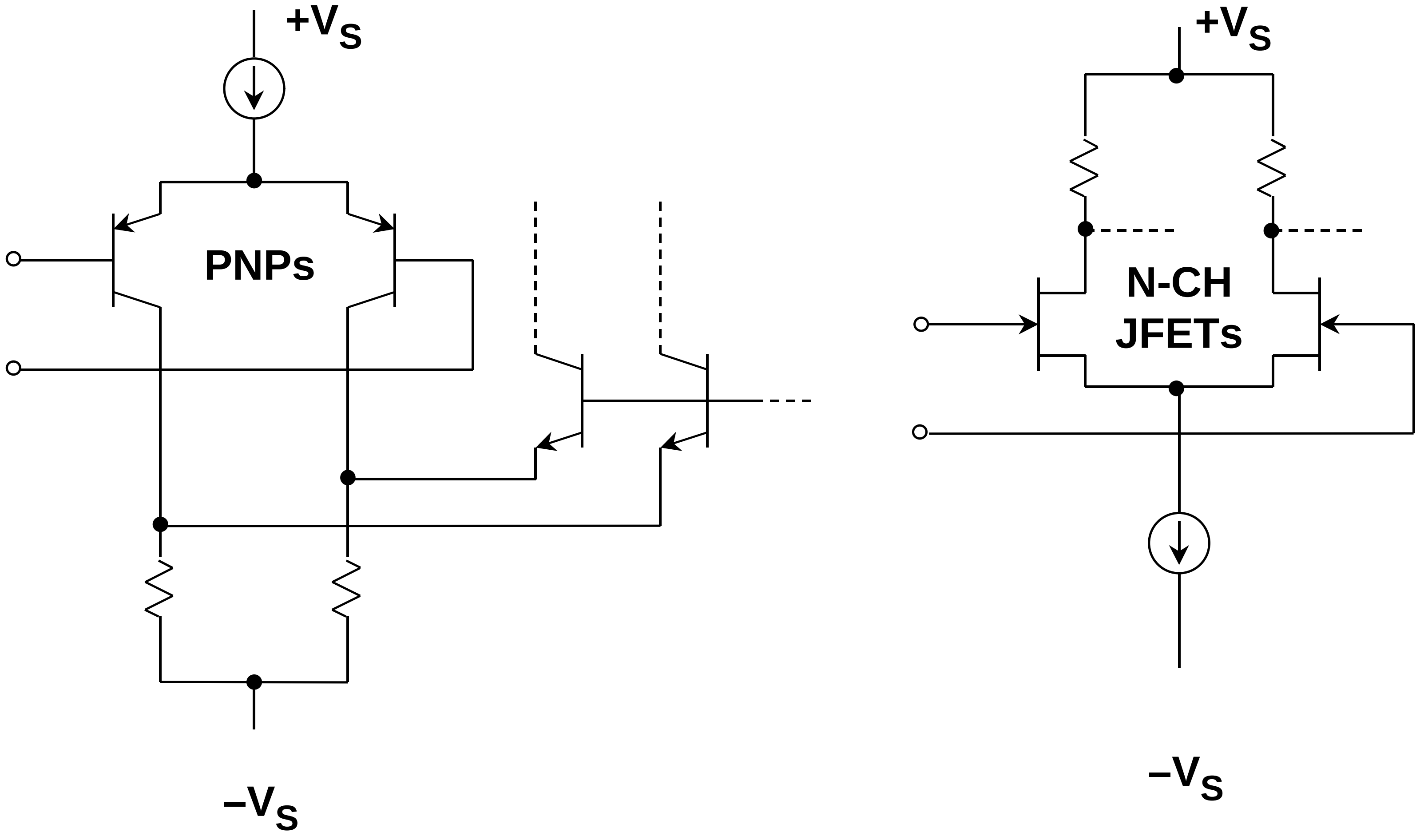
0.1Hz to 10Hz Noise = 200nV

SINGLE SUPPLY AMPLIFIERS

- **Single Supply Offers:**
  - Lower Power
  - Battery Operated Portable Equipment
  - Requires Only One Voltage

- **Design Tradeoffs:**
  - Reduced Signal Swing Increases Sensitivity to Errors Caused by Offset Voltage, Bias Current, Finite Open-Loop Gain, Noise, etc.
  - Must Usually Share Noisy Digital Supply
  - Rail-to-Rail Input and Output Needed to Increase Signal Swing
  - Precision Less than the best Dual Supply Op Amps but not Required for All Applications
  - Many Op Amps Specified for Single Supply, but do not have Rail-to-Rail Inputs or Outputs

PNP OR N-CHANNEL JFET STAGES
ALLOW INPUT SIGNAL TO GO TO THE NEGATIVE RAIL



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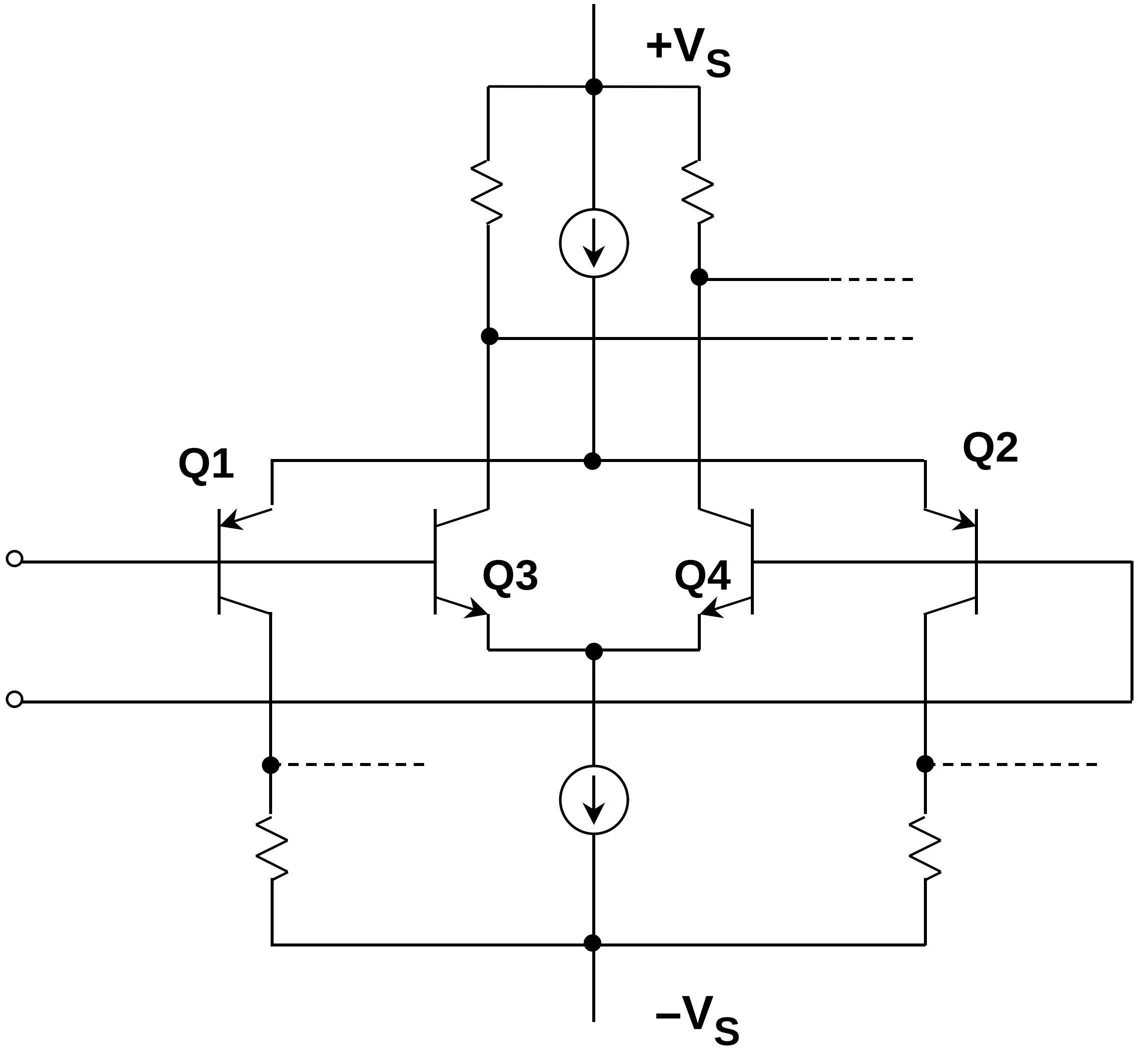
TRUE RAIL-TO-RAIL INPUT STAGE



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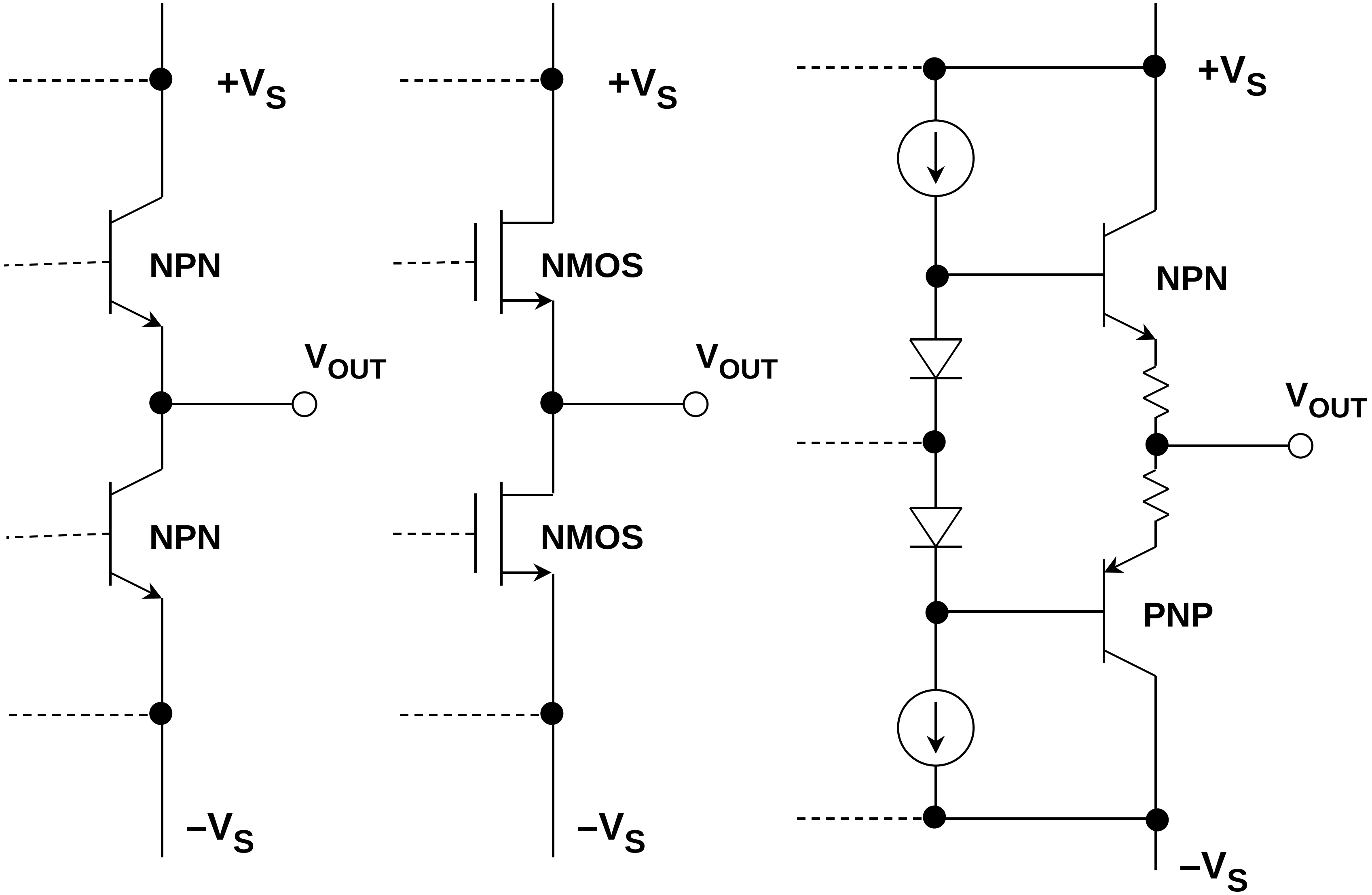
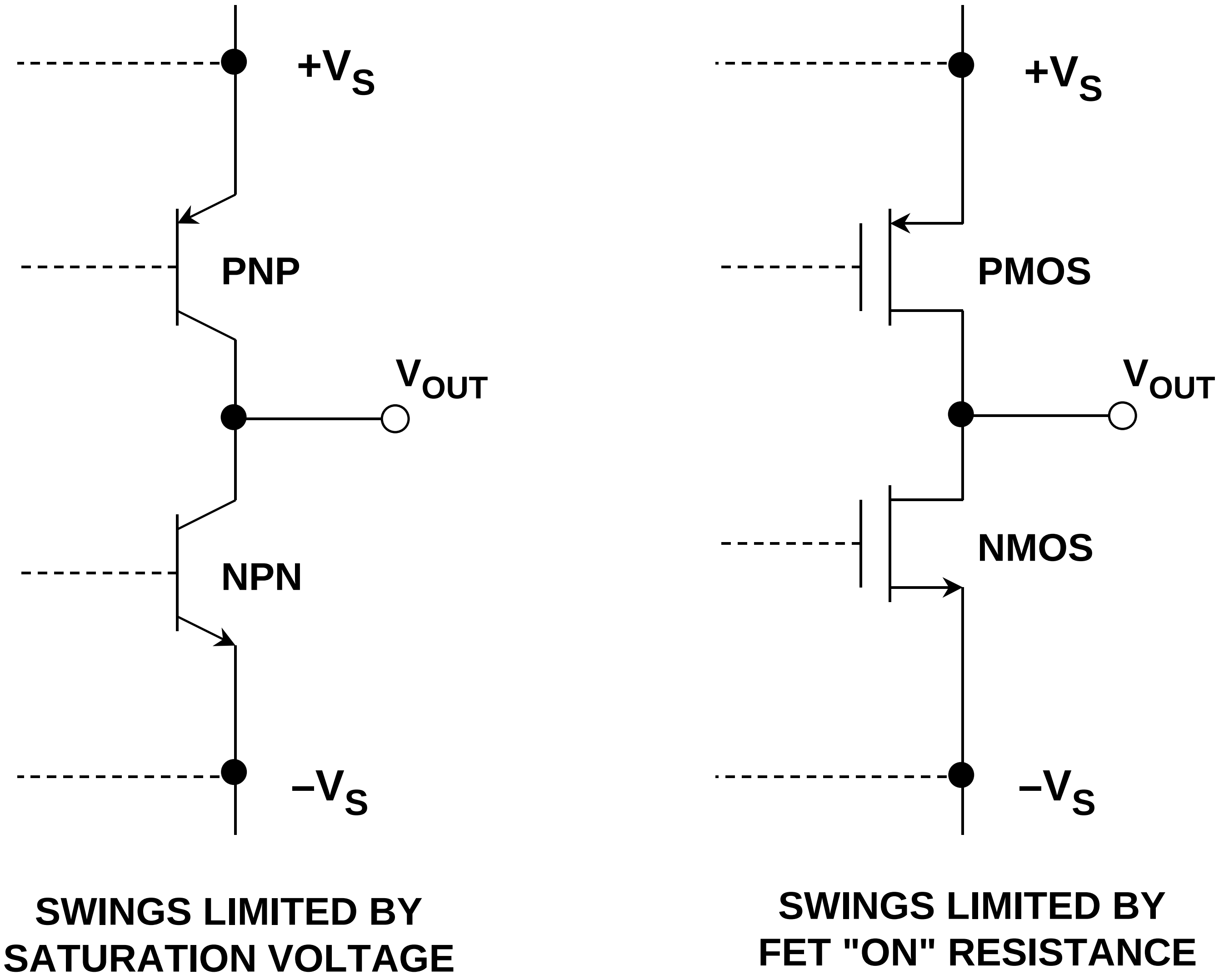
TRADITIONAL OUTPUT STAGES



a

3.21

"ALMOST" RAIL-TO-RAIL OUTPUT STRUCTURES



PRECISION SINGLE-SUPPLY OP AMP PERFORMANCE CHARACTERISTICS

****LISTED IN ORDER OF INCREASING SUPPLY CURRENT**

**PART NO.	V_{OS} max	V_{OS} TC	A_{VOL}min	NOISE (1kHz)	INPUT	OUTPUT	I_{SY}/AMP
OP181/281/481	1500µV	10µV/°C	5M	70nV/√Hz	0, 4V	"R/R"	4µA
OP193/293/493	75µV	0.2µV/°C	200k	65nV/√Hz	0, 4V	5mV, 4V	15µA
OP196/296/496	300µV	1.5µV/°C	150k	26nV/√Hz	R/R	"R/R"	50µA
OP191/291/491	700µV	1.1µV/°C	25k	35nV/√Hz	R/R	"R/R"	400µA
*AD820/822/824	400µV	2µV/°C	500k	16nV/√Hz	0, 4V	"R/R"	800µA
OP184/284/484	65µV	0.2µV/°C	50k	3.9nV/√Hz	R/R	"R/R"	1250µA
OP113/213/413	125µV	0.2µV/°C	2M	4.7nV/√Hz	0, 4V	5mV, 4V	1750µA

*JFET INPUT

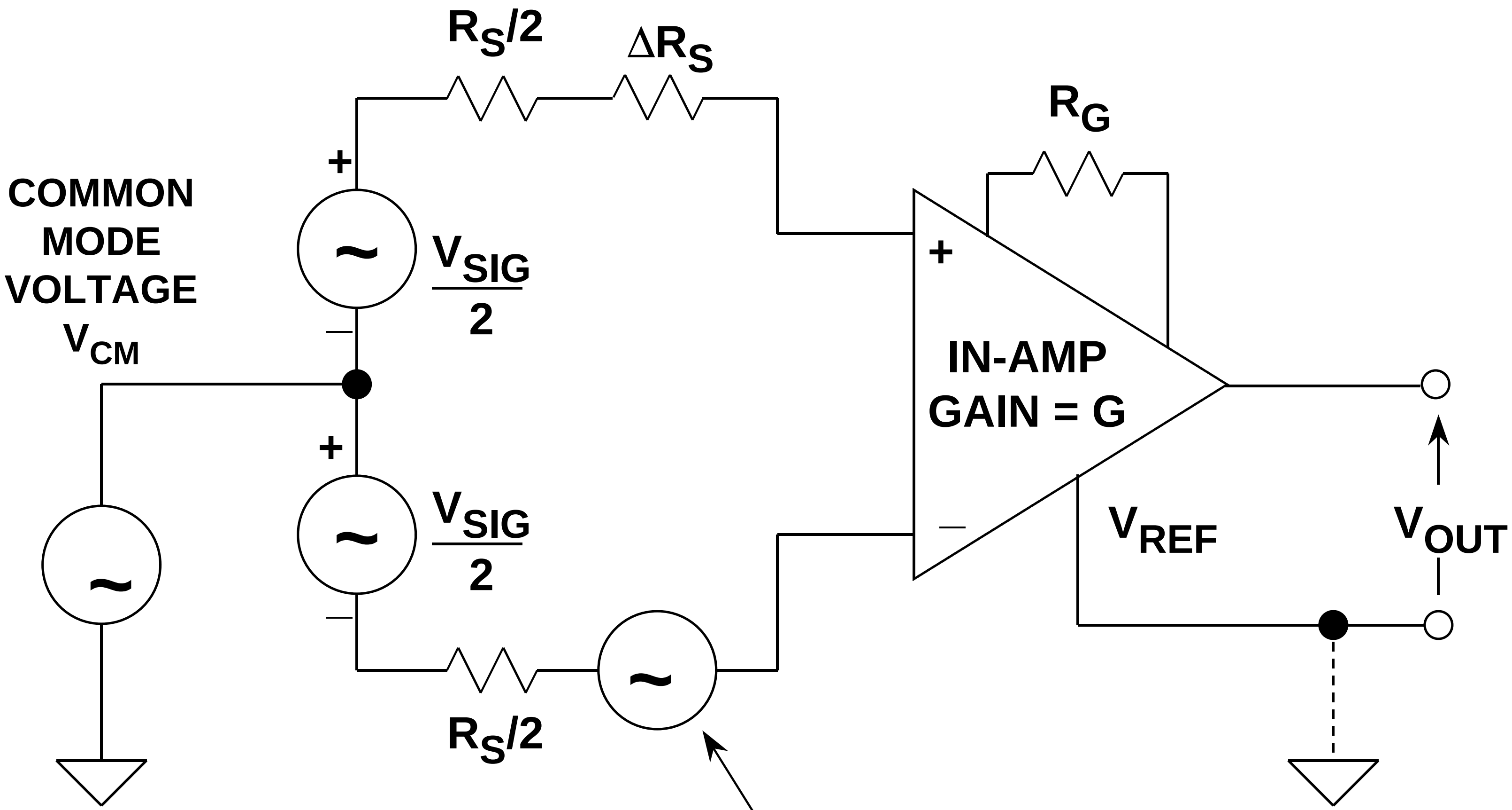
NOTE: Unless Otherwise Stated Specifications are Typical @ +25°C V_S = +5V

OP AMP PROCESS TECHNOLOGY SUMMARY

- **BIPOLAR (NPN-BASED): This is Where it All Started!!**
- **COMPLEMENTARY BIPOLAR (CB): Rail-to-Rail, Precision, High Speed**
- **BIPOLAR + JFET (BiFET): High Input Impedance, High Speed**
- **COMPLEMENTARY BIPOLAR + JFET (CBFET): High Input Impedance, Rail-to-Rail Output, High Speed**

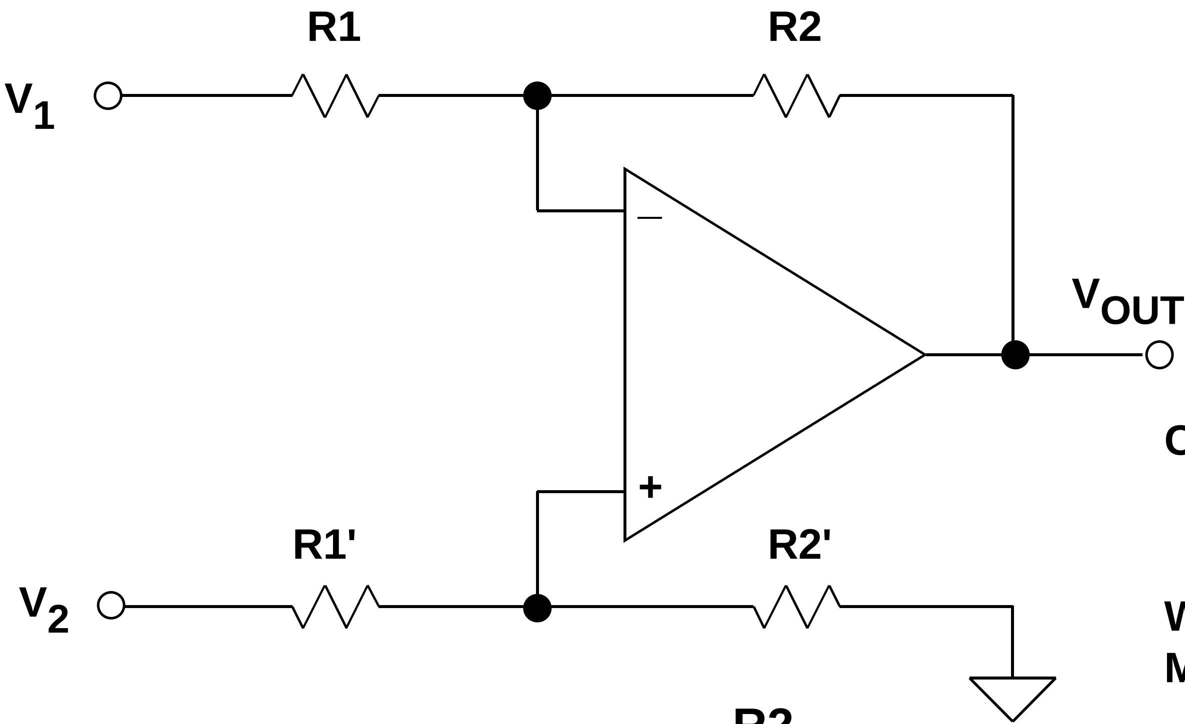
- **COMPLEMENTARY MOSFET (CMOS): Low Cost, Non-Critical Op Amps**
- **BIPOLAR + CMOS (BiCMOS): Bipolar Input Stage adds Linearity, Low Power, Rail-to-Rail Output**
- **COMPLEMENTARY BIPOLAR + CMOS (CBCMOS): Rail-to-Rail Inputs, Rail-to-Rail Outputs, Good Linearity, Low Power**

INSTRUMENTATION AMPLIFIER



COMMON MODE ERROR (RTI) = $\frac{V_{CM}}{CMRR}$

OP AMP SUBTRACTOR

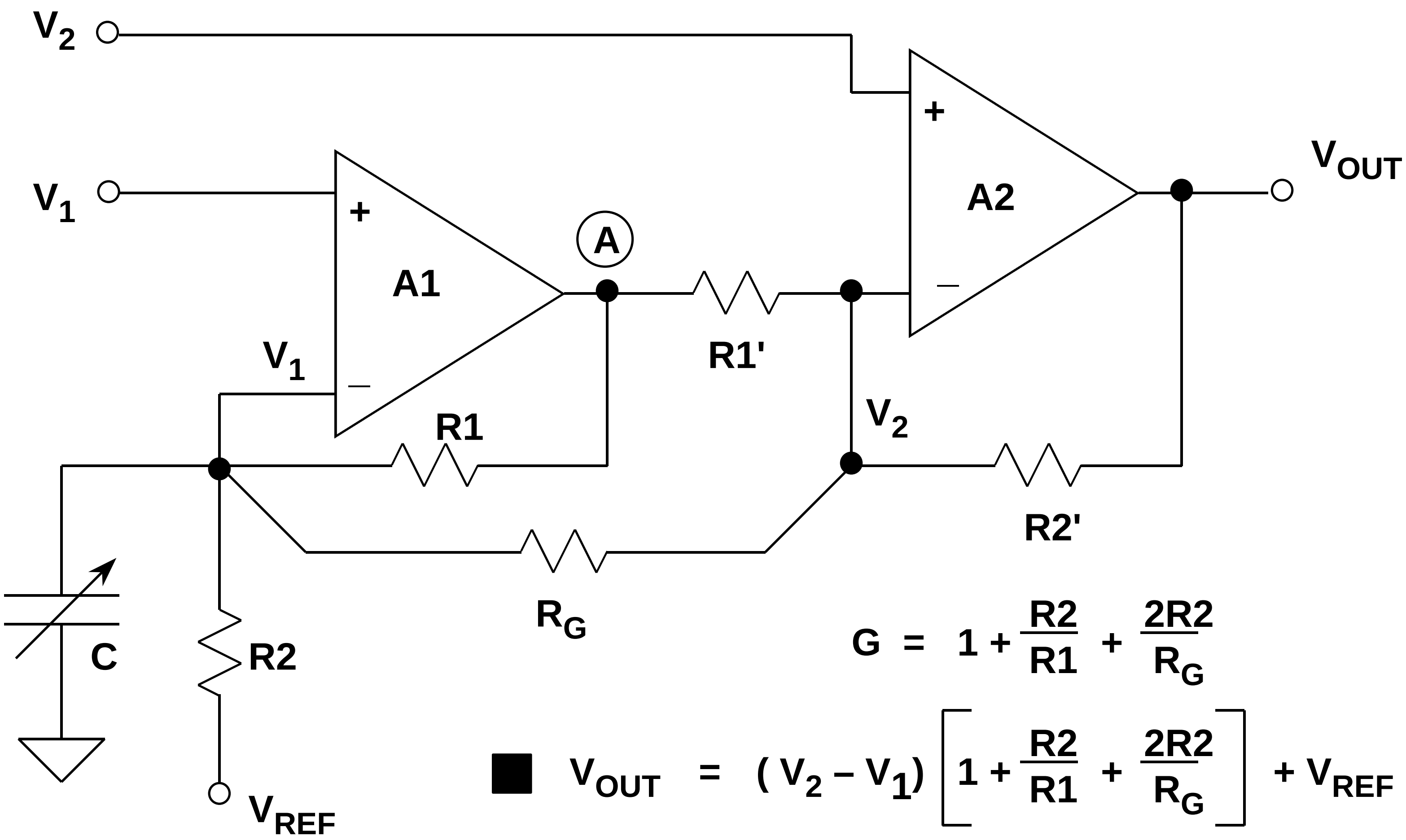


$$CMR = 20 \log_{10} \left[\frac{1 + \frac{R2}{R1}}{Kr} \right]$$

Where Kr = Total Fractional Mismatch of R1 - R2

- $V_{OUT} = (V_2 - V_1) \frac{R2}{R1}$
- $\frac{R2}{R1} = \frac{R2'}{R1'}$ CRITICAL FOR HIGH CMR
- EXTREMELY SENSITIVE TO SOURCE IMPEDANCE IMBALANCE
- 0.1% TOTAL MISMATCH YIELDS $\approx$ 66dB CMR FOR R1 = R2

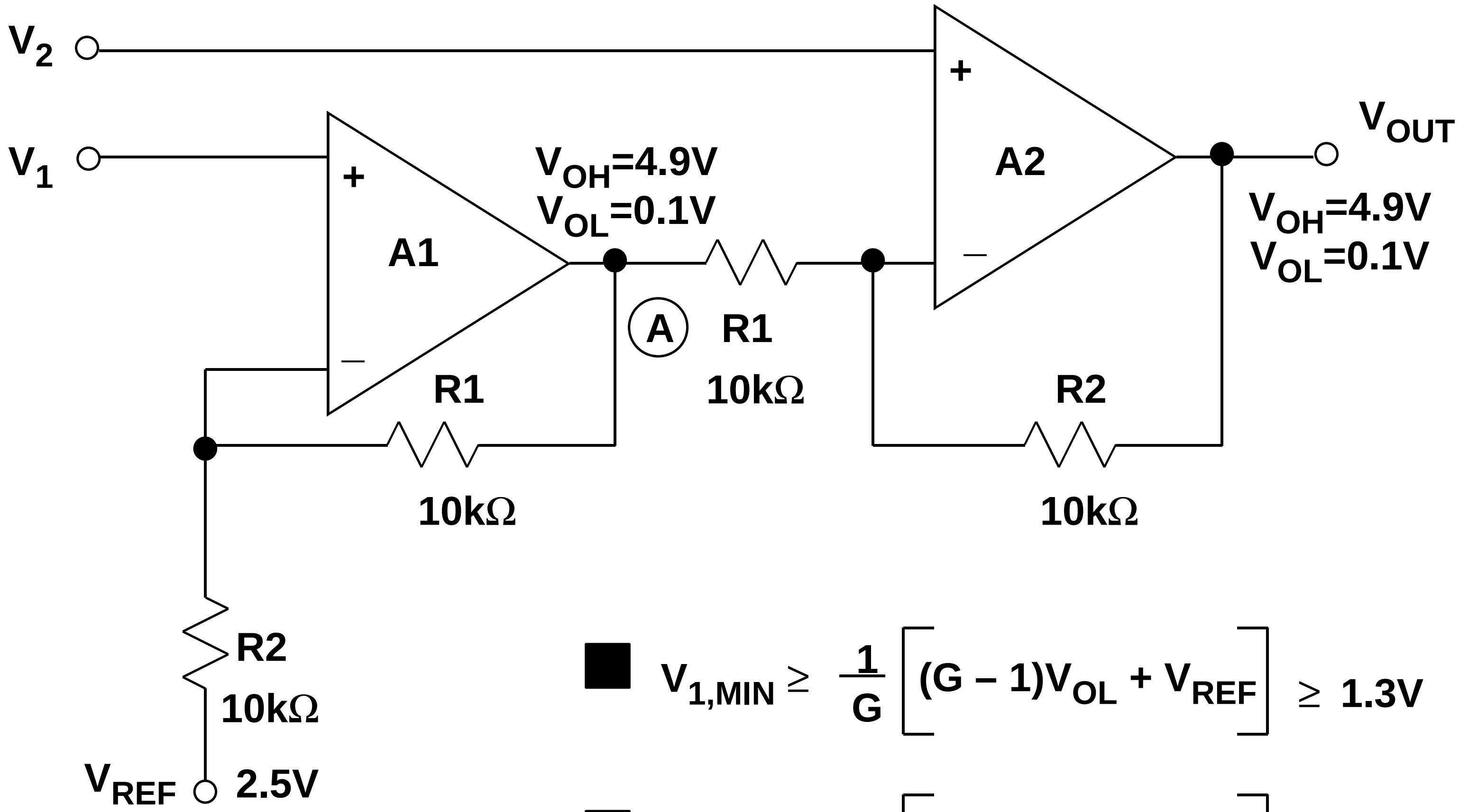
TWO OP AMP INSTRUMENTATION AMPLIFIER



$$G = 1 + \frac{R2}{R1} + \frac{2R2}{R_G}$$

- $V_{OUT} = (V_2 - V_1)\left[1 + \frac{R2}{R1} + \frac{2R2}{R_G}\right] + V_{REF}$
- $\frac{R2}{R1} = \frac{R2'}{R1'}$
- $CMR \le 20\log\left[\frac{GAIN \times 100}{\%\ MISMATCH}\right]$

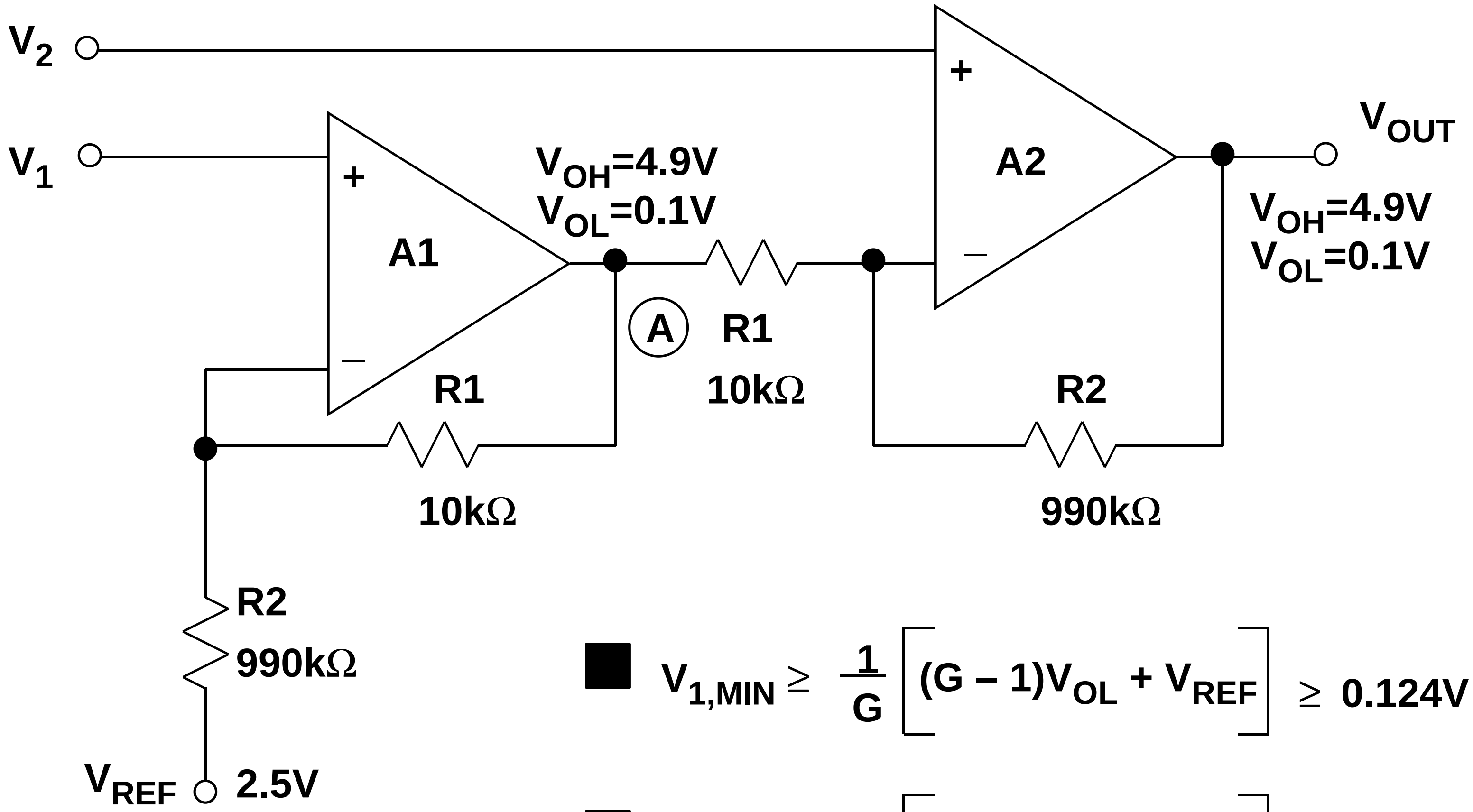
SINGLE SUPPLY RESTRICTIONS: V_S = +5V, G = 2



$$V_{REF} = \frac{V_{OH} + V_{OL}}{2} = 2.5V$$

- $V_{1,MIN} \geq \frac{1}{G}\left[(G-1)V_{OL} + V_{REF}\right] \geq 1.3V$
- $V_{1,MAX} \leq \frac{1}{G}\left[(G-1)V_{OH} + V_{REF}\right] \leq 3.7V$
- $\left|V_2 - V_1\right|_{MAX} \leq \frac{V_{OH} - V_{OL}}{G} \leq 2.4V$

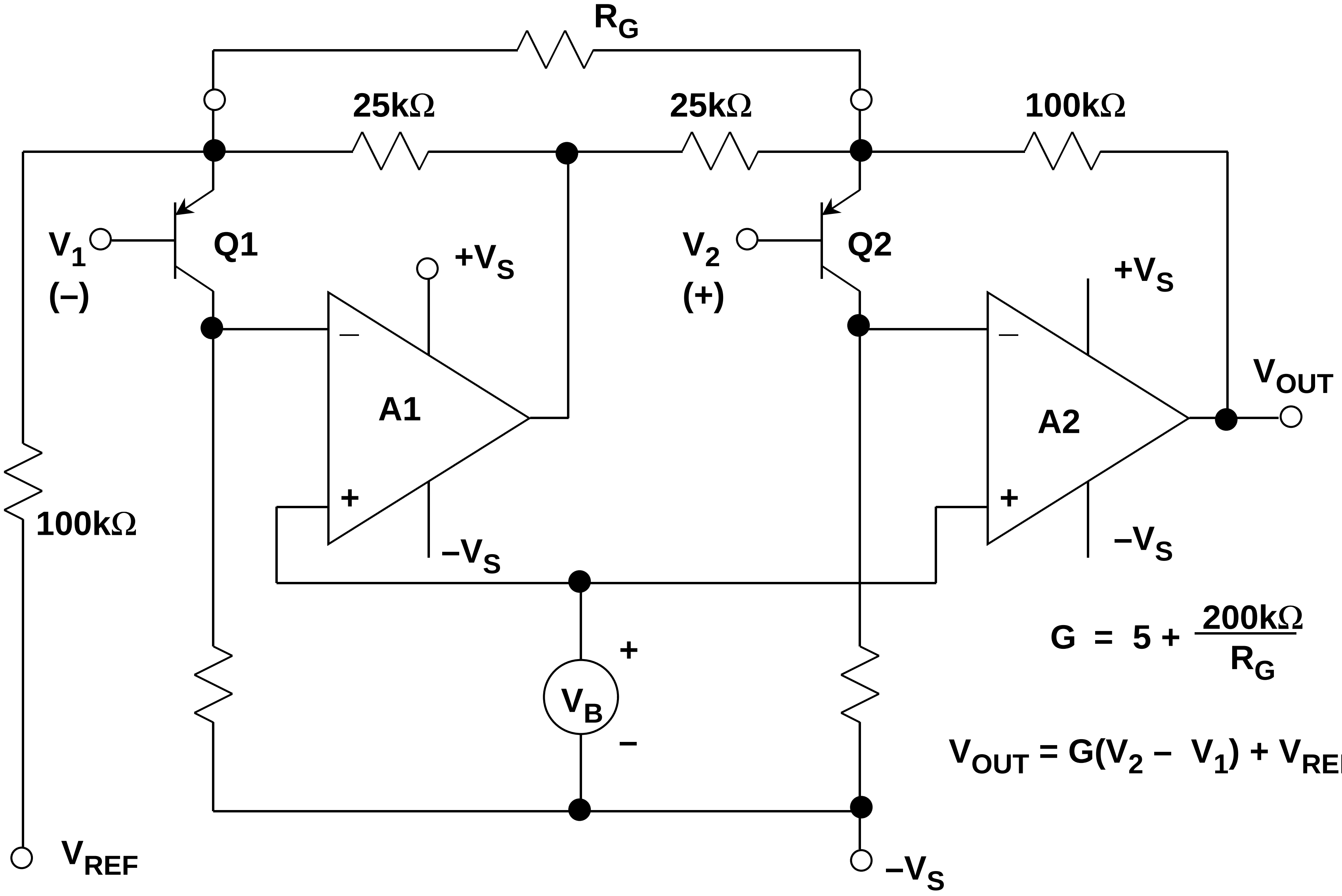
SINGLE SUPPLY RESTRICTIONS: V_S = +5V, G = 100



$$V_{REF} = \frac{V_{OH} + V_{OL}}{2} = 2.5V$$

- $V_{1,MIN} \geq \frac{1}{G}\left[(G-1)V_{OL} + V_{REF}\right] \geq 0.124V$
- $V_{1,MAX} \leq \frac{1}{G}\left[(G-1)V_{OH} + V_{REF}\right] \leq 4.876V$
- $\left|V_2 - V_1\right|_{MAX} \leq \frac{V_{OH} - V_{OL}}{G} \leq 0.048V$

AD627 IN-AMP ARCHITECTURE



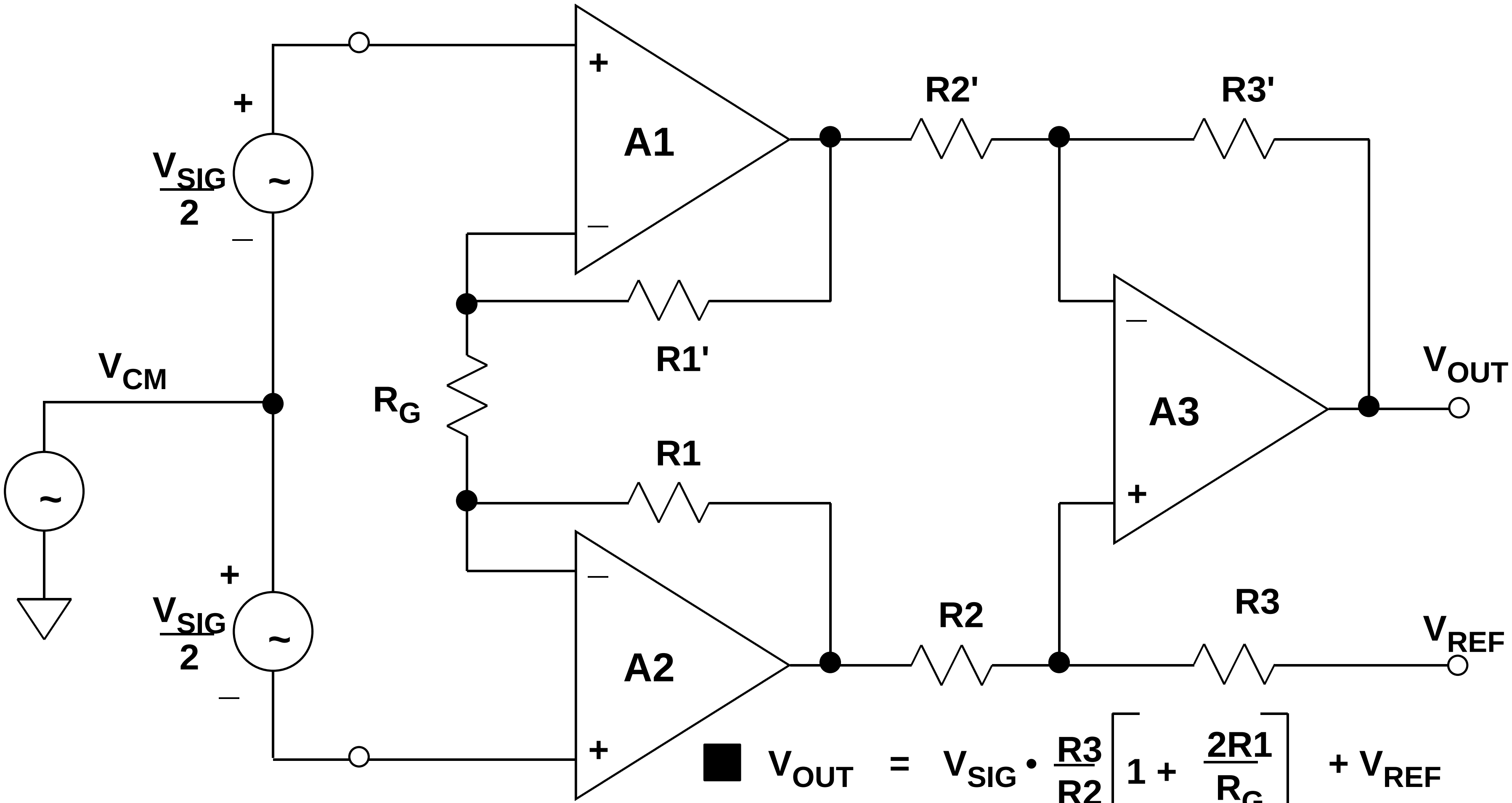
$$G = 5 + \frac{200k\Omega}{R_G}$$

$$V_{OUT} = G(V_2 - V_1) + V_{REF}$$

AD627 IN-AMP KEY SPECIFICATIONS

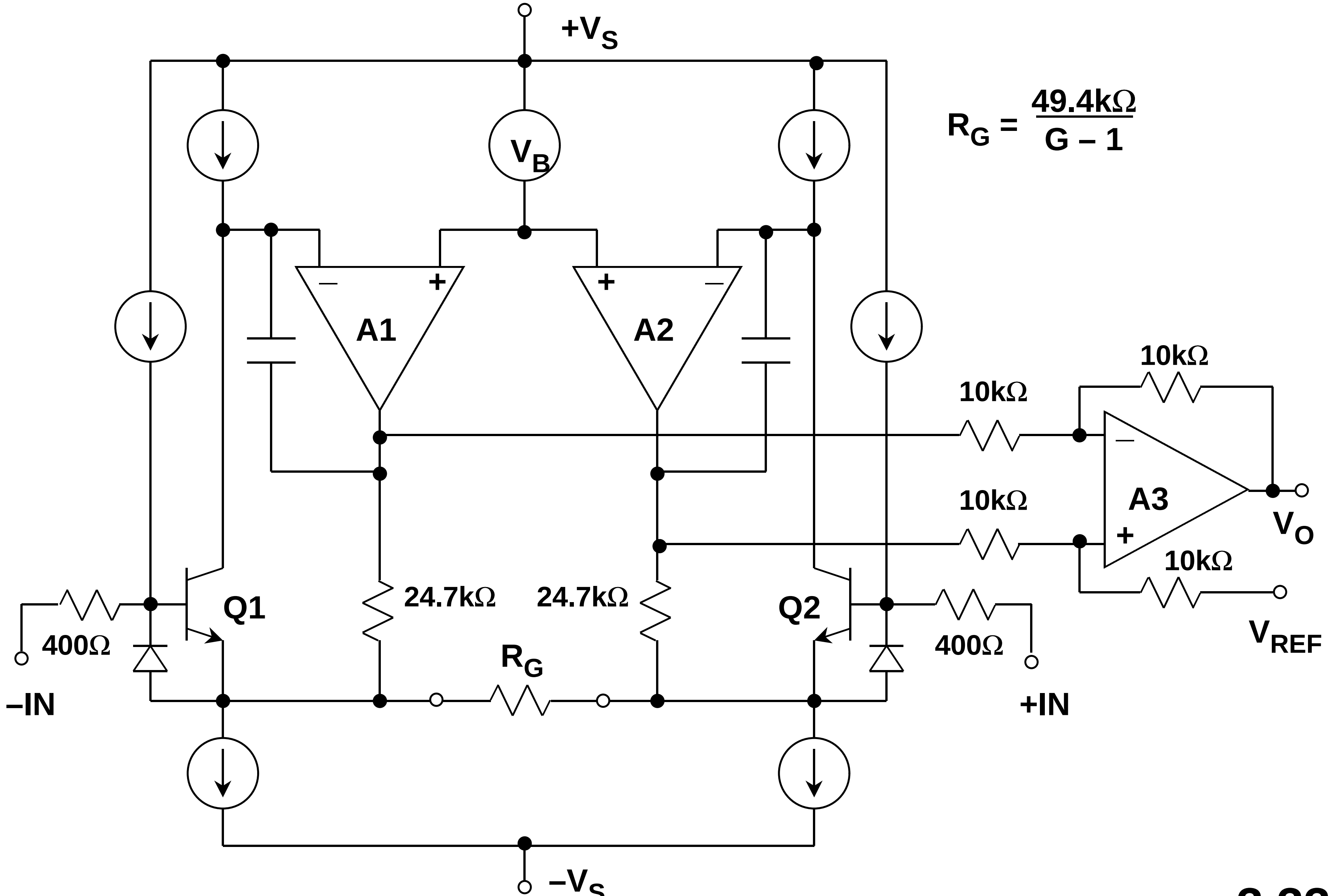
- Wide Supply Range : +2.7V to ±18V
- Input Voltage Range: $-V_S$ – 0.1V to $+V_S$ – 1V
- 85µA Supply Current
- Gain Range: 5 to 1000
- 75µV Maximum Input Offset Volage (AD627B)
- 10ppm/°C Maximum Offset Voltage TC (AD627B)
- 10ppm Gain Nonlinearity
- 85dB CMR @ 60Hz, 1kΩ Source Imbalance (G = 5)
- 3µV p-p 0.1Hz to 10Hz Input Voltage Noise (G = 5)

THREE OP AMP INSTRUMENTATION AMPLIFIER

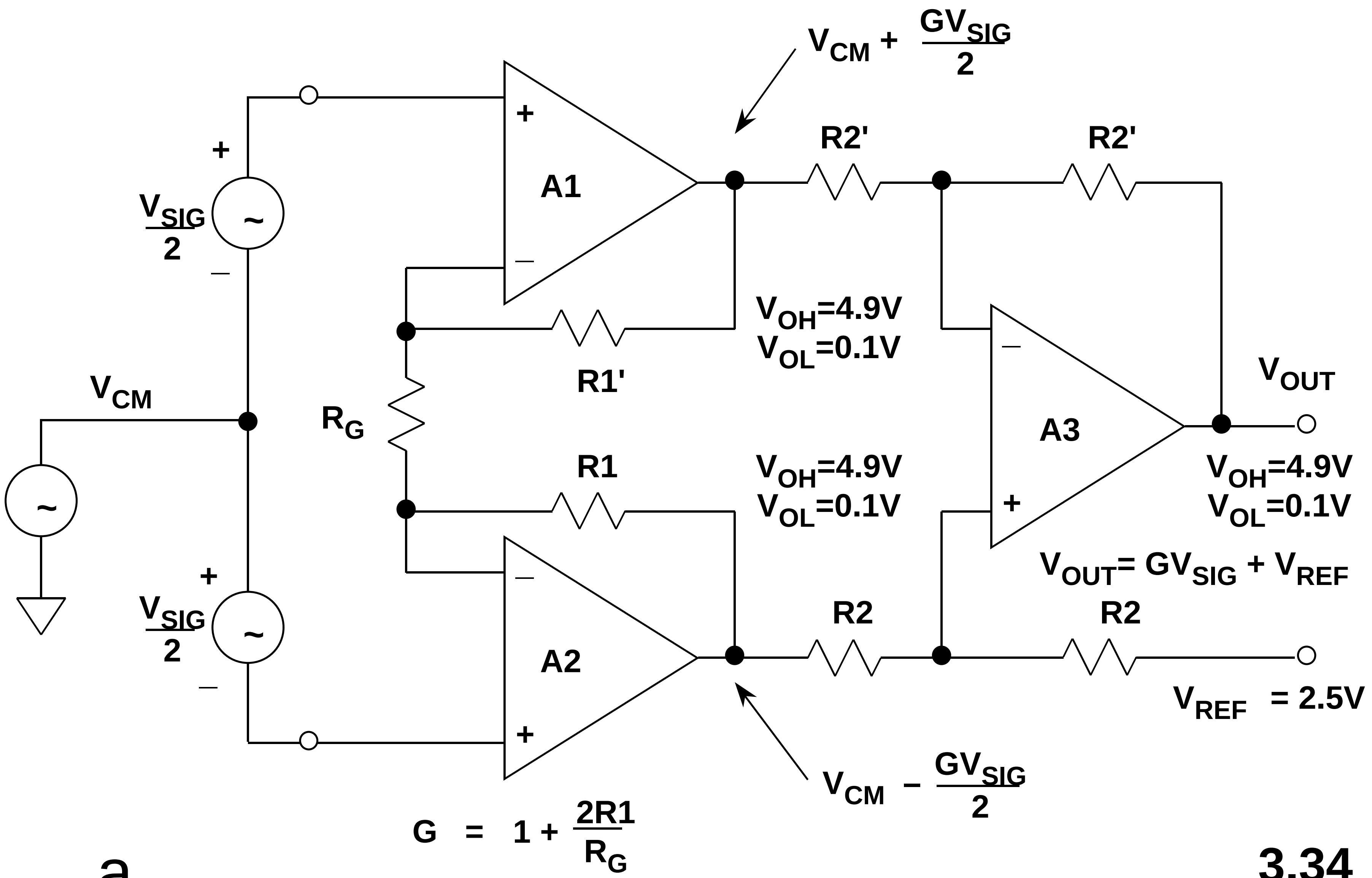


- $V_{OUT} = V_{SIG} \cdot \frac{R3}{R2}\left[1 + \frac{2R1}{R_G}\right] + V_{REF}$
- CMR $\le 20\log\left[\frac{\text{GAIN} \times 100}{\text{\% MISMATCH}}\right]$
- IF R2 = R3, $G = 1 + \frac{2R1}{R_G}$

AD620 IN-AMP SIMPLIFIED SCHEMATIC

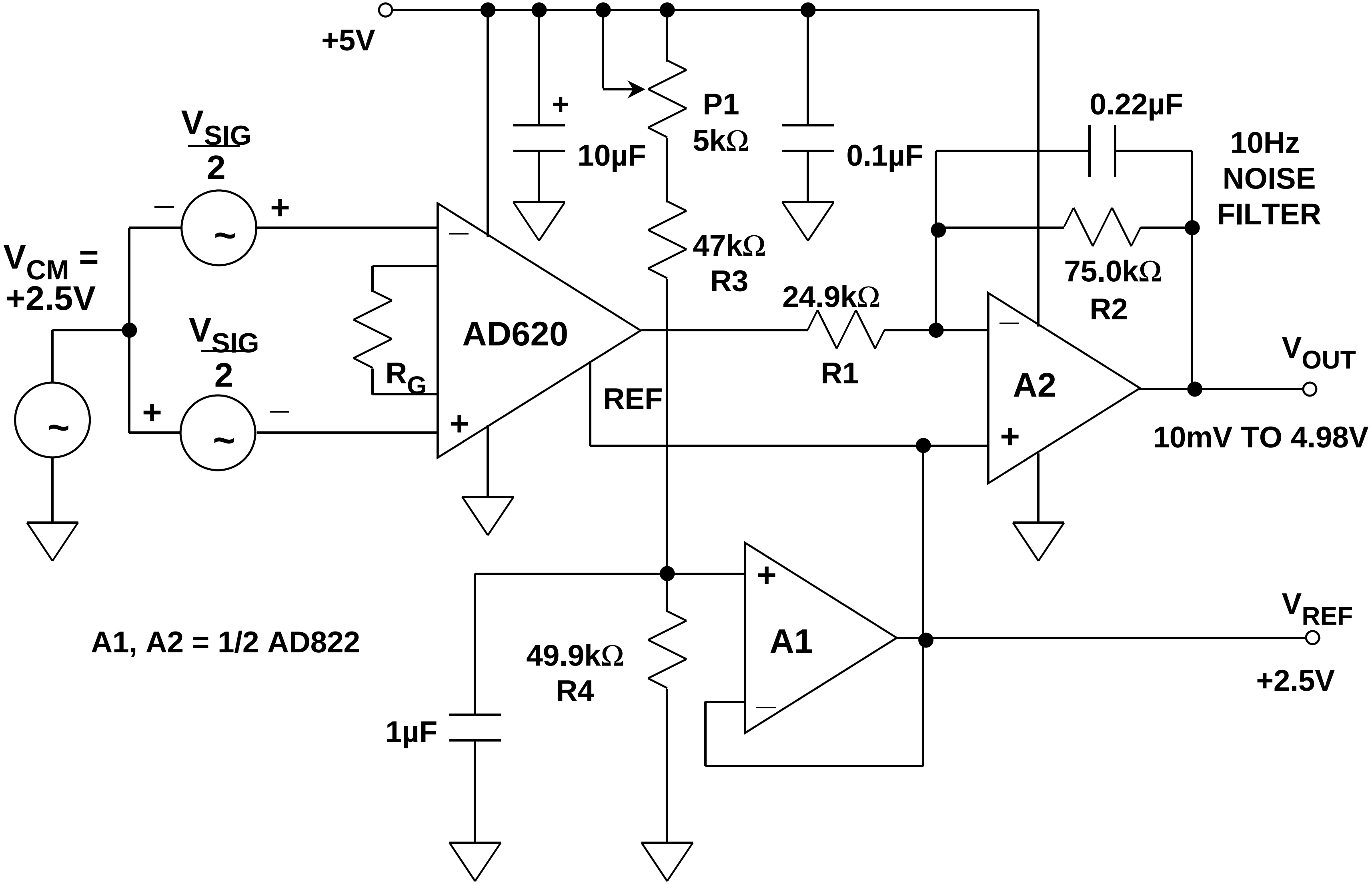


THREE OP AMP IN-AMP
SINGLE +5V SUPPLY RESTRICTIONS



a

A PRECISION SINGLE-SUPPLY COMPOSITE IN-AMP WITH RAIL-TO-RAIL OUTPUT



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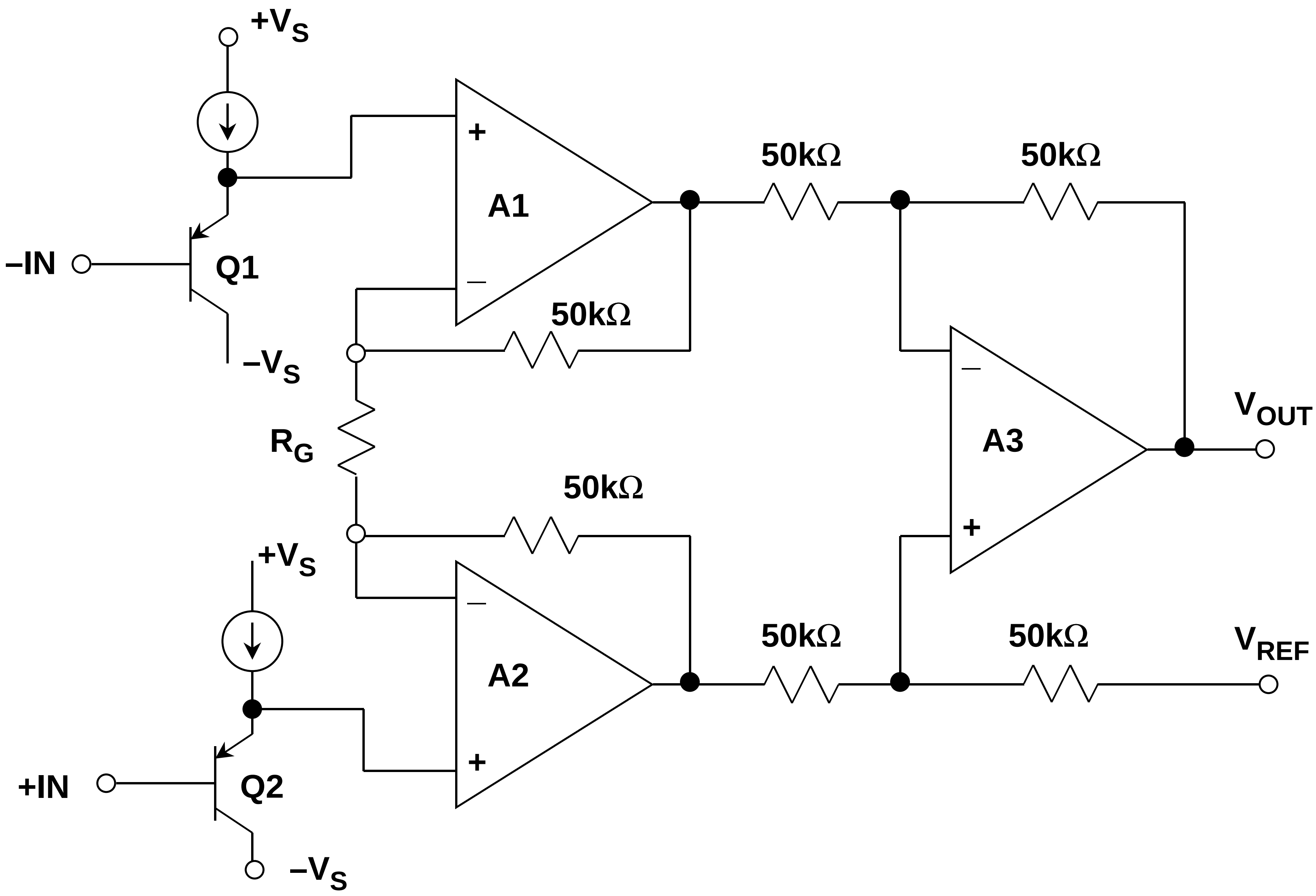
PERFORMANCE SUMMARY OF THE +5V SINGLE-SUPPLY AD620/AD822 COMPOSITE IN-AMP

CIRCUIT GAIN	R_G (Ω)	V_{OS}, RTI (µV)	TC V_{OS}, RTI (µV/°C)	NONLINEARITY (ppm) *	BANDWIDTH (kHz)**
10	21.5k	1000	1000	< 50	600
30	5.49k	430	430	< 50	600
100	1.53k	215	215	< 50	300
300	499	150	150	< 50	120
1000	149	150	150	< 50	30

* Nonlinearity Measured Over Output Range: $0.1V < V_{OUT} < 4.90V$
** Without 10Hz Noise Filter

AD623 SINGLE-SUPPLY IN-AMP ARCHITECTURE



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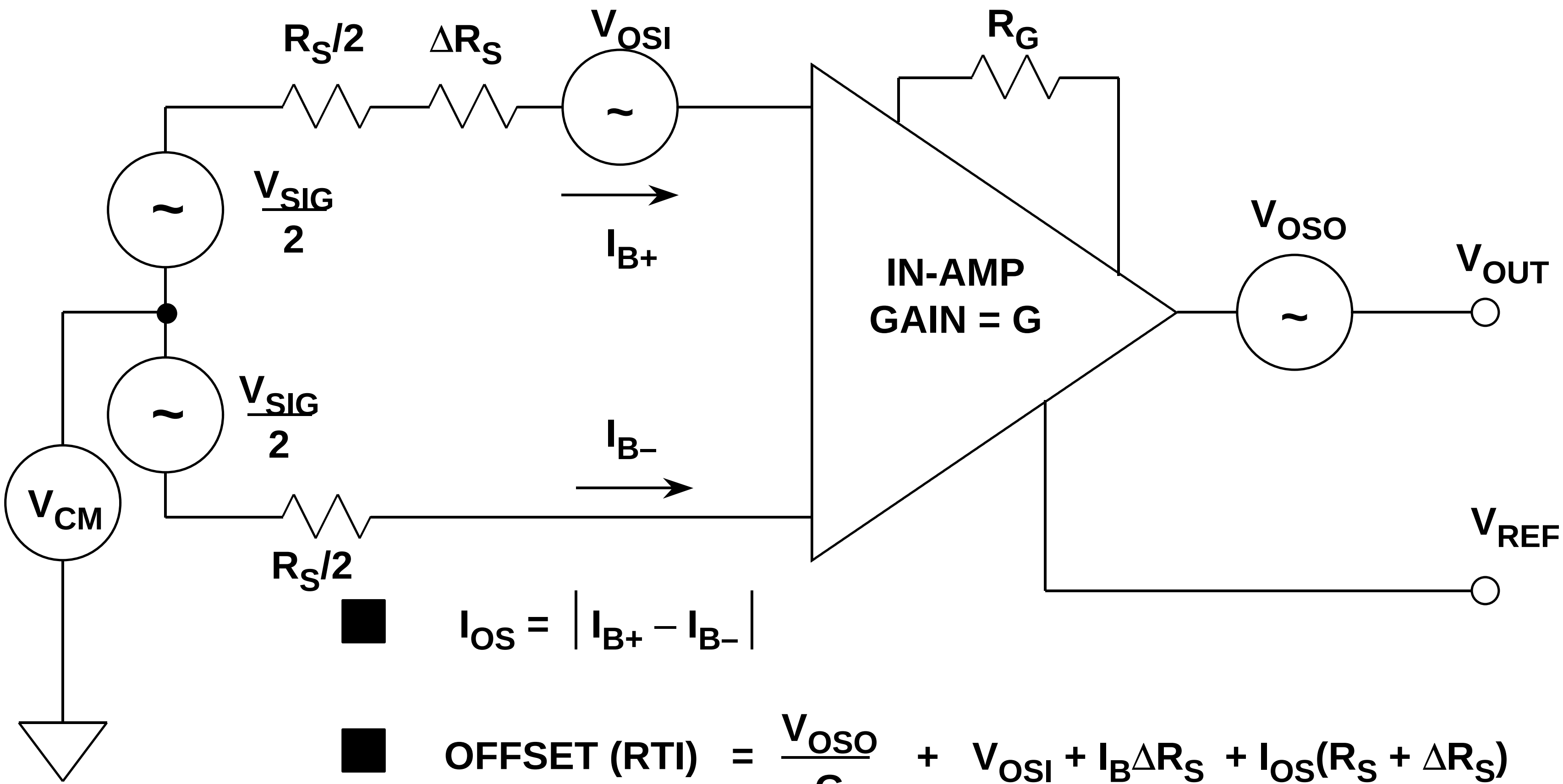
AD623 IN-AMP KEY SPECIFICATIONS

- Wide Supply Range: +3V to ±6V
- Input Voltage Range: $-V_S - 0.15V$ to $+V_S - 1.5V$
- 575µA Maximum Supply Current
- Gain Range: 1 to 1000
- 100µV Maximum Input Offset Voltage (AD623B)
- 1µV/°C Maximum Offset Voltage TC (AD623B)
- 50ppm Gain Nonlinearity
- 105dB CMR @ 60Hz, 1kΩ Source Imbalance, $G \geq 100$
- 3µV p-p 0.1Hz to 10Hz Input Voltage Noise (G = 1)

IN-AMP OFFSET VOLTAGE MODEL

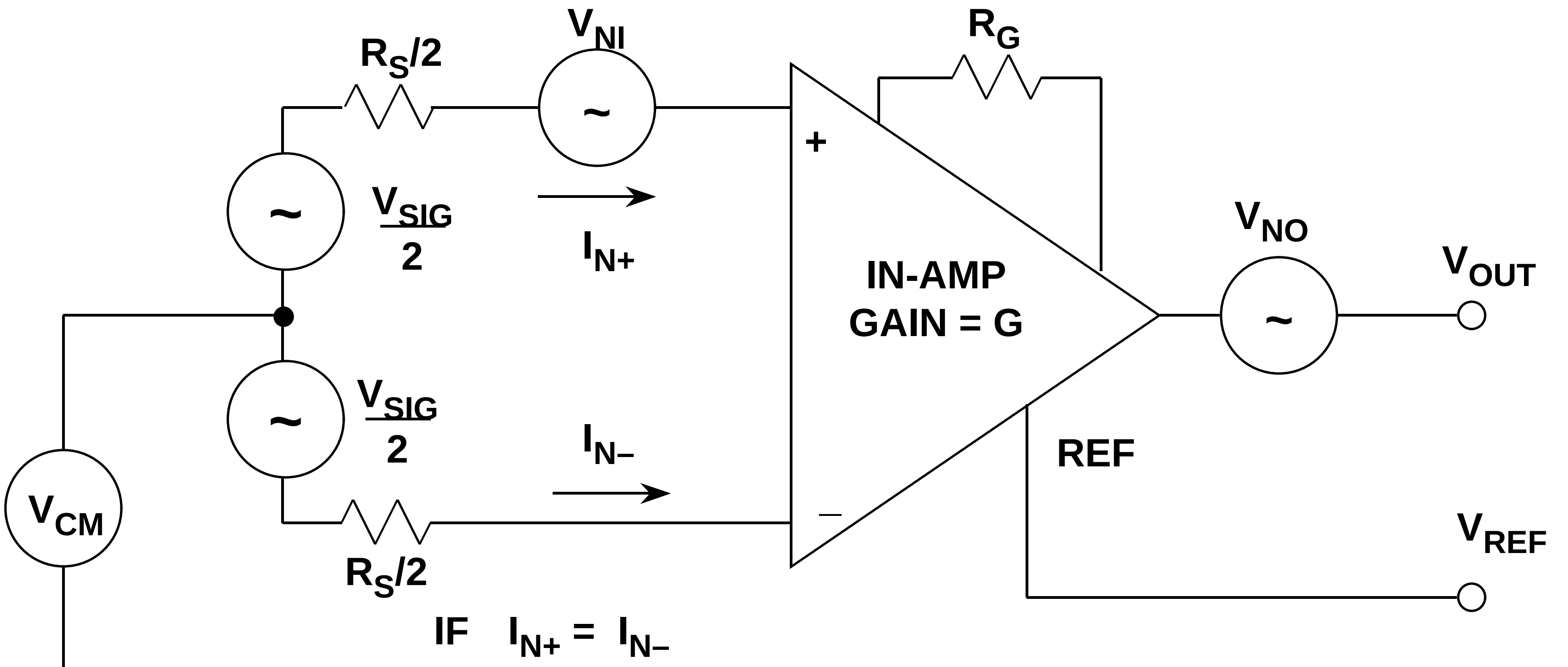


- $I_{OS} = \left| I_{B+} - I_{B-} \right|$
- OFFSET (RTI) $= \dfrac{V_{OSO}}{G} + V_{OSI} + I_B \Delta R_S + I_{OS}(R_S + \Delta R_S)$
- OFFSET (RTO) $= V_{OSO} + G\left[V_{OSI} + I_B \Delta R_S + I_{OS}(R_S + \Delta R_S)\right]$

INSTRUMENTATION AMPLIFIER AMPLIFIER DC ERRORS REFERRED TO THE INPUT (RTI)

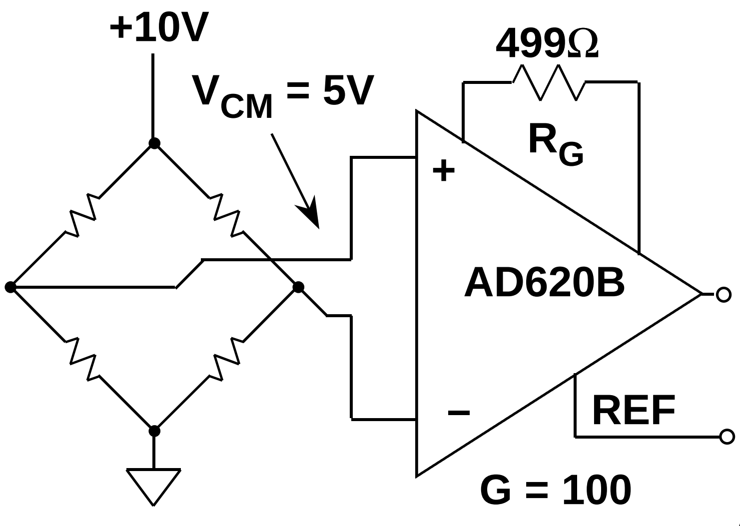
ERROR SOURCE	RTI VALUE
Gain Accuracy (ppm)	Gain Accuracy × FS Input
Gain Nonlinearity (ppm)	Gain Nonlinearity × FS Input
Input Offset Voltage, V_{OSI}	V_{OSI}
Output Offset Voltage, V_{OSO}	$V_{OSO} \div G$
Input Bias Current, I_B, Flowing in ΔR_S	$I_B \Delta R_S$
Input Offset Current, I_{OS}, Flowing in R_S	$I_{OS}(R_S + \Delta R_S)$
Common Mode Input Voltage, V_{CM}	$V_{CM} \div CMRR$
Power Supply Variation, ΔV_S	$\Delta V_S \div PSRR$

IN-AMP NOISE MODEL



- NOISE (RTI) $= \sqrt{BW} \bullet \sqrt{\frac{V_{NO}^2}{G^2} + V_{NI}^2 + \frac{I_N^2 R_S^2}{2}}$
- NOISE (RTO) $= \sqrt{BW} \bullet \sqrt{V_{NO}^2 + G^2 \left[V_{NI}^2 + \frac{I_N^2 R_S^2}{2} \right]}$
- BW = 1.57 × IN-AMP Bandwidth @ Gain = G

AD620B BRIDGE AMPLIFIER DC ERROR BUDGET



350Ω, 100mV FS
LOAD CELL

AD620B SPECS @ +25°C, ±15V

V_{OSI} + V_{OSO}/G = 55µV max

I_{OS} = 0.5nA max

Gain Error = 0.15%

Gain Nonlinearity = 40ppm

0.1Hz to 10Hz Noise = 280nVp-p

CMR = 120dB @ 60Hz

MAXIMUM ERROR CONTRIBUTION, +25°C
FULLSCALE: V_{IN} = 100mV, V_{OUT} = 10V

V_{OS}	55µV ÷ 100mV	550ppm
I_{OS}	350Ω × 0.5nA ÷ 100mV	1.8ppm
Gain Error	0.15%	1500ppm
Gain Nonlinearity	40ppm	40ppm
CMR Error	120dB 1ppm × 5V ÷ 100mV	50ppm
0.1Hz to 10Hz 1/f Noise	280nV ÷ 100mV	2.8ppm
Total Unadjusted Error	≈ 9 Bits Accurate	2145ppm
Resolution Error	≈ 14 Bits Accurate	42.8ppm

PRECISION IN-AMPS:
DATA FOR V_S = ±15V, G = 1000

	Gain Accuracy *	Gain Nonlinearity	V_{OS} Max	V_{OS} TC	CMR Min	0.1Hz to 10Hz p-p Noise
AD524C	0.5% / P	100ppm	50µV	0.5µV/°C	120dB	0.3µV
AD620B	0.5% / R	40ppm	50µV	0.6µV/°C	120dB	0.28µV
AD621B[1]	0.05% / P	10ppm	50µV	1.6µV/°C	100dB	0.28µV
AD622	0.5% / R	40ppm	125µV	1µV/°C	103dB	0.3µV
AD624C[2]	0.25% / R	50ppm	25µV	0.25µV/°C	130dB	0.2µV
AD625C	0.02% / R	50ppm	25µV	0.25µV/°C	125dB	0.2µV
AMP01A	0.6% / R	50ppm	50µV	0.3µV/°C	125dB	0.12µV
AMP02E	0.5% / R	60ppm	100µV	2µV/°C	115dB	0.4µV

* / P = Pin Programmable
* / R = Resistor Programmable

[1] G = 100
[2] G = 500

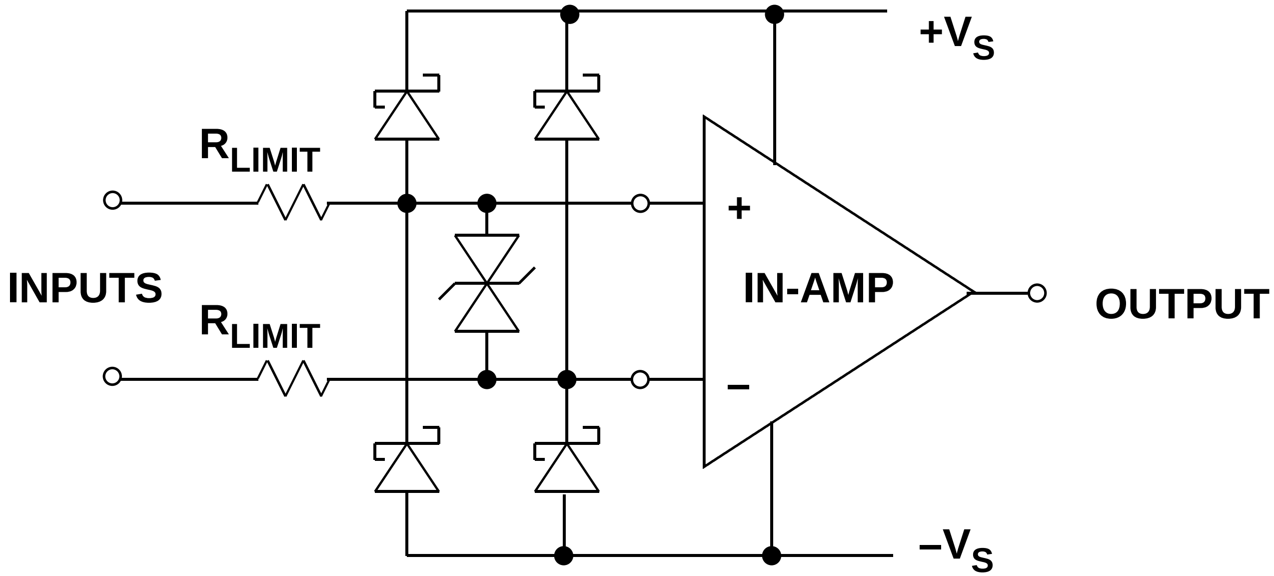
SINGLE SUPPLY IN-AMPS: DATA FOR V_S = +5V, G = 1000

	Gain Accuracy *	Gain Nonlinearity	V_{OS} Max	V_{OS} TC	CMR Min	0.1Hz to 10Hz p-p Noise	Supply Current
AD623B	0.5% / R	50ppm	100µV	1µV/°C	105dB	1.5µV	575µA
AD627B	0.35% / R	10ppm	75µV	1µV/°C	85dB	1.5µV	85µA
AMP04E	0.4% / R	250ppm	150µV	3µV/°C	90dB	0.7µV	290µA
AD626B[1]	0.6% / P	200ppm	2.5mV	6µV/°C	80dB	2µV	700µA

* / P = Pin Programmable
* / R = Resistor Programmable

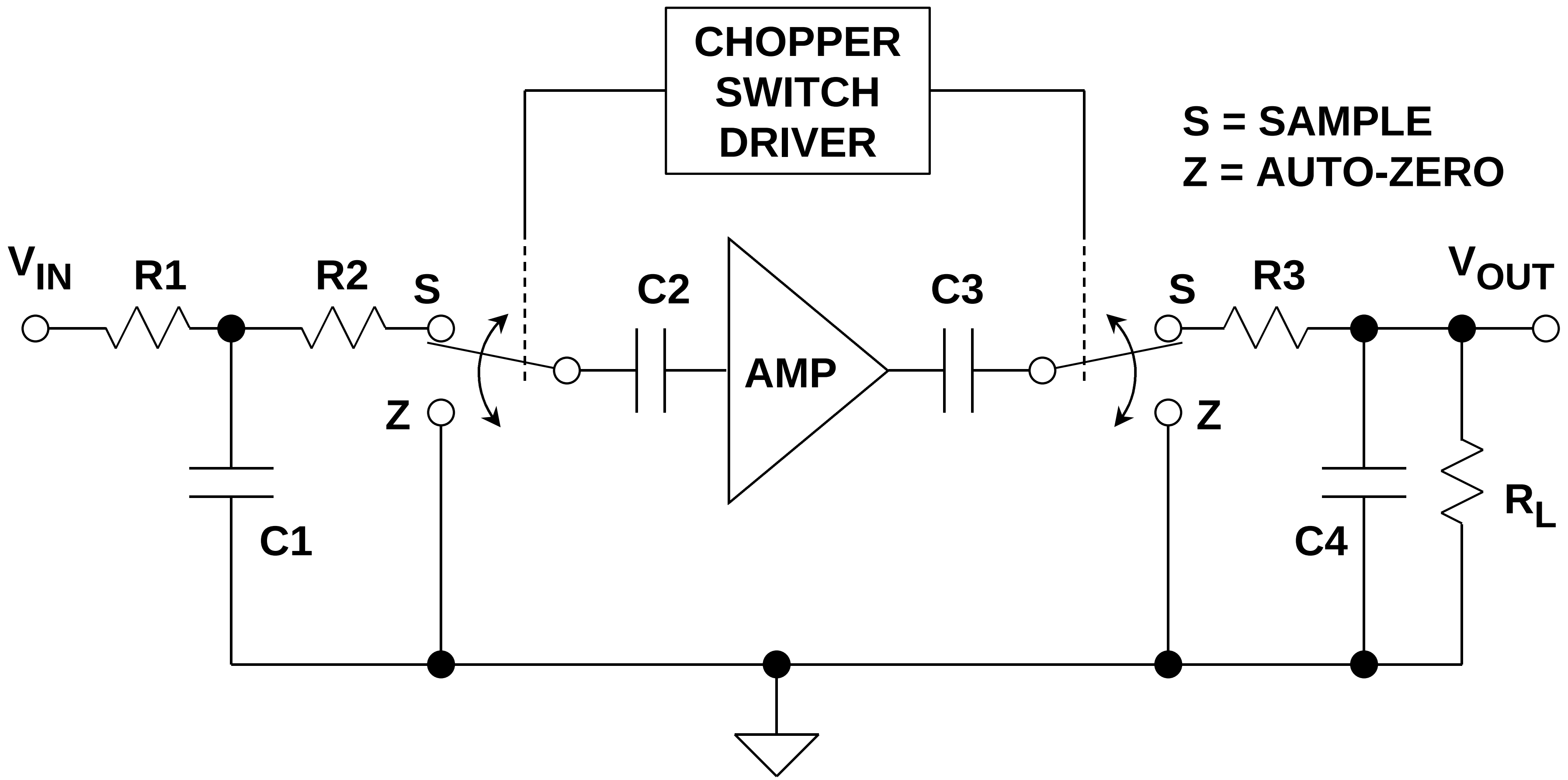
[1] Differential Amplifier, G = 100

INSTRUMENTATION AMPLIFIER INPUT OVERVOLTAGE CONSIDERATIONS

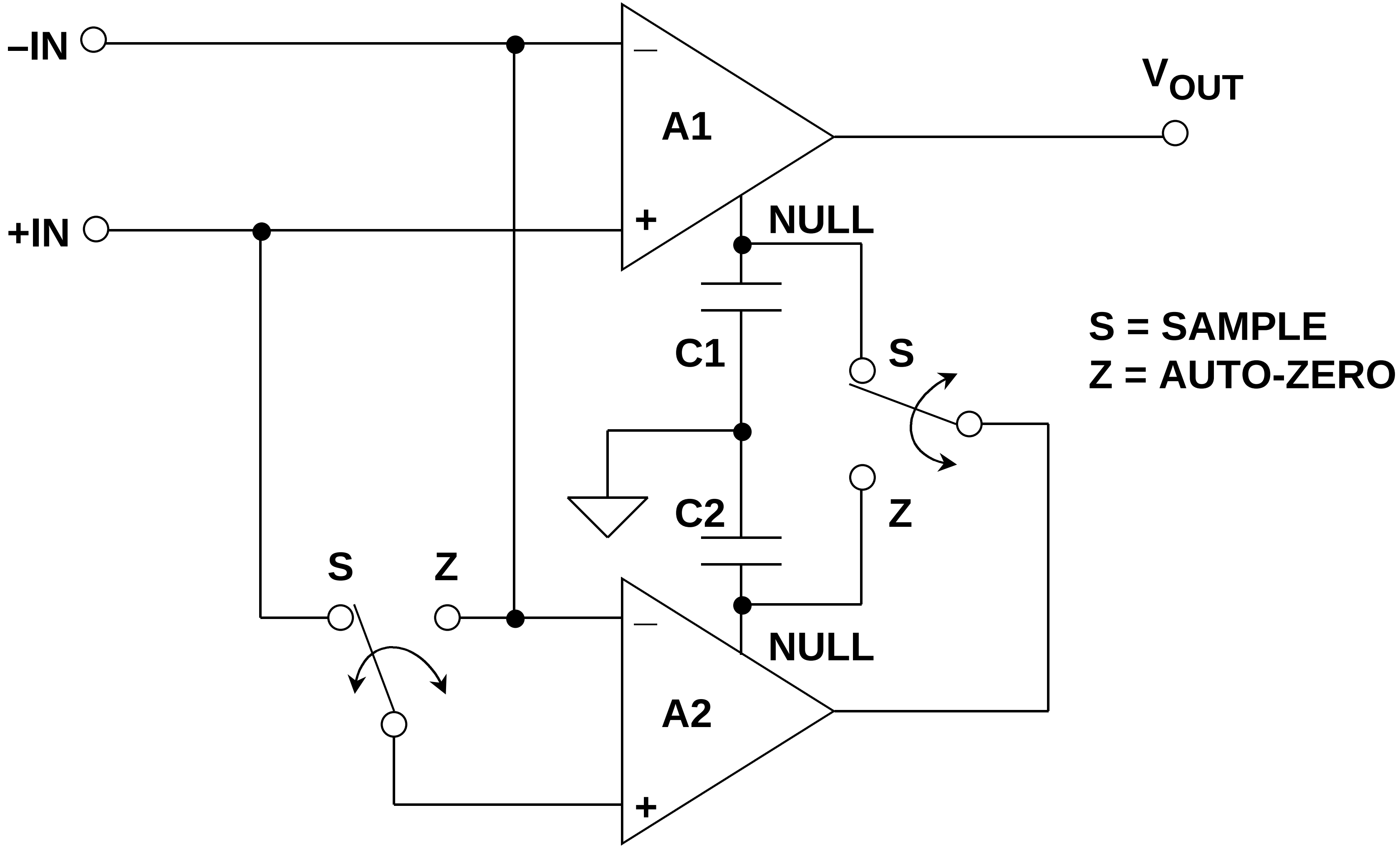


- Always Observe Absolute Maximum Data Sheet Specs!
- Schottky Diode Clamps to the Supply Rails Will Limit Input to Approximately ±V_S ±0.3V, TVSs Limit Differential Voltage
- External Resistors (or Internal Thin-Film Resistors) Can Limit Input Current, but will Increase Noise
- Some In-Amps Have Series-Protection Input FETs for Lower Noise and Higher Input Over-Voltages (up to ±60V, Depending on Device)

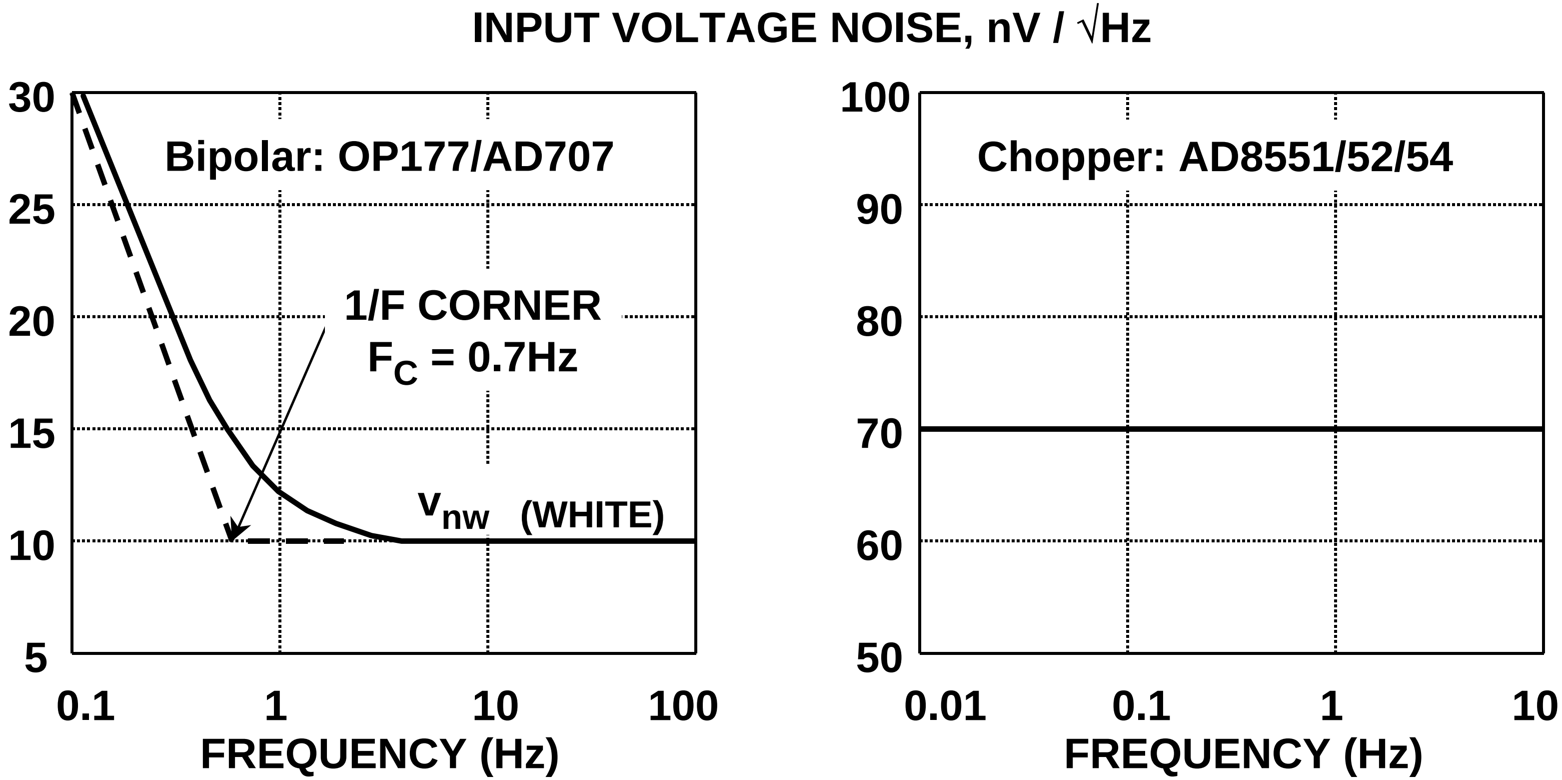
CLASSIC CHOPPER AMPLIFIER



CHOPPER STABILIZED AMPLIFIER



NOISE: BIPOLAR VS. CHOPPER AMPLIFIER



NOISE BW	BIPOLAR (OP177/AD707)	CHOPPER (AD8551/52/54)
0.1Hz to 10Hz	0.238µV p-p	1.45 µV p-p
0.01Hz to 1Hz	0.135µV p-p	0.46µV p-p
0.001Hz to 0.1Hz	0.120µV p-p	0.145µV p-p
0.0001Hz to 0.01Hz	0.118µV p-p	0.046µV p-p

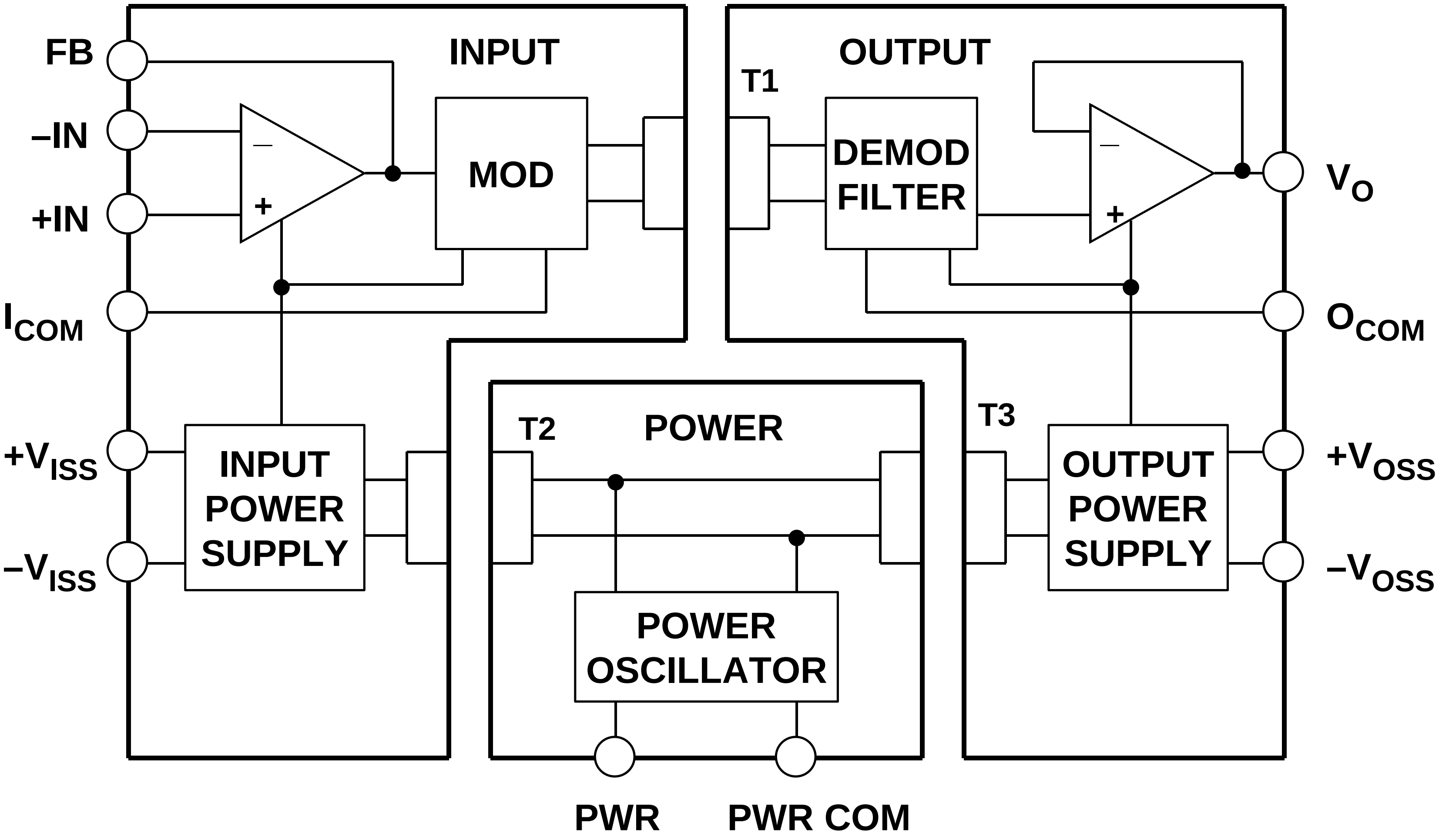
AD8551/52/54 CHOPPER STABILIZED RAIL-TO-RAIL INPUT/OUTPUT AMPLIFIERS

- **Single Supply: +2.7V to +5V**
- **5µV Max. Input Offset Voltage**
- **0.04µV/°C Input Offset Voltage Drift**
- **120dB CMR, PSR**
- **600µA Supply Current / Op Amp**
- **2ms Overload Recovery Time**
- **70nV/√Hz Input Voltage Noise**
- **1.5MHz Gain-Bandwidth Product**
- **Single (AD8551), Dual (AD8552) and Quad (AD8554)**

APPLICATIONS FOR ISOLATION AMPLIFIERS

- Sensor is at a High Potential Relative to Other Circuitry (or may become so under Fault Conditions)
- Sensor May Not Carry Dangerous Voltages, Irrespective of Faults in Other Circuitry
  (e.g. Patient Monitoring and Intrinsically Safe Equipment for use with Explosive Gases)
- To Break Ground Loops

AD210 3-PORT ISOLATION AMPLIFIER



AD210 ISOLATION AMPLIFIER KEY FEATURES

- Transformer Coupled
- High Common Mode Voltage Isolation:
    - 2500V RMS Continuous
    - ±3500V Peak Continuous
- Wide Bandwidth: 20kHz (Full Power)
- 0.012% Maximum Linearity Error
- Input Amplifier: Gain 1 to 100
- Isolated Input and Output Power Supplies, ±15V, ±5mA

MOTOR CONTROL CURRENT SENSING