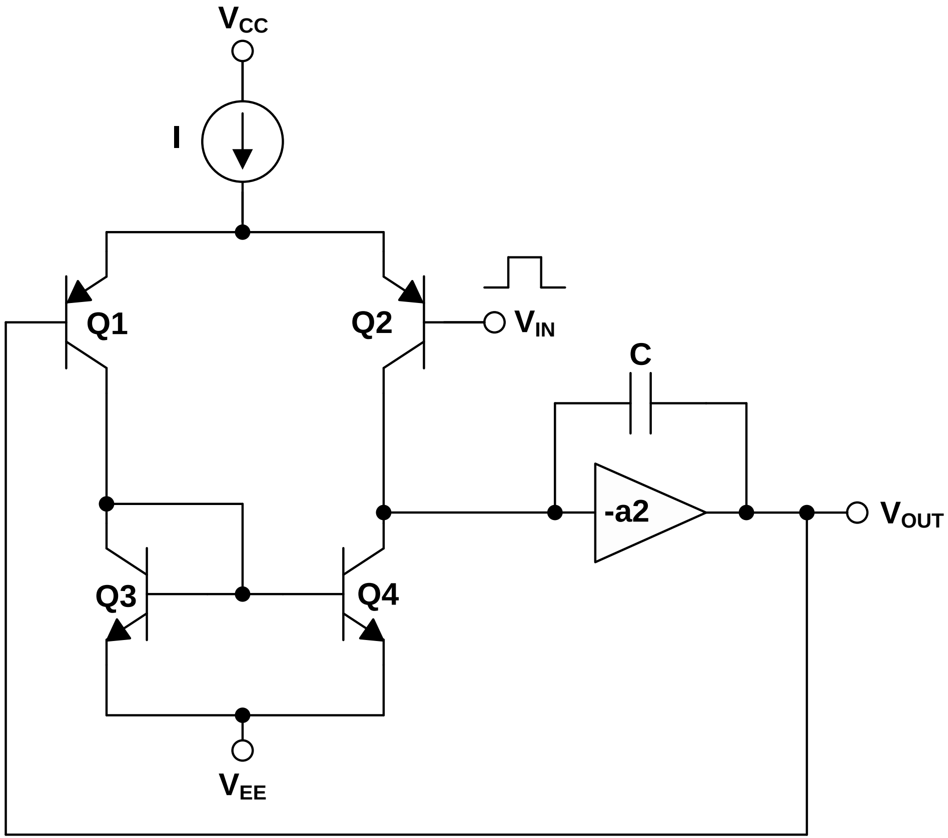
Current-Feedback Amplifiers – Part 2

TIPL 2012

TI Precision Labs: High-Speed Operational Amplifiers

Prepared and Presented by Samir Cherian

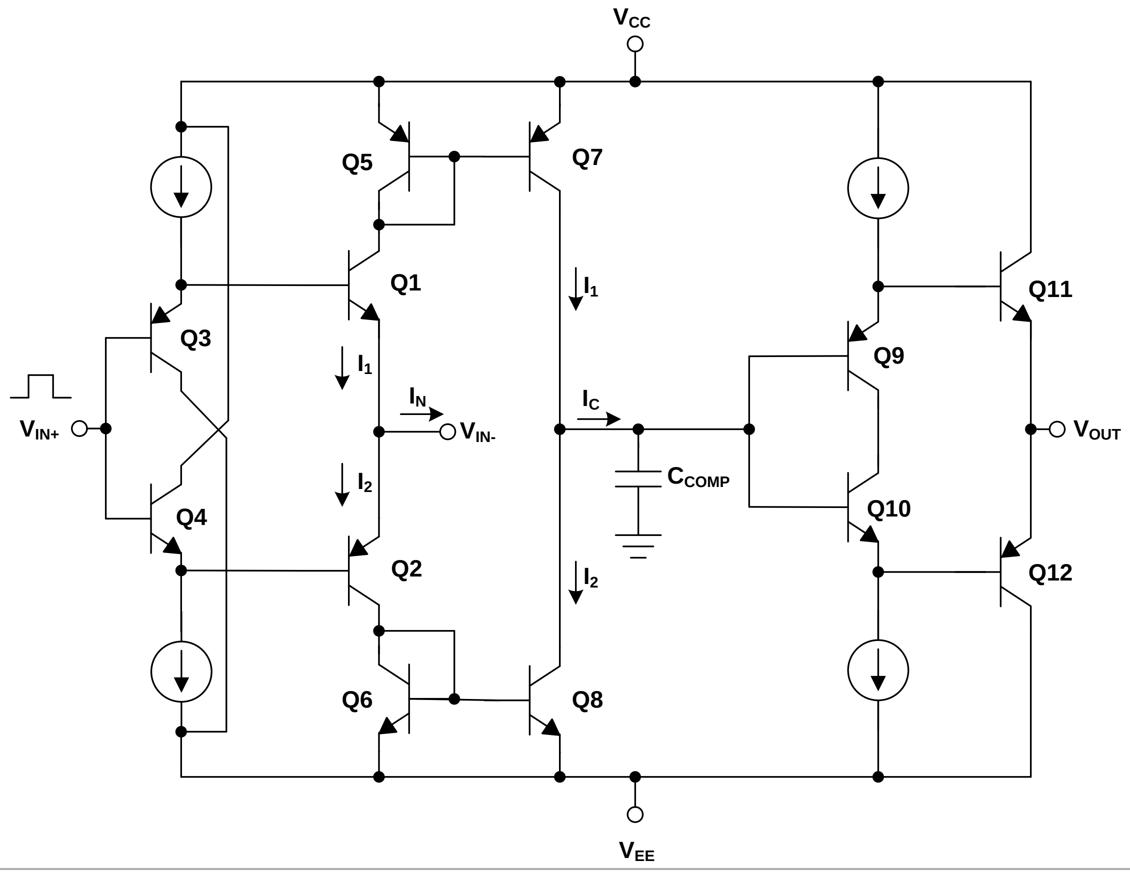
Slew-rate Limitation of VFB



- If I = 100µA and C = 10pF, then,

  $\text{Slew Rate} = 100\mu A / 10pF = 10V / \mu s$

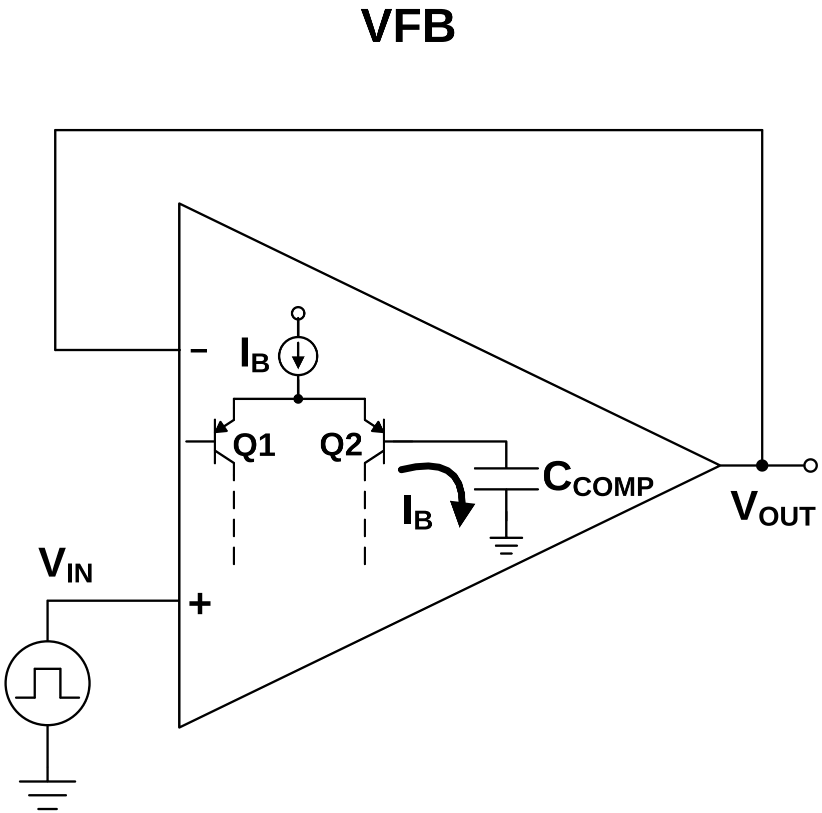
Slew Rate Enhancement with CFB

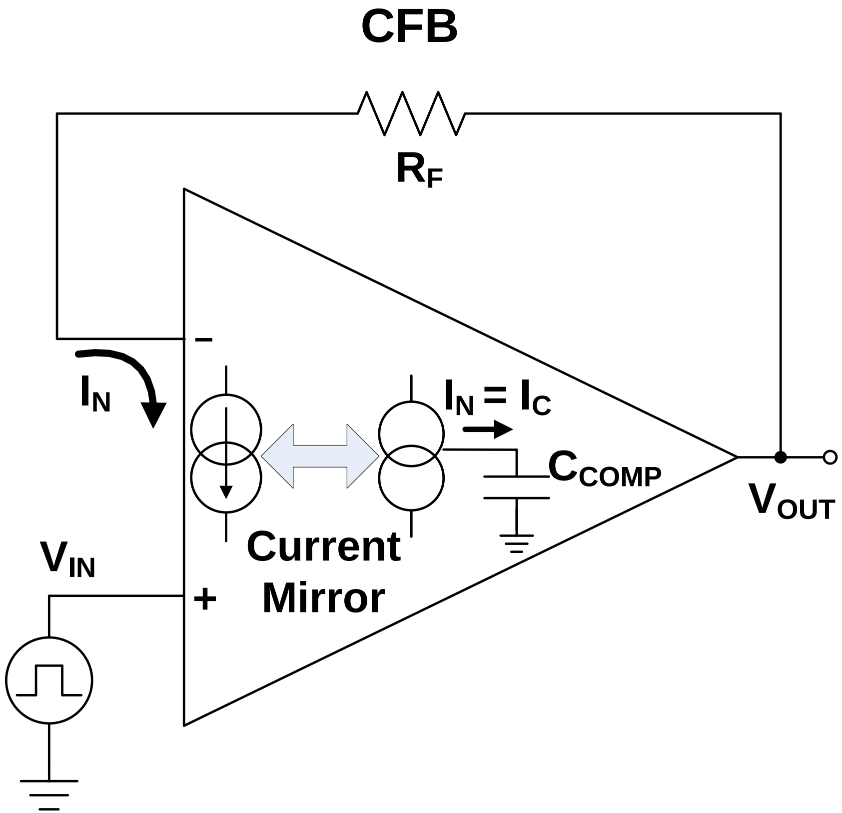


$I_N = I_1 - I_2$

$I_N = I_C$

Slew Rate VFB vs CFB





Slew Rate: VFB vs CFB

Current Feedback

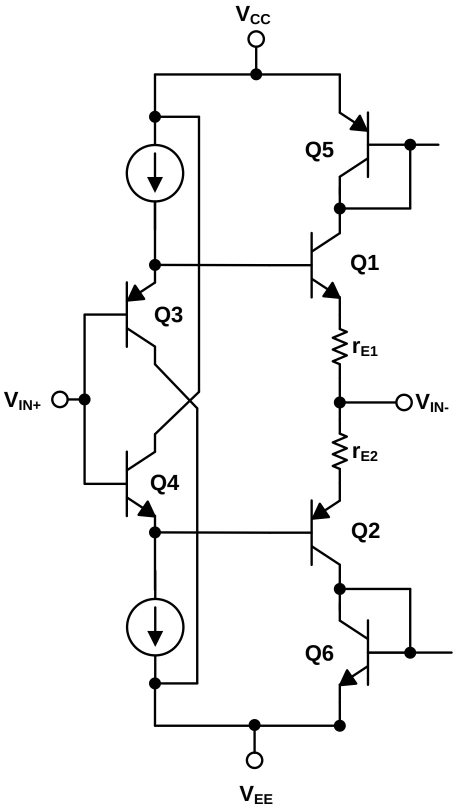
Device	Slew Rate (V/µs)	I_Q (mA)
OPA683	210	0.79
OPA684	820	1.7
OPA691	2100	5.1
OPA695	4300	12.9
THS3001	**6300**	**6.6**
THS3061	**7000**	**8.3**
THS3091	**7300**	**9.5**

Voltage Feedback

Device	Slew Rate (V/µs)	I_Q (mA)
THS4281	35	0.8
LMH6619	57	1.45
OPA820	240	5.6
OPA846	625	12.6
OPA637	**100**	**7**
THS4051	**240**	**8.5**
THS4631	**1000**	**11.5**

Products in bold text are high-voltage op-amps with max. supply >24V

Low-Power CFB Amplifier Designs

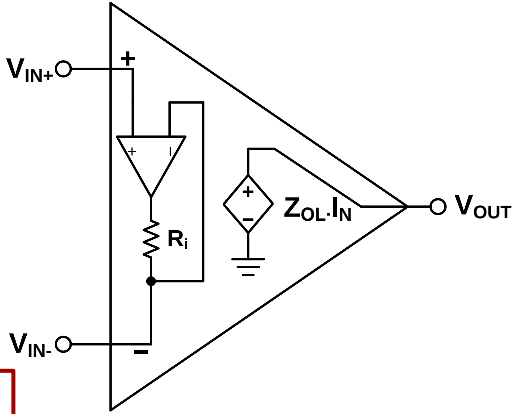


$$r_E = \frac{V_T}{I_E}\ ,$$

r_E = Emitter Resistance

V_T = Thermal Voltage

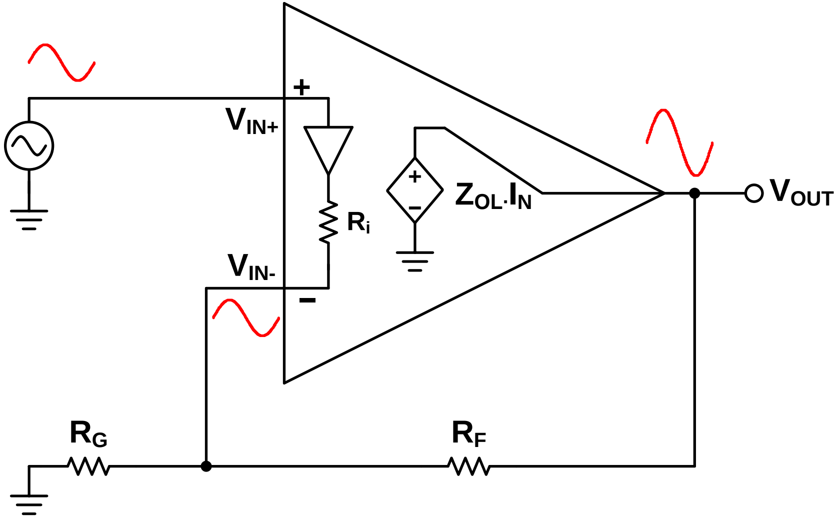
I_E = Emitter Current

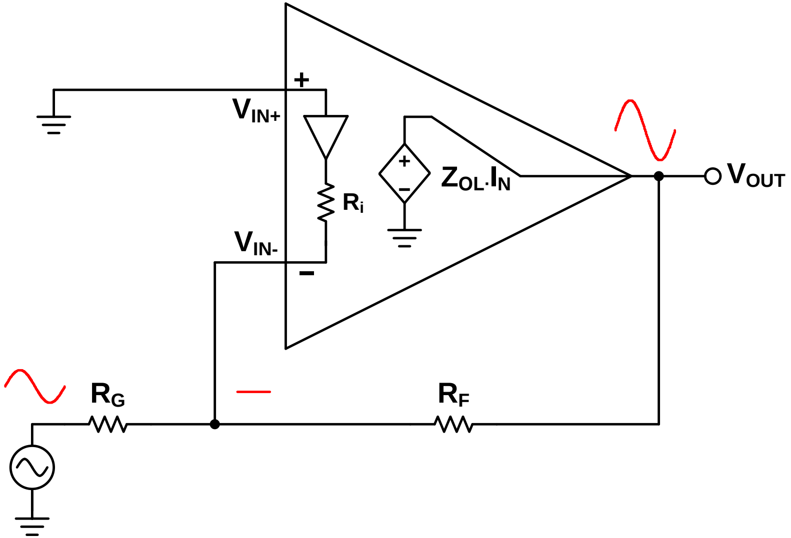


Feedback Transimpedance =(R_F + R_i × NoiseGain)

Specification	OPA691 (Open Loop Buffer)	OPA683 (Closed Loop Buffer)
Quiescent Current, I_Q	5.1 mA	0.82 mA
Inverting Input Resistance, R_i	35 Ω	4.5 Ω

Noninverting versus Inverting Configuration

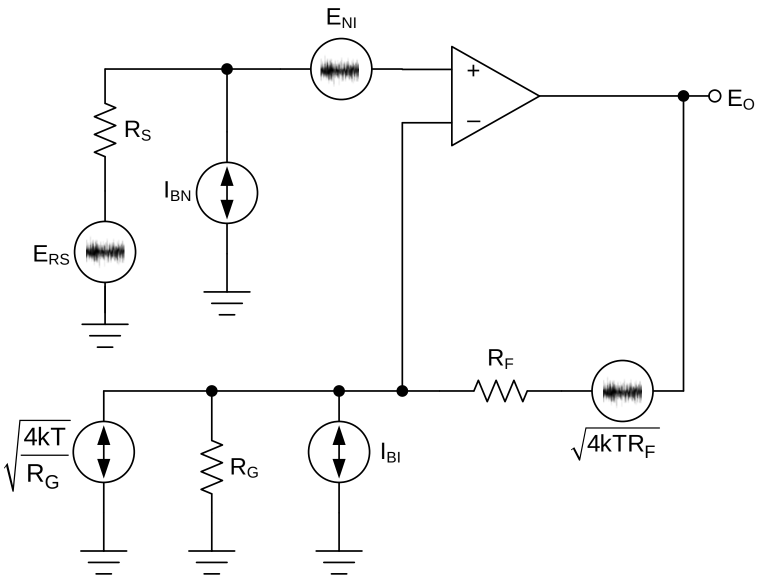




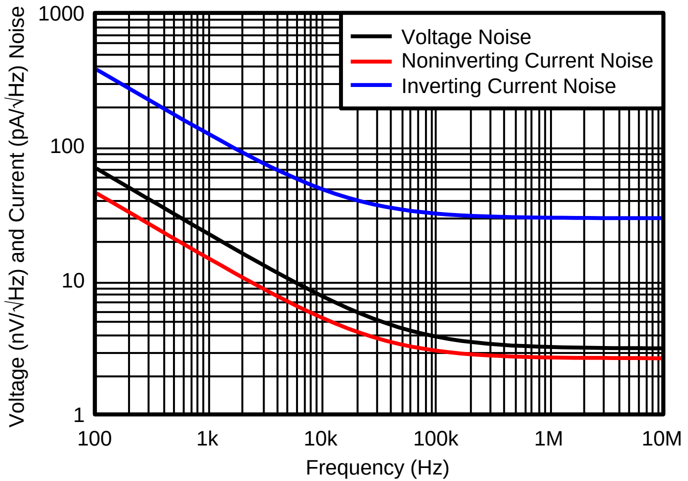
Slew rate (25% to 75% level)	G = 2, V_O = 10-V step, R_F = 1.21 kΩ	T_A = 25°C	5000	V/µs
	G = 5, V_O = 20-V step, R_F = 1 kΩ	T_A = 25°C	7300	

$$\text{Slew Rate} = 8V_{PEAK} \cdot 2\pi \cdot 100\text{MHz} = 5025\text{V} / \mu\text{sec}$$

CFB Noise Analysis



THS3217 Noise Performance



$$E_0 = \sqrt{\left(E_{NI}^2 + (i_{BN}R_S)^2 + 4kTR_S\right)G_N^2 + (i_{BI}R_F)^2 + 4kTR_FG_N},$$

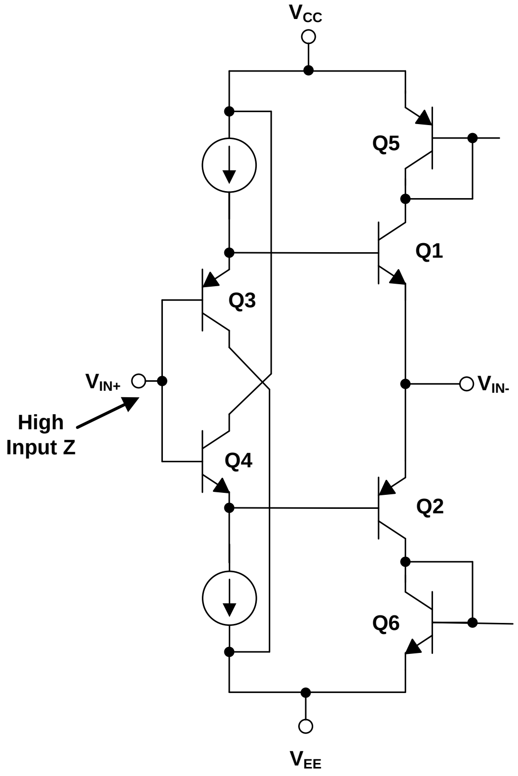
E_{NI}= Amplifier Voltage Noise

i_{BN}= Noninverting Current Noise

i_{BI}= Inverting Current Noise

G_N= Noise Gain = $(1+R_F/R_G)$

Input Bias Current and Current Noise



Specification	THS4271 (VFA)	OPA695 (CFA)	Units
I_B, Non-inverting Bias Current	6	±13	µA
I_B, Inverting Bias Current		±20	µA
I_{BOS}, Bias Current Offset	±1	20	µA
Non-inverting Bias Current Noise	3	18	pA/√Hz
Inverting Bias Current Noise		22	pA/√Hz

Summary Comparison

Parameters	VFA	CFA
DC Accuracy	**Good**	Poor
Output Swing	**Many rail-to-rail output options**	Larger headroom needed for output
Distortion	Better low-frequency distortion	Better high-frequency distortion
Slew Rate	Limited slew rate	**Very high slew rate facilitating high full-power bandwidth**
Bandwidth	Bandwidth varies with gain	**Almost constant bandwidth over gain**
Gain Stability	Restriction on the minimum stable gain for decompensated amplifiers	**Stable across gains if feedback transimpedance is kept constant**
Noise	**Low input-referred voltage and current noise**	Higher input-referred current noise (unequal for inverting and non-inverting inputs)
Typical Applications	- Applications requiring DC precision - Pulse-oriented application - High-speed and precise ADC interface - Transimpedance	- DAC interface - Output drivers - High-speed ADC interface - Sallen-Key filters.

Thanks for your time and please take the quiz!