

Conception Electronique

Retours sur TD

Composants et structures

LED et circuit d'émission

Amplificateur Linéaire Intégré / Comparateur

Structure E1 : détection de luminosité

Amplificateur Linéaire Intégré / Régime Linéaire

Structure C1 : mise en forme d'un capteur de force

Capteur et plage de fonctionnement

Structure C2 : capteur de température

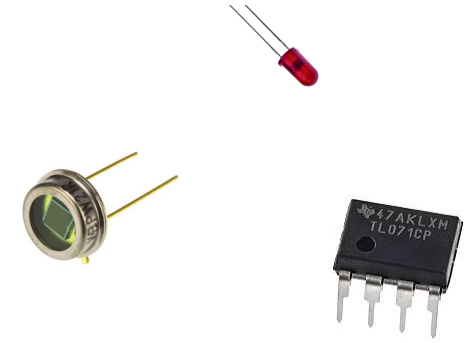
Diode Zener

Structure F2 : filtre universel

Photodétection

Structures P1 et P2 : Photodétection

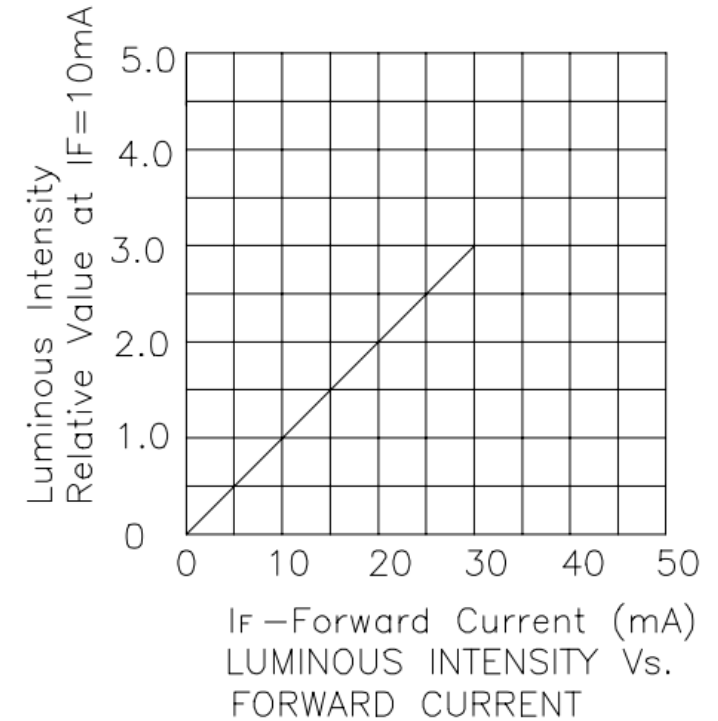
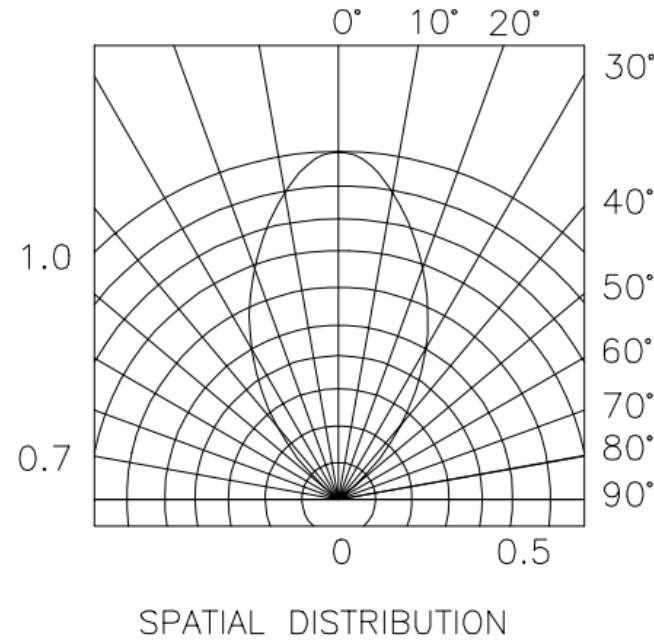
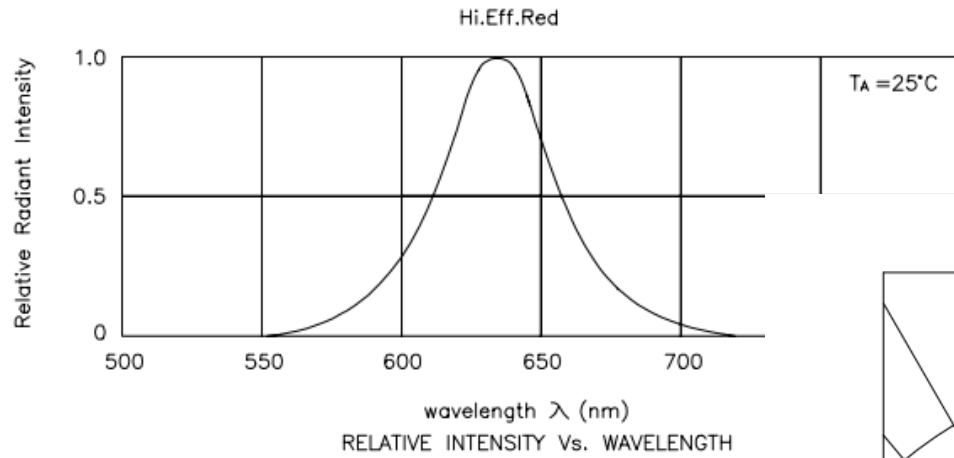
Amplificateur Linéaire Intégré / Modèle d'ordre 1



LED et circuit d'émission



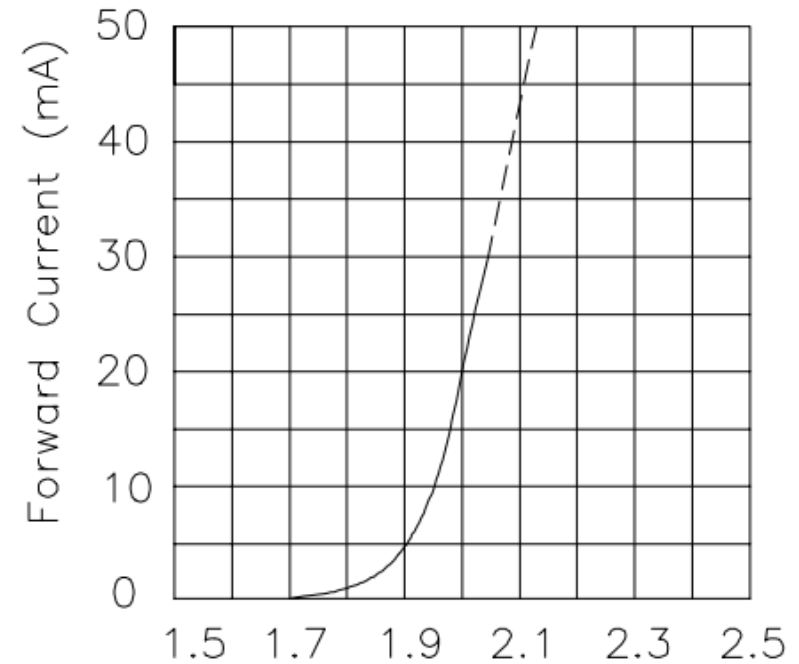
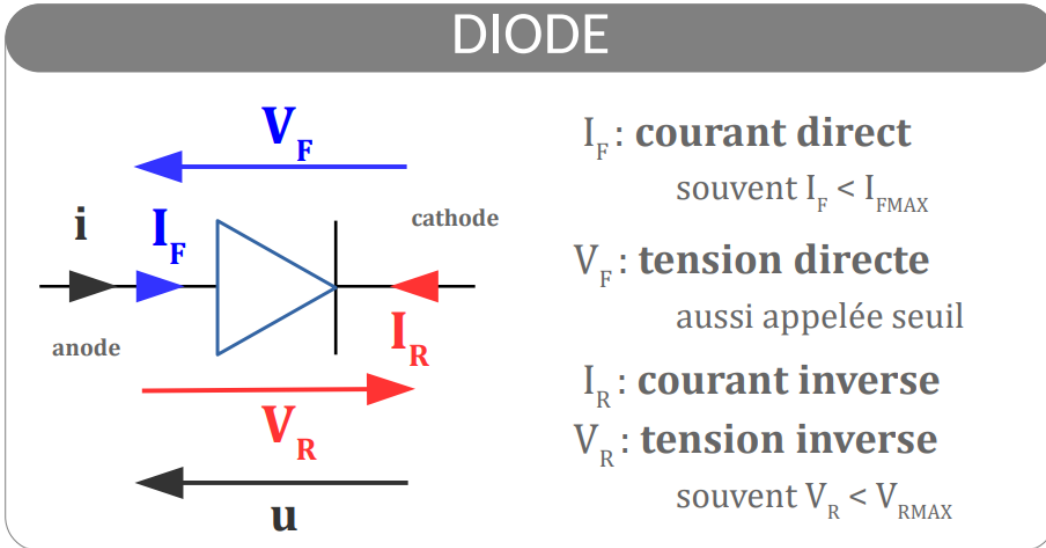
Source de photons



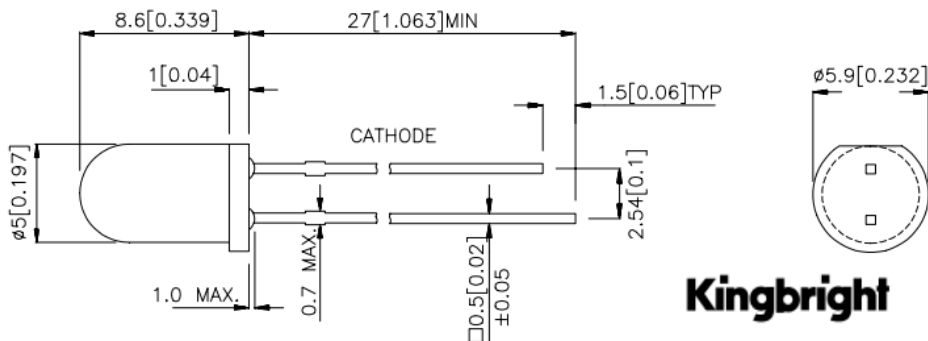
LED et circuit d'émission



Caractéristiques électriques et symbole



Forward Current (mA)
 FORWARD CURRENT Vs.
 FORWARD VOLTAGE



High Efficiency Red

L-531D

LED et circuit d'émission



Emetteur à LED

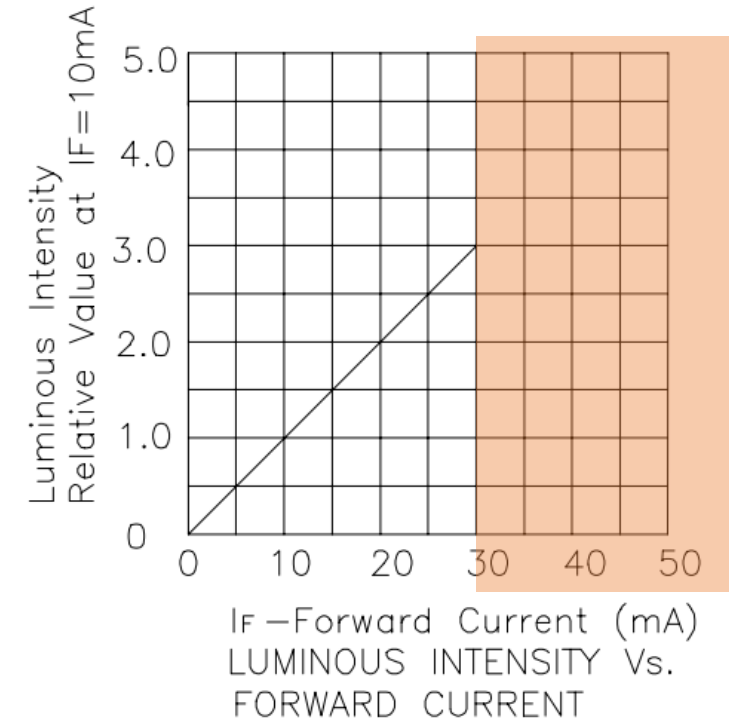
Idéalement : source de courant

Absolute Maximum Ratings at $T_A=25^\circ\text{C}$

Parameter	High Efficiency Red	Units
Power dissipation	105	mW
DC Forward Current	30	mA
Peak Forward Current [1]	160	mA
Reverse Voltage	5	V
Operating/Storage Temperature	-40°C To +85°C	
Lead Solder Temperature [2]	260°C For 5 Seconds	

Notes:

- 1/10 Duty Cycle, 0.1ms Pulse Width.
- 2mm below package base.



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High Efficiency Red

L-53ID

LED et circuit d'émission



Emetteur à LED

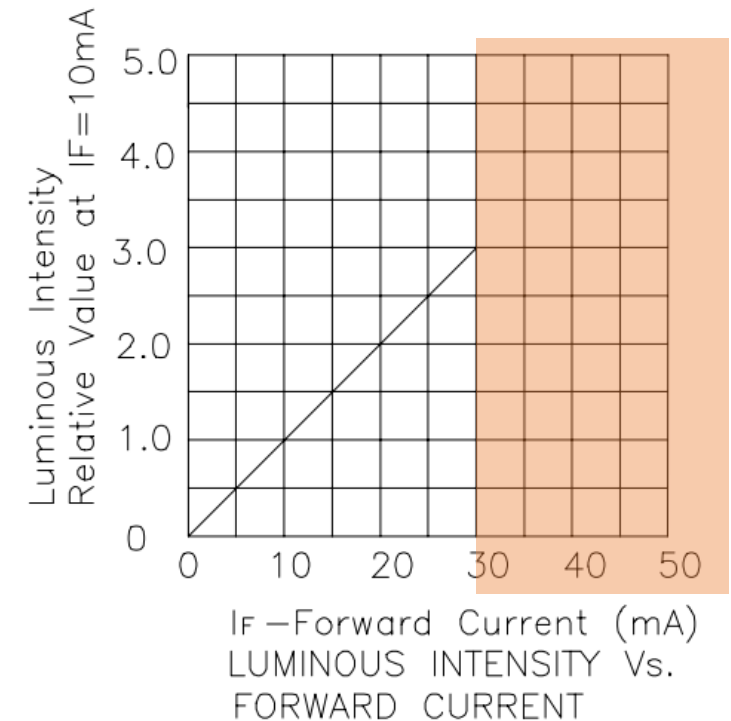
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High Efficiency Red L-53ID

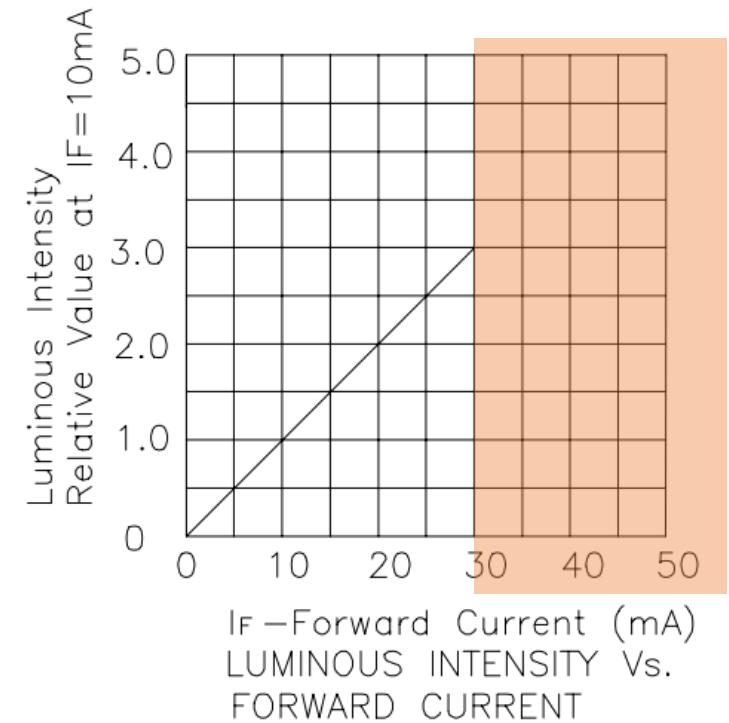
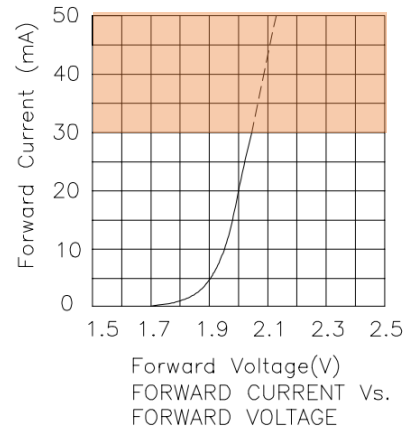
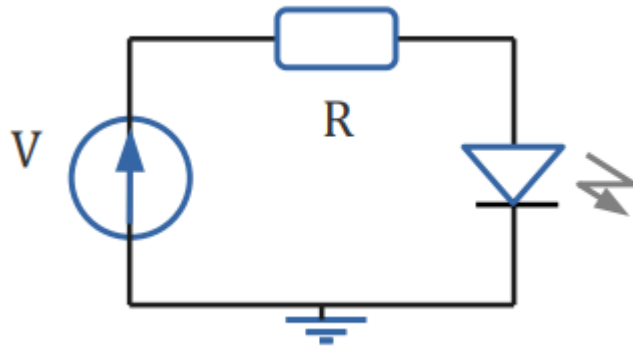
LED et circuit d'émission



Emetteur à LED

Idéalement : source de courant

En pratique : source de tension associée à une résistance



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High Efficiency Red

L-531D

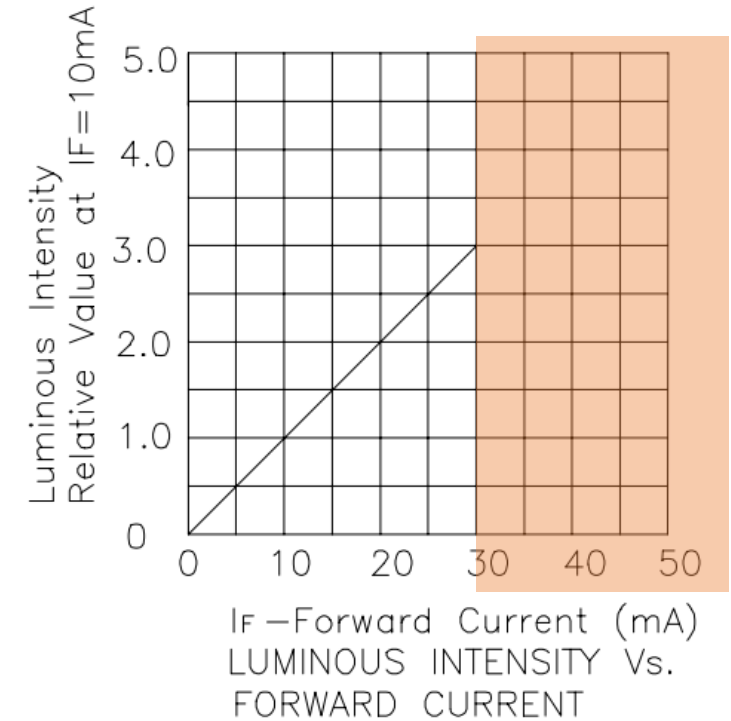
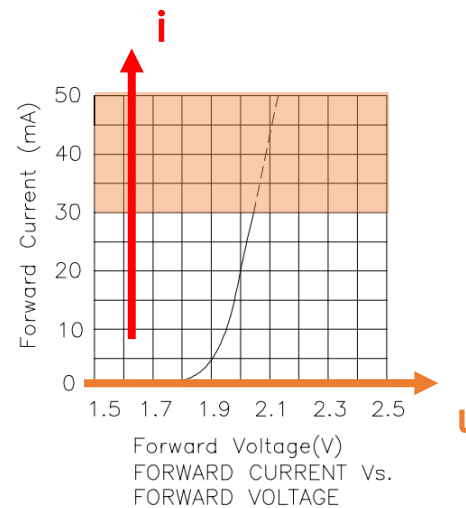
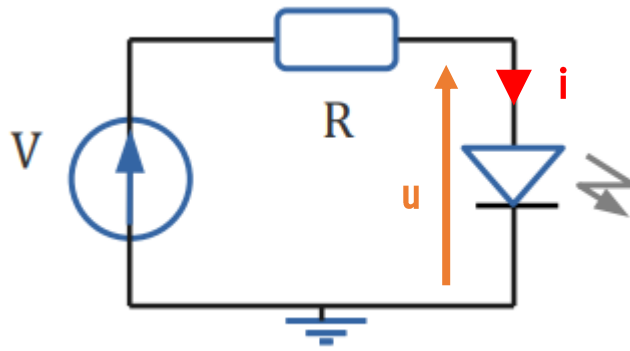
LED et circuit d'émission



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L-531D

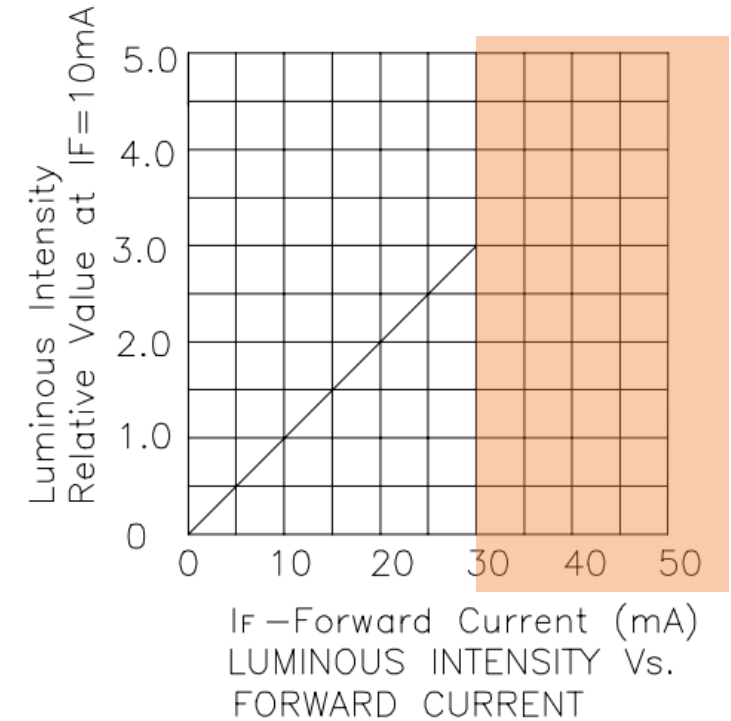
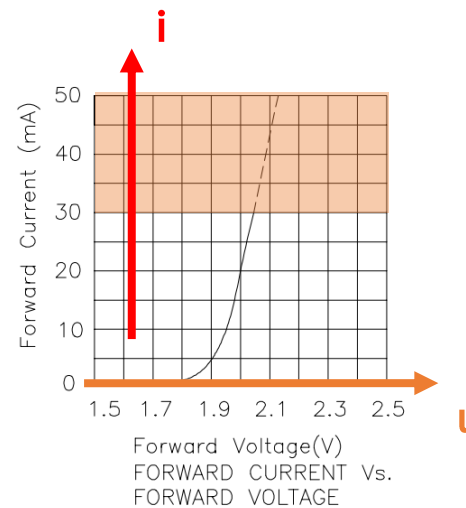
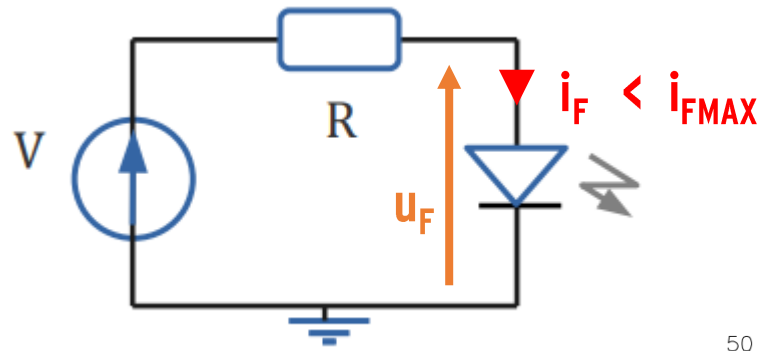
LED et circuit d'émission



Emetteur à LED

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High Efficiency Red

L-531D

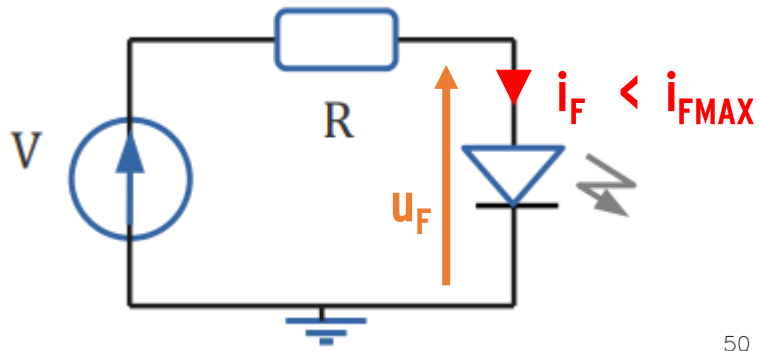
LED et circuit d'émission



Emetteur à LED

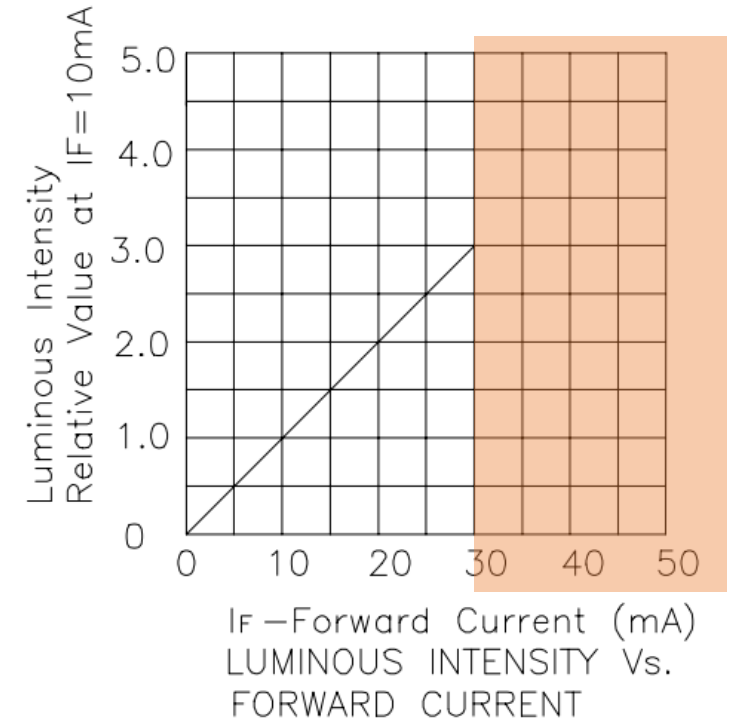
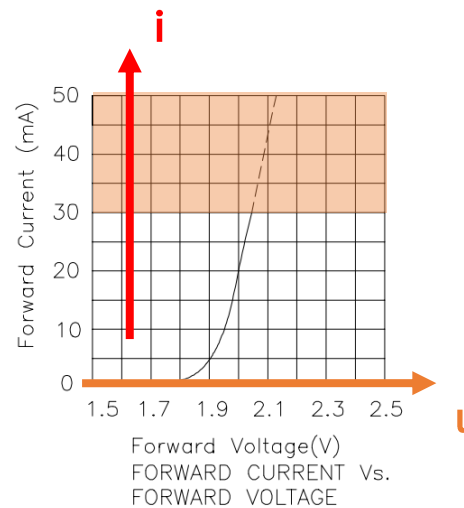
Idéalement : source de courant

En pratique : source de tension associée à une résistance



Loi d'Ohms et loi des mailles

$$R \cdot i_F = V - u_F$$



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High Efficiency Red

L-531D

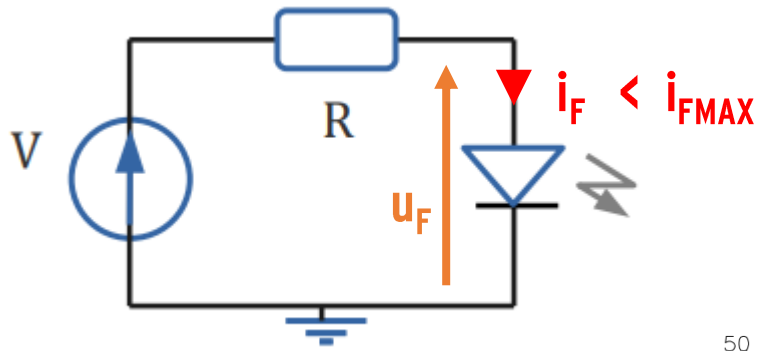
LED et circuit d'émission



Emetteur à LED

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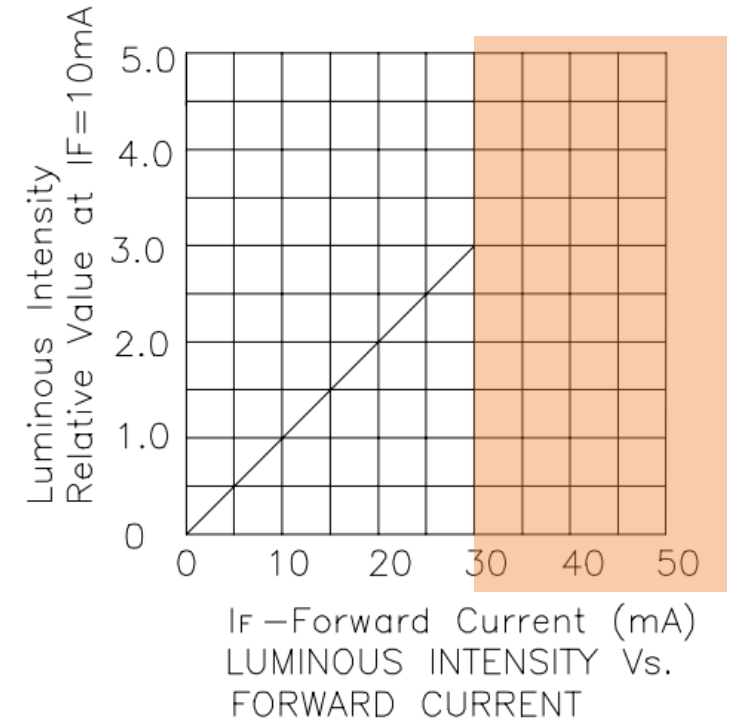
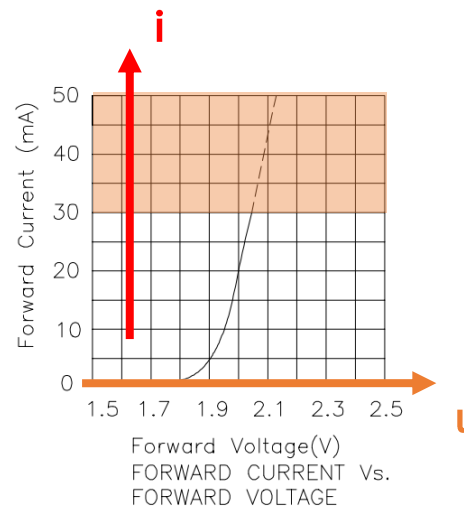
En pratique : source de tension associée à une résistance



Loi d'Ohms et loi des mailles

$$R \cdot i_F = V - u_F$$

$$i_F = (V - u_F) / R < i_{FMAX}$$



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High Efficiency Red

L-531D

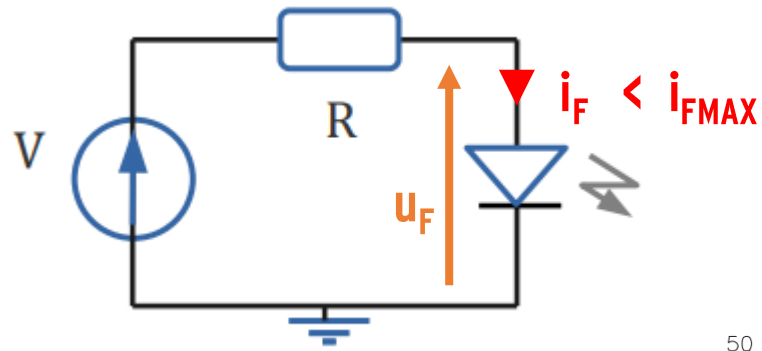
LED et circuit d'émission



Emetteur à LED

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Loi d'Ohms et loi des mailles

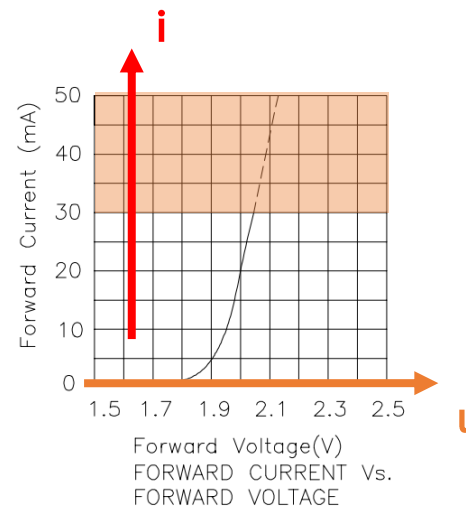
$$R \cdot i_F = V - u_F$$

$$i_F = (V - u_F) / R < i_{FMAX}$$

Cas critique

$$i_F = i_{FMAX} \quad \text{lorsque } V = V_{MAX}$$

$$i_{FMAX} = (V_{MAX} - u_F) / R$$



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High Efficiency Red

L-531D

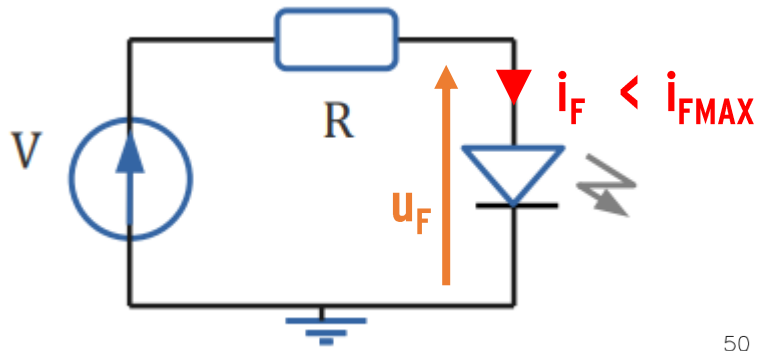
LED et circuit d'émission



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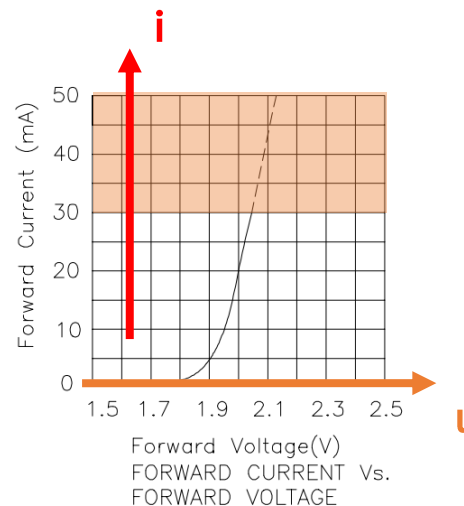
$$i_F = (V - u_F) / R < i_{FMAX}$$

Cas critique

$$i_F = i_{FMAX} \text{ lorsque } V = V_{MAX}$$

$$i_{FMAX} = (V_{MAX} - u_F) / R$$

$$R > (V_{MAX} - u_F) / i_{FMAX}$$



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High Efficiency Red

L-531D

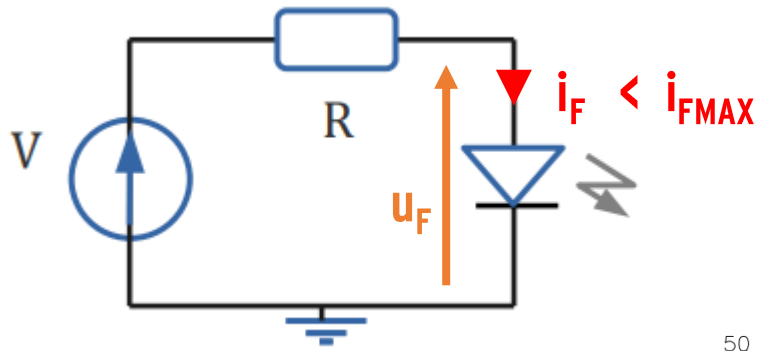
LED et circuit d'émission



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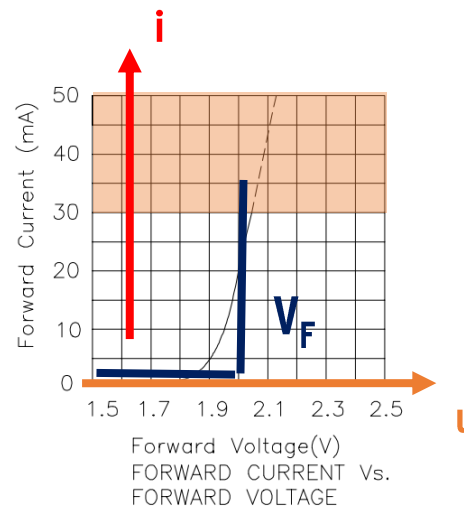
$$i_F = (V - u_F) / R < i_{FMAX}$$

Cas critique

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High Efficiency Red

L-531D

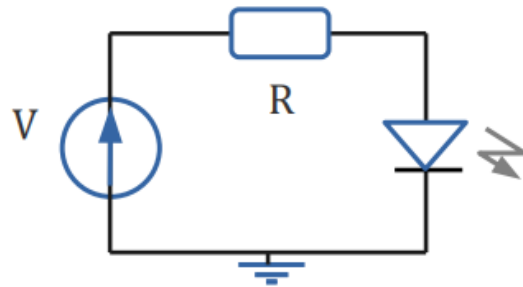
LED et circuit d'émission



Emetteur à LED

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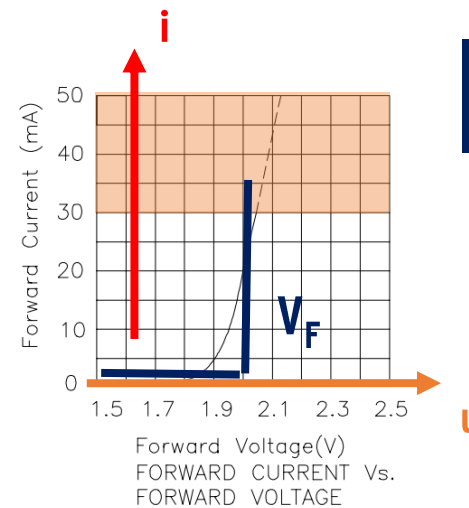
Cas critique

$$i_F = i_{FMAX} \quad \text{lorsque } V = V_{MAX}$$

$$i_{FMAX} = (V_{MAX} - u_F) / R$$

Electrical / Optical Characteristics at $T_A=25^\circ\text{C}$

Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
λ_{peak}	Peak Wavelength	High Efficiency Red	627		nm	$I_F=20\text{mA}$
λ_D	Dominate Wavelength	High Efficiency Red	625		nm	$I_F=20\text{mA}$
$\Delta\lambda_{1/2}$	Spectral Line Half-width	High Efficiency Red	45		nm	$I_F=20\text{mA}$
C	Capacitance	High Efficiency Red	15		pF	$V_F=0\text{V}; f=1\text{MHz}$
V_F	Forward Voltage	High Efficiency Red	2.0	2.5	V	$I_F=20\text{mA}$
I_R	Reverse Current	High Efficiency Red		10	μA	$V_R = 5\text{V}$



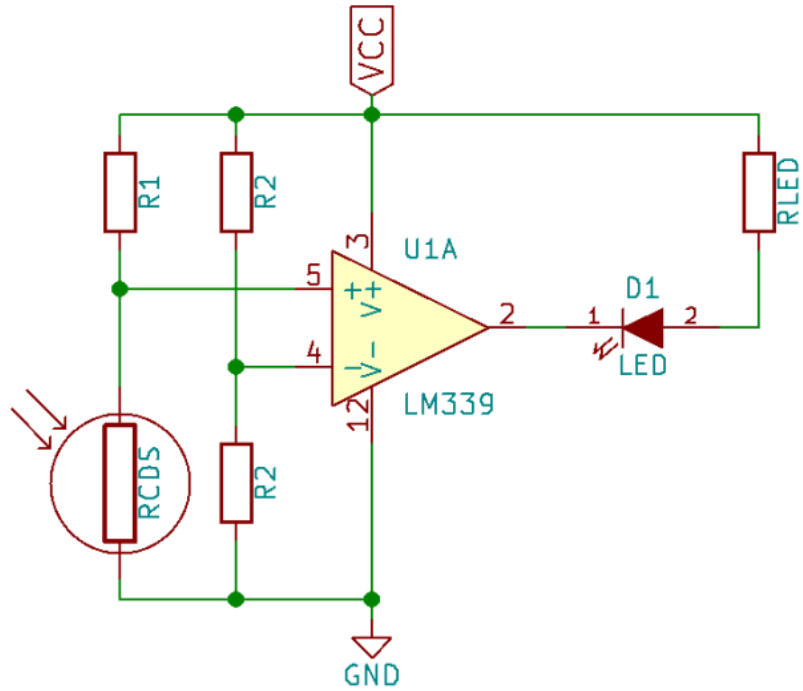
$$R > (V_{MAX} - V_F) / i_{FMAX}$$

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 High Efficiency Red L-53ID

LED dans les structures

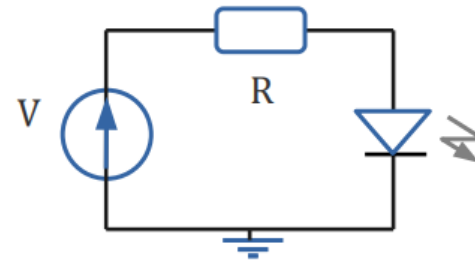


Structure E1



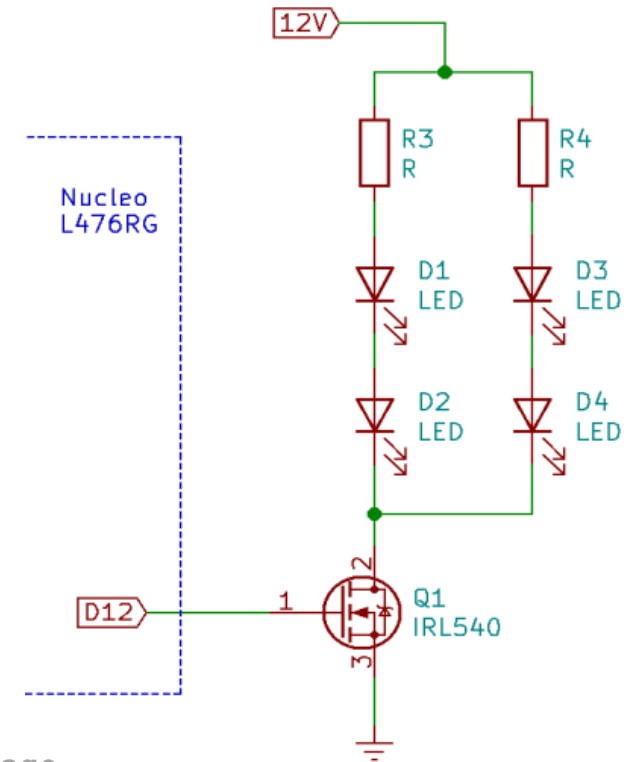
Voyant d'affichage

Structures P1 et P2



Source d'émission

Structure N2



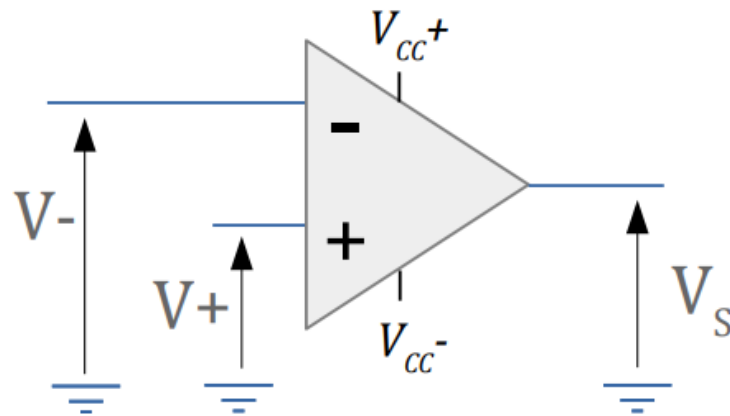
Eclairage

Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



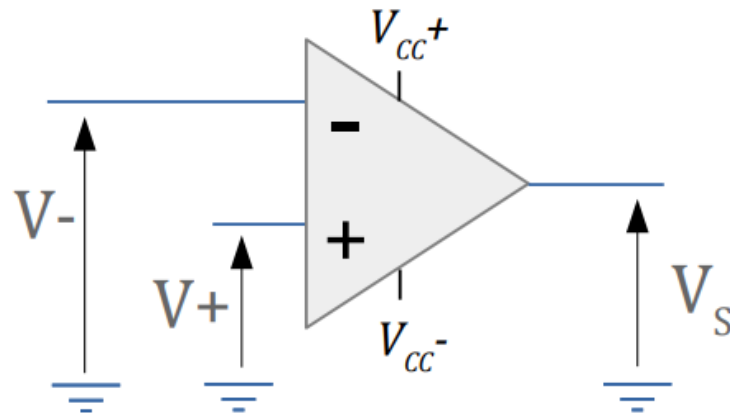
Cas idéal : $i_+ = i_- = 0$

Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



Cas idéal : $i_+ = i_- = 0$

6.2 Absolute Maximum Ratings: All Devices Except TL07xH

over operating free-air temperature range (unless otherwise noted) ⁽¹⁾

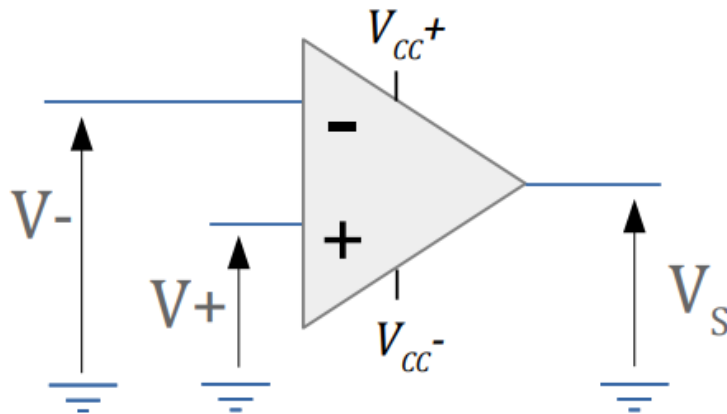
		MIN	MAX	UNIT
$V_{CC+} - V_{CC-}$	Supply voltage	-0.3	36	V
V_I	Input voltage ⁽³⁾	$V_{CC-} - 0.3$	$V_{CC+} + 36$	V
I_{IK}	Input clamp current		-50	mA
	Duration of output short circuit ⁽²⁾	Unlimited		
T_J	Operating virtual junction temperature		150	°C
	Case temperature for 60 seconds - FK package		260	°C
	Lead temperature 1.8 mm (1/16 inch) from case		300	°C
T_{stg}	Storage temperature	-65	150	°C

Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



Limite de la tension de sortie

$$V_{CC-} < V_S < V_{CC+}$$

Cas idéal : $i_+ = i_- = 0$

6.2 Absolute Maximum Ratings: All Devices Except TL07xH

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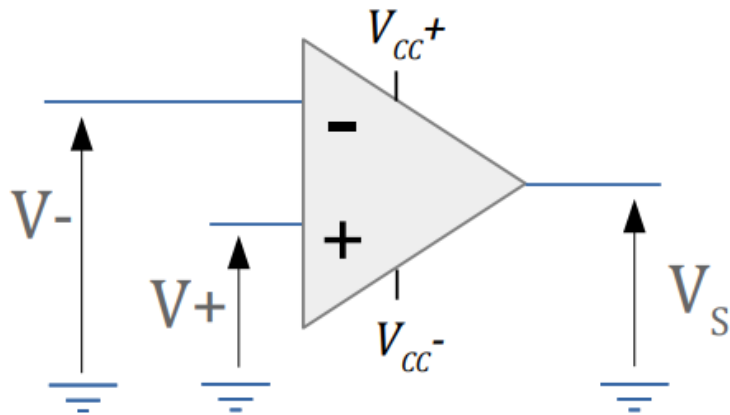
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Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$

Limite de la tension de sortie

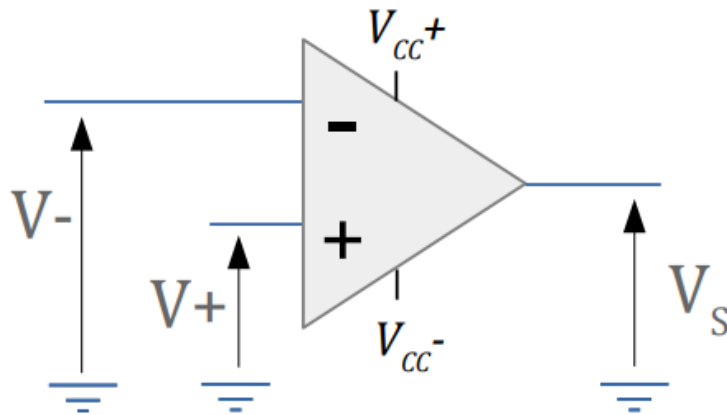
$$V_{CC}^- < V_S < V_{CC}^+$$

Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z_{ID}	Differential		100 2	MΩ pF
Z_{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, (V_{CC-}) + 0.3 \text{ V} < V_O < (V_{CC+}) - 0.3 \text{ V}$	118 125	dB
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, R_L = 2 \text{ k}\Omega, (V_{CC-}) + 1.2 \text{ V} < V_O < (V_{CC+}) - 1.2 \text{ V}$	115 120	dB
FREQUENCY RESPONSE				
GBW	Gain-bandwidth product		5.25	MHz
SR	Slew rate	$V_S = 40 \text{ V}, G = +1, C_L = 20 \text{ pF}$	20	V/μs

$$A_{OL} = 20 \cdot \log(A)$$

$$\rightarrow A = 10^{(A_{OL} / 20)} \approx 10^6$$

Limite de la tension de sortie

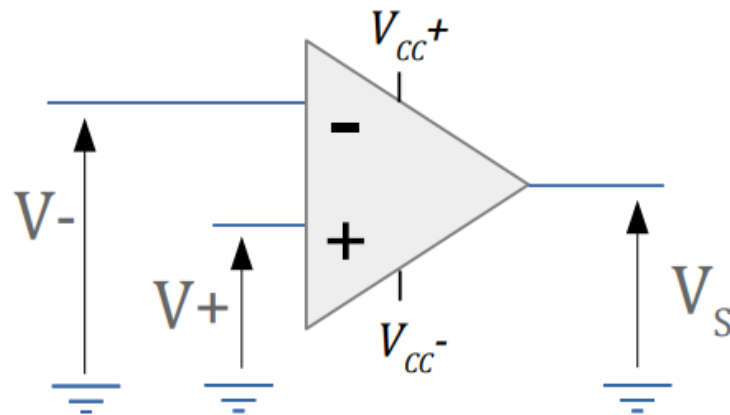
$$V_{CC-} < V_S < V_{CC+}$$

Amplificateur Linéaire Intégré



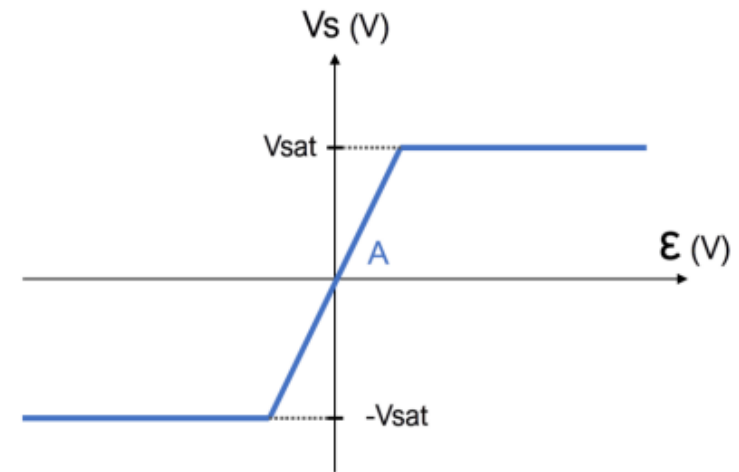
Composant actif

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$



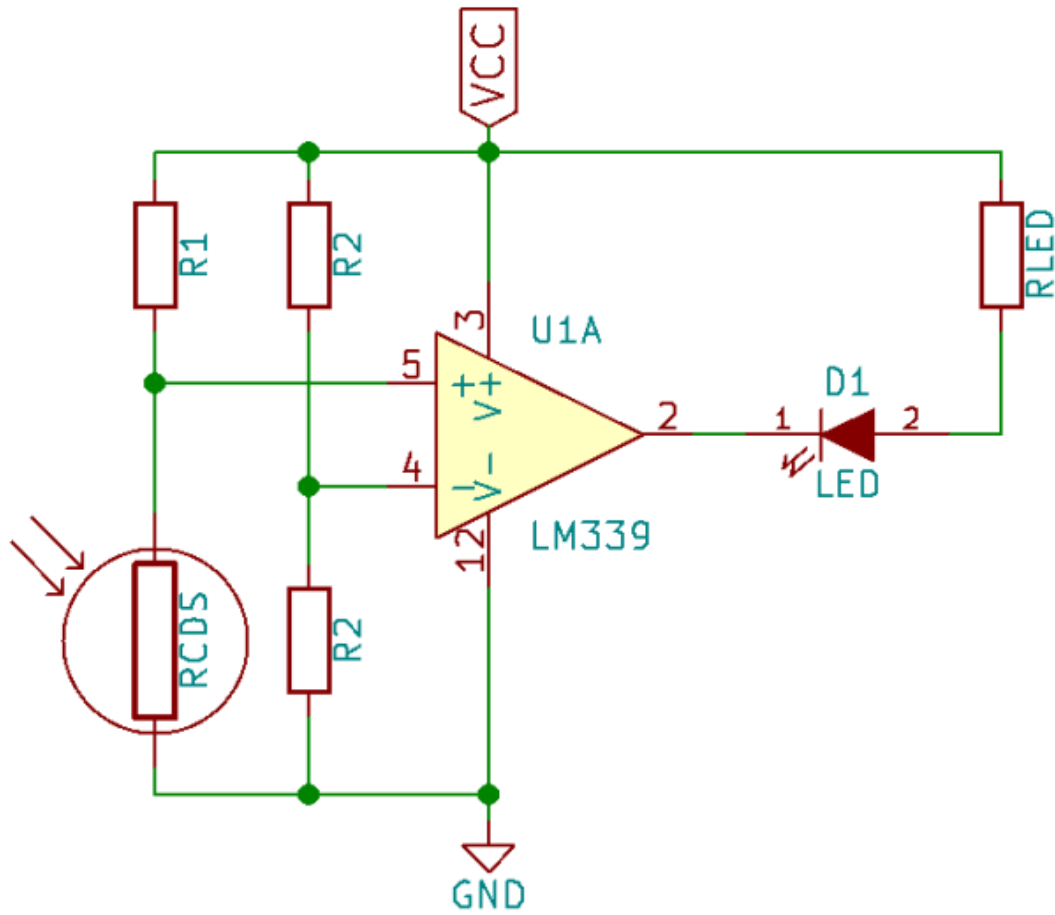
$$A_{0L} = 20 \cdot \log(A)$$

$$\rightarrow A = 10^{(A_{0L} / 20)} \approx 10^6$$

Limite de la tension de sortie

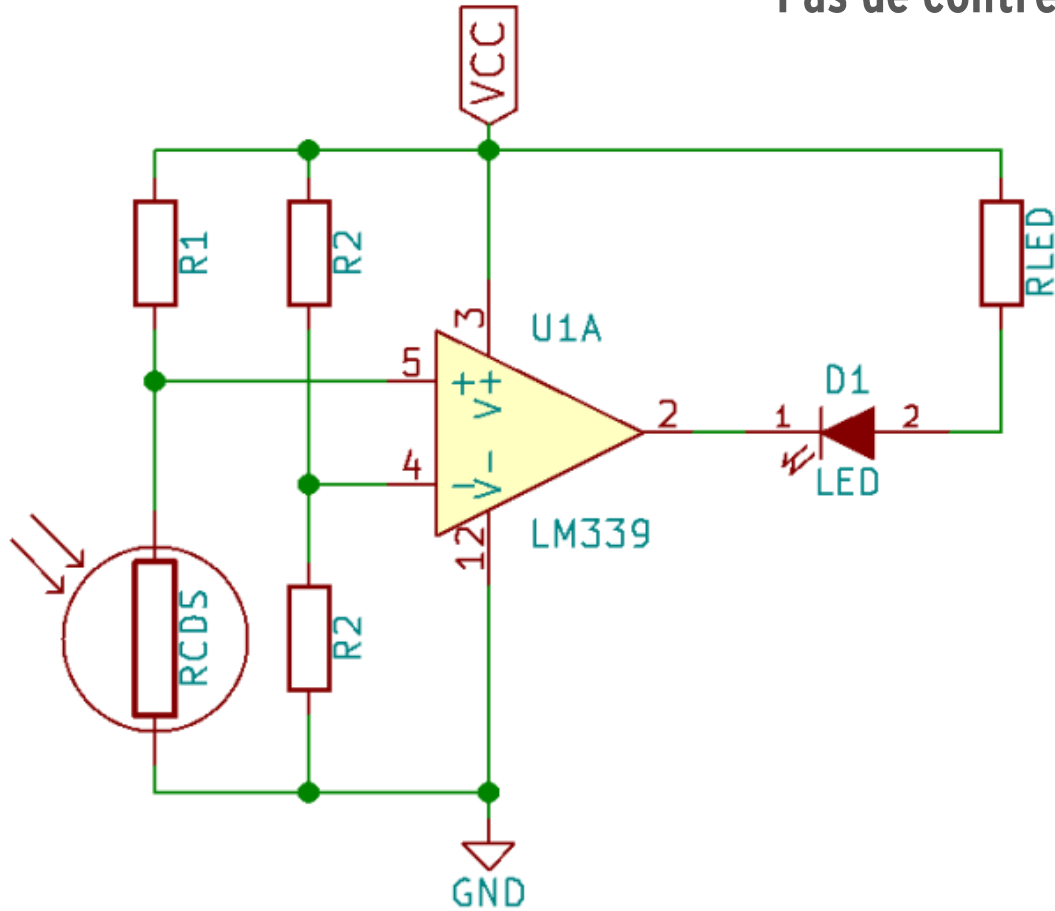
$$V_{CC^-} < V_S < V_{CC^+}$$

Structure E1

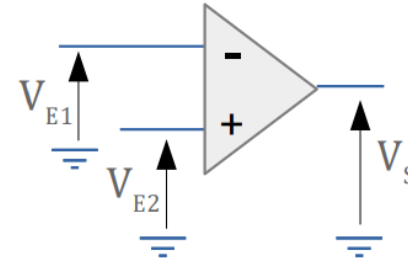


Structure E1

Pas de contre-réaction → Boucle ouverte



→ Comparateur



$$V_S = V_{CC+}$$

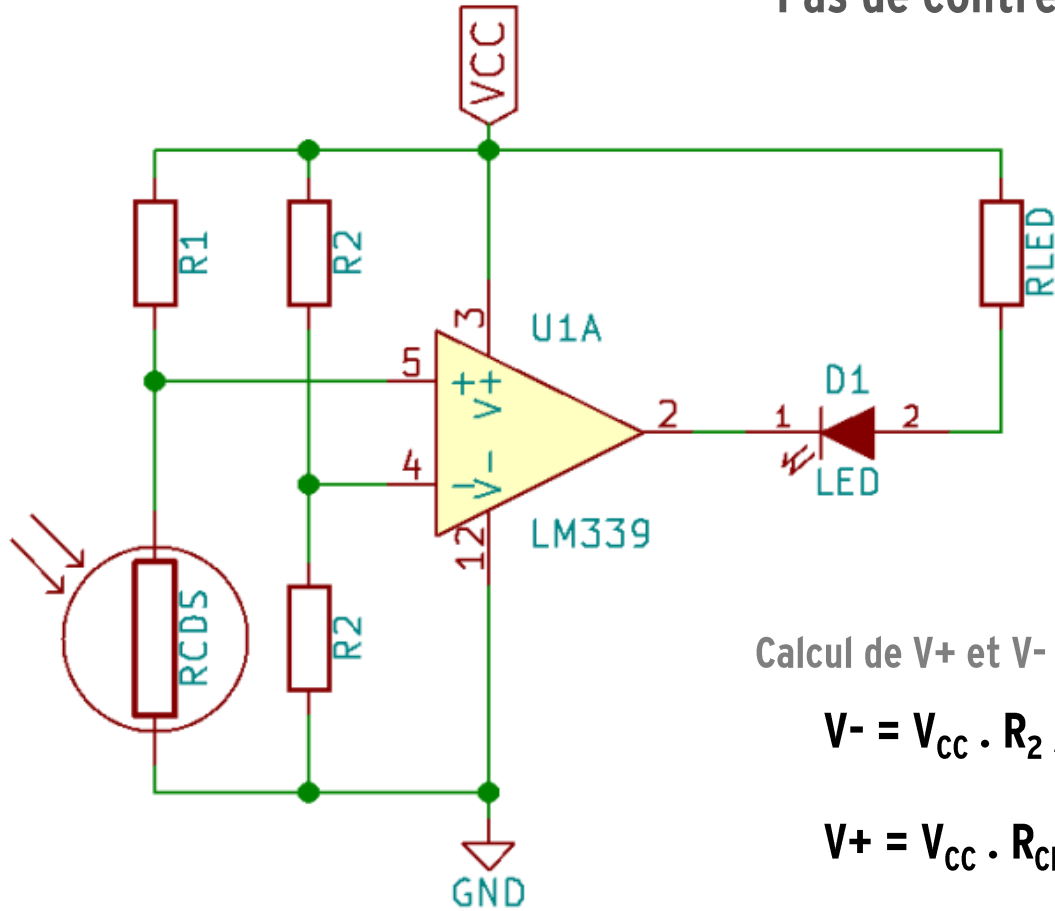
Si $V_{E2} > V_{E1}$

$$V_S = V_{CC-}$$

Si $V_{E1} > V_{E2}$

Structure E1

Pas de contre-réaction → Boucle ouverte

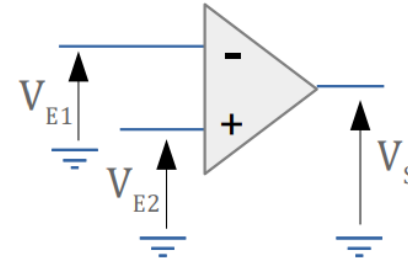


Calcul de V+ et V- (pont diviseur)

$$V_- = V_{CC} \cdot R_2 / (R_2 + R_2)$$

$$V_+ = V_{CC} \cdot R_{CDS} / (R_1 + R_{CDS})$$

→ Comparateur



$$V_S = V_{CC}^+$$

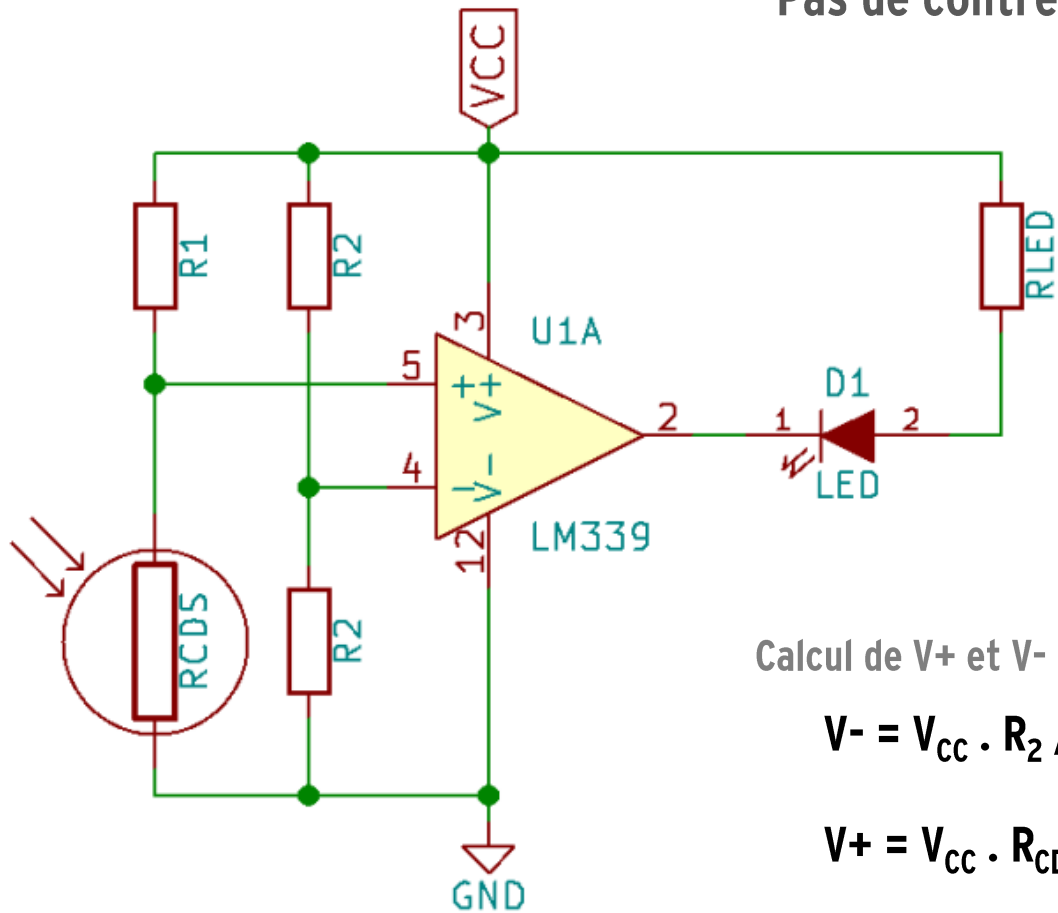
Si $V_{E2} > V_{E1}$

$$V_S = V_{CC}^-$$

Si $V_{E1} > V_{E2}$

Structure E1

Pas de contre-réaction → Boucle ouverte

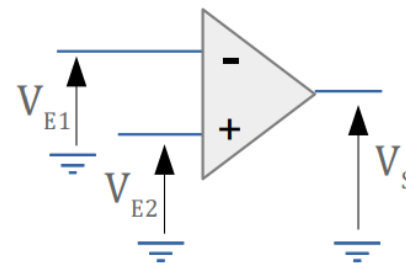


Calcul de V_+ et V_- (pont diviseur)

$$V_- = V_{CC} \cdot R_2 / (R_2 + R_2)$$

$$V_+ = V_{CC} \cdot R_{CDS} / (R_1 + R_{CDS})$$

→ Comparateur

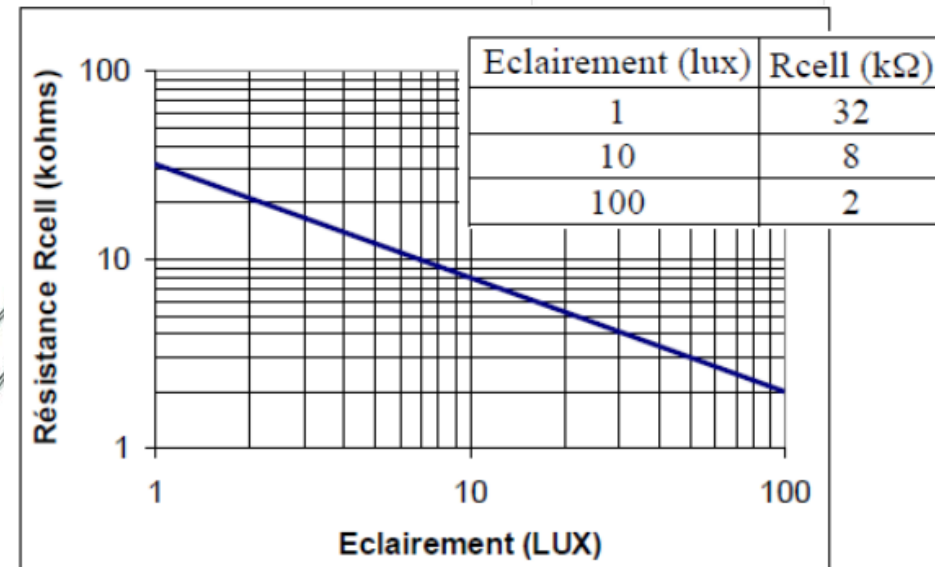


$$V_S = V_{CC}^+$$

$$\text{Si } V_{E2} > V_{E1}$$

$$V_S = V_{CC}^-$$

$$\text{Si } V_{E1} > V_{E2}$$

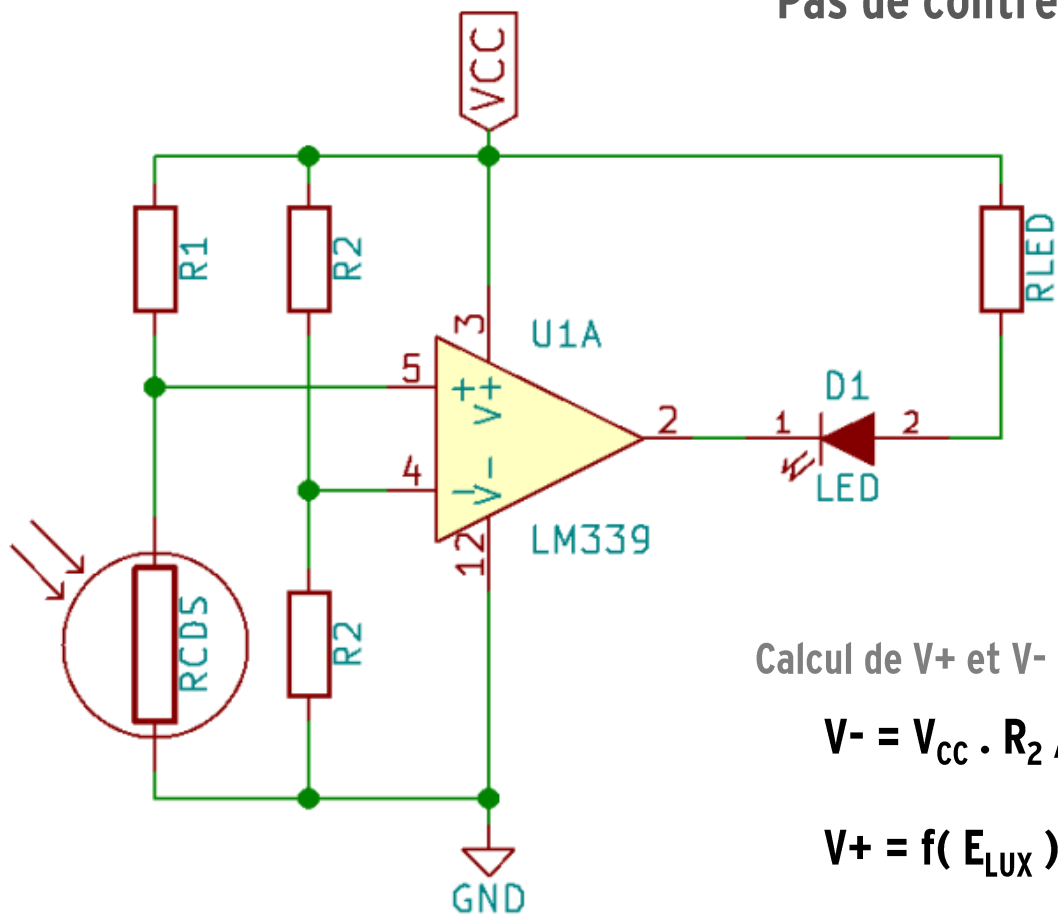


Evolution de la résistance en fonction de l'éclairage



Structure E1

Pas de contre-réaction → Boucle ouverte

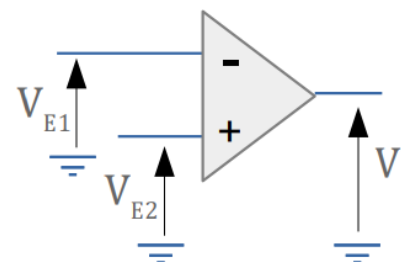


Calcul de $V+$ et $V-$ (pont diviseur)

$$V^- = V_{CC} \cdot R_2 / (R_2 + R_2)$$

$$V^+ = f(E_{LUX})$$

→ Comparateur

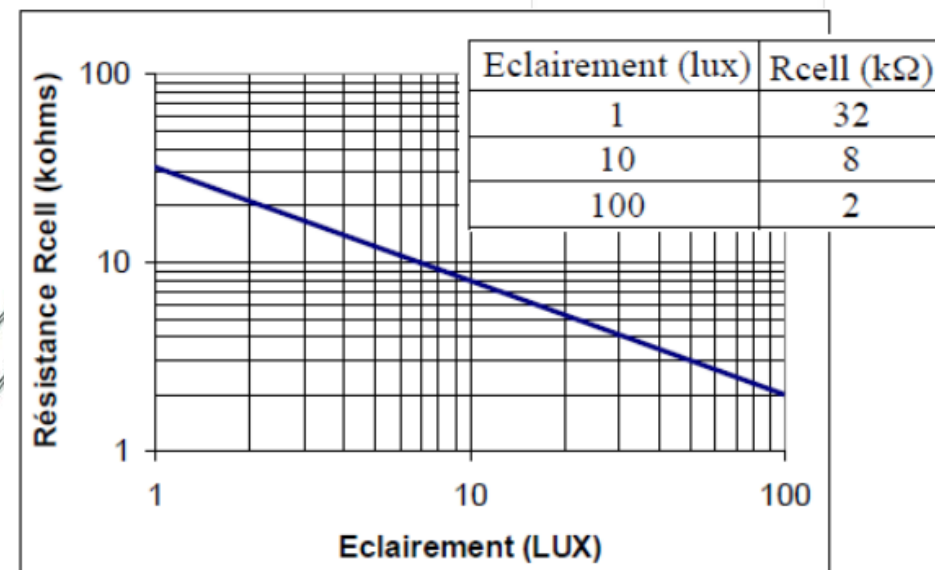


$$V_S = V_{CC}^+$$

$$\text{Si } V_{E2} > V_{E1}$$

$$V_S = V_{CC}^-$$

$$\text{Si } V_{E1} > V_{E2}$$

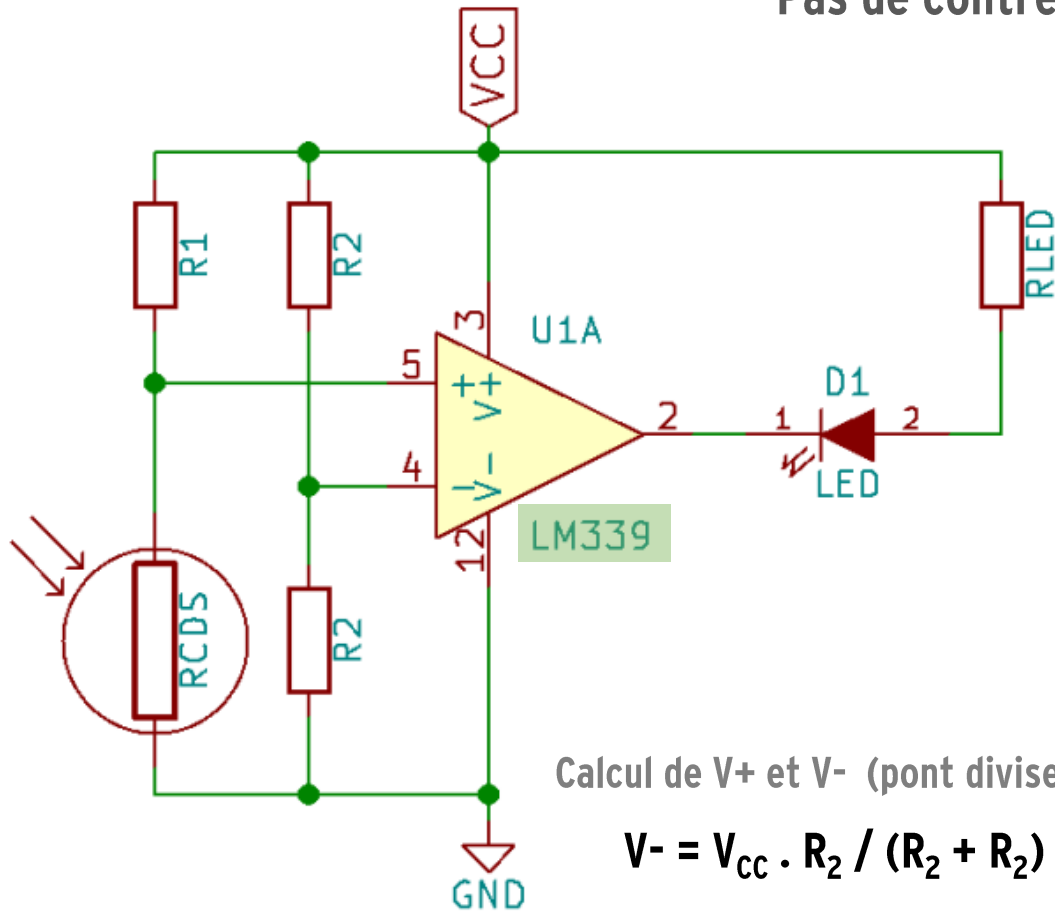


Evolution de la résistance en fonction de l'éclairage



Structure E1

Pas de contre-réaction → Boucle ouverte



Calcul de V_+ et V_- (pont diviseur)

$$V_- = V_{CC} \cdot R_2 / (R_2 + R_2)$$

$$V_+ = f(E_{LUX})$$

→ Comparateur à collecteur ouvert

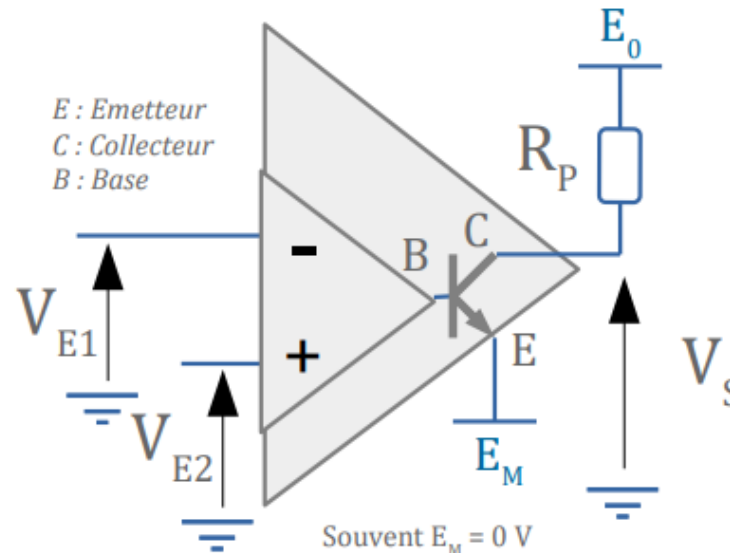
Comparateur associé à un transistor T :

I_B : courant entrant dans la base

I_C : courant entrant dans le collecteur

→ si $I_B > 0$ alors $I_C > 0$, T = interrupteur fermé

→ sinon $I_C = 0$, T = interrupteur ouvert



$$\text{Si } V_{E2} > V_{E1} \\ \rightarrow I_B > 0$$

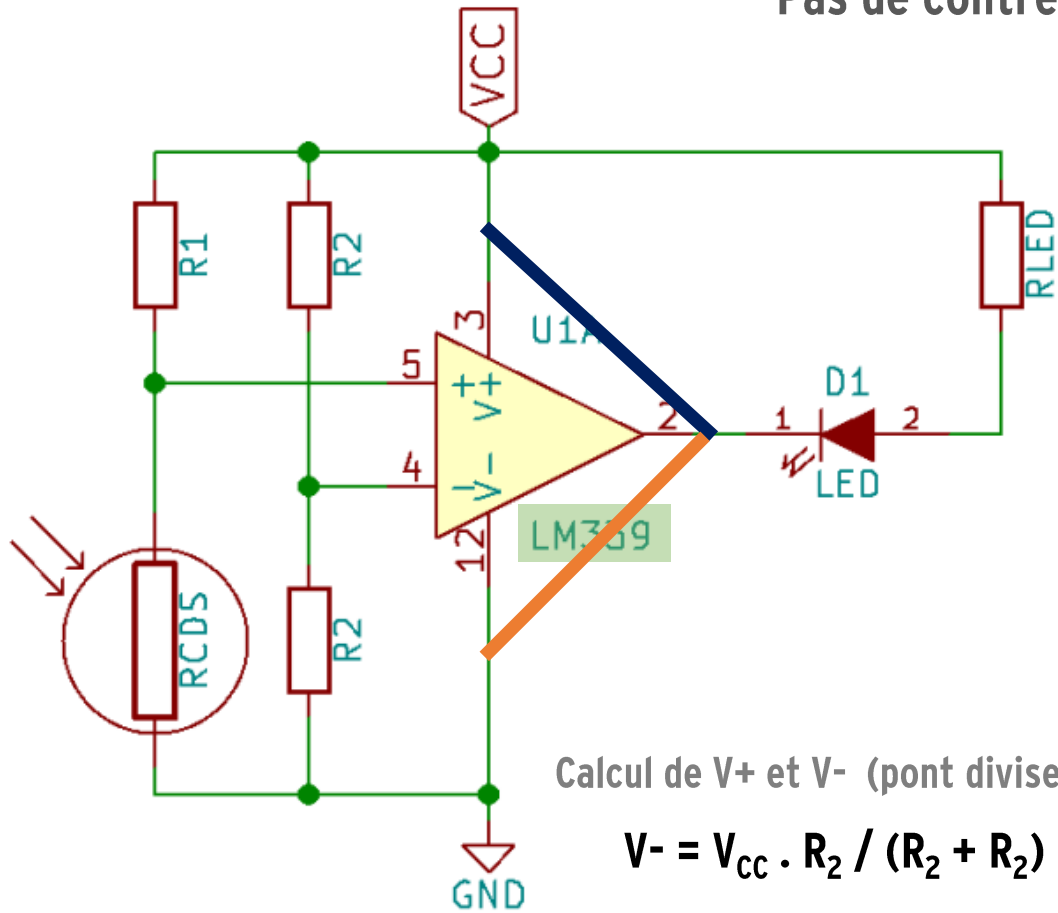
$$V_S = E_M$$

$$\text{Si } V_{E1} > V_{E2} \\ \rightarrow I_B = 0$$

$$V_S = E_0$$

Structure E1

Pas de contre-réaction → Boucle ouverte



Calcul de V_+ et V_- (pont diviseur)

$$V_- = V_{CC} \cdot R_2 / (R_2 + R_2)$$

$$V_+ = f(E_{LUX})$$

→ Comparateur à collecteur ouvert

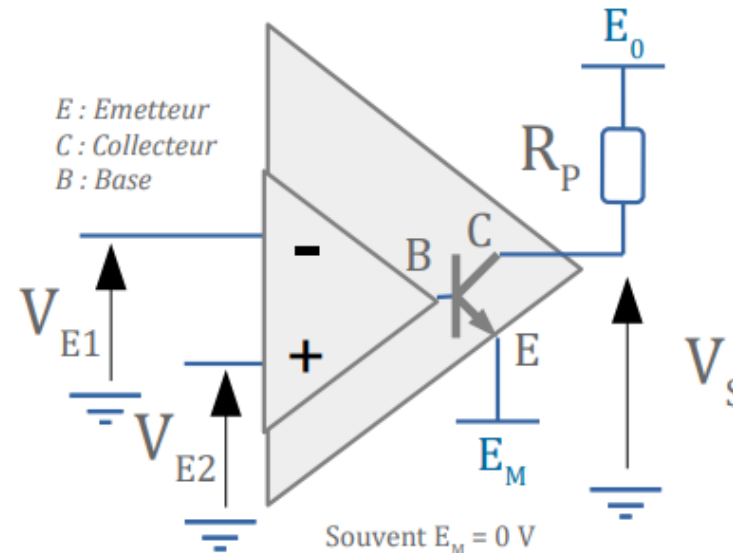
Comparateur associé à un transistor T :

I_B : courant entrant dans la base

I_C : courant entrant dans le collecteur

→ si $I_B > 0$ alors $I_C > 0$, T = interrupteur fermé

→ sinon $I_C = 0$, T = interrupteur ouvert



$$\text{Si } V_{E2} > V_{E1} \\ \rightarrow I_B > 0$$

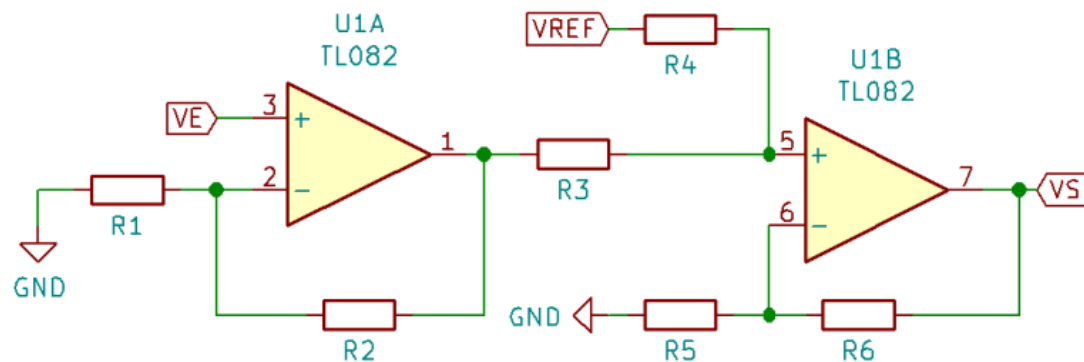
$$\underline{V_S = E_M}$$

$$\text{Si } V_{E1} > V_{E2} \\ \rightarrow I_B = 0$$

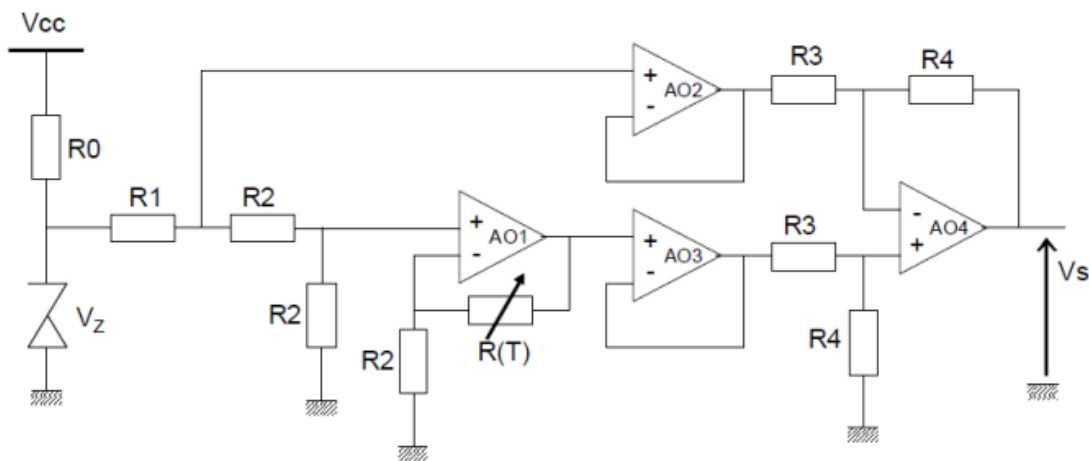
$$\underline{V_S = E_0}$$

Autres structures à ALI

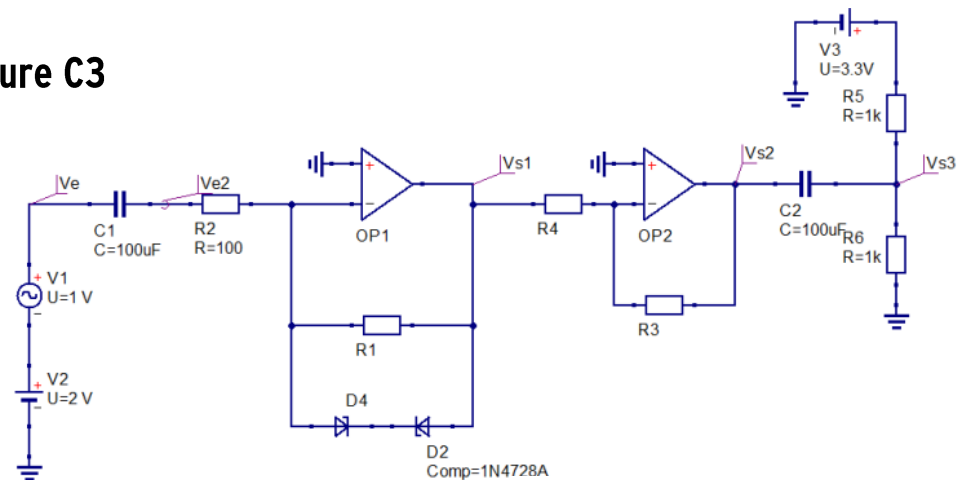
Structure C1



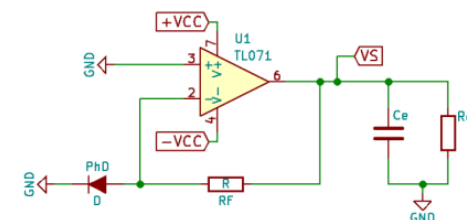
Structure C2



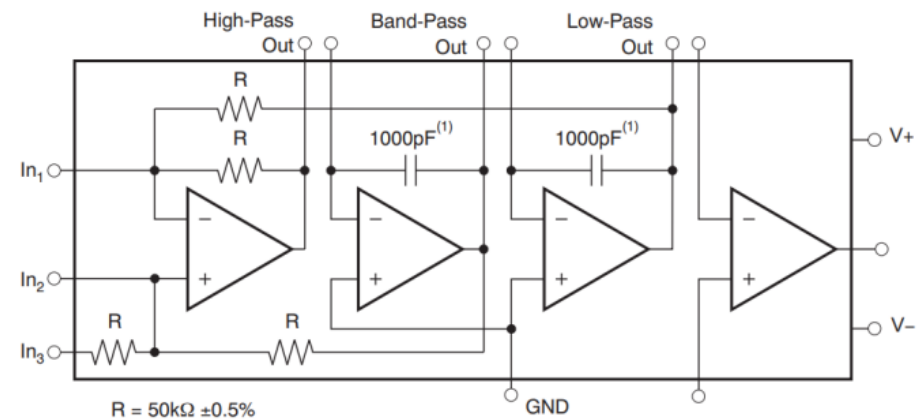
Structure C3



Structure P2

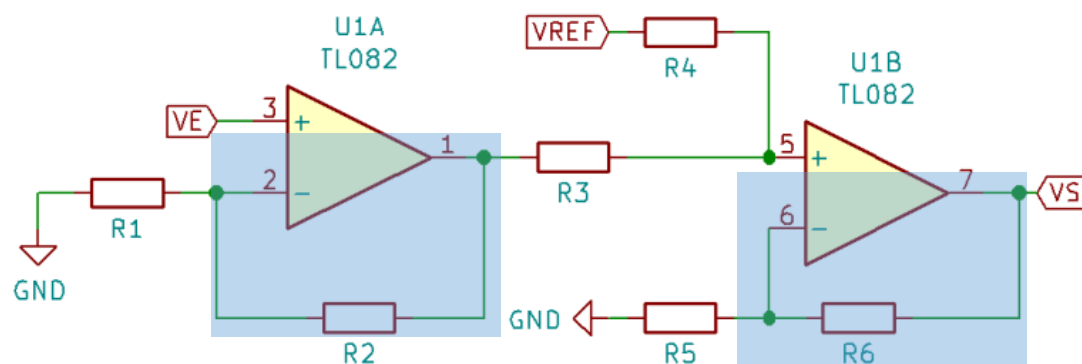


Structure F2

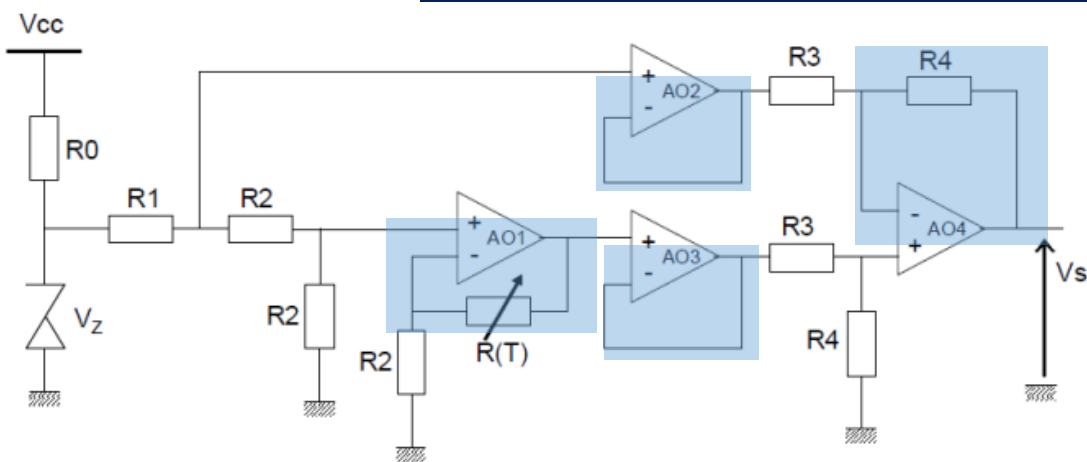


Autres structures à ALI

Structure C1

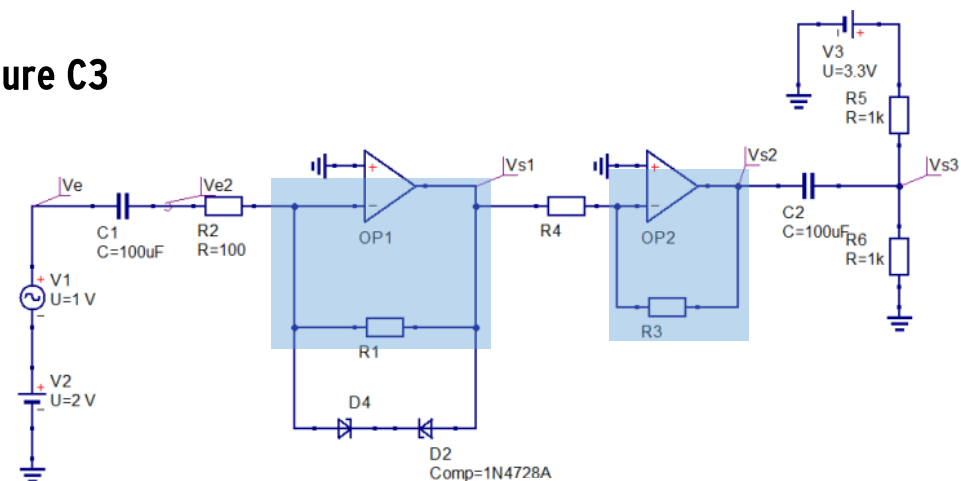


Structure C2

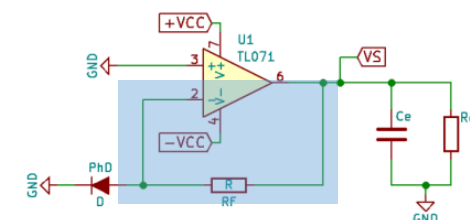


**Contre-réaction négative
→ FONCTIONNEMENT LINEAIRE**

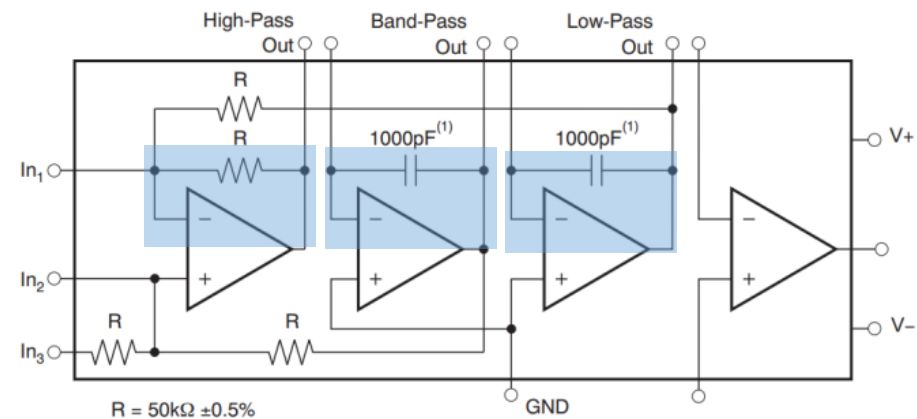
Structure C3



Structure P2



Structure F2

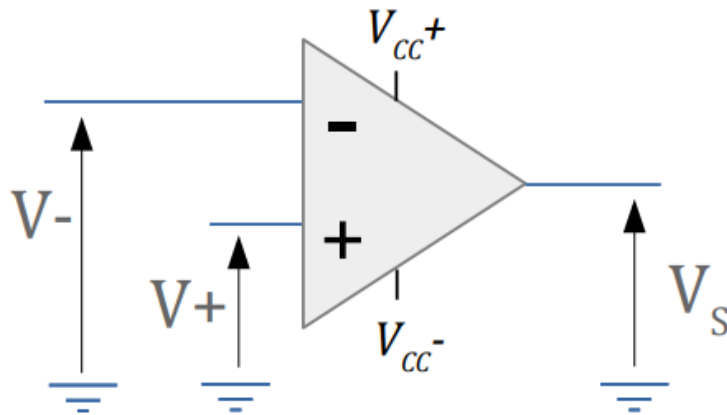


Amplificateur Linéaire Intégré



Composant actif

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z_{ID}	Differential		100 2	MΩ pF
Z_{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, (V_{CC-}) + 0.3 \text{ V} < V_O < (V_{CC+}) - 0.3 \text{ V}$	118 125	dB
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, R_L = 2 \text{ k}\Omega, (V_{CC-}) + 1.2 \text{ V} < V_O < (V_{CC+}) - 1.2 \text{ V}$	115 120	dB
FREQUENCY RESPONSE				
GBW	Gain-bandwidth product		5.25	MHz
SR	Slew rate	$V_S = 40 \text{ V}, G = +1, C_L = 20 \text{ pF}$	20	V/μs

Limite de la tension de sortie

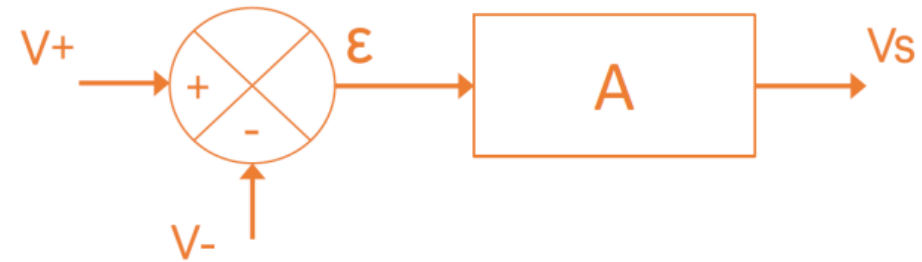
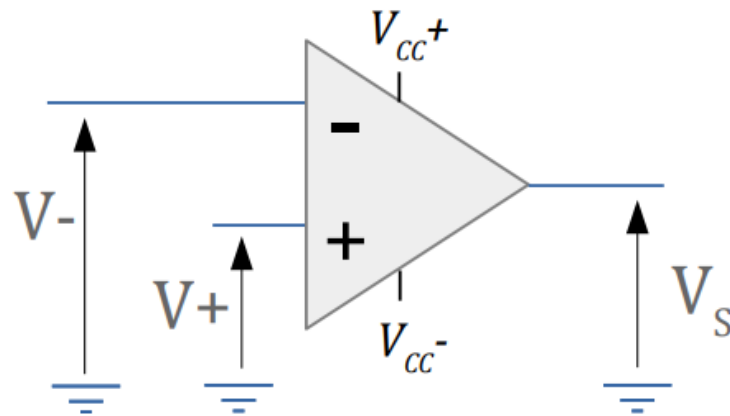
$$V_{CC-} < V_S < V_{CC+}$$

Amplificateur Linéaire Intégré



Modélisation des systèmes par schéma bloc

Systeme en boucle ouverte (zone linéaire)



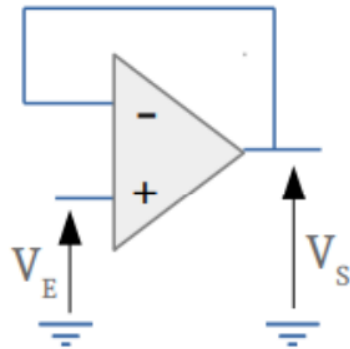
$$V_S = A \cdot (V^+ - V^-)$$

Amplificateur Linéaire Intégré



Modélisation des systèmes par schéma bloc

Rebouclage entre la sortie et l'entrée négative



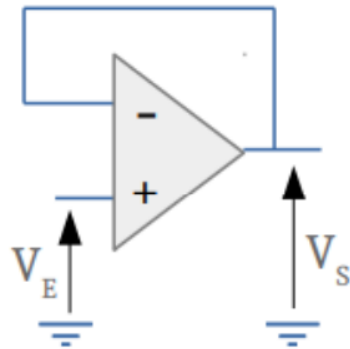
$$V_S = A \cdot (V^+ - V^-)$$

Amplificateur Linéaire Intégré

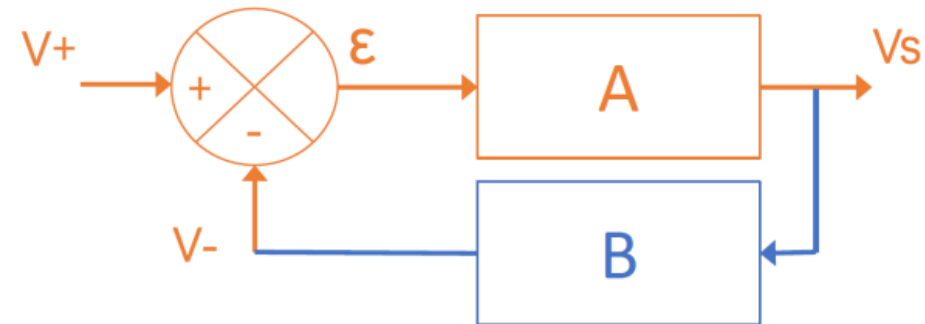


Modélisation des systèmes par schéma bloc

Rebouclage entre la sortie et l'entrée négative



$$V_S = A \cdot (V^+ - V^-)$$



$$V^+ = V_E$$

$$V^- = B \cdot V_S$$

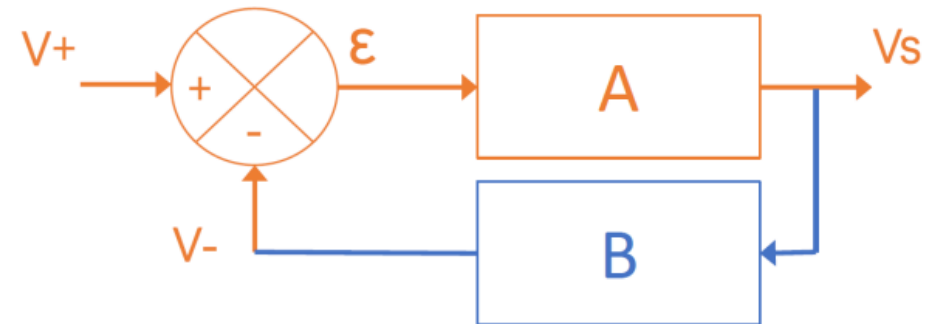
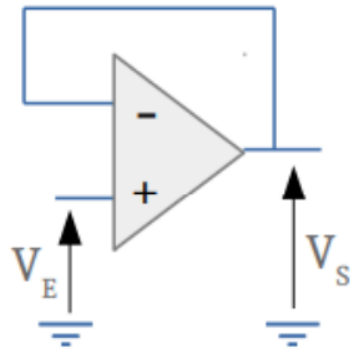
$$\rightarrow V_S = A \cdot (V_E - B \cdot V_S)$$

Amplificateur Linéaire Intégré



Modélisation des systèmes par schéma bloc

Rebouclage entre la sortie et l'entrée négative



$$V^+ = V_E$$

$$V^- = B \cdot V_S$$

$$V_S = A \cdot (V^+ - V^-)$$

$$\rightarrow V_S = A \cdot (V_E - B \cdot V_S)$$

$$V_S = \frac{A}{1 + A \cdot B} V_E$$

Amplificateur Linéaire Intégré

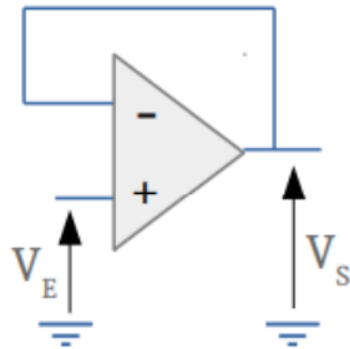


Modélisation des systèmes par schéma bloc

Rebouclage entre la sortie et l'entrée négative

$$V^+ = V_E$$

$$V^- = V_S$$



→ Fonctionnement linéaire

$$V^+ = V^-$$

$$V_S = V_E$$

Amplificateur Linéaire Intégré

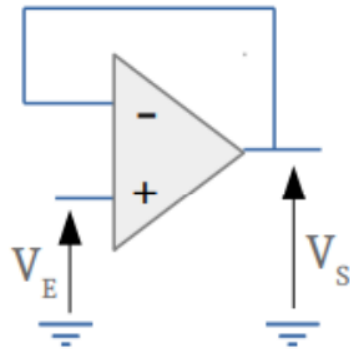


Modélisation des systèmes par schéma bloc

Rebouclage entre la sortie et l'entrée négative

$$V^+ = V_E$$

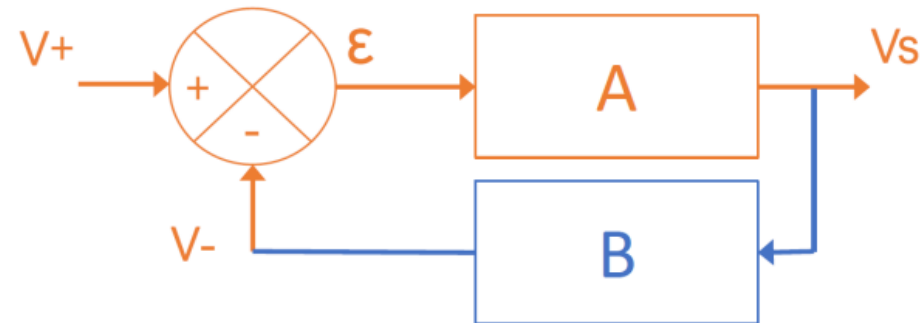
$$V^- = V_S$$



→ Fonctionnement linéaire

$$V^+ = V^-$$

$$V_S = V_E$$



$$V_S = \frac{A}{1 + A \cdot B} V_E$$

Amplificateur Linéaire Intégré

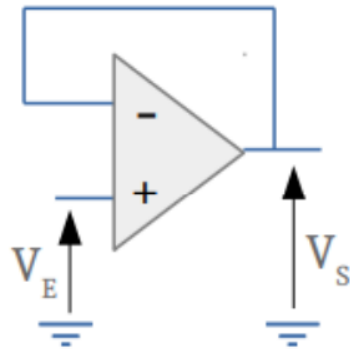


ALI en boucle fermée / Fonctionnement linéaire

Rebouclage entre la sortie et l'entrée négative

$$V^+ = V_E$$

$$V^- = V_S$$

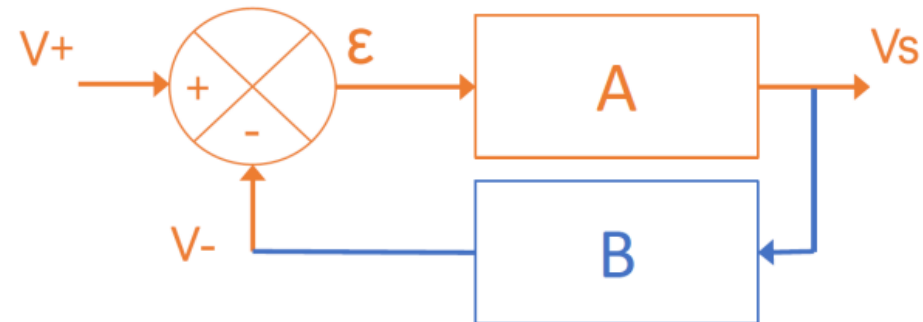


→ Fonctionnement linéaire

Hypothèse

$$V^+ = V^-$$

$$V_S = V_E$$



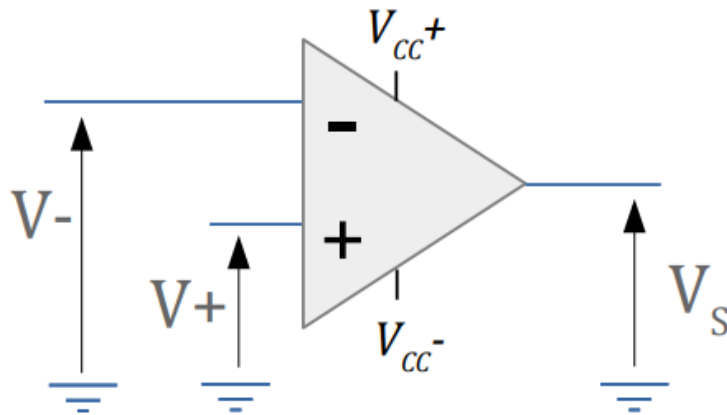
$$V_S = \frac{A}{1 + A \cdot B} V_E$$

Amplificateur Linéaire Intégré



Autre hypothèse...

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z_{ID}	Differential		100 2	MΩ pF
Z_{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, (V_{CC-}) + 0.3 \text{ V} < V_O < (V_{CC+}) - 0.3 \text{ V}$	118 125	dB
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, R_L = 2 \text{ k}\Omega, (V_{CC-}) + 1.2 \text{ V} < V_O < (V_{CC+}) - 1.2 \text{ V}$	115 120	dB
FREQUENCY RESPONSE				
GBW	Gain-bandwidth product		5.25	MHz
SR	Slew rate	$V_S = 40 \text{ V}, G = +1, C_L = 20 \text{ pF}$	20	V/μs

Limite de la tension de sortie

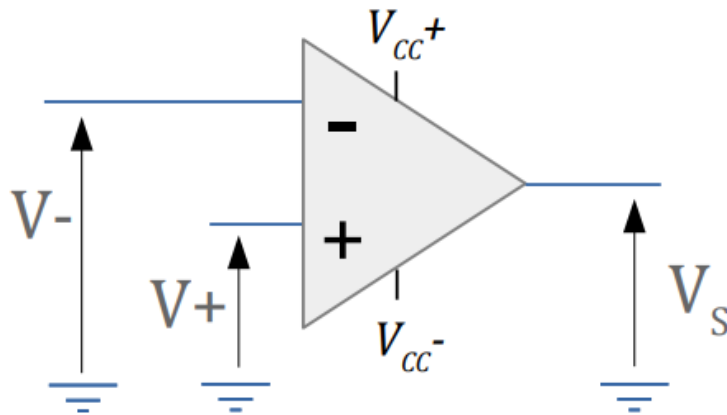
$$V_{CC-} < V_S < V_{CC+}$$

Amplificateur Linéaire Intégré



Autre hypothèse... vérifiée

Nécessitant une source d'énergie externe



$$V_S = A \cdot (V^+ - V^-)$$

Cas idéal : $i_+ = i_- = 0$

6.17 Electrical Characteristics: TL07xH

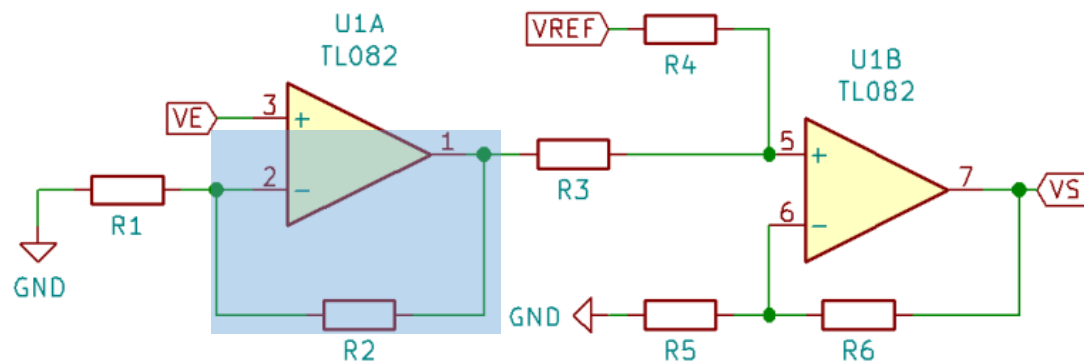
INPUT CAPACITANCE				
Z_{ID}	Differential		100 2	MΩ pF
Z_{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, (V_{CC-}) + 0.3 \text{ V} < V_O < (V_{CC+}) - 0.3 \text{ V}$	118 125	dB
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GBW	Gain-bandwidth product		5.25	MHz
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Limite de la tension de sortie

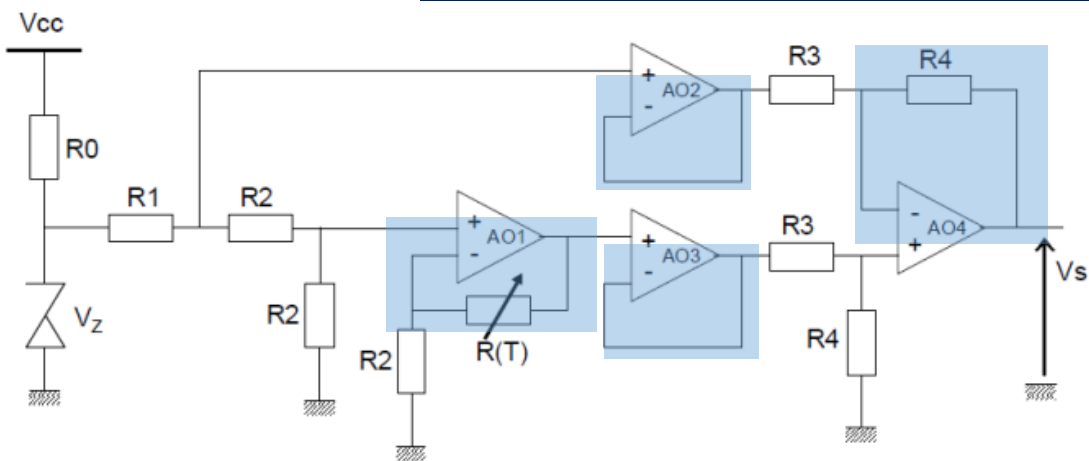
$$V_{CC-} < V_S < V_{CC+}$$

Autres structures à ALI

Structure C1

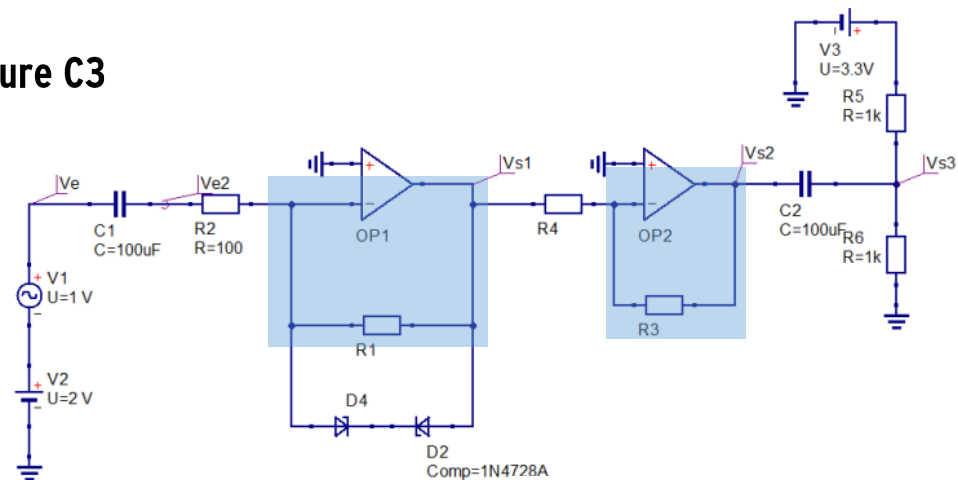


Structure C2

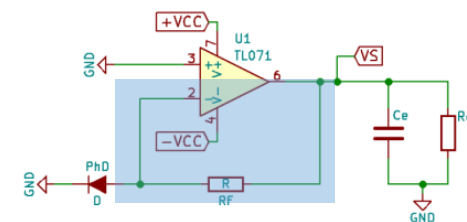


**Contre-réaction négative
→ FONCTIONNEMENT LINEAIRE**

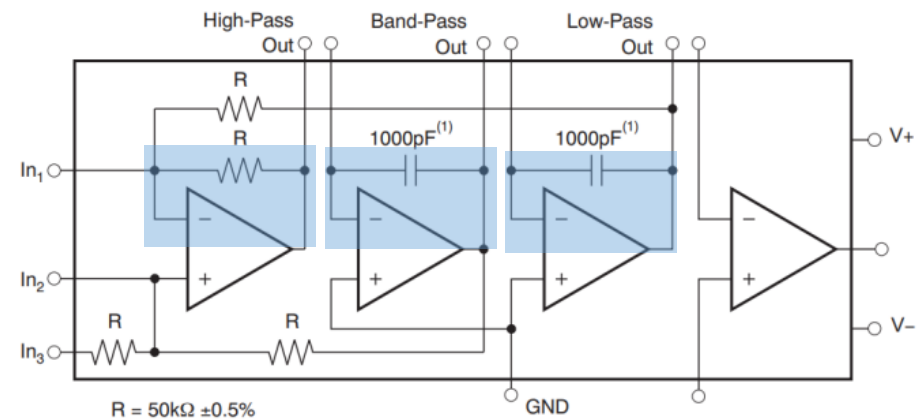
Structure C3



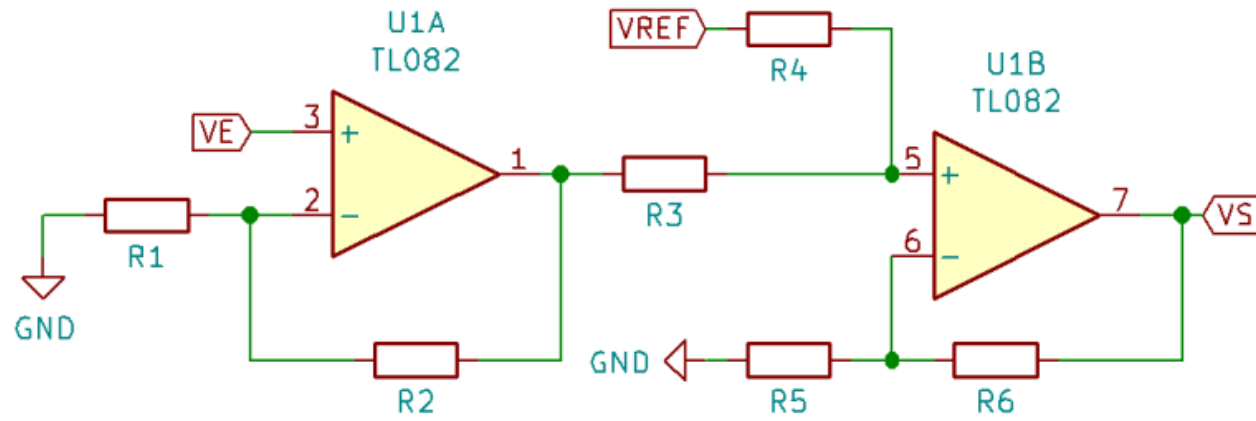
Structure P2



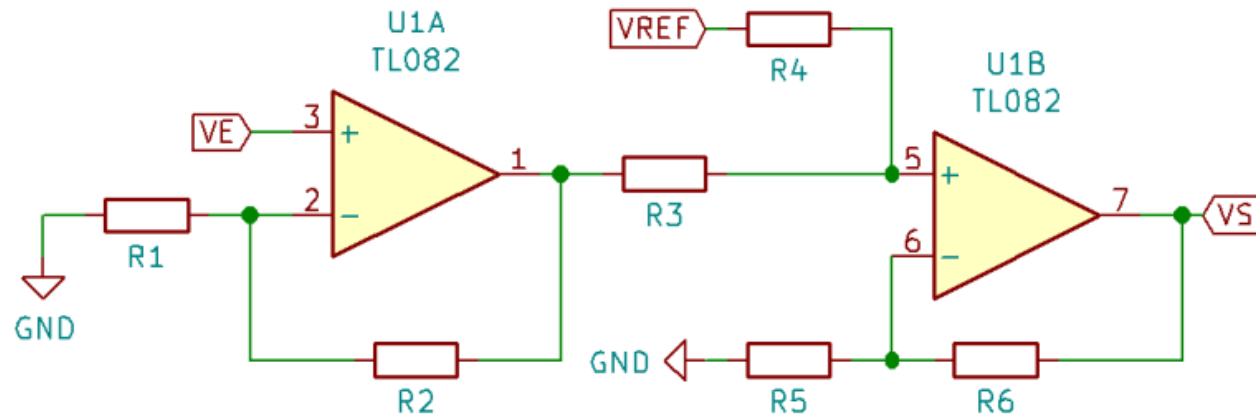
Structure F2



Structure C1



Structure C1



Montage non inverseur

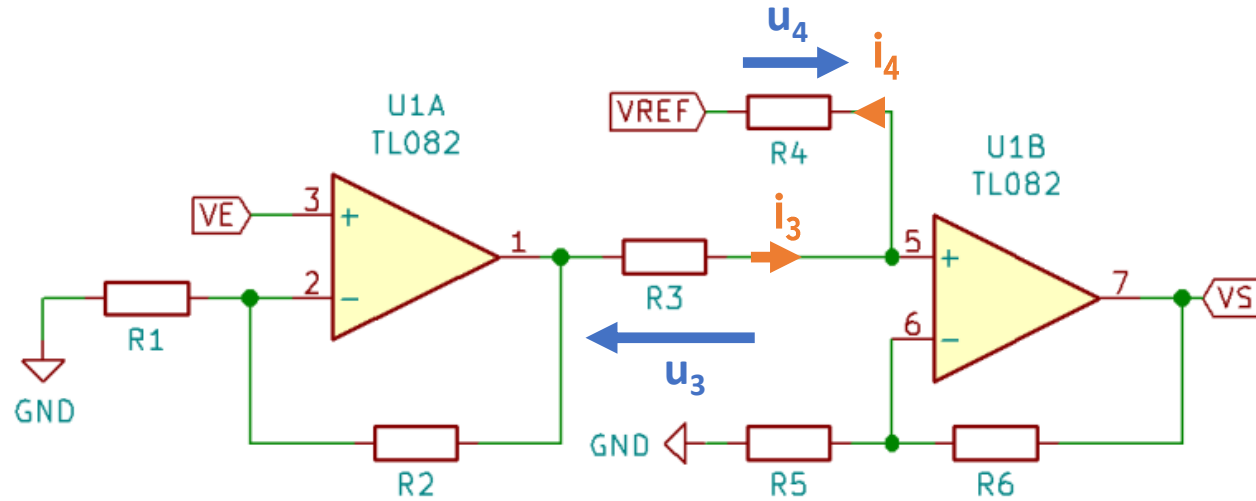
$$V^+ = V_E$$

$$V^- = R_1 \cdot V_{S1} / (R_1 + R_2)$$

$$V_{S1} = (1 + R_2/R_1) \cdot V_E$$

$$V_{S1} = a_1 \cdot V_E$$

Structure C1



Montage non inverseur

Montage additionneur

$$V^+ = V_E$$

$$V^- = R_1 \cdot V_{S1} / (R_1 + R_2)$$

$$V_{S1} = (1 + R_2/R_1) \cdot V_E$$

$$V_{S1} = a_1 \cdot V_E$$

$$\parallel \quad i_3 = u_3 / R_3 = (V_{S1} - V^+) / R_3$$

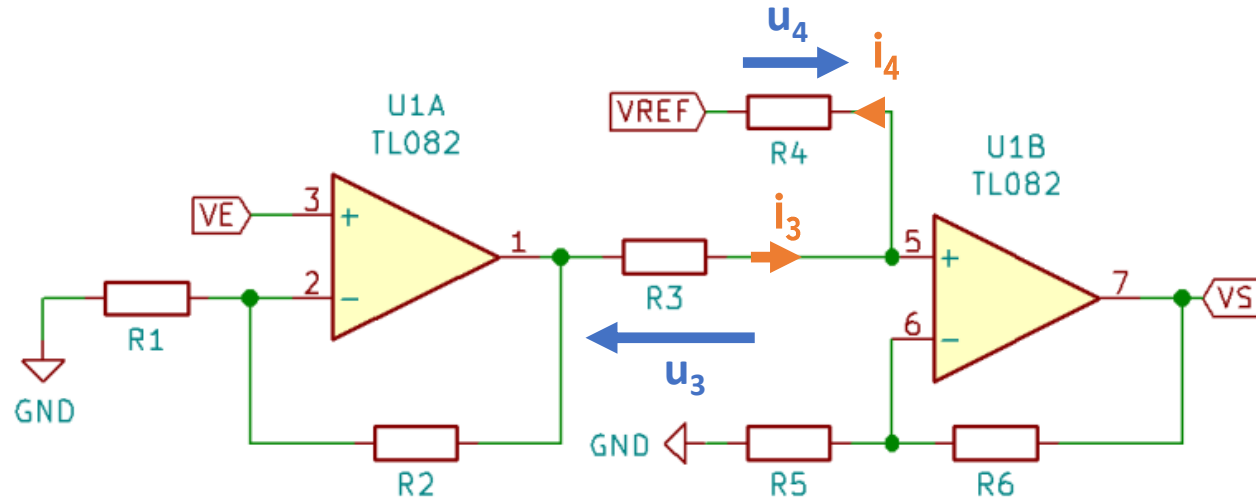
$$\parallel \quad i_4 = u_4 / R_4 = (V^+ - V_{REF}) / R_4$$

$$\parallel \quad i_3 = i_4$$

\parallel

\parallel

Structure C1



Montage non inverseur

$$V^+ = V_E$$

$$V^- = R_1 \cdot V_{S1} / (R_1 + R_2)$$

$$V_{S1} = (1 + R_2/R_1) \cdot V_E$$

$$V_{S1} = a_1 \cdot V_E$$

Montage additionneur

$$i_3 = u_3 / R_3 = (V_{S1} - V^+) / R_3$$

$$i_4 = u_4 / R_4 = (V^+ - V_{REF}) / R_4$$

$$i_3 = i_4$$

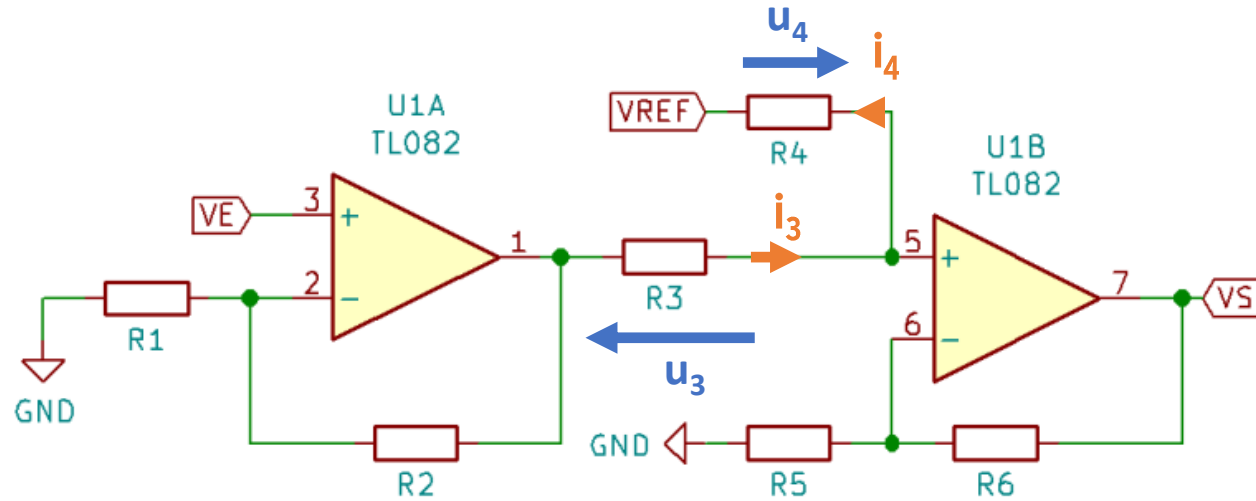
$$V_S = (R_5 + R_6) / R_5 \cdot (R_3 + R_4) \cdot (V_{REF} \cdot R_4 + V_{S1} \cdot R_3)$$

$$V_S = a_2 \cdot (V_{S1} + b \cdot V_{REF})$$

$$V^+ = (V_{REF} \cdot R_4 + V_{S1} \cdot R_3) / (R_3 + R_4)$$

$$V^- = V_S \cdot R_5 / (R_5 + R_6)$$

Structure C1



$$V_S = a_1 \cdot a_2 \cdot V_E + a_2 \cdot b \cdot V_{REF}$$

Sensibilité

Constante

Montage non inverseur

$$V^+ = V_E$$

$$V^- = R_1 \cdot V_{S1} / (R_1 + R_2)$$

$$V_{S1} = (1 + R_2/R_1) \cdot V_E$$

$$V_{S1} = a_1 \cdot V_E$$

Montage additionneur

$$i_3 = u_3 / R_3 = (V_{S1} - V^+) / R_3$$

$$i_4 = u_4 / R_4 = (V^+ - V_{REF}) / R_4$$

$$i_3 = i_4$$

$$V_S = (R_5 + R_6) / R_5 \cdot (R_3 + R_4) \cdot (V_{REF} \cdot R_4 + V_{S1} \cdot R_3)$$

$$V_S = a_2 \cdot (V_{S1} + b \cdot V_{REF})$$

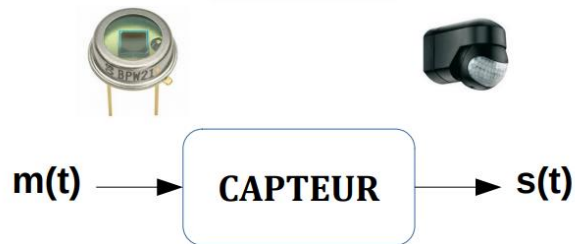
$$V^+ = (V_{REF} \cdot R_4 + V_{S1} \cdot R_3) / (R_3 + R_4)$$

$$V^- = V_S \cdot R_5 / (R_5 + R_6)$$

Capteur



Transforme une grandeur physique en une grandeur électrique



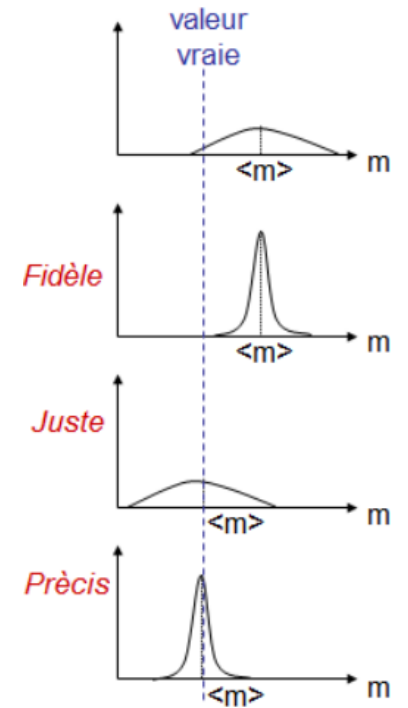
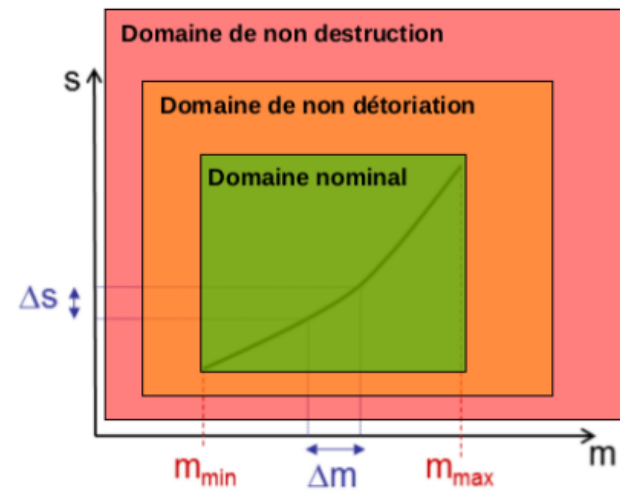
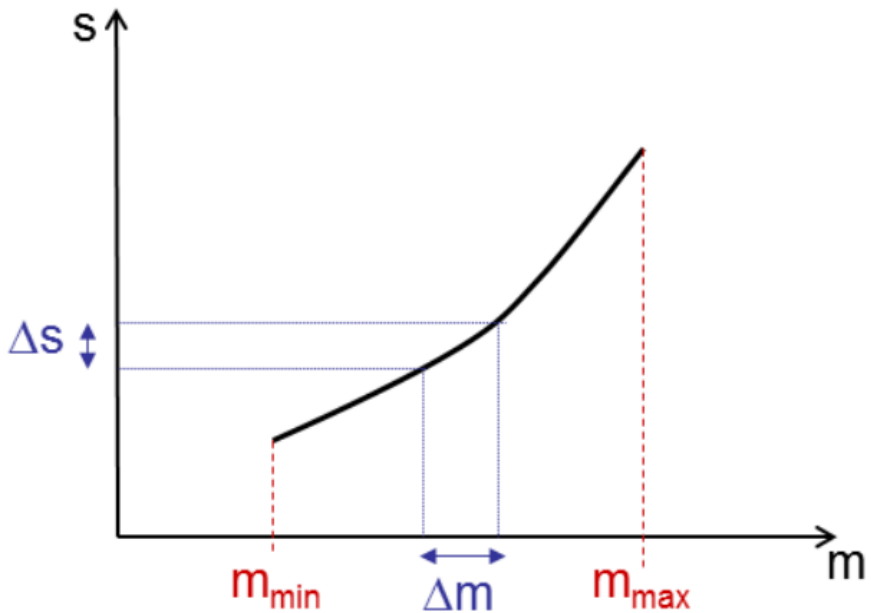
ÉTENDUE DE MESURE

Plage dans laquelle le capteur répond aux spécifications

$$E.M. = m_{\max} - m_{\min}$$

SENSIBILITÉ

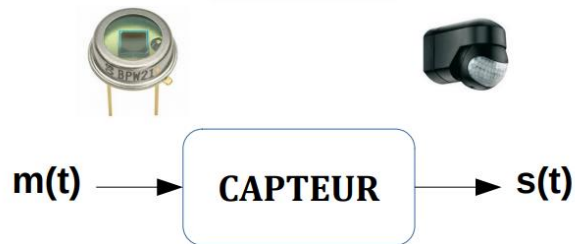
Pente de la tangente à la caractéristique entrée/sortie en un point donné

$$S(P) = \Delta S / \Delta m_p$$


Capteur



Transforme une grandeur physique en une grandeur électrique



Caractéristiques électriques

Modèle	FN3000 ¹	FN3000-A1
Alimentation	1 à 10 Vcc	10 à 30Vcc
Sensibilité à l'E.M. ²	±2mV/V	±2V ±0.2V
Décalage initial	±1mV	2.5V ±0.2V
Impédance d'entrée / Consommation	350 à 700Ω	<50mA
Impédance de sortie	350 à 700Ω	1 kΩ ⁶
Isolement sous 50Vcc	≥100MΩ	≥100MΩ

CARACTERISTIQUES (valeurs typiques à température 23±3°C)

Paramètres	
Plage d'utilisation en température (PUT)	-20 à 80° C [-4 à 176° F]
Plage de compensation en température (PCT)	0 à 60° C [32 à 140° F]
Dérive du zéro dans la PCT	<0.5% E.M. / 50° C [100° F]
Dérive de sensibilité dans la PCT	<1% de la valeur lue / 50° C [100° F]
Surcharge admissible	
Sans altération des performances	1.5 x E.M.
Sans destruction	3 x E.M.
Précision	
Linéarité	±0.1% E.M.
Hystérésis	±0.1% E.M.

FN3000

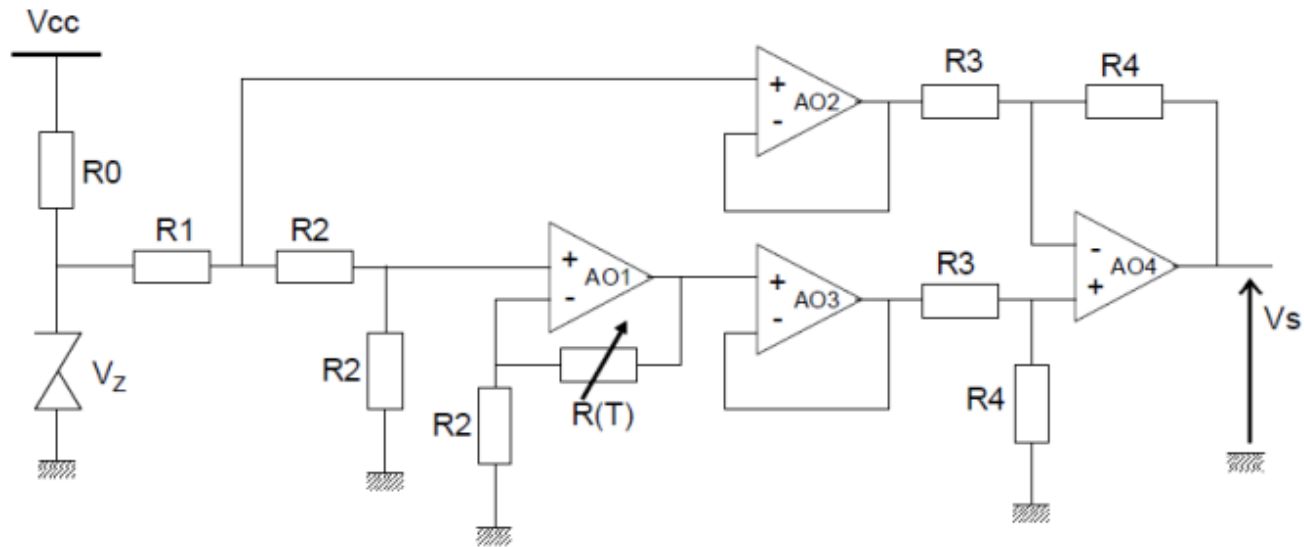
Capteur de force Traction et Compression



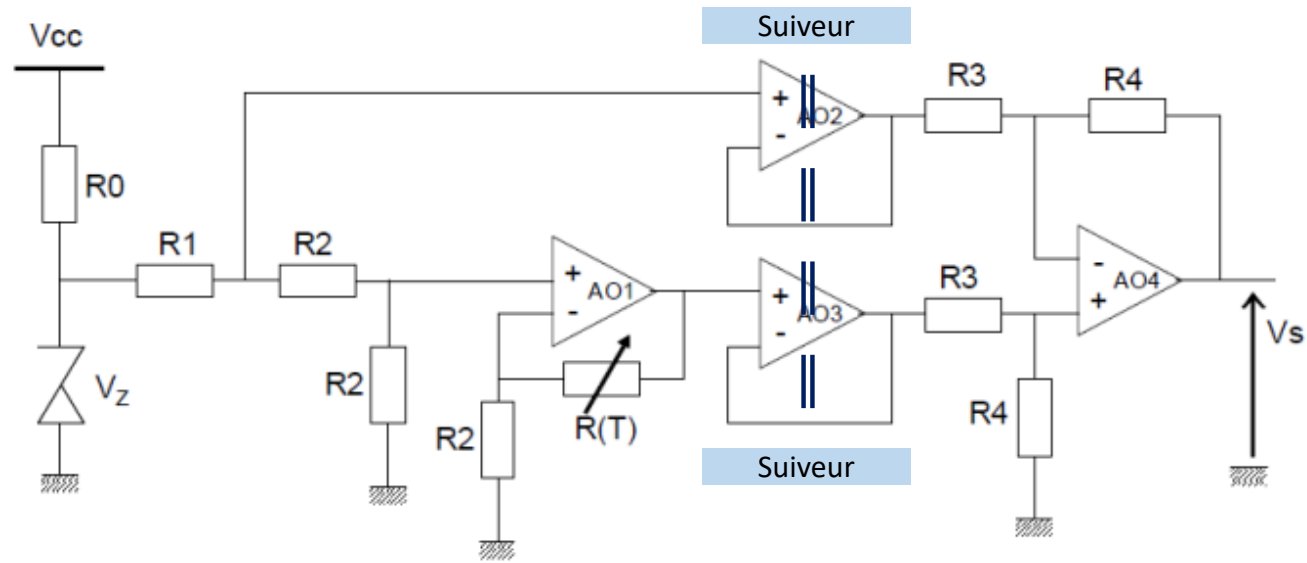
ETENDUES DE MESURE (EM)

Etendues en N	10k	25k	50k
Etendues en lbf	2k	5k	10k
Raideur en N/m	2.5x10 ⁸	5x10 ⁸	1x10 ⁹
Raideur en lbf/ft	1.7x10 ⁷	3.4x10 ⁷	6.9x10 ⁷
Matériau	Aluminium	Acier inoxydable	

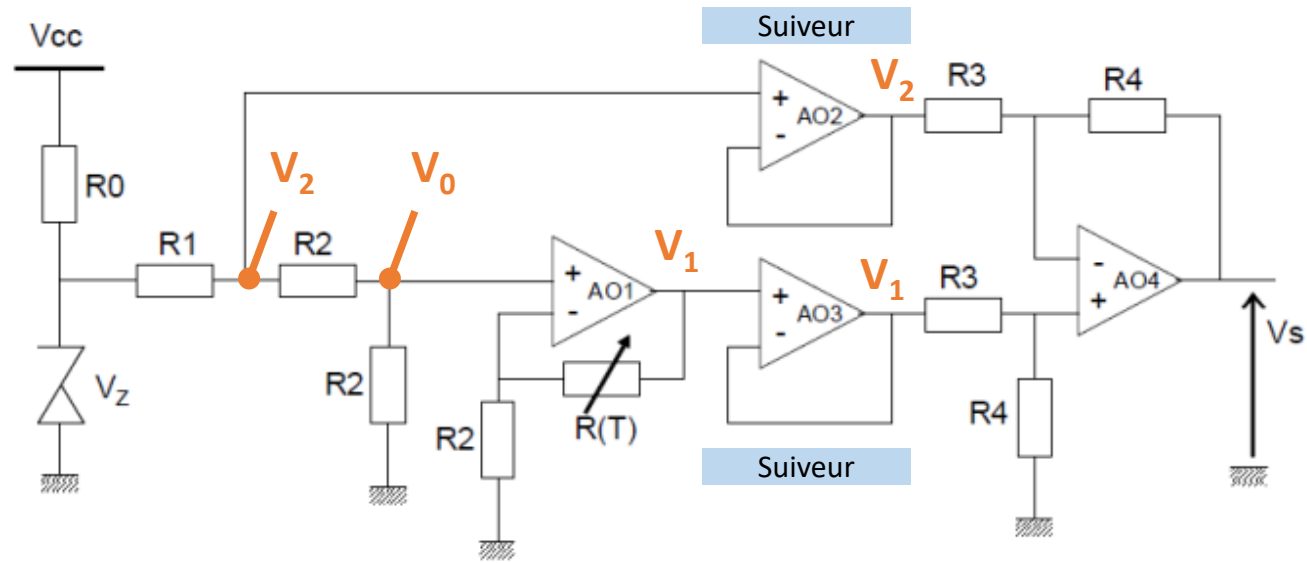
Structure C2



Structure C2



Structure C2



Non-inverseur

Soustracteur

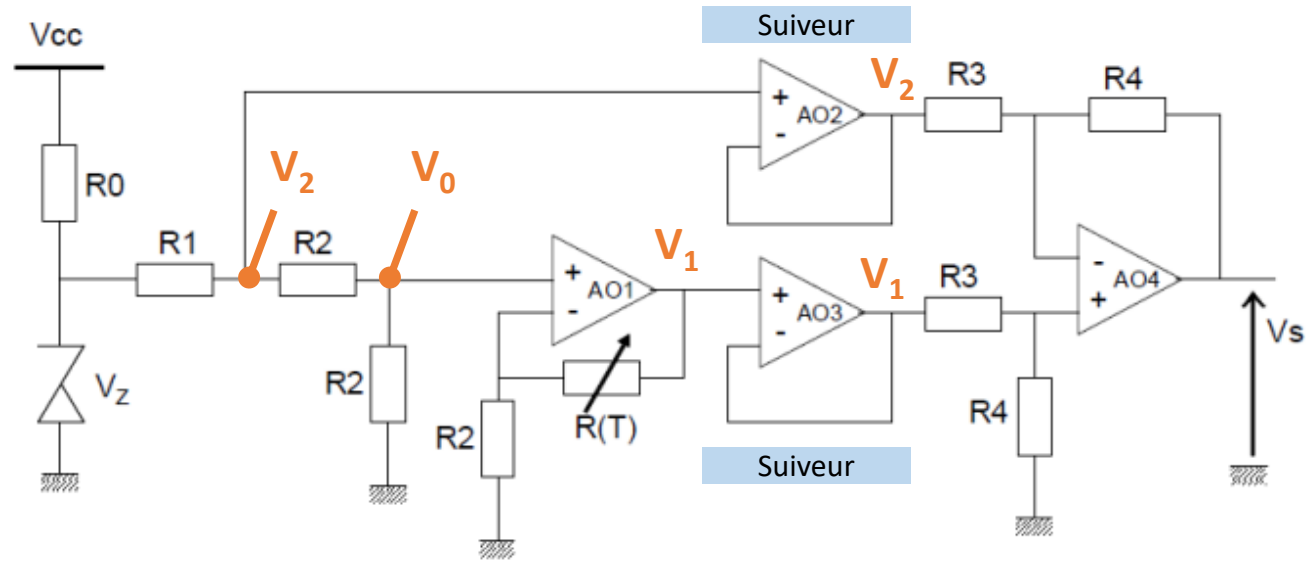
$$V_1 = V_0 \cdot (1 + R_2 / R_T)$$

$$V_S = R_4 / R_3 \cdot (V_1 - V_2)$$

Non-inverseur et pont diviseur

$$V_1 = (V_2 / 2) \cdot (1 + R_2 / R_T)$$

Structure C2



Non-inverseur

$$V_1 = V_0 \cdot (1 + R_2 / R_T)$$

Non-inverseur et pont diviseur

$$V_1 = (V_2 / 2) \cdot (1 + R_2 / R_T)$$

Soustracteur

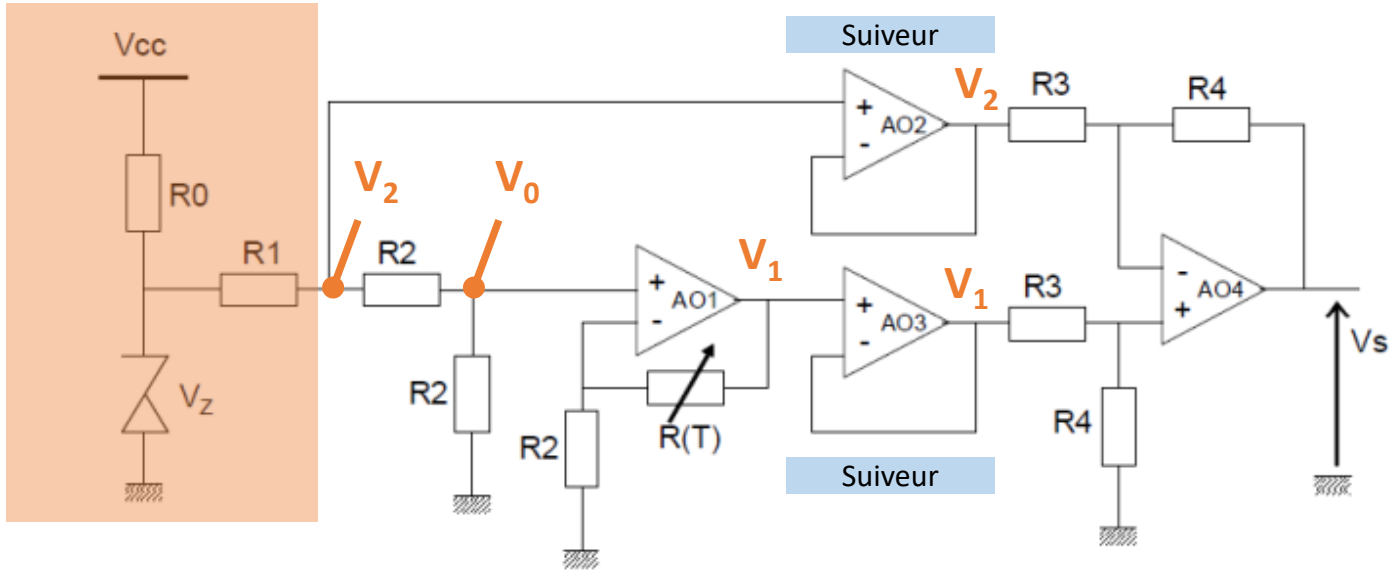
$$V_S = R_4 / R_3 \cdot (V_1 - V_2)$$

$$V_S = (R_4 / 2 \cdot R_3) \cdot V_2 (R_2 / R_T - 1)$$

Sensibilité

Offset

Structure C2



Non-inverseur

$$V_1 = V_0 \cdot (1 + R_2 / R_T)$$

Non-inverseur et pont diviseur

$$V_1 = (V_2 / 2) \cdot (1 + R_2 / R_T)$$

Soustracteur

$$V_S = R_4 / R_3 \cdot (V_1 - V_2)$$

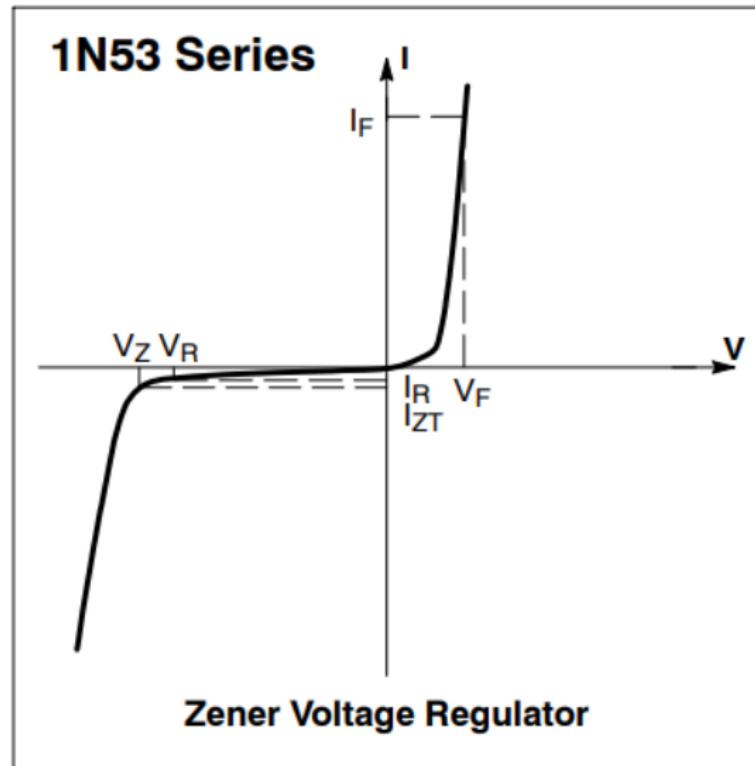
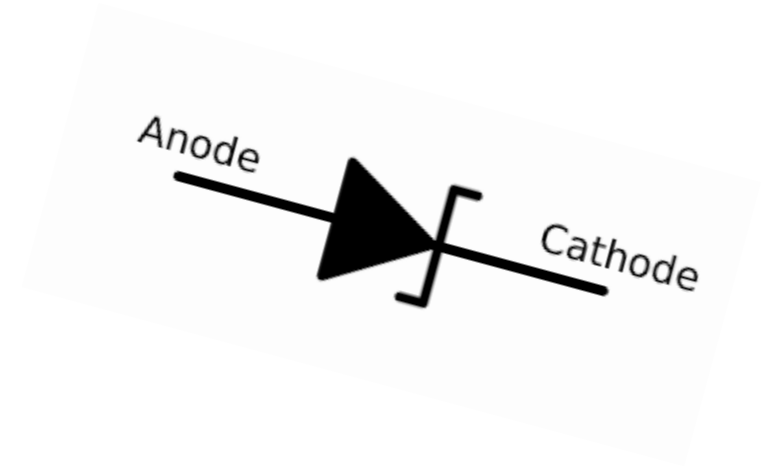
$$V_S = (R_4 / 2 \cdot R_3) \cdot V_2 (R_2 / R_T - 1)$$

Sensibilité

Offset

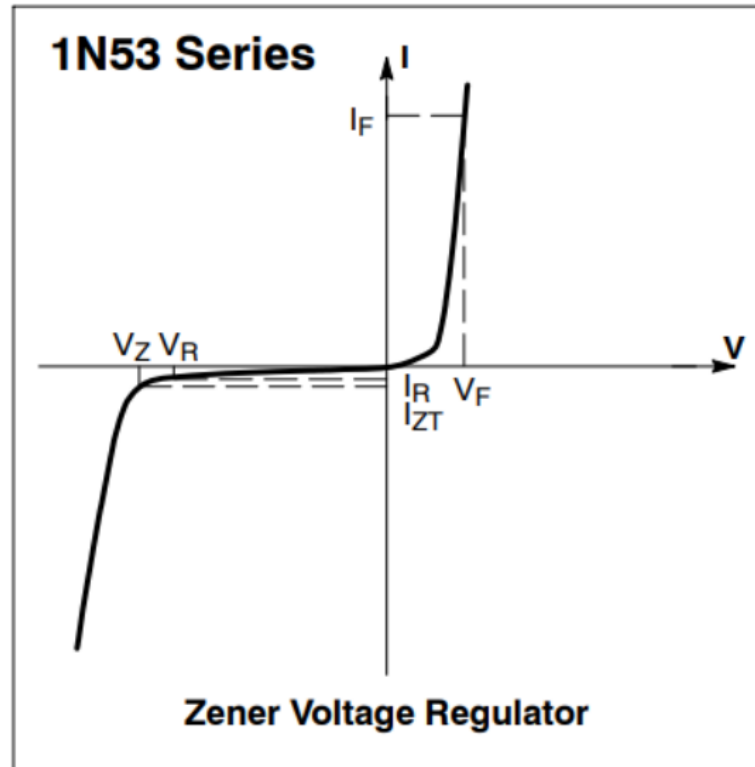
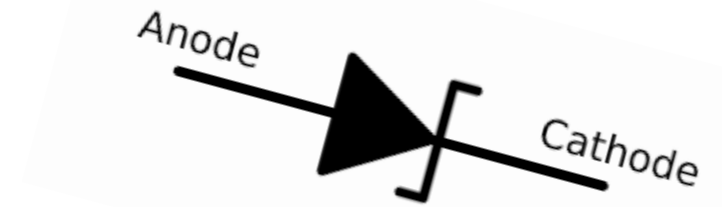
Diode Zener

Composant non-linéaire « réversible »



Diode Zener

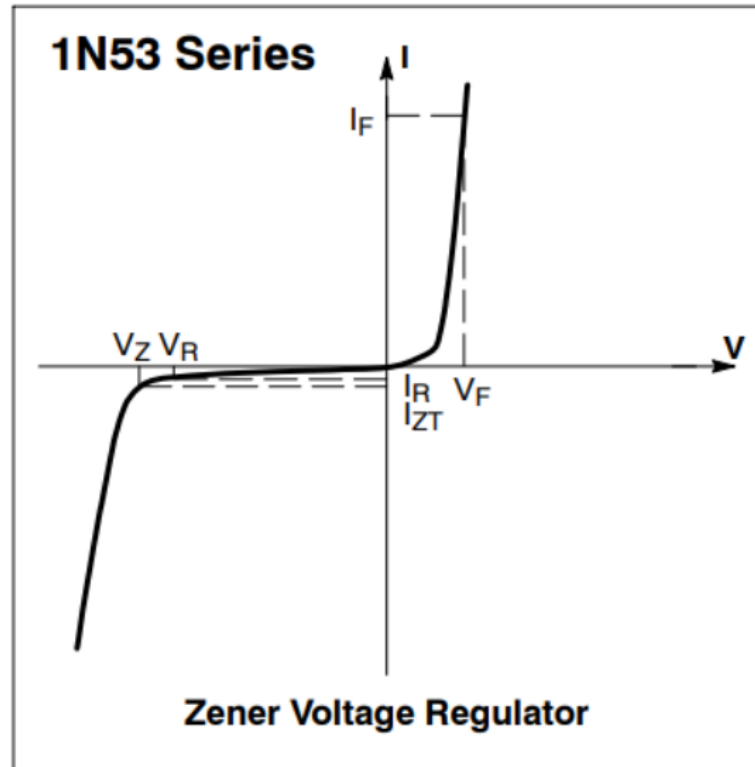
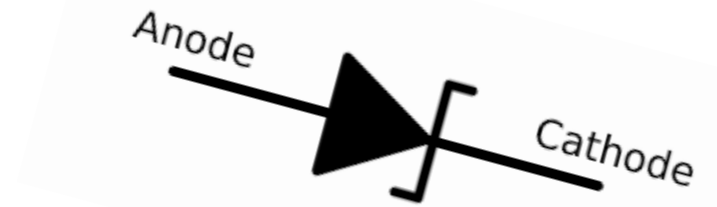
Composant non-linéaire « réversible »



ELECTRICAL CHARACTERISTICS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified)									
PART NUMBER	ZENER VOLTAGE RANGE ⁽¹⁾	TEST CURRENT		REVERSE LEAKAGE CURRENT		DYNAMIC RESISTANCE $f = 1\text{ kHz}$		SURGE CURRENT ⁽³⁾	REGULATOR CURRENT ⁽²⁾
	V_Z at I_{ZT1}	I_{ZT1}	I_{ZT2}	I_R at V_R		Z_{ZT} at I_{ZT1}	Z_{ZK} at I_{ZT2}	I_R	I_{ZM}
	V	mA	mA	μA	V	Ω	Ω	mA	mA
	NOM.			MAX.		TYP.	MAX.		MAX.
1N4728A	3.3	76	1	100	1	10	400	1380	276
1N4729A	3.6	69	1	100	1	10	400	1260	252
1N4730A	3.9	64	1	50	1	9	400	1190	234
1N4755A	43	6	0.25	5	32.7	70	1500	110	22
1N4756A	47	5.5	0.25	5	35.8	80	1500	95	19
1N4757A	51	5	0.25	5	38.8	95	1500	90	18
1N4758A	56	4.5	0.25	5	42.6	110	2000	80	16
1N4759A	62	4	0.25	5	47.1	125	2000	70	14
1N4760A	68	3.7	0.25	5	51.7	150	2000	65	13
1N4761A	75	3.3	0.25	5	56	175	2000	60	12

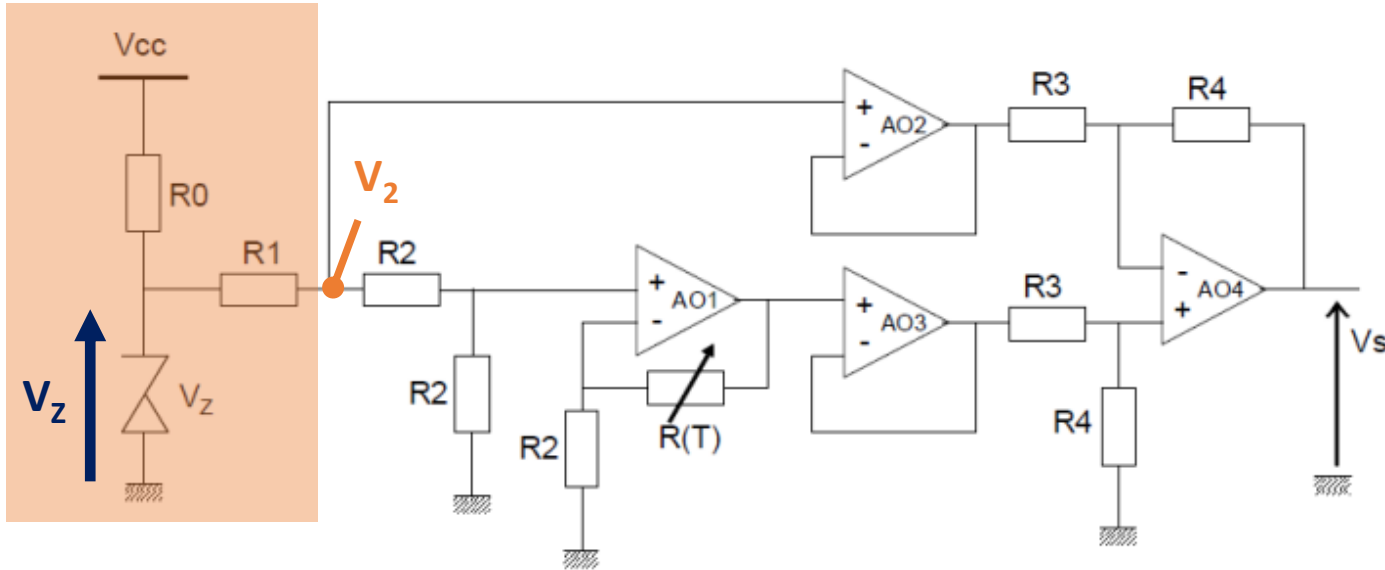
Diode Zener

Composant non-linéaire « réversible »



ELECTRICAL CHARACTERISTICS ($T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified)									
PART NUMBER	ZENER VOLTAGE RANGE ⁽¹⁾	TEST CURRENT		REVERSE LEAKAGE CURRENT		DYNAMIC RESISTANCE $f = 1\text{ kHz}$		SURGE CURRENT ⁽³⁾	REGULATOR CURRENT ⁽²⁾
	V_Z at I_{ZT1}	I_{ZT1}	I_{ZT2}	I_R at V_R		Z_{ZT} at I_{ZT1}	Z_{ZK} at I_{ZT2}	I_R	I_{ZM}
	V	mA	mA	μA	V	Ω	Ω	mA	mA
	NOM.			MAX.		TYP.	MAX.		MAX.
1N4728A	3.3	76	1	100	1	10	400	1380	276
1N4729A	3.6	69	1	100	1	10	400	1260	252
1N4730A	3.9	64	1	50	1	9	400	1190	234
1N4755A	43	6	0.25	5	32.7	70	1500	110	22
1N4756A	47	5.5	0.25	5	35.8	80	1500	95	19
1N4757A	51	5	0.25	5	38.8	95	1500	90	18
1N4758A	56	4.5	0.25	5	42.6	110	2000	80	16
1N4759A	62	4	0.25	5	47.1	125	2000	70	14
1N4760A	68	3.7	0.25	5	51.7	150	2000	65	13
1N4761A	75	3.3	0.25	5	56	175	2000	60	12

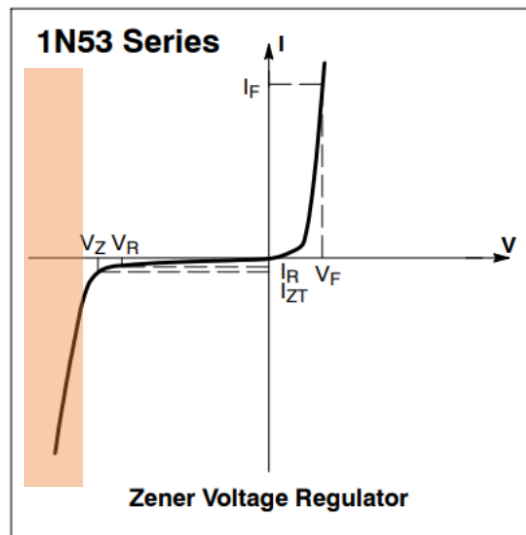
Structure C2



$$V_S = (R_4 / 2.R_3) \cdot V_2 (R_2 / R_T - 1)$$

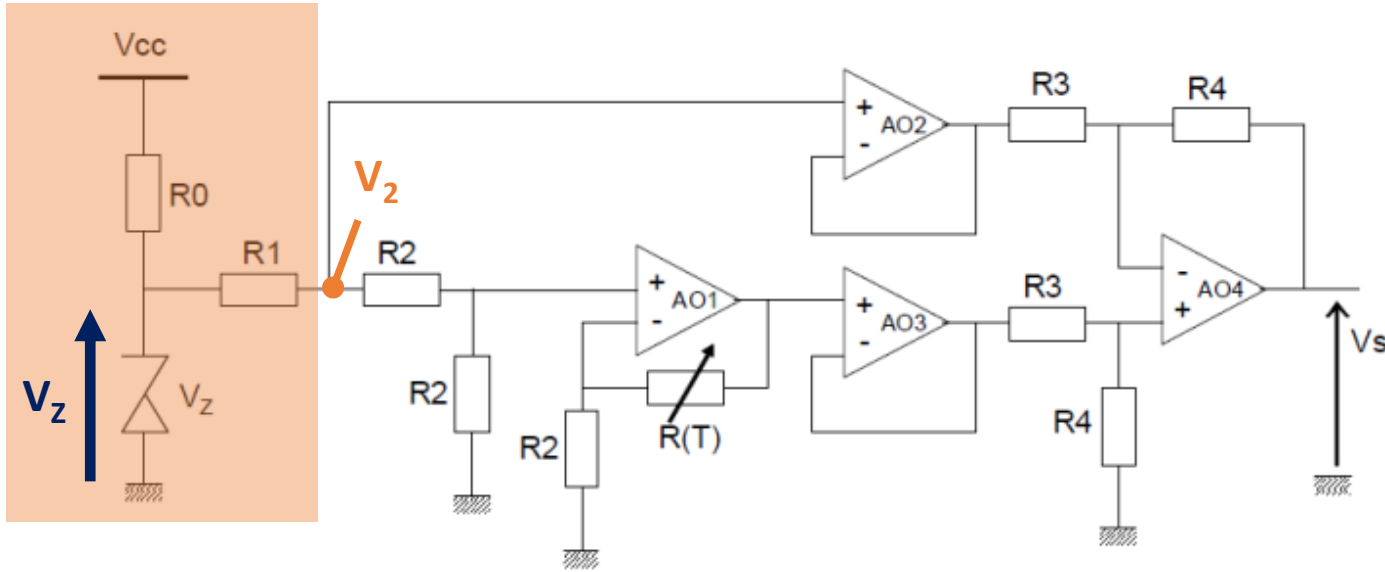
Sensibilité

Offset



Si $V_{CC} > V_Z$

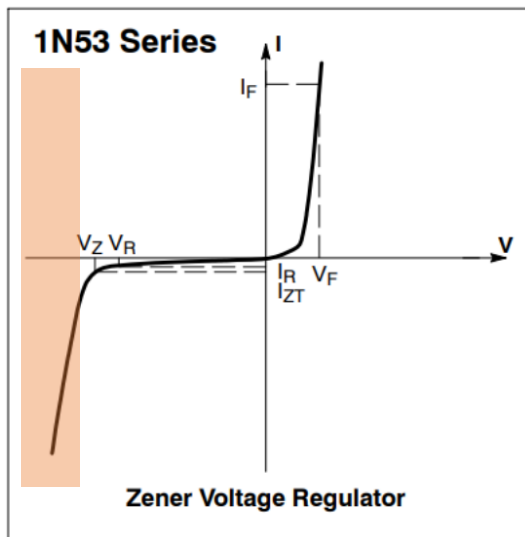
Structure C2



$$V_S = (R_4 / 2.R_3) \cdot V_2 (R_2 / R_T - 1)$$

Sensibilité

Offset



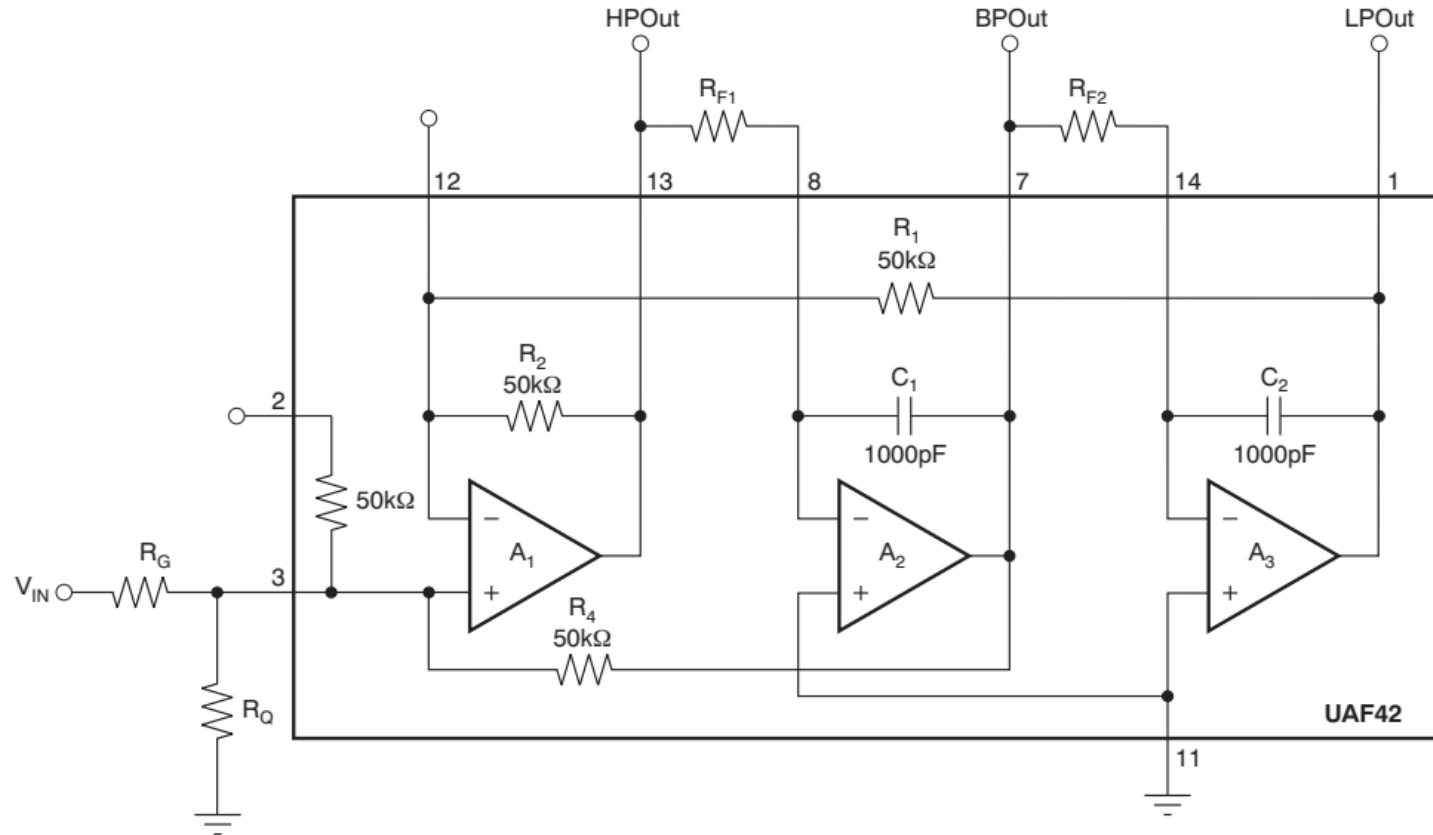
Régulateur de tension

Si $V_{CC} > V_Z$

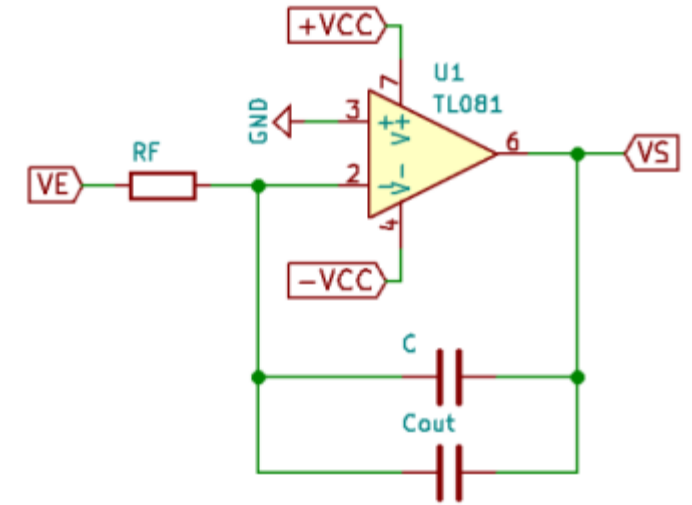
$$V_2 = V_Z \cdot 2 \cdot R_2 / (R_1 + 2 \cdot R_2)$$

Tension Stable

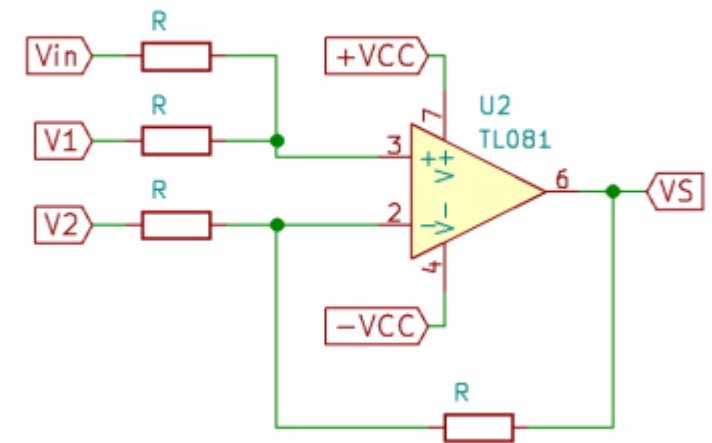
Structure F2



Intégrateur



Additionneur



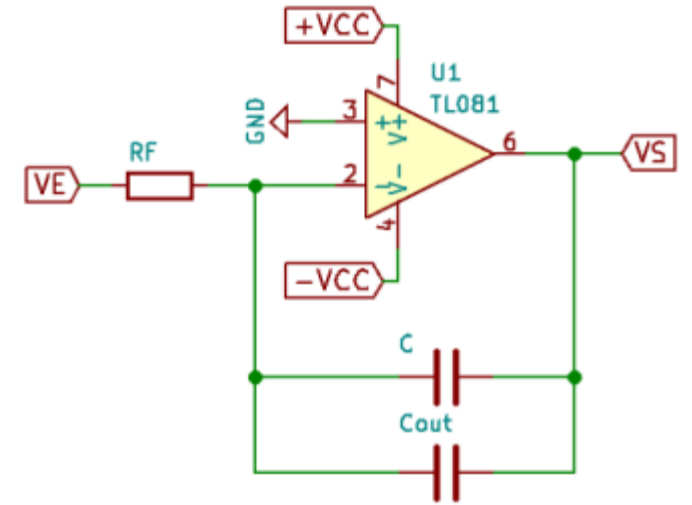
Structure F2

$$V_S = V_E / (j \cdot \omega \cdot R_F \cdot (C + C_{OUT}))$$

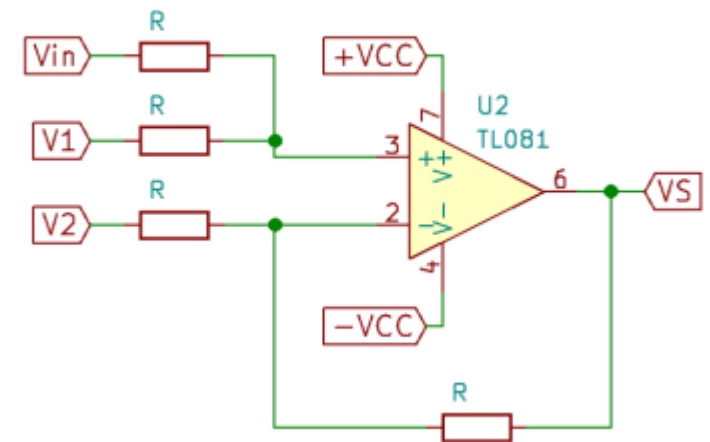
$$V_S = V_E / (j \cdot \omega / \omega_C)$$

$$V_S = V_{in} + V_1 - V_2$$

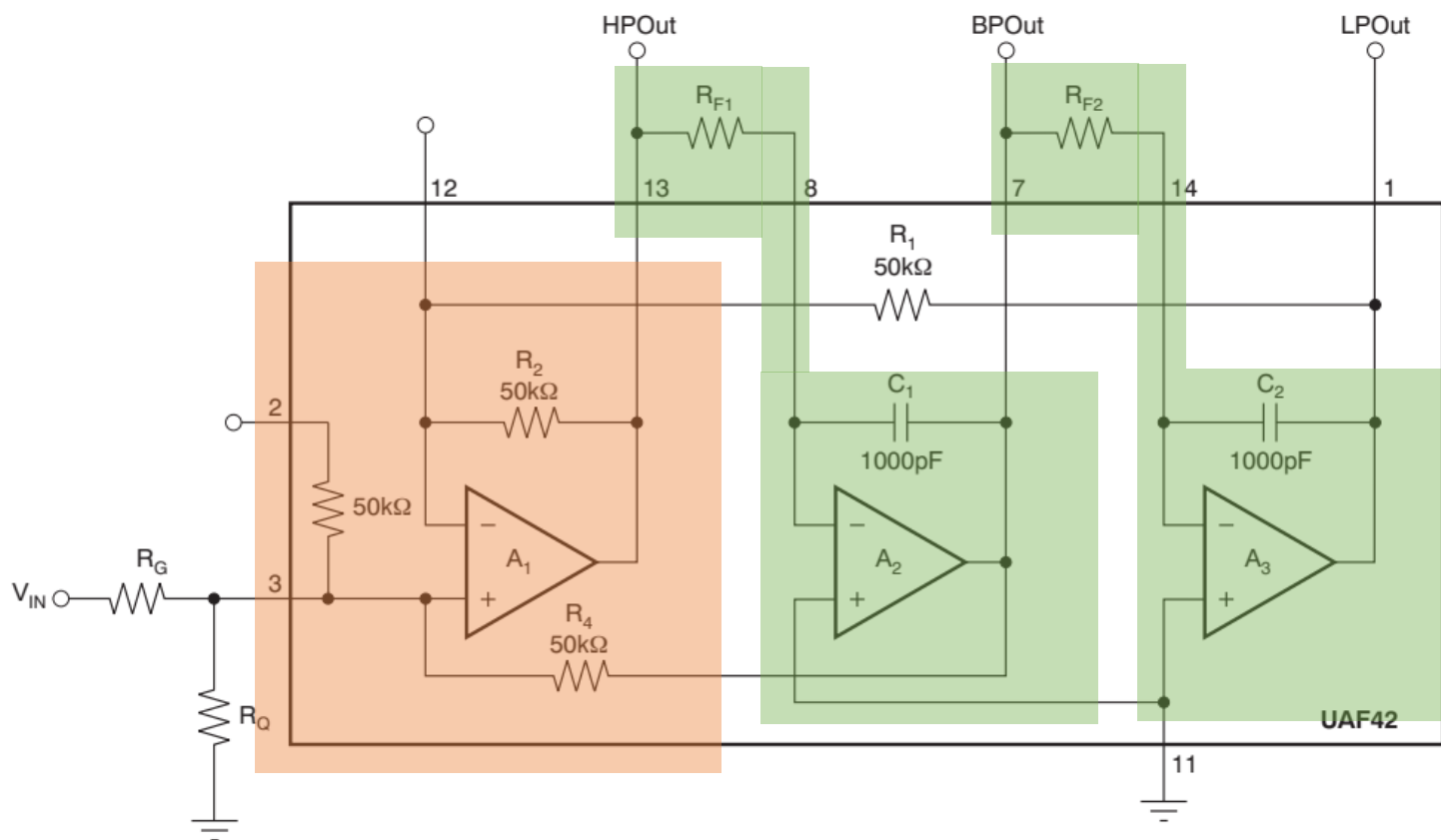
Intégrateur



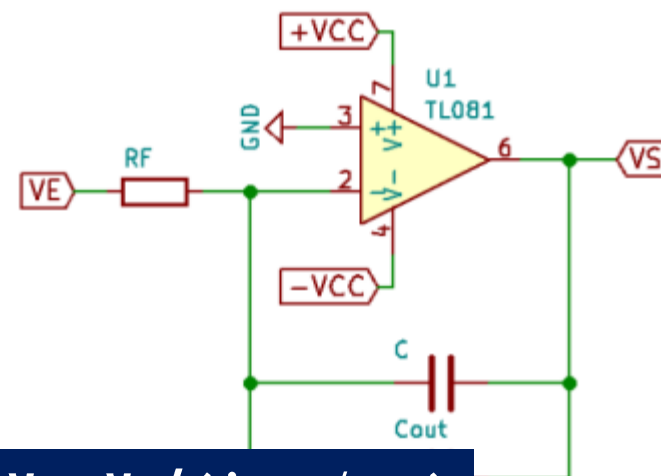
Additionneur



Structure F2

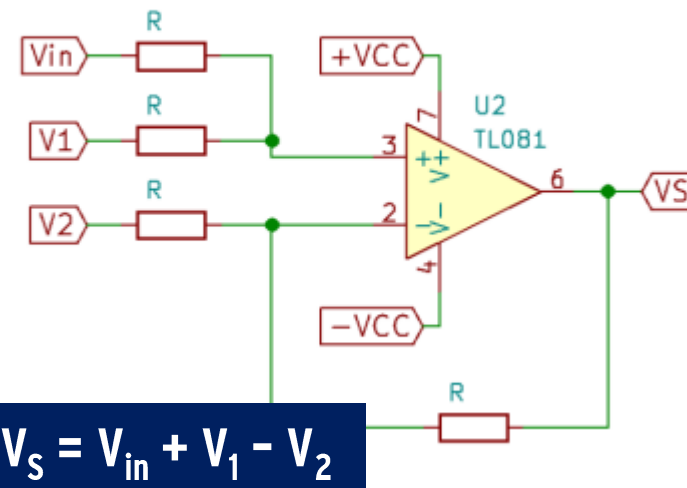


Intégrateur



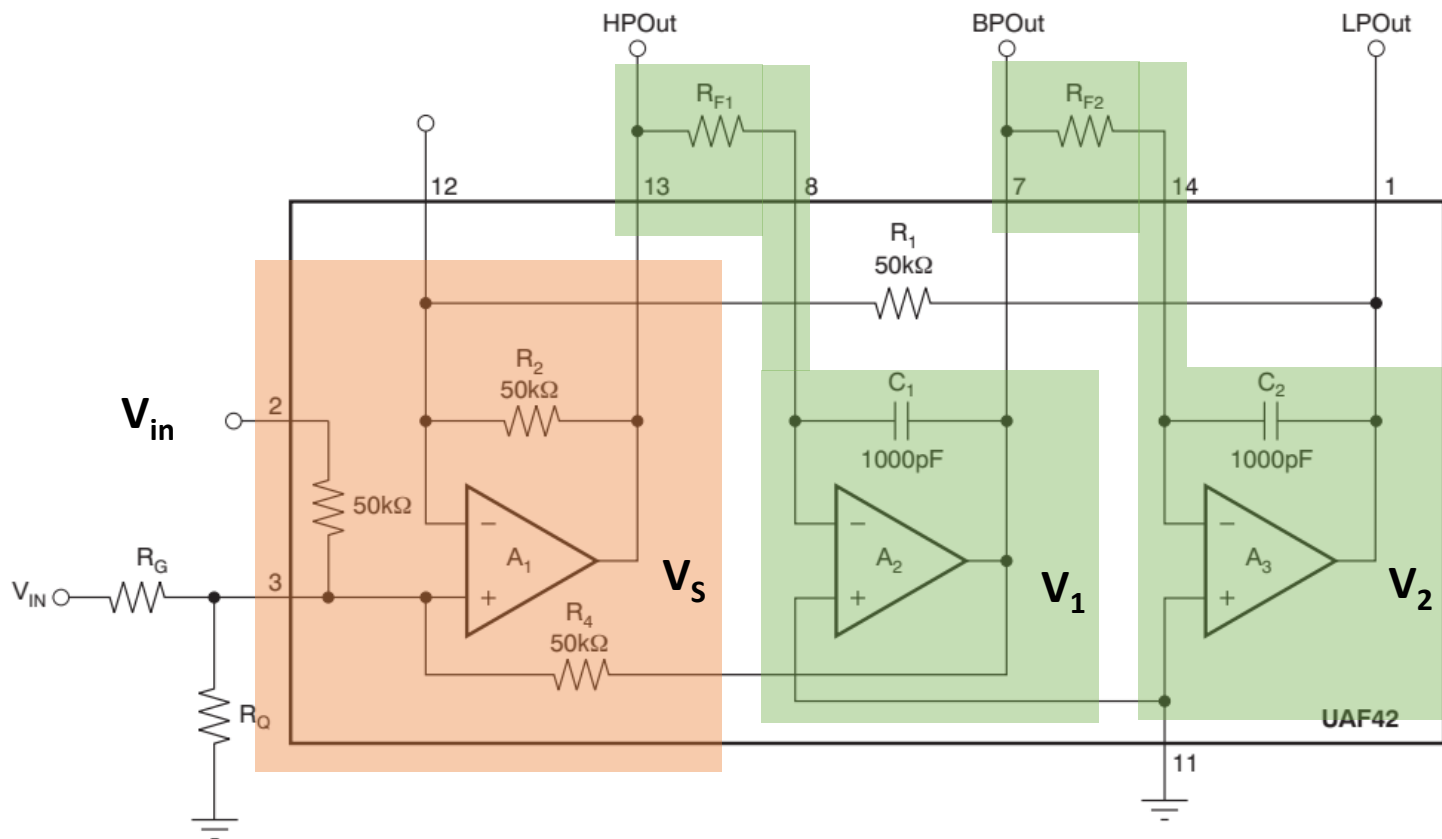
$$V_S = V_E / (j \cdot \omega / \omega_C)$$

Additionneur

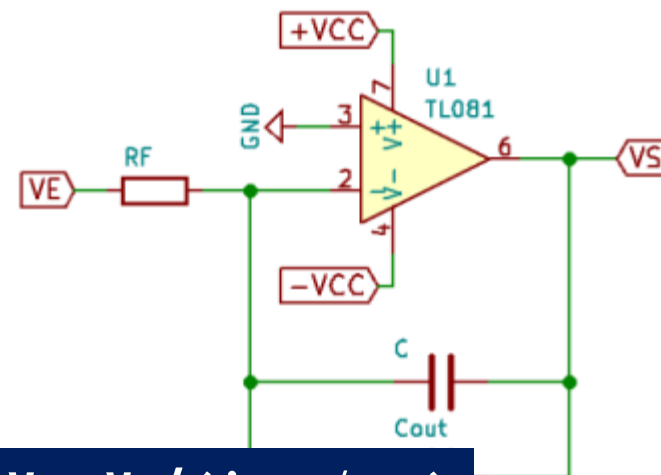


$$V_S = V_{in} + V_1 - V_2$$

Structure F2

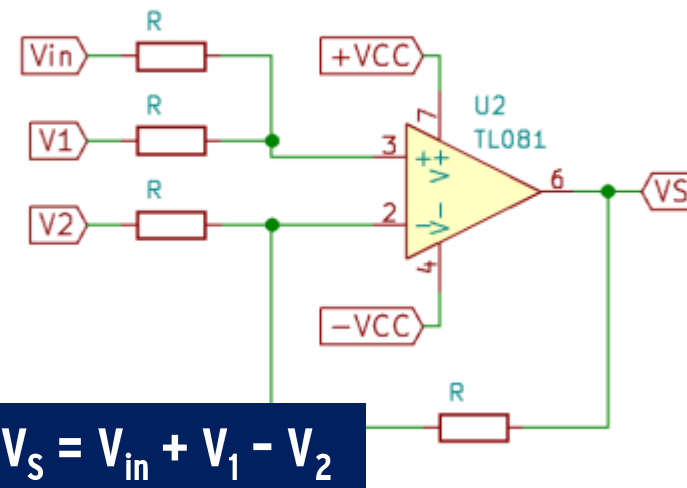


Intégrateur



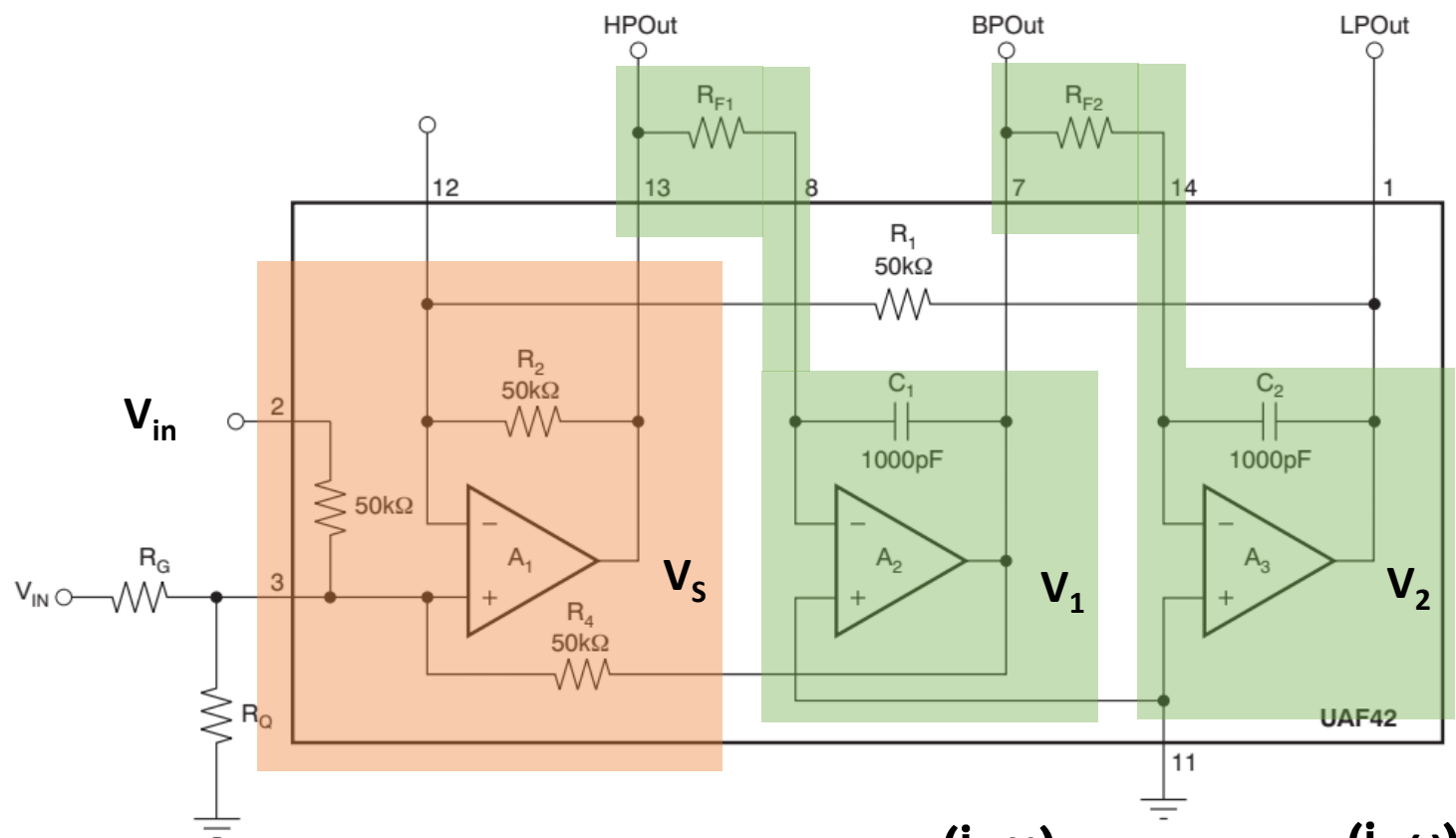
$$V_S = V_E / (j \cdot \omega / \omega_C)$$

Additionneur



$$V_S = V_{in} + V_1 - V_2$$

Structure F2

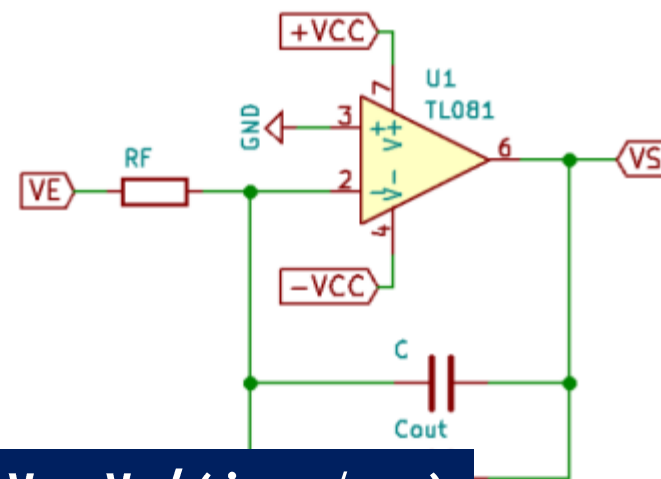


$$V_1 = V_S / \frac{(j \cdot \omega)}{\omega_{c1}}$$

$$V_2 = V_1 / \frac{(j \cdot \omega)}{\omega_{c2}}$$

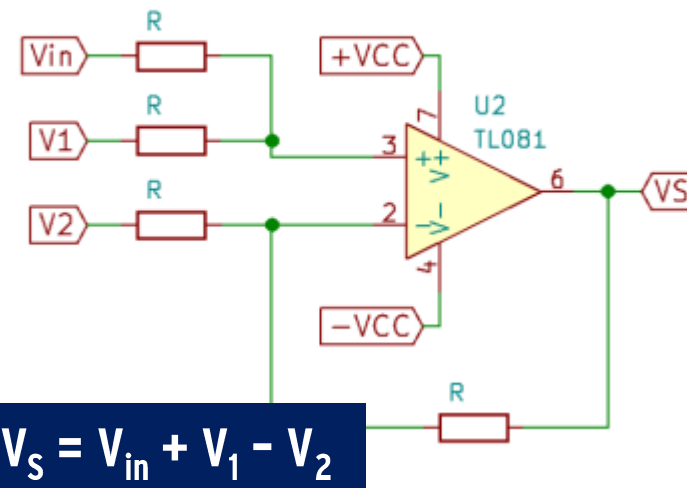
$$V_2 = V_S / \left(\frac{(j \cdot \omega)}{\omega_{c1}} \cdot \frac{(j \cdot \omega)}{\omega_{c2}} \right)$$

Intégrateur



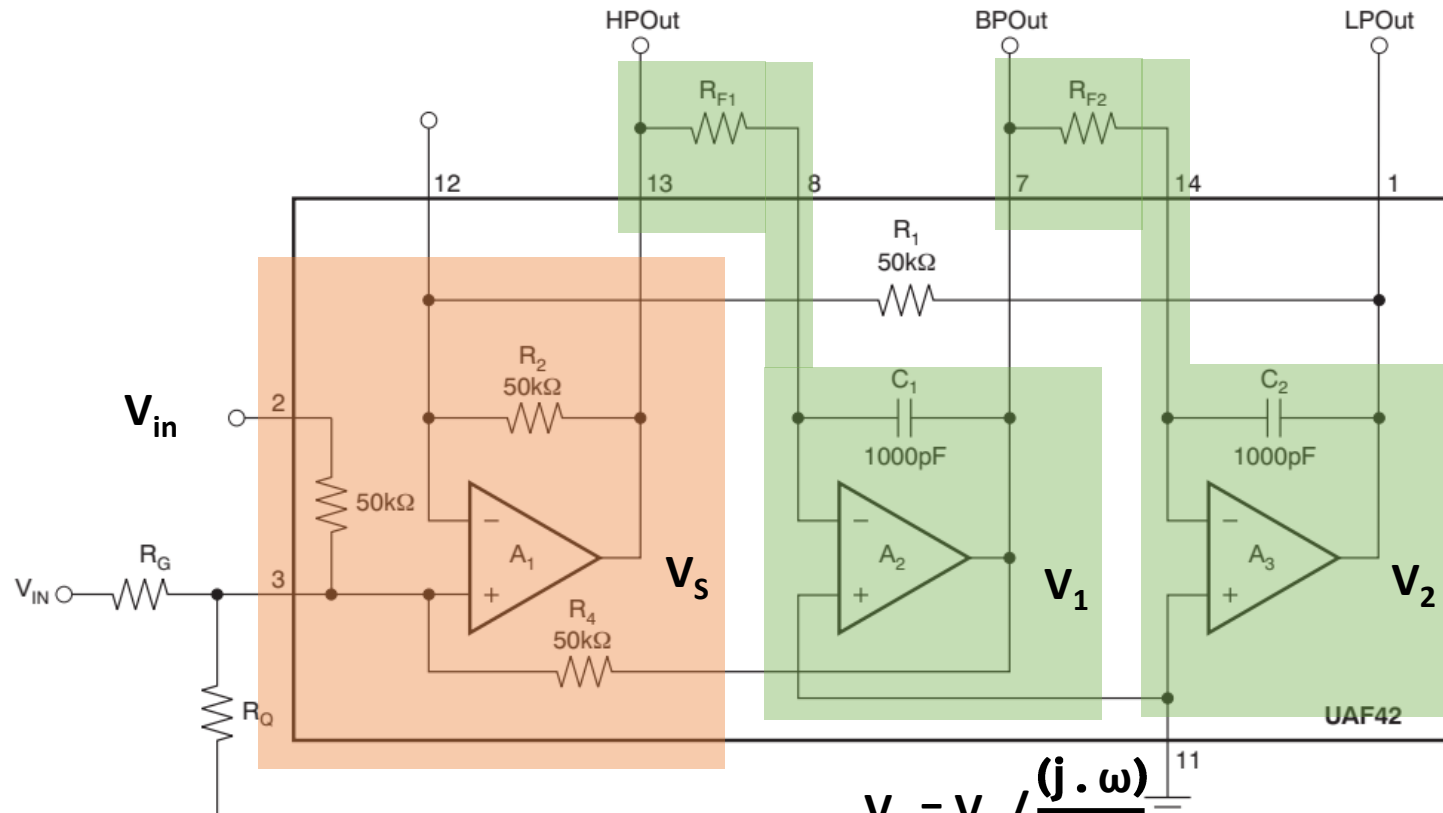
$$V_S = V_E / (j \cdot \omega / \omega_C)$$

Additionneur



$$V_S = V_{in} + V_1 - V_2$$

Structure F2

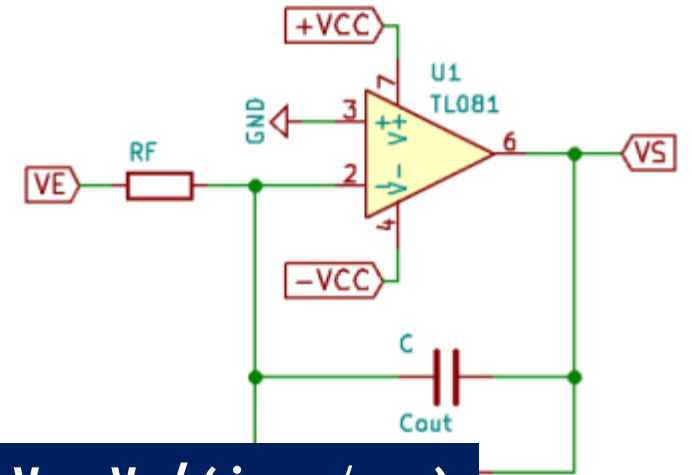


$$V_S = V_{in} \cdot \frac{(j\omega)^2}{(\omega_{c1} \cdot \omega_{c2})} \cdot \frac{1}{1 - \frac{(j\omega)}{\omega_{c2}} + \frac{(j\omega)^2}{(\omega_{c1} \cdot \omega_{c2})}}$$

$$V_1 = V_S / \frac{(j\omega)}{\omega_{c1}} \quad V_2 = V_1 / \frac{(j\omega)}{\omega_{c2}}$$

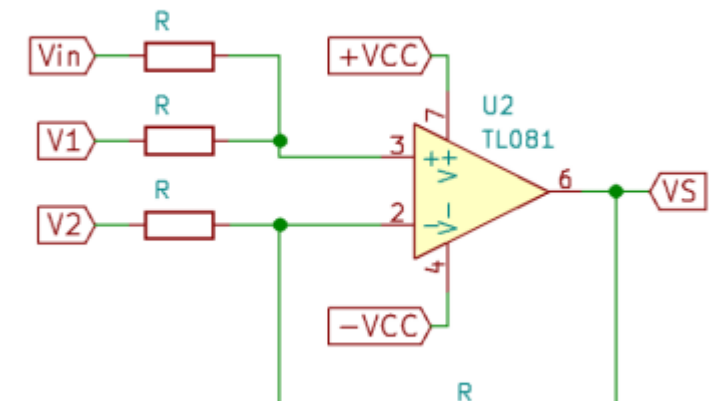
$$V_2 = V_S / \left(\frac{(j\omega)}{\omega_{c1}} \cdot \frac{(j\omega)}{\omega_{c2}} \right)$$

Intégrateur



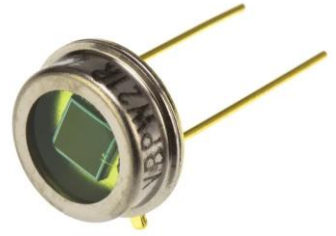
$$V_S = V_E / (j \cdot \omega / \omega_C)$$

Additionneur

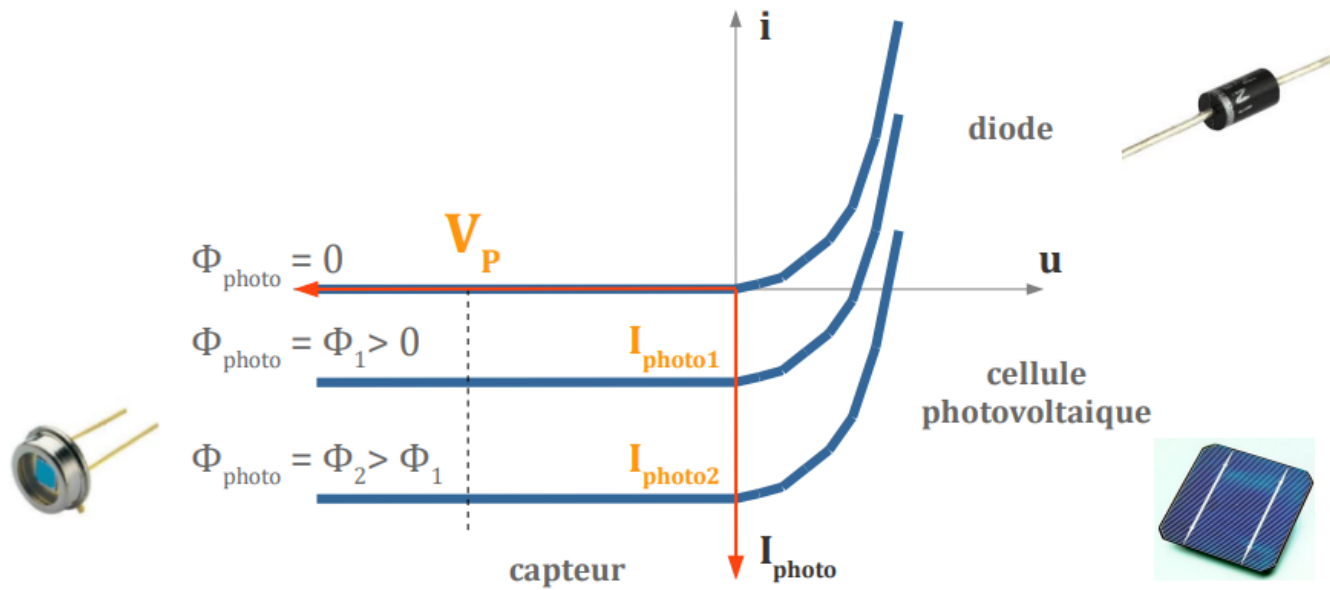


$$V_S = V_{in} + V_1 - V_2$$

Photodiode



Diode mais...



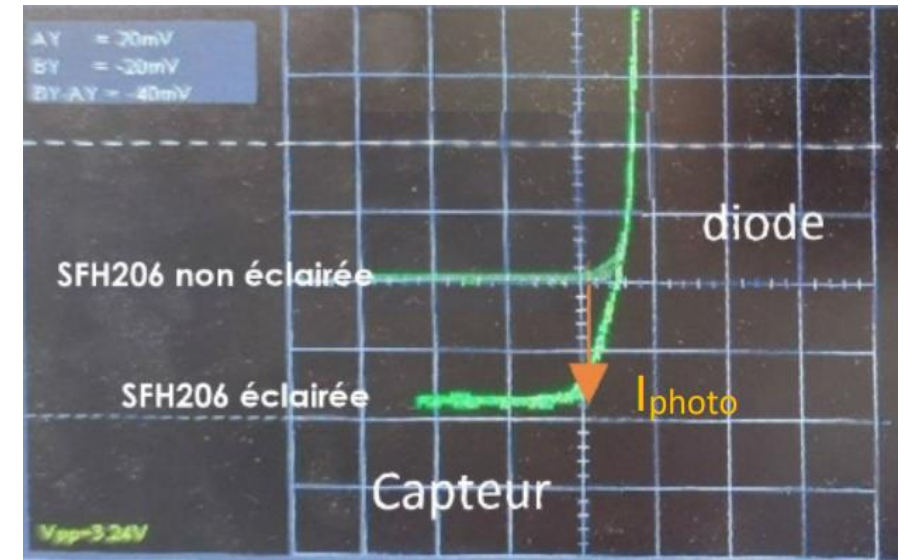
$$I_{photo} = S_{\lambda} \cdot \eta \cdot \Phi_{photo}$$

A $\frac{A}{W}$ W

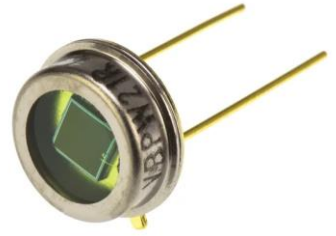
Sensibilité spectrale

Rendement quantique

Flux lumineux



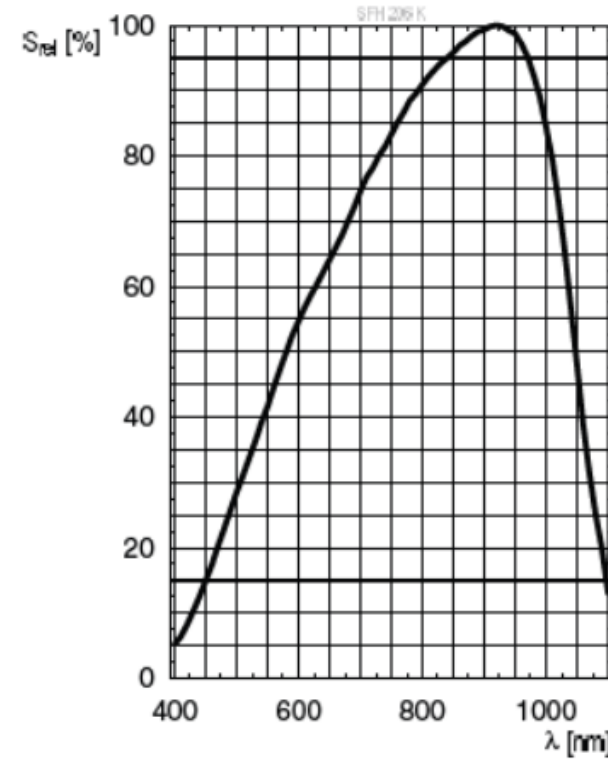
Photodiode



Diode mais...

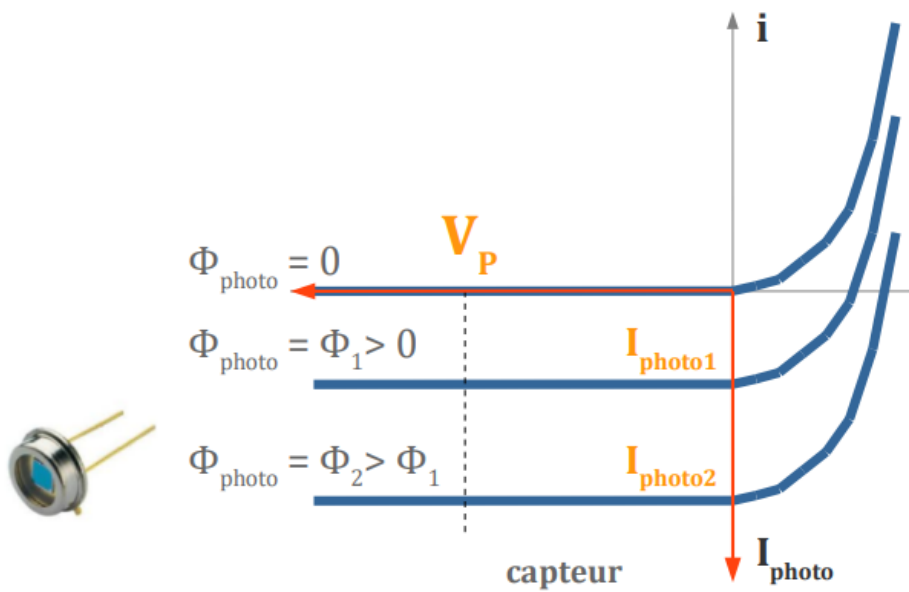
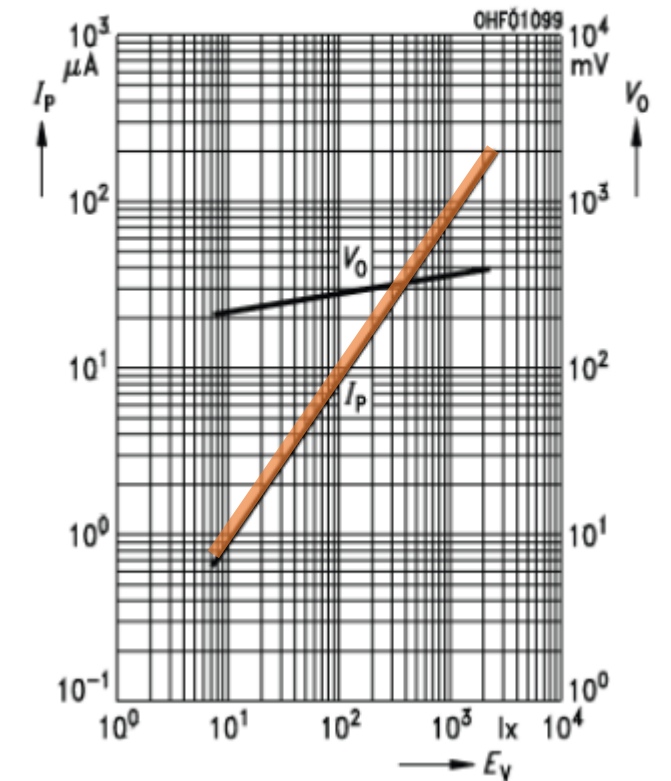
SFH 206 K

Relative Spectral Sensitivity



Photocurrent/Open-Circuit Voltage

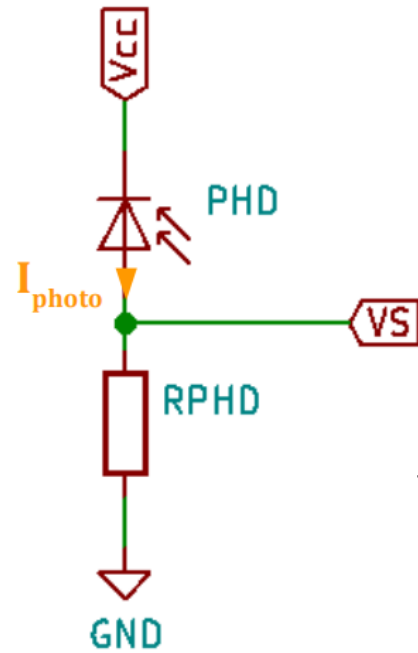
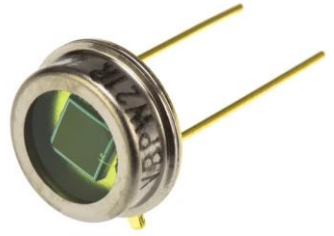
$$I_p (V_R = 5 V) / V_o = f(E_v)$$



$$I_{photo} = S_{\lambda} \cdot \eta \cdot \Phi_{photo}$$

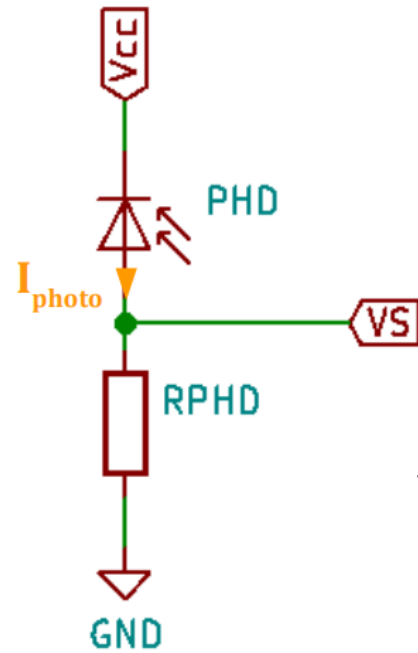
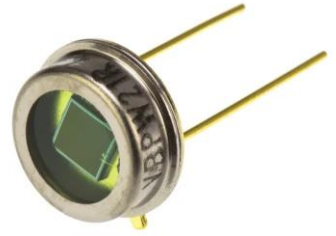
A A/W W
 Sensibilité spectrale Rendement quantique Flux lumineux

Structure P1

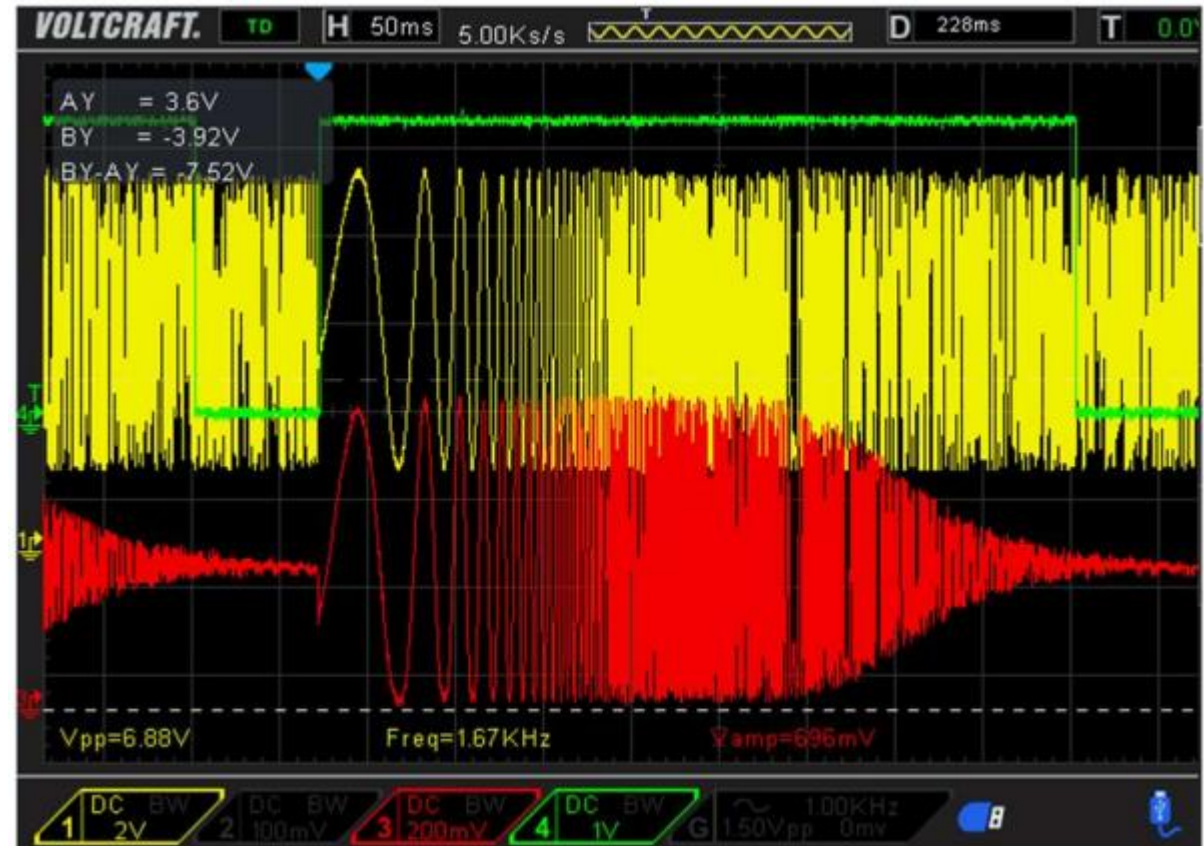


$$V_S = R_{PHD} \cdot I_{photo}$$

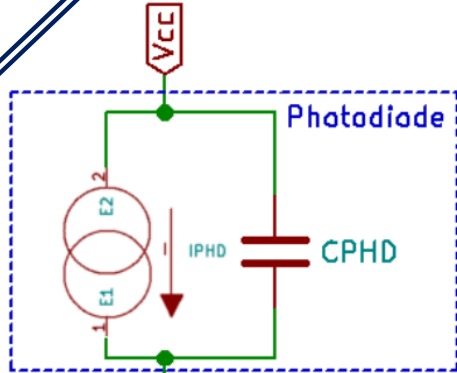
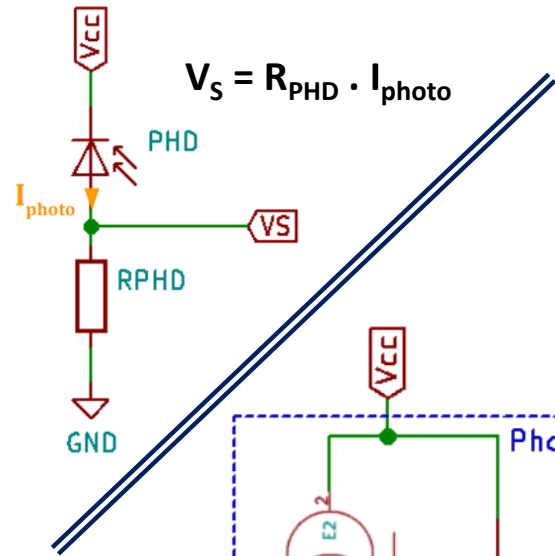
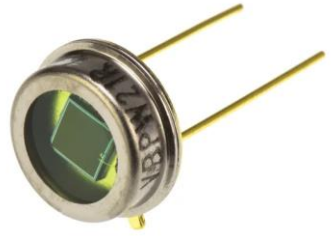
Structure P1



$$V_S = R_{PHD} \cdot I_{photo}$$



Structure P1

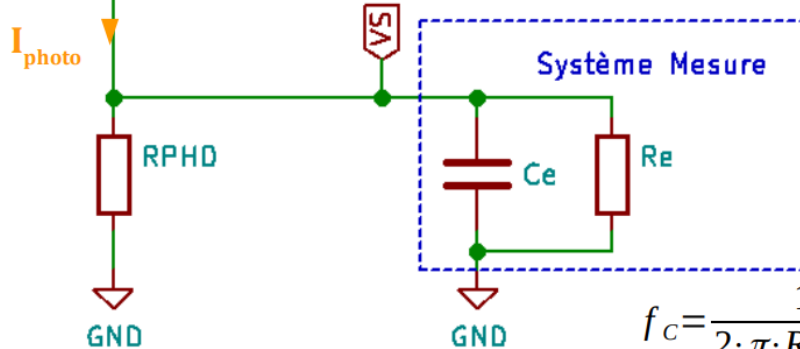


$$\frac{V_S}{I_{Phd}} = \frac{R_{eq}}{1 + j \cdot \omega \cdot R_{eq} \cdot C_{eq}}$$

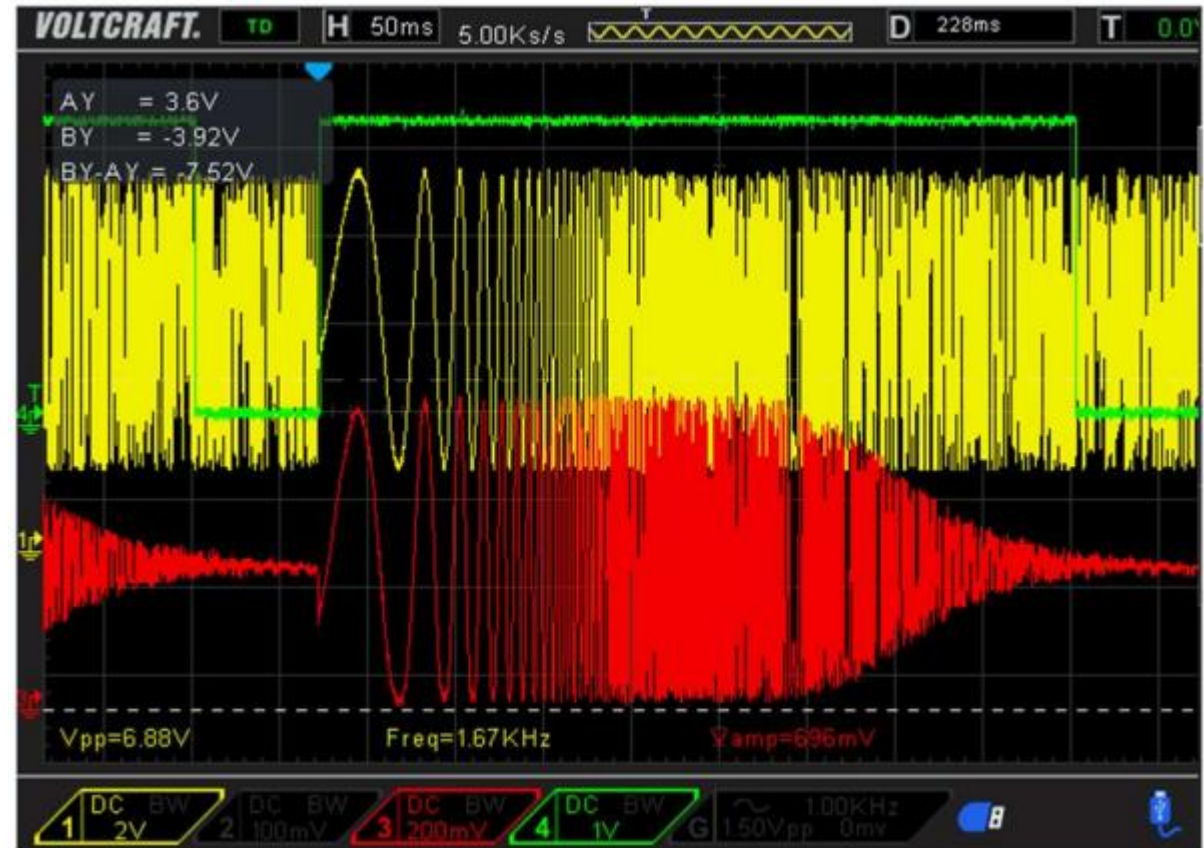
Avec :

$$R_{eq} = \frac{R_{phd} \cdot R_e}{R_{phd} + R_e}$$

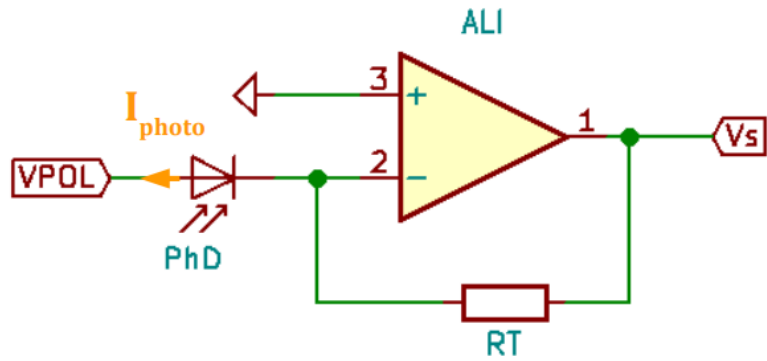
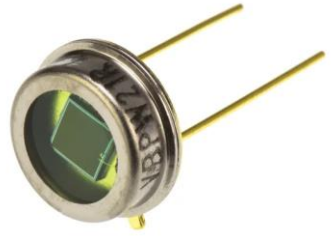
$$C_{eq} = C_{phd} + C_e$$



$$f_c = \frac{1}{2 \cdot \pi \cdot R_{eq} \cdot C_{eq}}$$

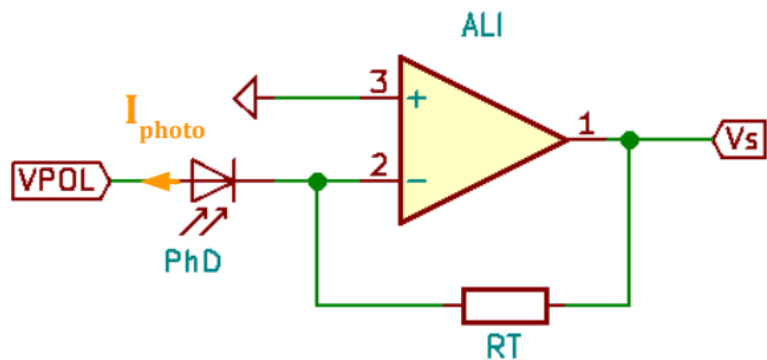
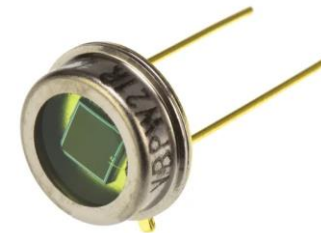


Structure P2

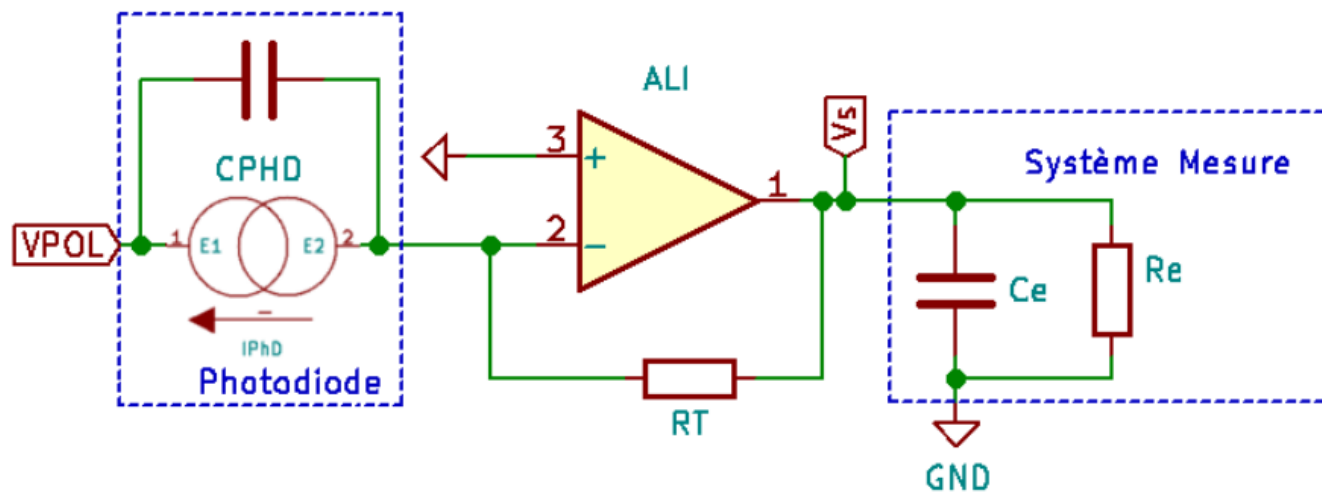


$$V_S = R_T \cdot I_{\text{photo}}$$

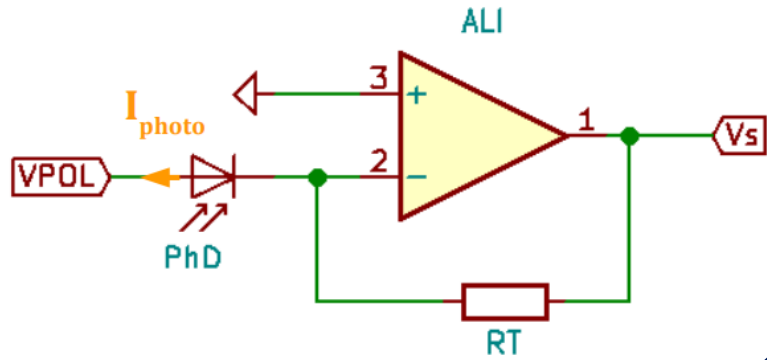
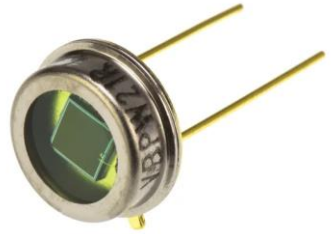
Structure P2



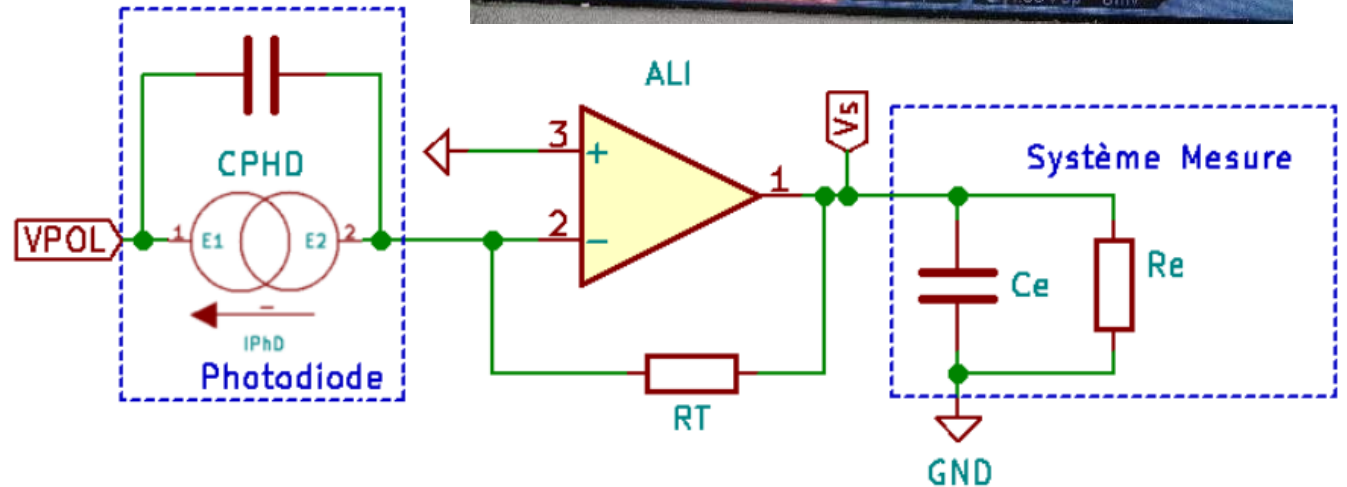
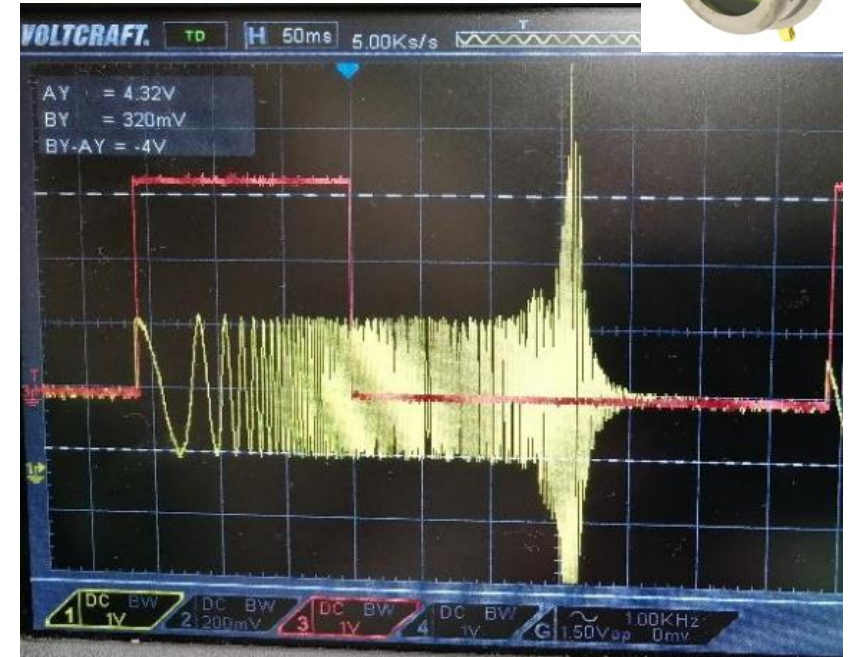
$$V_S = R_T \cdot I_{\text{photo}}$$



Structure P2



$$V_S = R_T \cdot I_{\text{photo}}$$



Amplificateur Linéaire Intégré



Produit Gain-Bande-Passante constant

Comportement passe-bas

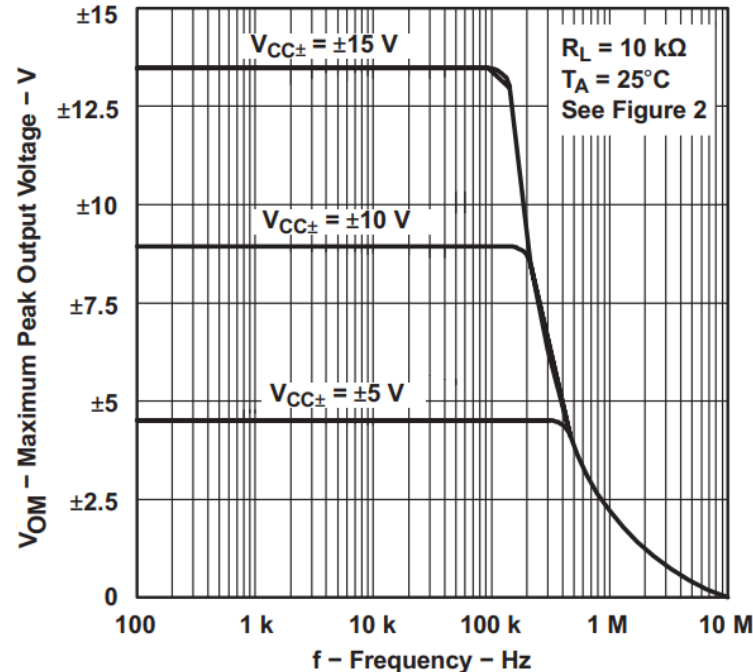


Figure 6-41. Maximum Peak Output Voltage vs Frequency

$$V_S = A \cdot (V^+ - V^-)$$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z_{ID}	Differential		100 2	MΩ pF
Z_{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2,$ $(V_{CC-}) + 0.3 \text{ V} < V_O < (V_{CC+}) - 0.3 \text{ V}$	118	125
A_{OL}	Open-loop voltage gain	$V_S = 40 \text{ V}, V_{CM} = V_S / 2, R_L =$ $2 \text{ k}\Omega, (V_{CC-}) + 1.2 \text{ V} < V_O < (V_{CC+}) - 1.2 \text{ V}$	115	120
FREQUENCY RESPONSE				
GBW	Gain-bandwidth product		5.25	MHz
SR	Slew rate	$V_S = 40 \text{ V}, G = +1, C_L = 20 \text{ pF}$	20	V/μs

Amplificateur Linéaire Intégré



Produit Gain-Bande-Passante constant

Comportement passe-bas

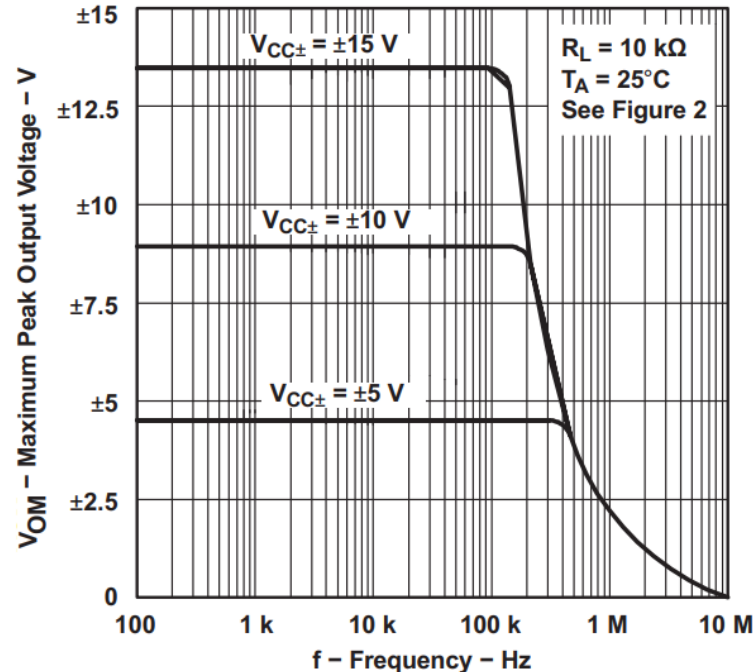


Figure 6-41. Maximum Peak Output Voltage vs Frequency

$$A \cdot f_c = GBW = \text{cte}$$

$$V_S = A \cdot (V^+ - V^-)$$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z _{ID}	Differential		100 2	MΩ pF
Z _{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
A _{OL}	Open-loop voltage gain	V _S = 40 V, V _{CM} = V _S / 2, (V _{CC-}) + 0.3 V < V _O < (V _{CC+}) - 0.3 V	118	125
A _{OL}	Open-loop voltage gain	V _S = 40 V, V _{CM} = V _S / 2, R _L = 2 kΩ, (V _{CC-}) + 1.2 V < V _O < (V _{CC+}) - 1.2 V	115	120
FREQUENCY RESPONSE				
GBW	Gain-bandwidth product		5.25	MHz
SR	Slew rate	V _S = 40 V, G = +1, C _L = 20 pF	20	V/μs

Amplificateur Linéaire Intégré



Produit Gain-Bande-Passante constant

Comportement passe-bas

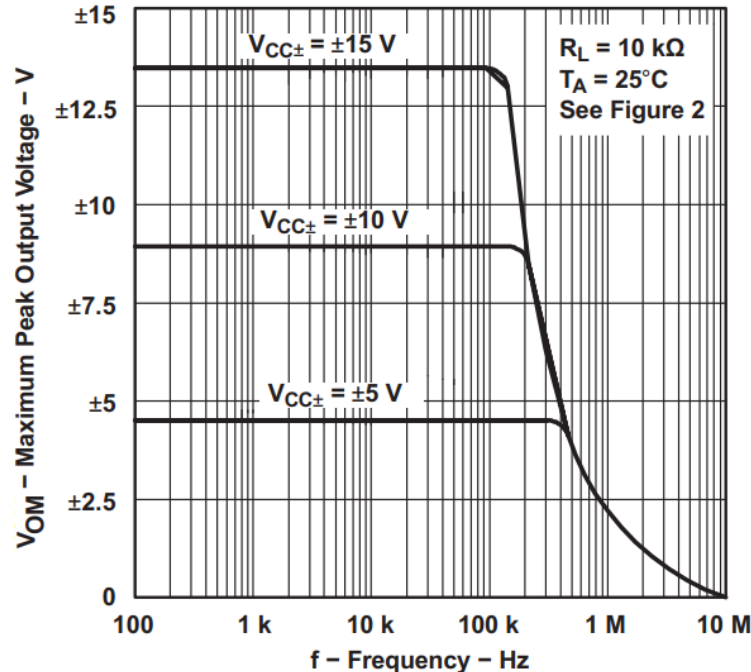


Figure 6-41. Maximum Peak Output Voltage vs Frequency

$$A \cdot f_c = GBW = cte$$

Bande-passante en boucle ouverte

$$f_c = GBW / A$$

$$A = 10^{(A_{OL} / 20)} \approx 10^6$$

6.17 Electrical Characteristics: TL07xH

INPUT CAPACITANCE				
Z _{ID}	Differential		100 2	MΩ pF
Z _{ICM}	Common-mode		6 1	TΩ pF
OPEN-LOOP GAIN				
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$$V_S = A \cdot (V^+ - V^-)$$

Amplificateur Linéaire Intégré



Produit Gain-Bande-Passante constant

Comportement passe-bas

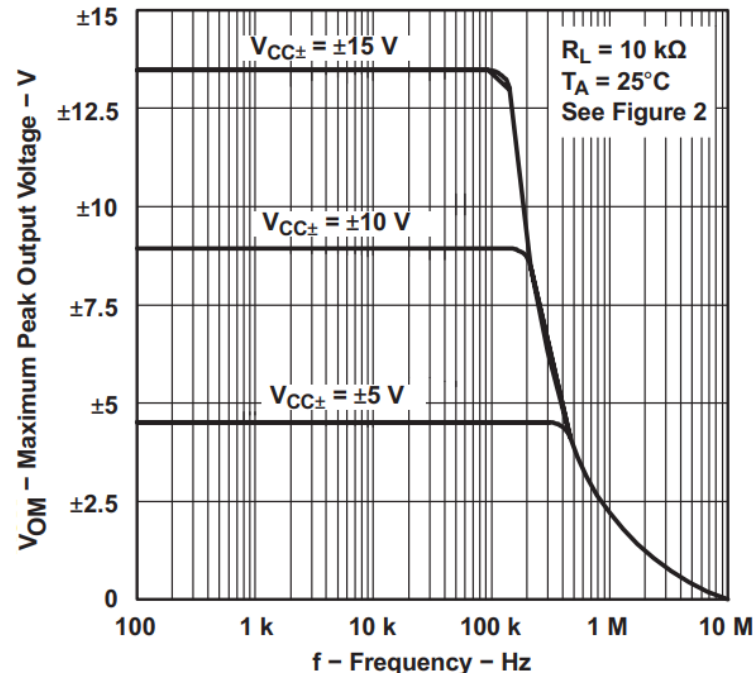


Figure 6-41. Maximum Peak Output Voltage vs Frequency

$$V_S = A \cdot (V^+ - V^-)$$

$$A \cdot f_c = \text{GBW} = \text{cte}$$

Bande-passante en boucle ouverte

$$f_c = \text{GBW} / A \rightarrow f_c \approx 5 \text{ Hz}$$

$$A = 10^{(A_{OL} / 20)} \approx 10^6$$

6.17 Electrical Characteristics: TL07xH

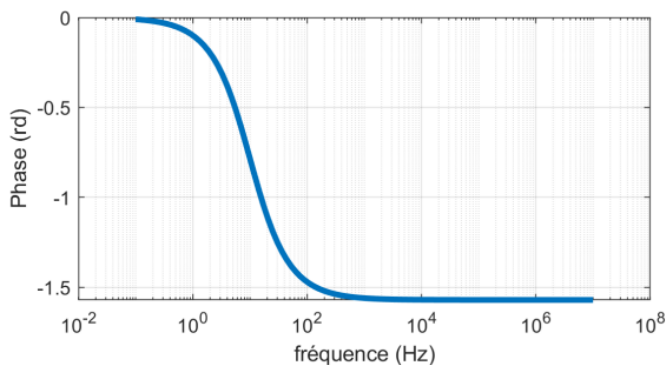
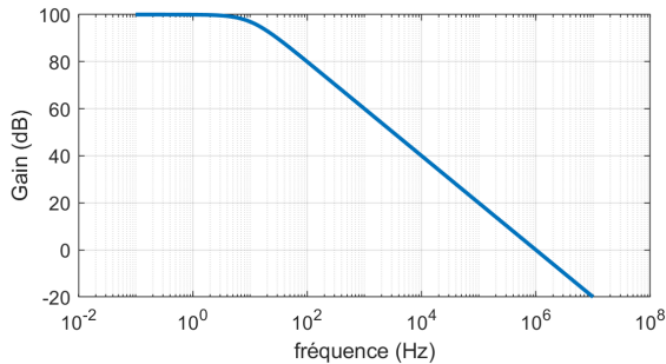
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Amplificateur Linéaire Intégré



Produit Gain-Bande-Passante constant

Comportement passe-bas



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Amplificateur Linéaire Intégré

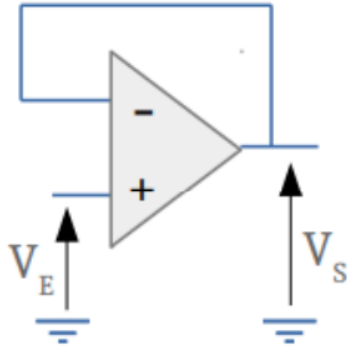


ALI en boucle fermée / Modèle d'ordre 1

Rebouclage entre la sortie et l'entrée négative

$$V^+ = V_E$$

$$V^- = V_S$$



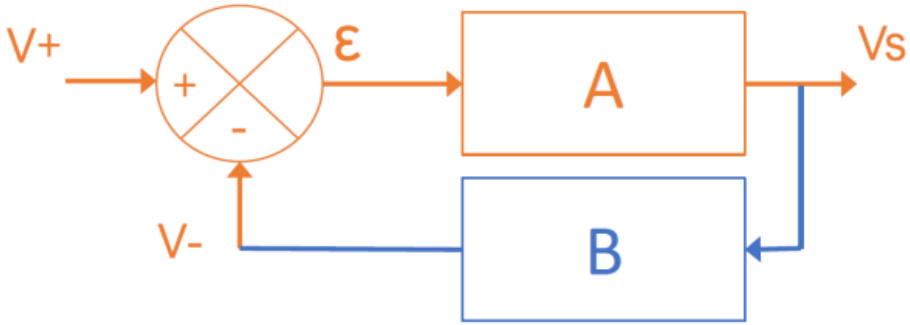
→ Fonctionnement linéaire

Hypothèse

$$V^+ = V^-$$

$$V_S = V_E$$

$$A(j\omega) = \frac{A_{MAX}}{1 + j \frac{\omega}{\omega_c}}$$

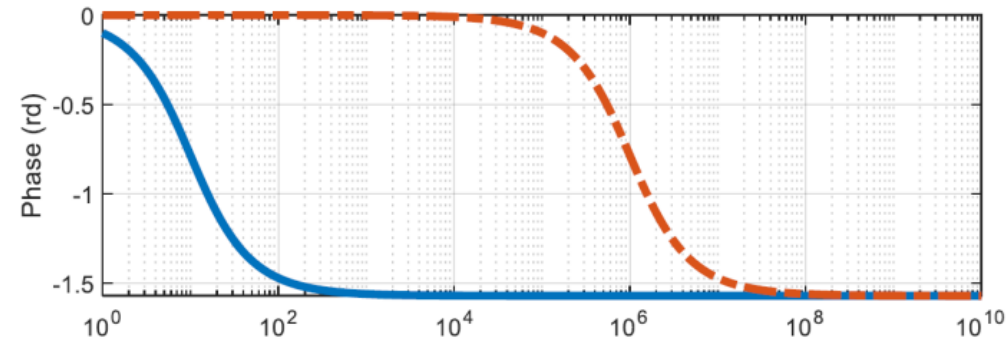
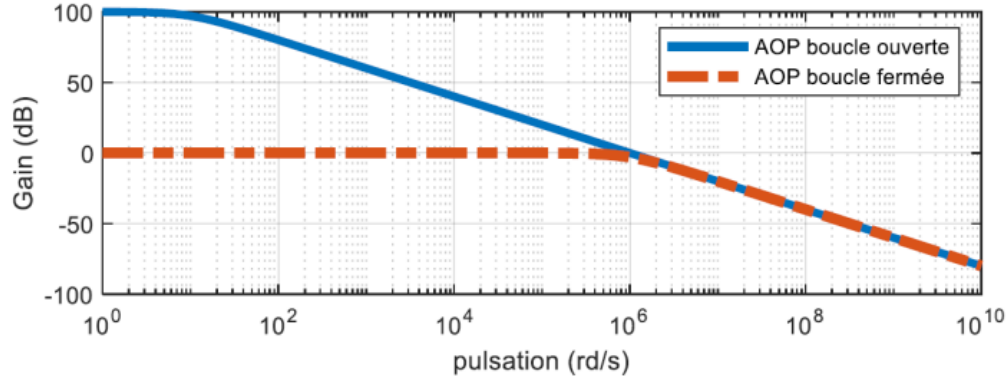


$$V_S = \frac{A(j\omega)}{1 + A(j\omega) \cdot B} V_E$$

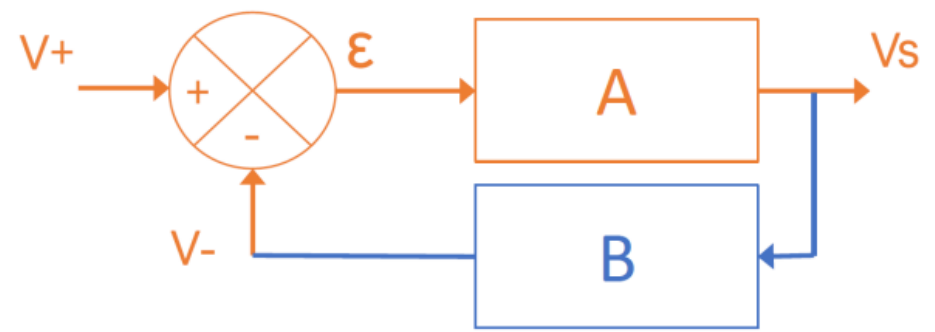
Amplificateur Linéaire Intégré



ALI en boucle fermée / Modèle d'ordre 1



$$A(j\omega) = \frac{A_{MAX}}{1 + j \frac{\omega}{\omega_c}}$$



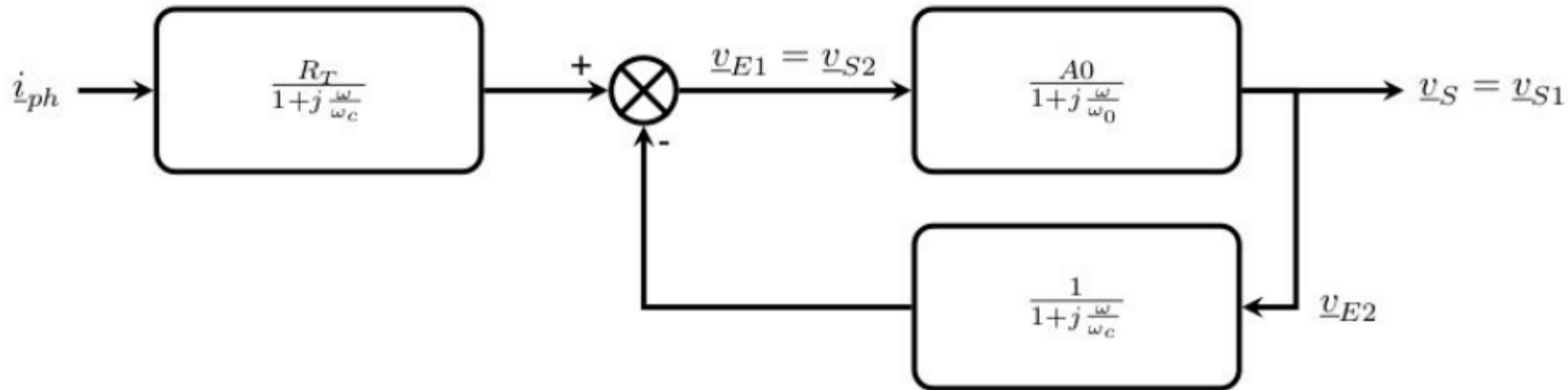
$$V_S = \frac{A(j\omega)}{1 + A(j\omega) \cdot B} V_E$$

Structure P2



Montage transimpédance / Modélisation

Et si B est d'ordre 1 ?



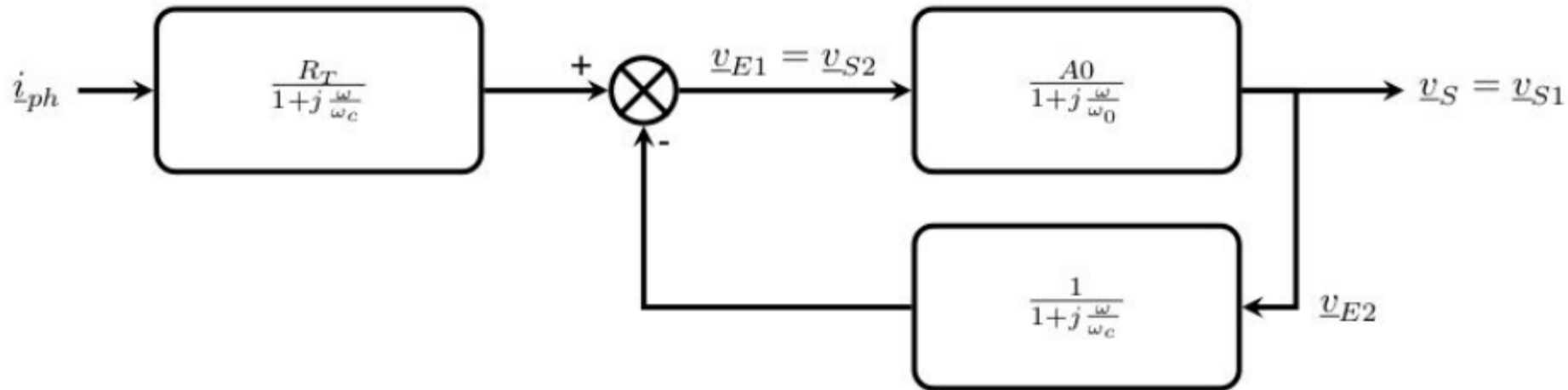
$$V_S = \frac{A(j\omega)}{1 + A(j\omega) \cdot B(j\omega)} V_E$$

Structure P2



Montage transimpédance / Modélisation

Et si B est d'ordre 1 ?



$$\frac{V_S}{I_{Phd}} = \frac{R_T \cdot A_0}{\left(1 + \frac{j \cdot \omega}{\omega_0}\right) \cdot \left(1 + \frac{j \cdot \omega}{\omega_c}\right) + A_0}$$

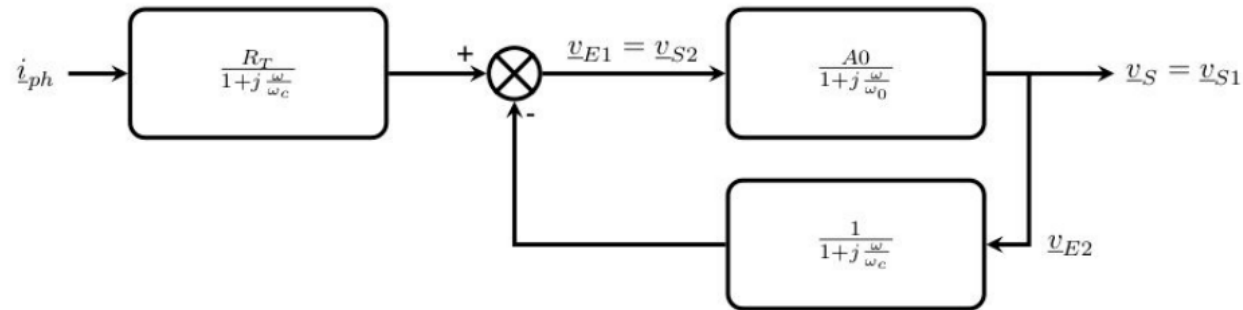
$$V_S = \frac{A(j\omega)}{1 + A(j\omega) \cdot B(j\omega)} V_E$$

Structure P2



Montage transimpédance / Modélisation

Et si B est d'ordre 1 ?



$$\frac{V_S}{I_{Phd}} = \frac{R_T \cdot A_0}{\left(1 + \frac{j \cdot \omega}{\omega_0}\right) \cdot \left(1 + \frac{j \cdot \omega}{\omega_c}\right) + A_0}$$

$$V_S = \frac{A(j\omega)}{1 + A(j\omega) \cdot B(j\omega)} V_E$$