AMPLIFICADORES DE INSTRUMENTACIÓN

Gonzalo Uribarri
Laboratorio de sistemas Dinámicos
DF FCEN

Plan de la charla

- **Introducción**: Motivar la necesidad de un amplificador de instrumentación en nuestro sistema.

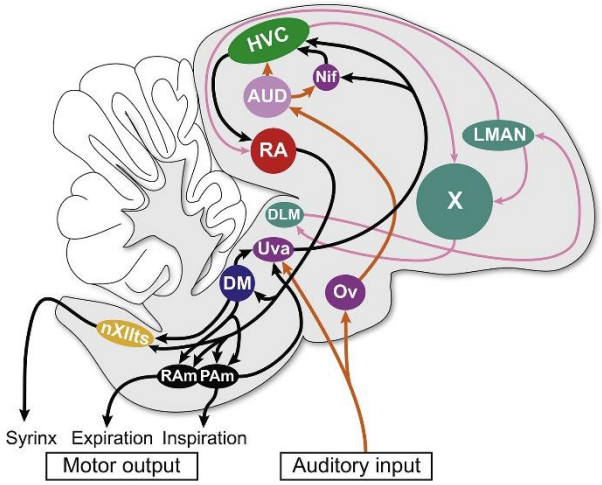
- **Desarrollo histórico:** Brevísima reseña de la evolución de la electrónica de amplificación de señales.

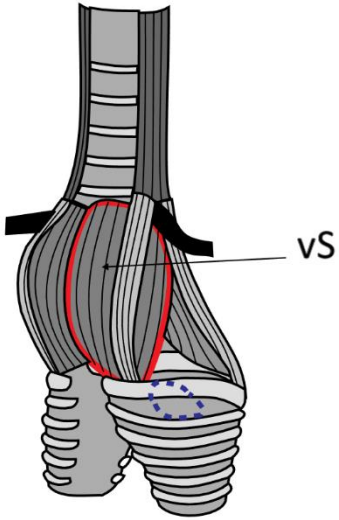
- **IN-AMP Moderno:** Presentación del circuito mas usado en amplificadores de instrumentación hoy en día.

Laboratorio de Sistemas Dinámicos

Aprendizaje Vocal

Sistema nervioso ⇄ Periferia ⇄ Entorno





[Alonso et al., 2015] [Döppler et al., 2018]

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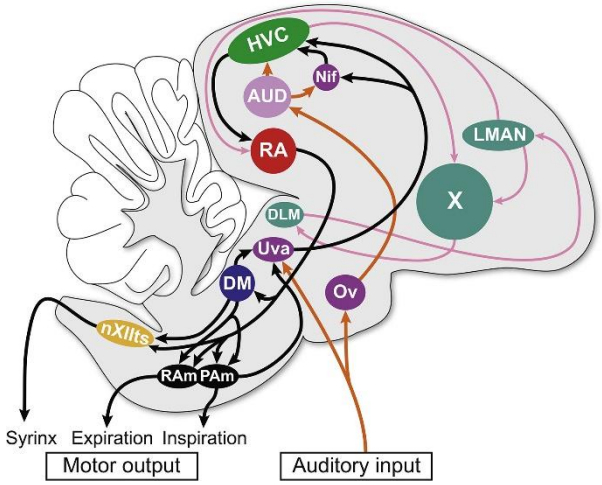

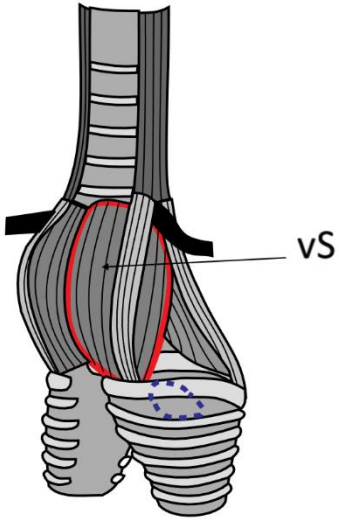

[Amador et al., 2017]

[Döppler et al., 2018]

Mediciones en el Laboratorio

Sistema nervioso

- Multi-Unit Recording
- Local Field Potential

Periferia

- Presión en sacos aéreos (Sensor Fuji-Kura)
- Actividad muscular (EMG)
- Desplazamiento abdominal (Sensor Hall)
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2 Señales simultaneas

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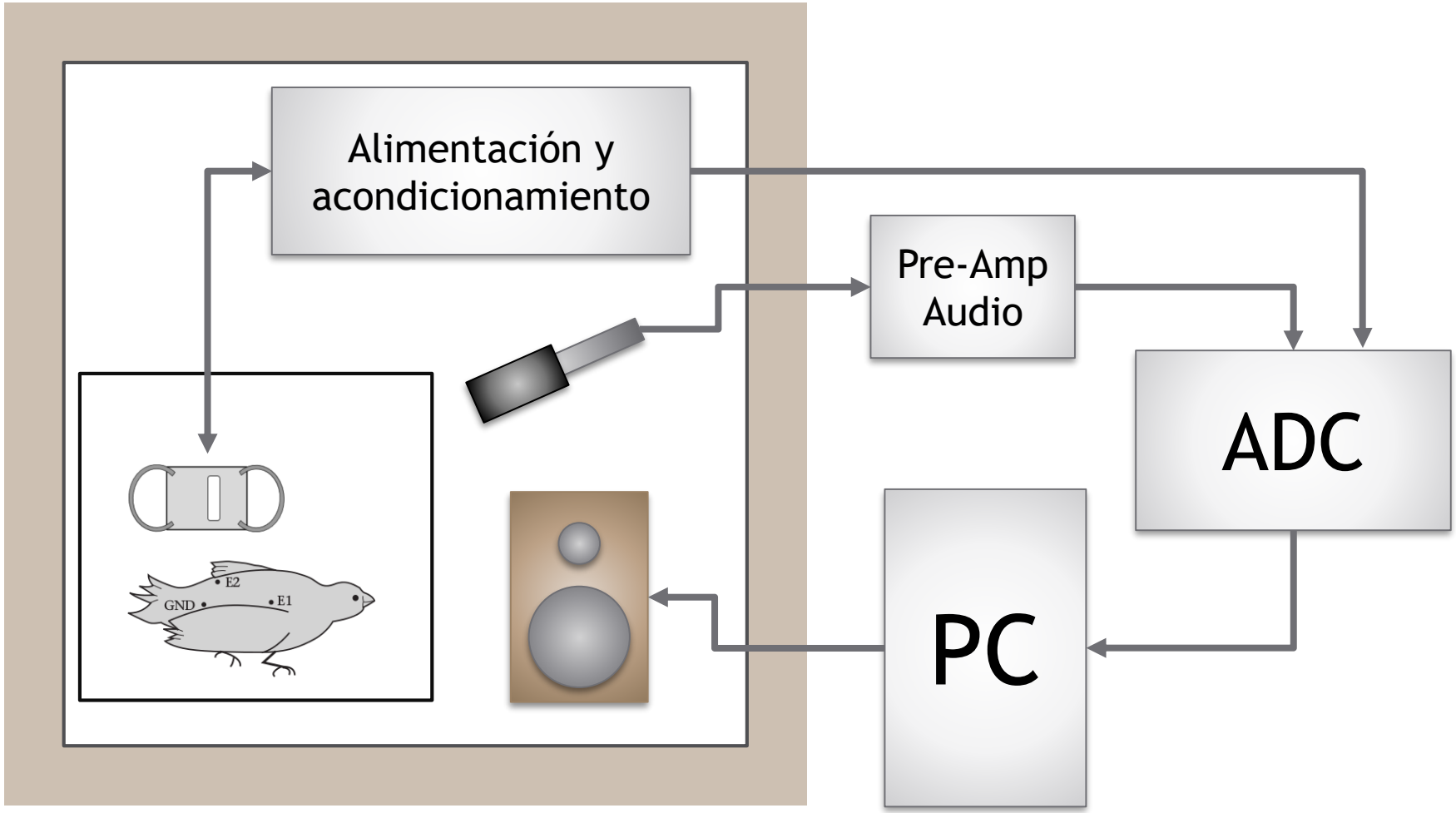
2 Señales simultaneas → 3 Señales Biológicas

COMING SOON

Setup de medición



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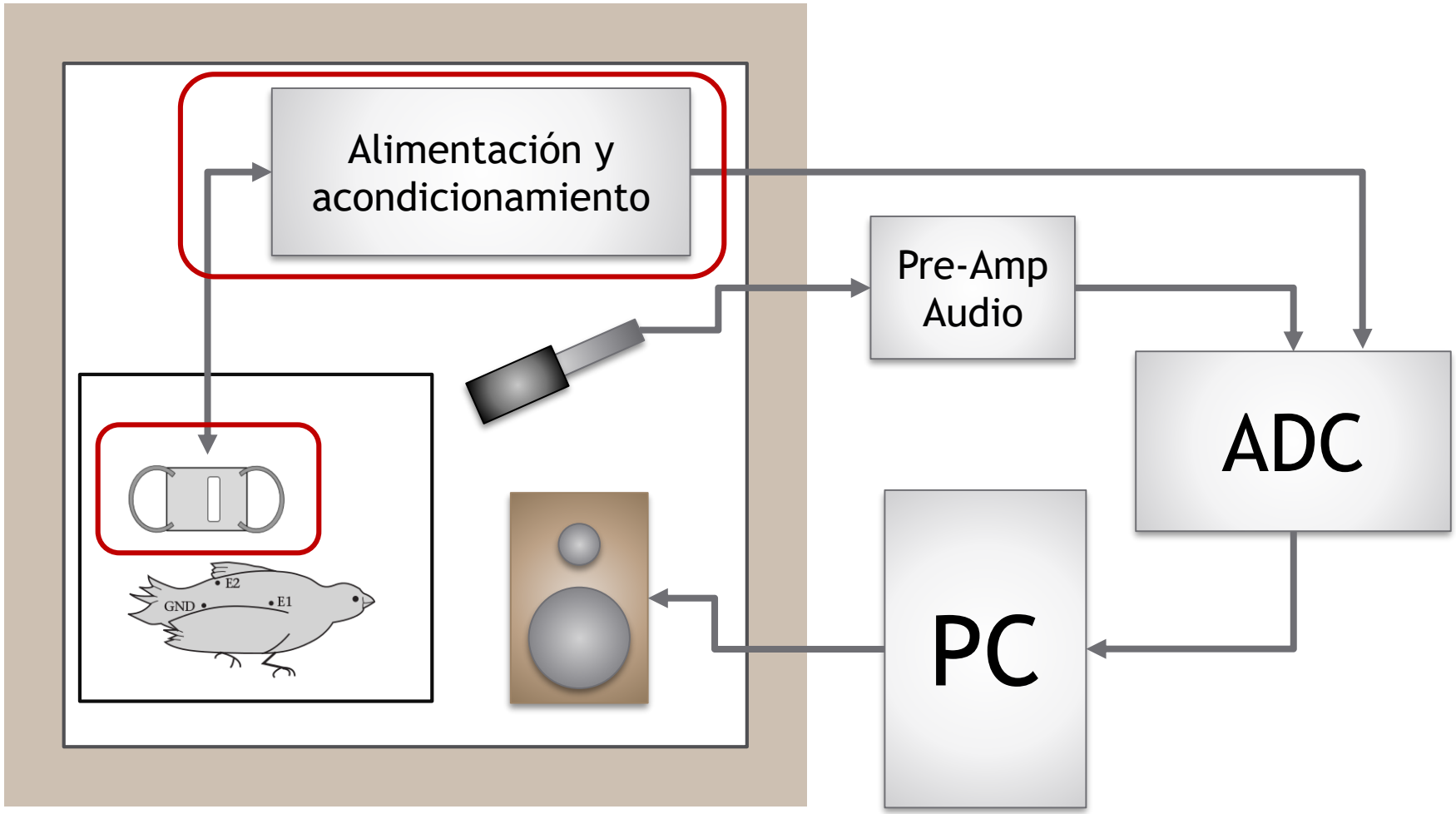

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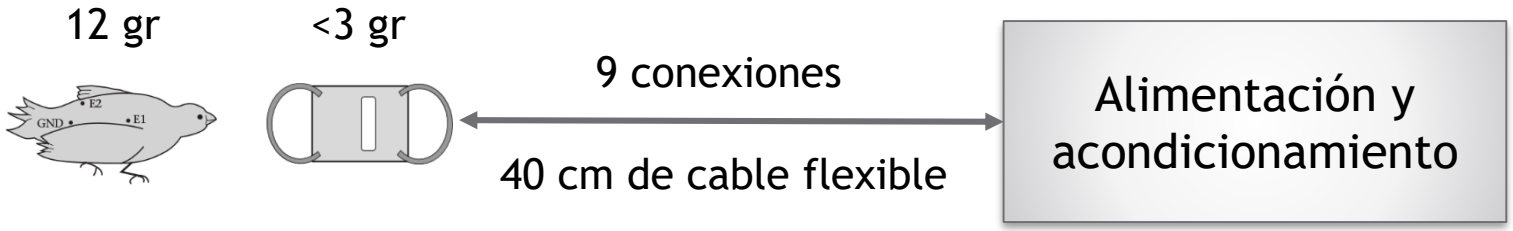
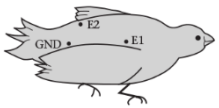
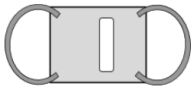


Setup de medición

12 gr



<3 gr



9 conexiones

40 cm de cable flexible

Alimentación y acondicionamiento

- Presión: Sensor Fuji-Kura ~100 mV ~1mA

- Desplazamiento abdominal: Sensor hall ~ 10V ~10mA

- Actividad muscular: EMG ~ 100 uV

Setup de medición

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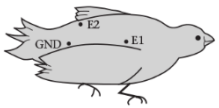

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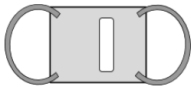

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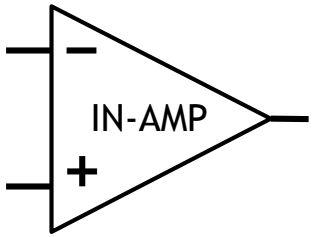
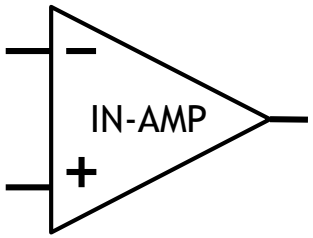


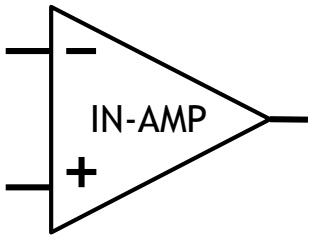
Amplificador de Instrumentación



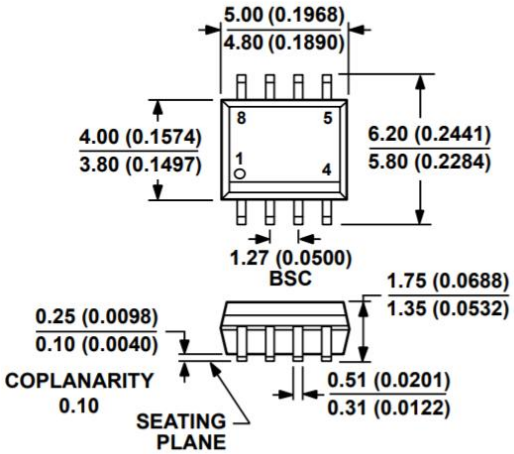
Características

- Alta ganancia
- Muy alto rechazo al modo común (CMRR)
- Muy alta impedancia de entrada
- Impedancia balanceada
- Respuesta lineal

Amplificador de Instrumentación



AD620 (~10 USD)



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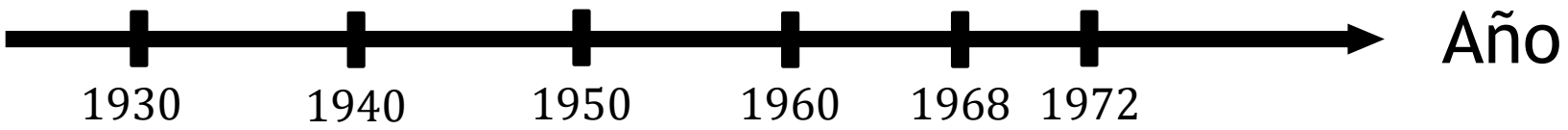

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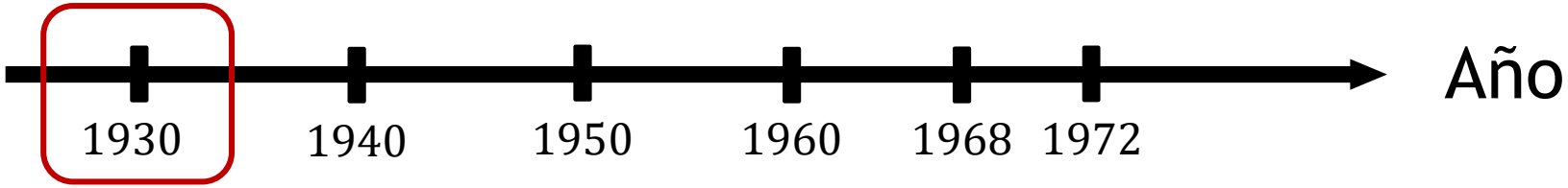
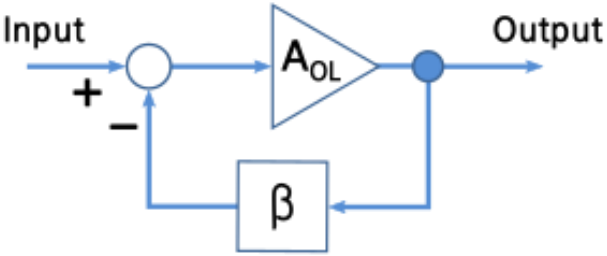


Harold S. Black (Western Electric Company)

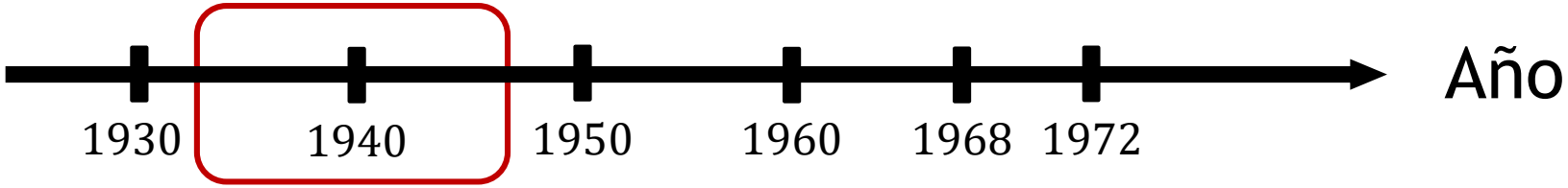
Amplificador de Realimentación negativa (1927 -1936)



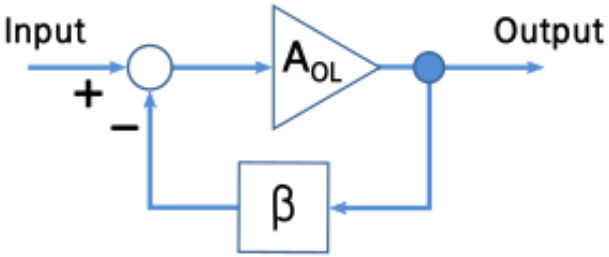
- Estabilización de ganancia
- Menor distorsión
- Mayor Bandwidth
- Menor ganancia

Tríodos para líneas telefónicas

Desarrollo histórico



Harry Nyquist



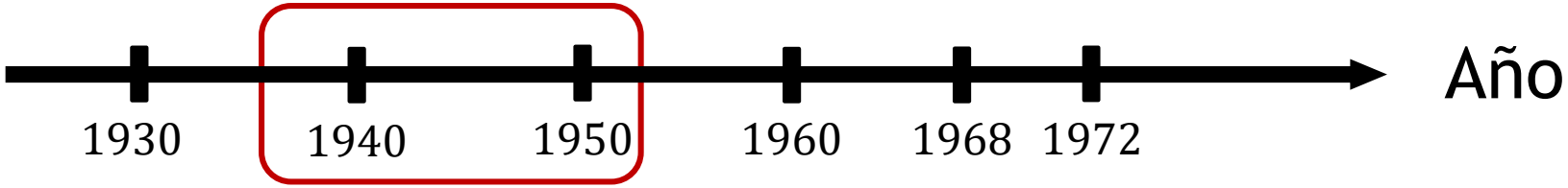
Hendrick Bode

Criterios de estabilidad en Feedback y mejoras en diseño (1933-1945)

AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES
BELL SYSTEM

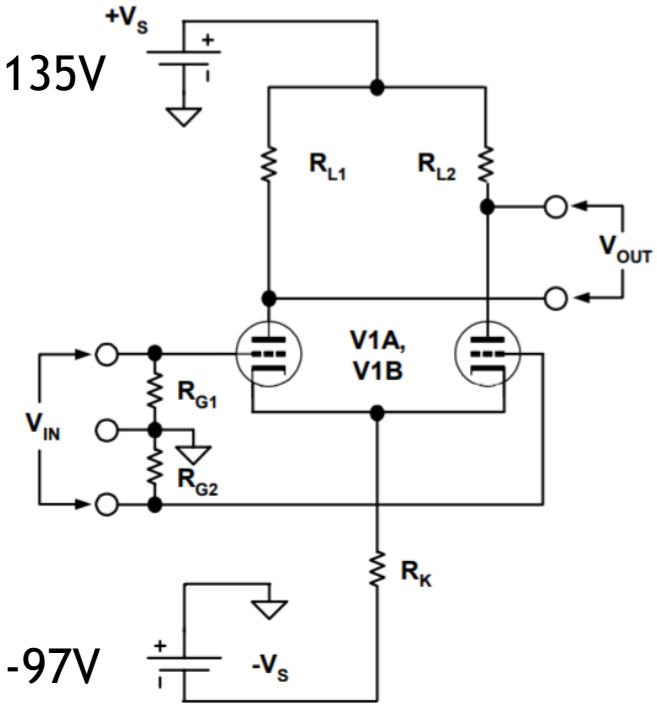
1939

Desarrollo histórico



Amplificador Diferencial (1937)
"Amplificadores Biológicos"

Otto Schmidt



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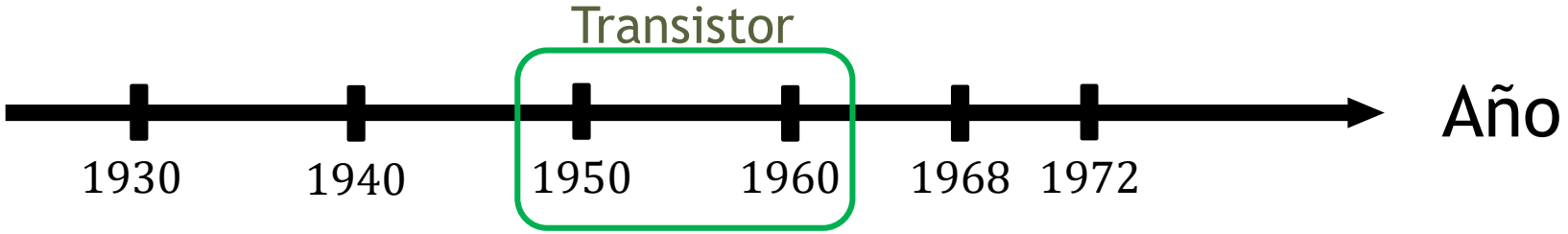

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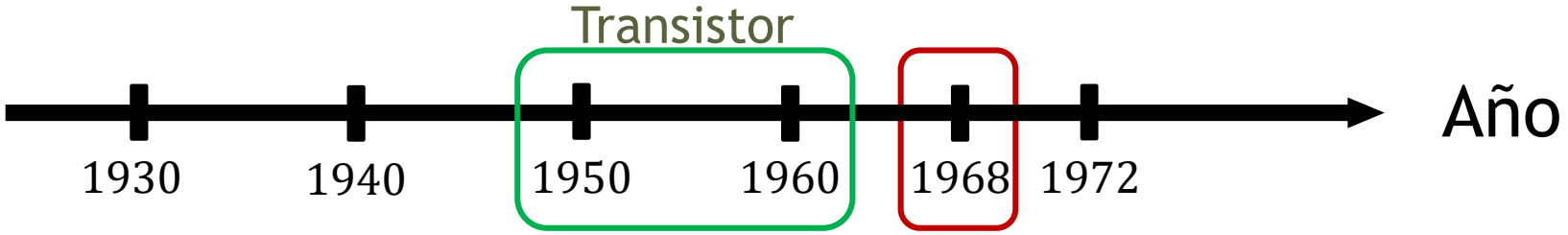
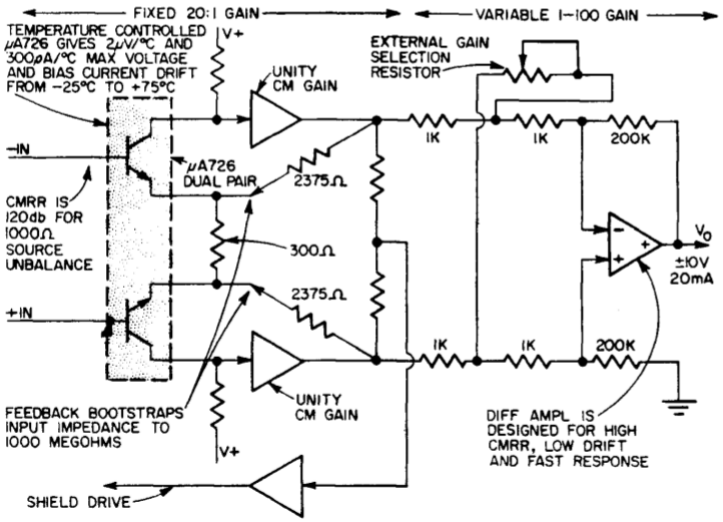


Primer IN-AMP: Model 601 (1968)

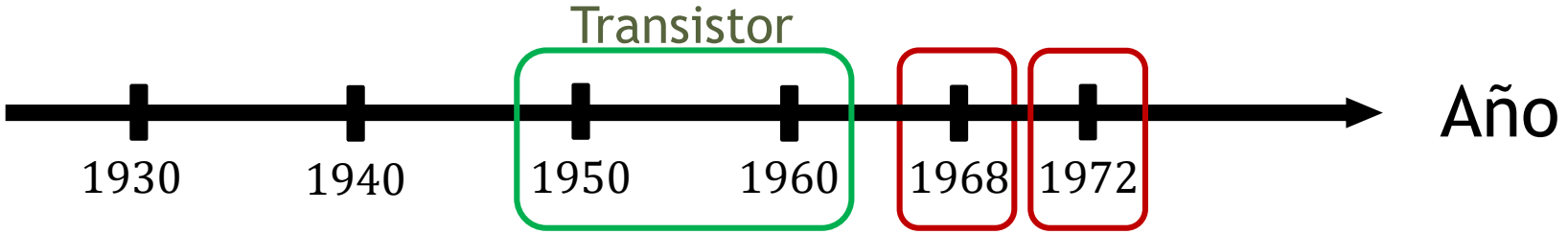


MODEL 601 WIDEBAND DIFFERENTIAL DC AMPLIFIER

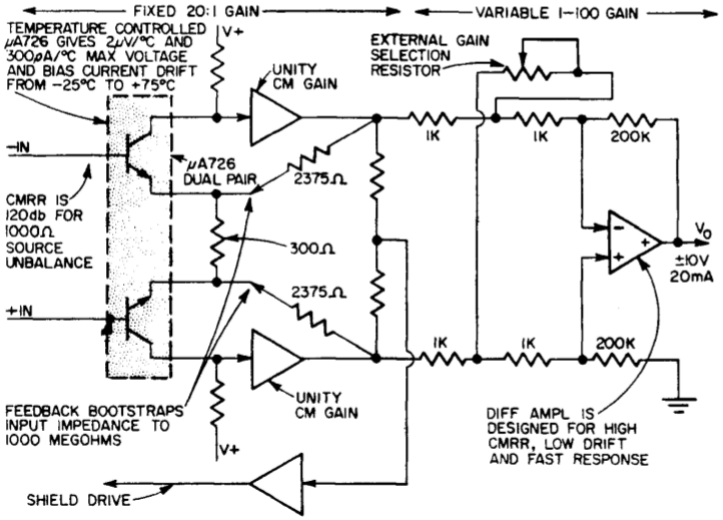
4 cm x 4 cm x 1,5 cm

$$CMRR = 20\log\left(\frac{A_d}{|A_{CM}|}\right) = 80dB \quad (G = 10)$$

Desarrollo histórico



Primer IN-AMP: Model 601 (1968)



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4 cm x 4 cm x 1,5 cm

$$CMRR = 20\log\left(\frac{A_d}{|A_{CM}|}\right) = 80dB \quad (G = 10)$$

Versión Moderna

AD 520 (1972)

Because of its small size, low cost, and complete-on-a-chip

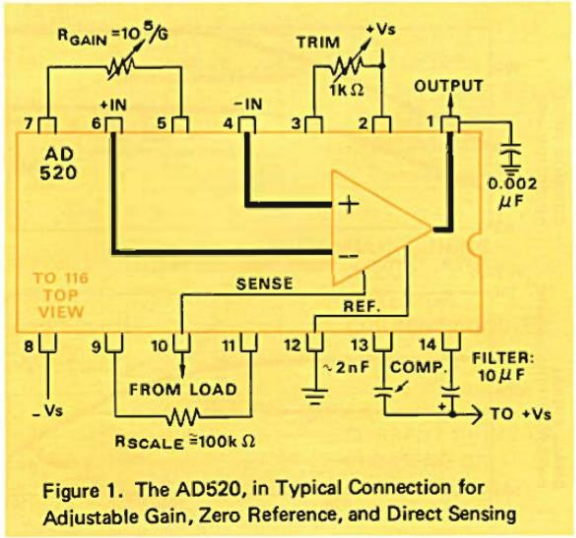
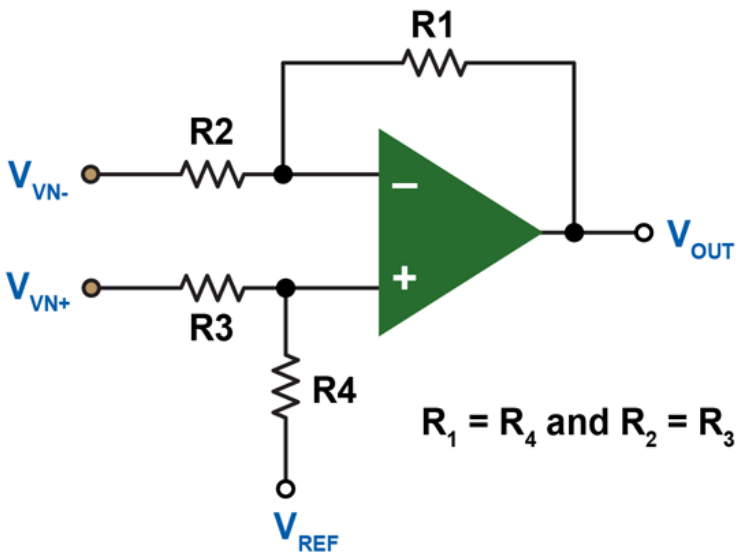


Figure 1. The AD520, in Typical Connection for Adjustable Gain, Zero Reference, and Direct Sensing

CMRR = 100dB

Amplificador diferencial

(versión naif de IN-AMP)



$$V_{out} = \frac{R2}{R1}(V_{IN+} - V_{IN-}) + V_{REF}$$

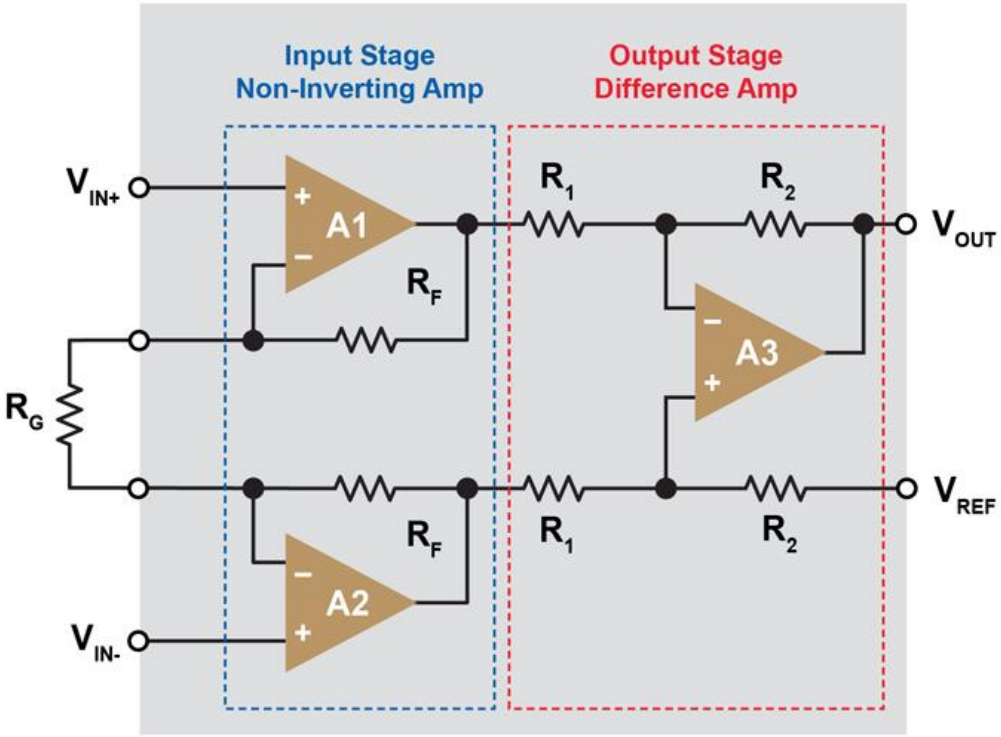
$$CMRR(dB) \approx 20 \log\left(\frac{1 + \frac{R2}{R1}}{Kr}\right)$$

Problemas

- Impedancia de entrada no balanceada
- CMRR determinado por Missmatch de las resistencias (Kr):

  1% off --> CMRR = 46 dB
- Impedancia de la fuente puede afectar el CMRR

Amplificador de Instrumentación



$$V_{out} = G(V_{IN+} - V_{IN-}) + V_{REF}$$

$$G = \left(1 + \frac{2R_F}{R_G}\right)\frac{R_2}{R_1}$$

$$CMRR(dB) \approx 20\log\left(\frac{100\,G}{Kr}\right)$$

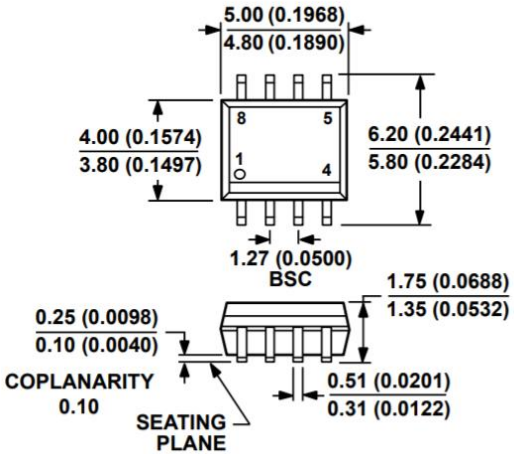
Ventajas

- Seteo de ganancia con Rg
- CMRR depende (poco) de resistencias internas
- Impedancia de entrada alta y balanceada

IN-AMP Moderno

AD620 (~10 USD)

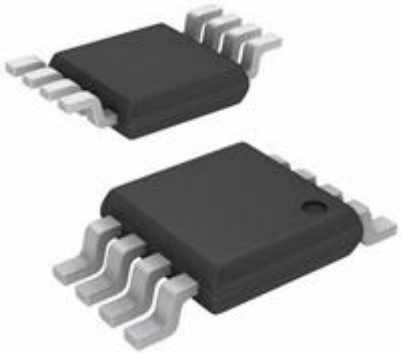
Analog Devices



CMRR = 110dB

INA827 (~17 USD)

Texas Instrument



CMRR = 106dB

GRACIAS