Endüstriyel Otomatik Kontrol Sistemleri

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Dersin Konusu: Endüstriyel Otomatik Kontrol Sistemlerinde Kullanılan Algılayıcılar, Dönüştürücüler ve Uygulamaları

Dersin Amacı:

Endüstriyel otomatik kontrol sistemlerinde kullanılan algılayıcılar ve dönüştürücülerin özellikleri, iç donanımı ve elektronik devrelerinin incelenmesi, uygulama devrelerinin analizi, incelenmesi ve tasarlanmasının öğretilmesidir.

2. Endüstriyel Otomatik Kontrol Sistemlerinde Kullanılan Algılayıcılar (sensors), Dönüştürücüler (transducers) ve Uygulamaları

- 2.1. Algılayıcı seçiminde kullanılan ölçütler
  - 2.1.1. Duyarlılık
  - 2.1.2. Doğrusallık
  - 2.1.3. Sınırlar
  - 2.1.4. Yanıt süresi
  - 2.1.5. Doğruluk
  - 2.1.6. Tekrarlanabilirlik
  - 2.1.7. Ayırıcılık
  - 2.1.8. Çıkışın tipi
- 2.2. Dönüştürücülerin fiziksel karakteristikleri
  - 2.2.1. Büyüklük ve ağırlık
  - 2.2.2. Güvenirlik
  - 2.2.3. Arabirim
- 2.3. Dönüştürücülerin gruplanması
  - 2.3.1.1. Temaslı dönüştürücüler
  - 2.3.1.2. Temassız dönüştürücüler

- **2.3.2. Temaslı dönüştürücüler**
  - **2.3.2.1. Anahtarlar**
  - **2.3.2.2. Piezoelektrik dönüştürücüler**
  - **2.3.2.3. Konum ve yer değiştirmeyi algılama**
    - **2.3.2.3.1. Potansiyometreler**
      - **2.3.2.3.1.1. Doğrusal hareketli (Lineer, sürgülü)**
      - **2.3.2.3.1.2. Dairesel hareketli (Rotary pot.)**
    - **2.3.2.3.2. Doğrusal değişen farksal transformatör (LVDT)**
    - **2.3.2.3.3. Mutlak optik kodlayıcı**
    - **2.3.2.3.4. Artırmalı optik kodlayıcı**
  - **2.3.2.4. Kuvvet algılama**
  - **2.3.2.5. Moment (torque) algılama**
  - **2.3.2.6. Uzaklık algılama (proximity sensor, yakın mesafe nesne algılama)**
    - **2.3.2.6.1. Optik uzaklık algılayıcı**
    - **2.3.2.6.2. Eddy akım algılayıcı**
    - **2.3.2.6.3. Ultrasonik yankı**
    - **2.3.2.6.4. Magnetik, Endüktif algılayıcılar**
    - **2.3.2.6.5. Kapasitif algılayıcılar.**
- **2.3.3. Temassız Dönüştürücüler**

2.4. Endüstriyel Uygulamalar

SENSORS OVERVIEW

- **Sensors:**

  Convert a Signal or Stimulus (Representing a Physical Property) into an Electrical Output

- **Transducers:**

  Convert One Type of Energy into Another

- **The Terms are often Interchanged**

- ***Active* Sensors Require an External Source of Excitation:**

  RTDs, Strain-Gages

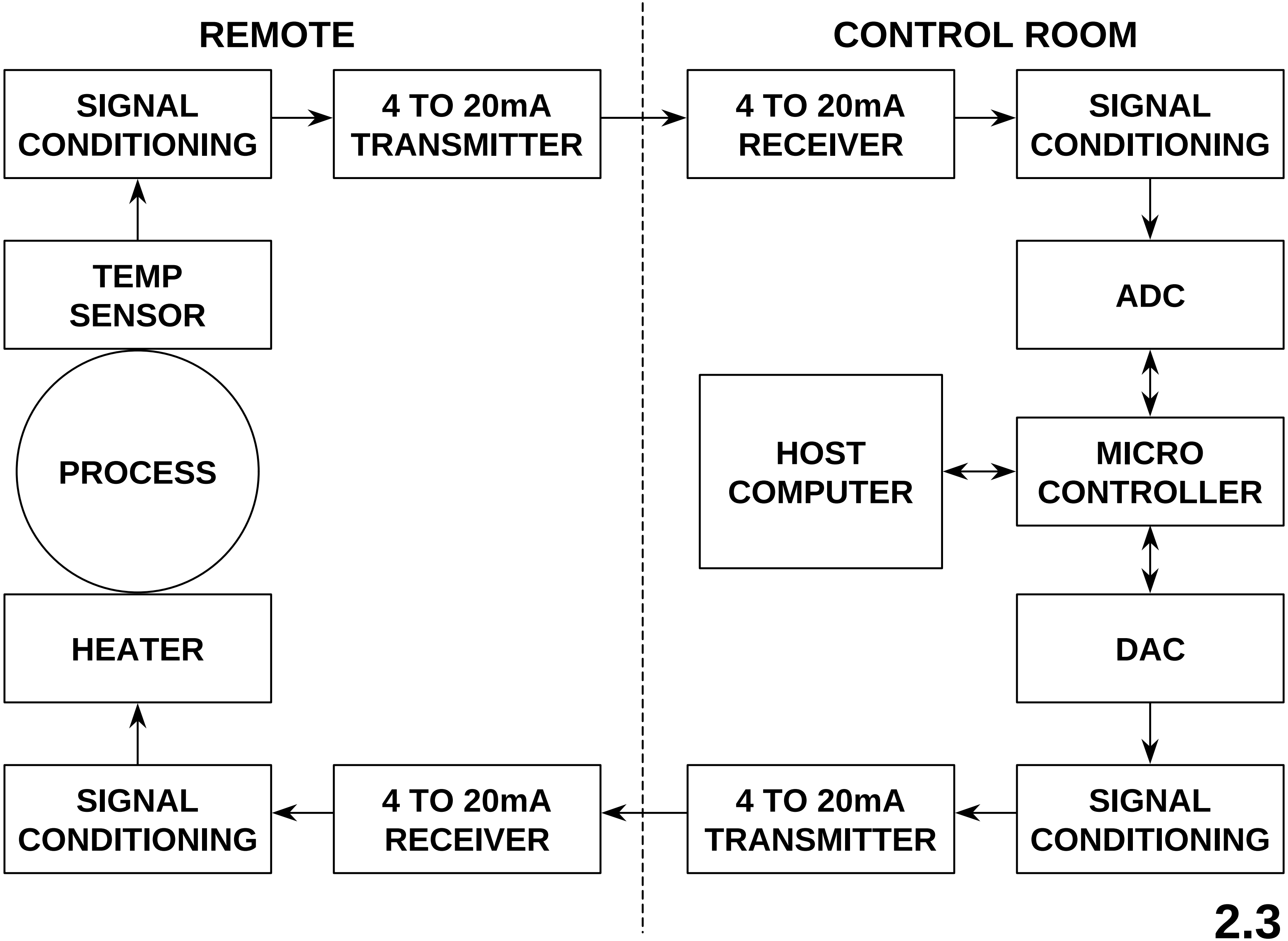
- ***Passive* (Self-Generating) Sensors do not:**

  Thermocouples, Photodiodes

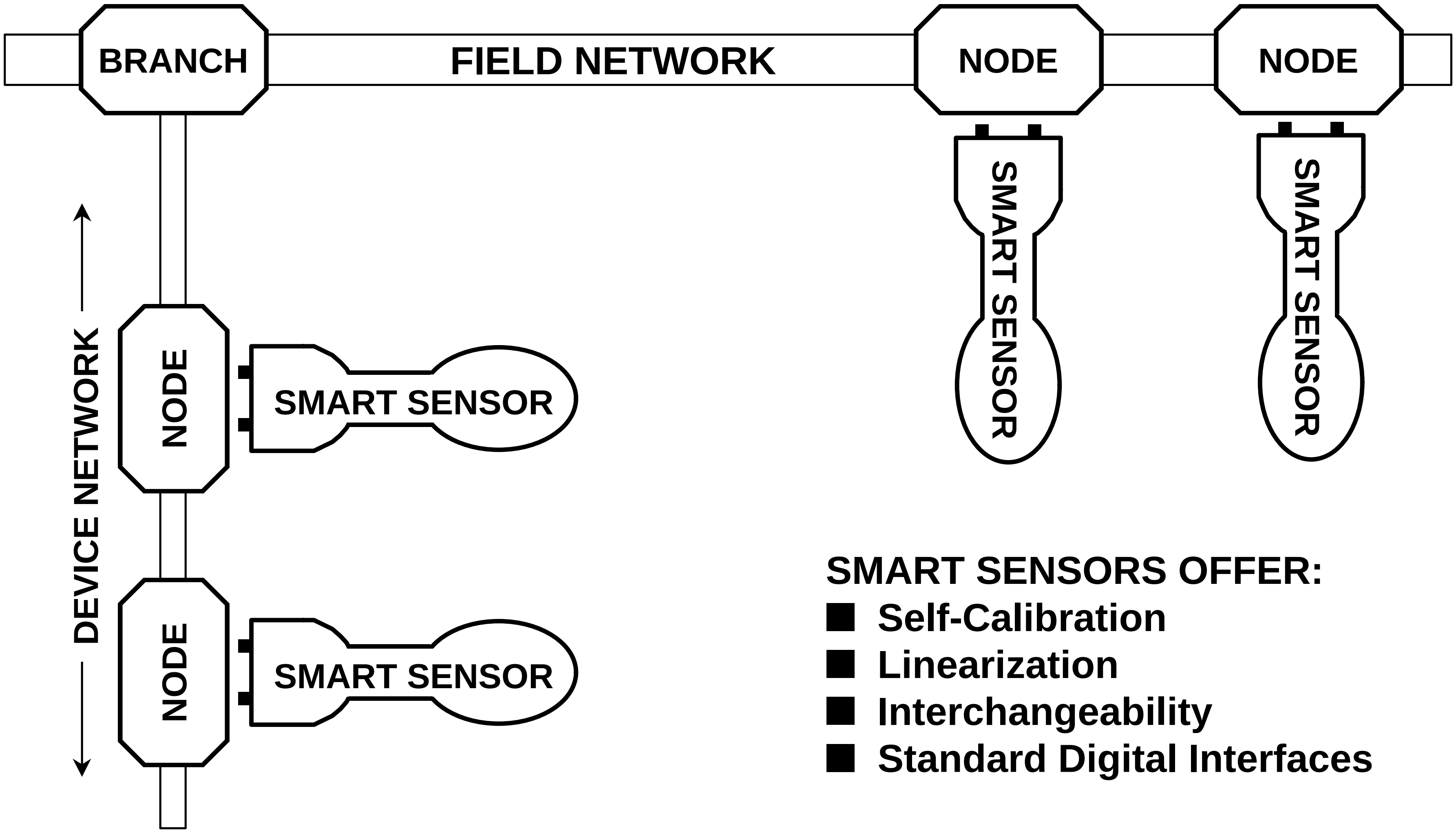
TYPICAL SENSORS AND THEIR OUTPUTS

PROPERTY	SENSOR	ACTIVE/ PASSIVE	OUTPUT
Temperature	Thermocouple	Passive	Voltage
	Silicon	Active	Voltage/Current
	RTD	Active	Resistance
	Thermistor	Active	Resistance
Force / Pressure	Strain Gage	Active	Resistance
	Piezoelectric	Passive	Voltage
Acceleration	Accelerometer	Active	Capacitance
Position	LVDT	Active	AC Voltage
Light Intensity	Photodiode	Passive	Current

TYPICAL INDUSTRIAL PROCESS CONTROL LOOP



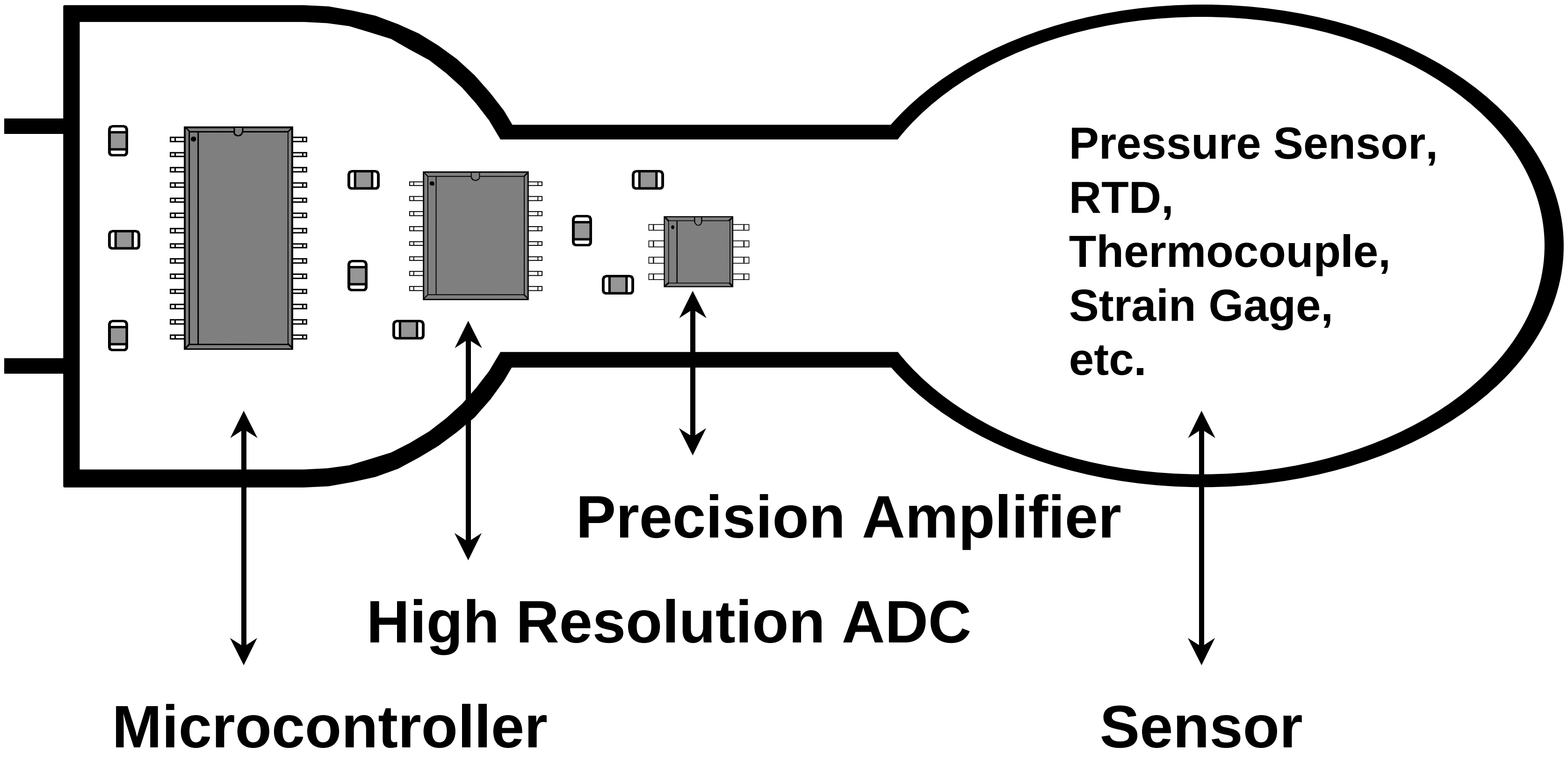
STANDARDIZATION AT THE DIGITAL INTERFACE USING SMART SENSORS



SMART SENSORS OFFER:

- Self-Calibration
- Linearization
- Interchangeability
- Standard Digital Interfaces

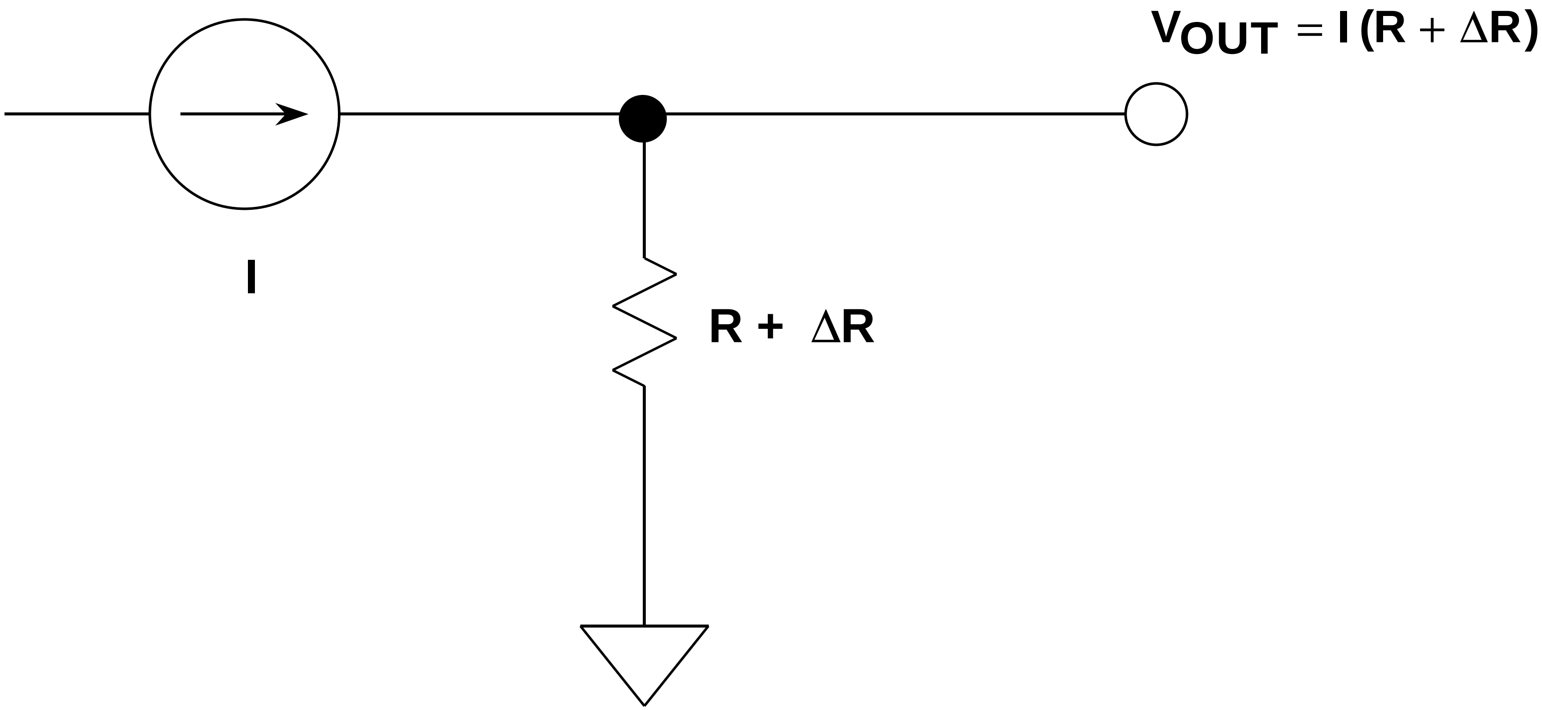
BASIC ELEMENTS IN A "SMART" SENSOR



RESISTANCE OF POPULAR SENSORS

■ Strain Gages	120Ω, 350Ω, 3500Ω
■ Weigh-Scale Load Cells	350Ω - 3500Ω
■ Pressure Sensors	350Ω - 3500Ω
■ Relative Humidity	100kΩ - 10MΩ
■ Resistance Temperature Devices (RTDs)	100Ω , 1000Ω
■ Thermistors	100Ω - 10MΩ

MEASURING RESISTANCE INDIRECTLY USING A CONSTANT CURRENT SOURCE



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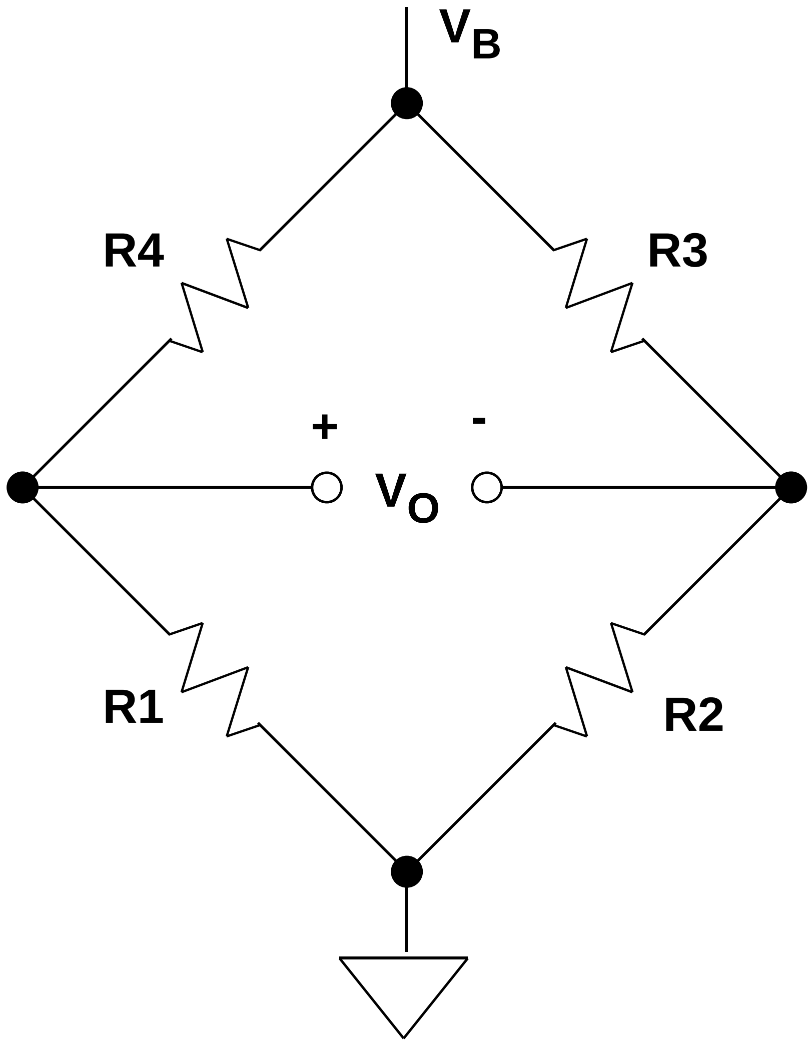
THE WHEATSTONE BRIDGE



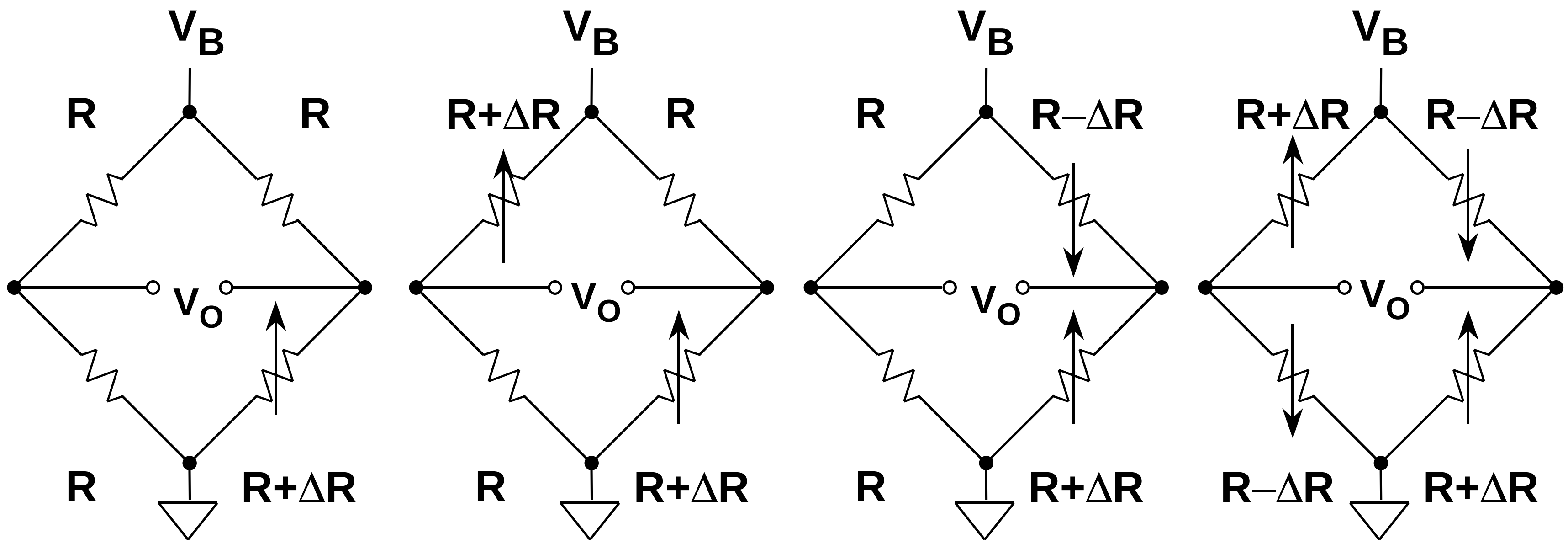
$$V_O = \frac{R1}{R1 + R4} V_B - \frac{R2}{R2 + R3} V_B$$

$$= \frac{\frac{R1}{R4} - \frac{R2}{R3}}{\left(1 + \frac{R1}{R4}\right)\left(1 + \frac{R2}{R3}\right)} V_B$$

AT BALANCE,

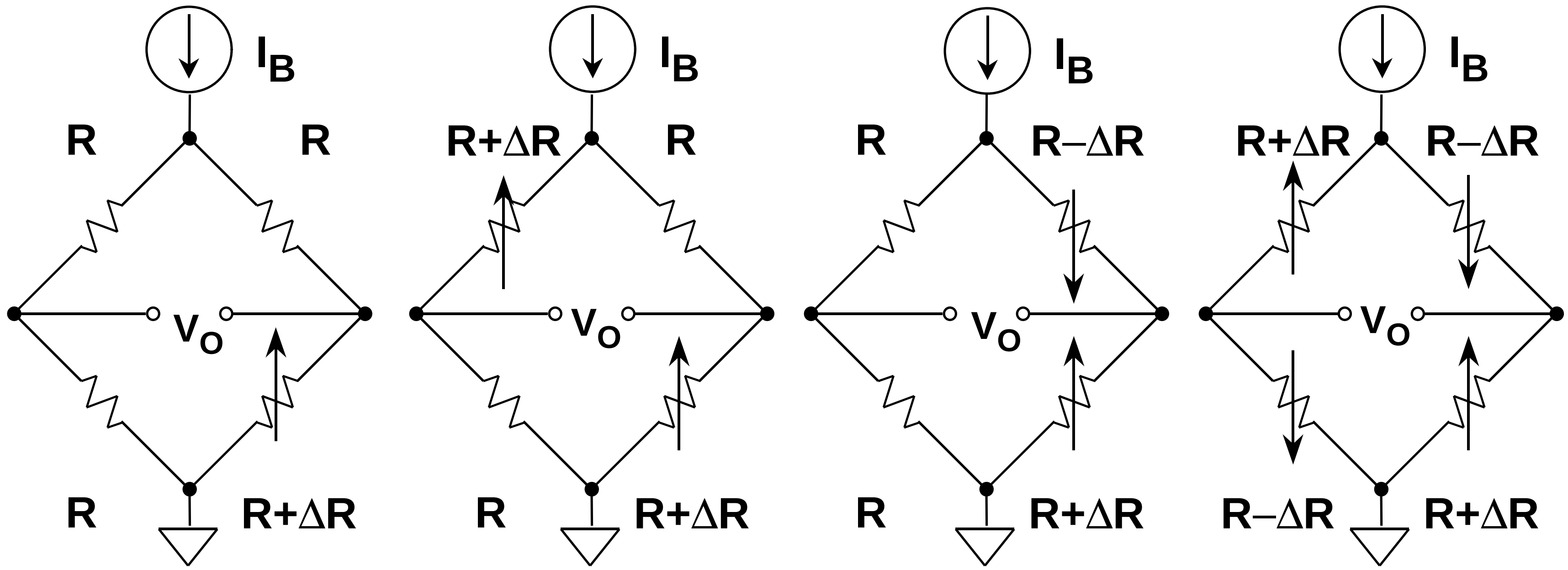
$$V_O = 0 \quad \text{IF} \quad \frac{R1}{R4} = \frac{R2}{R3}$$

OUTPUT VOLTAGE AND LINEARITY ERROR FOR CONSTANT VOLTAGE DRIVE BRIDGE CONFIGURATIONS



	(A)	(B)	(C)	(D)
V_O:	$\frac{V_B}{4}\left[\frac{\Delta R}{R+\frac{\Delta R}{2}}\right]$	$\frac{V_B}{2}\left[\frac{\Delta R}{R+\frac{\Delta R}{2}}\right]$	$\frac{V_B}{2}\left[\frac{\Delta R}{R}\right]$	$V_B\left[\frac{\Delta R}{R}\right]$
Linearity Error:	0.5%/%	0.5%/%	0	0
	(A) Single-Element Varying	(B) Two-Element Varying (1)	(C) Two-Element Varying (2)	(D) All-Element Varying

OUTPUT VOLTAGE AND LINEARITY ERROR FOR CONSTANT CURRENT DRIVE BRIDGE CONFIGURATIONS



	(A) Single-Element Varying	(B) Two-Element Varying (1)	(C) Two-Element Varying (2)	(D) All-Element Varying
V_O:	$\frac{I_B R}{4}\left[\frac{\Delta R}{R + \frac{\Delta R}{4}}\right]$	$\frac{I_B}{2}\left[\Delta R\right]$	$\frac{I_B}{2}\left[\Delta R\right]$	$I_B\left[\Delta R\right]$
Linearity Error:	0.25%/%	0	0	0

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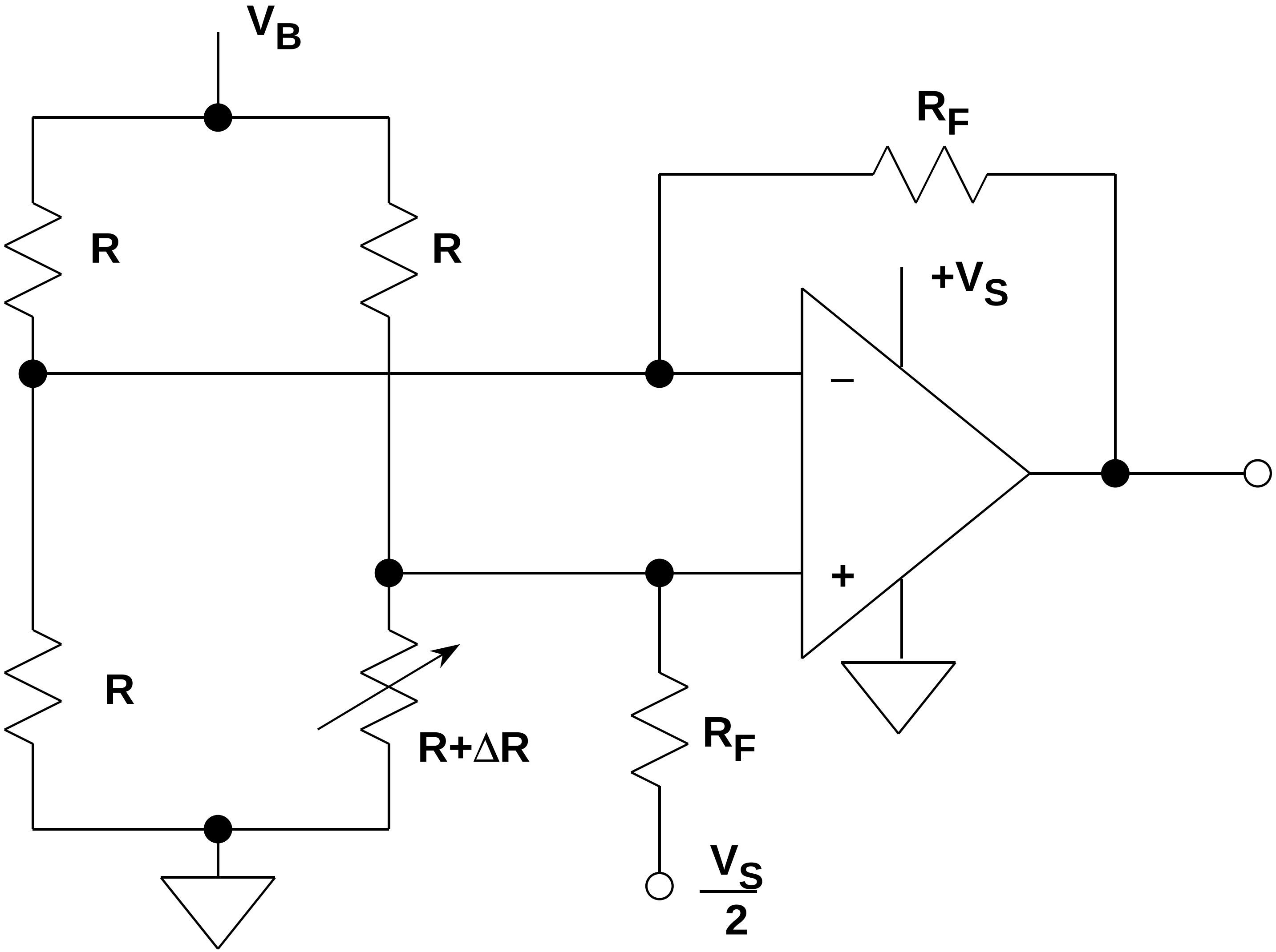
BRIDGE CONSIDERATIONS

- Selecting Configuration (1, 2, 4 - Element Varying)
- Selection of Voltage or Current Excitation
- Stability of Excitation Voltage or Current
- Bridge Sensitivity: FS Output / Excitation Voltage
  1mV / V to 10mV / V Typical
- Fullscale Bridge Outputs: 10mV - 100mV Typical
- Precision, Low Noise Amplification / Conditioning
  Techniques Required
- Linearization Techniques May Be Required
- Remote Sensors Present Challenges

USING A SINGLE OP AMP AS A BRIDGE AMPLIFIER FOR A SINGLE-ELEMENT VARYING BRIDGE



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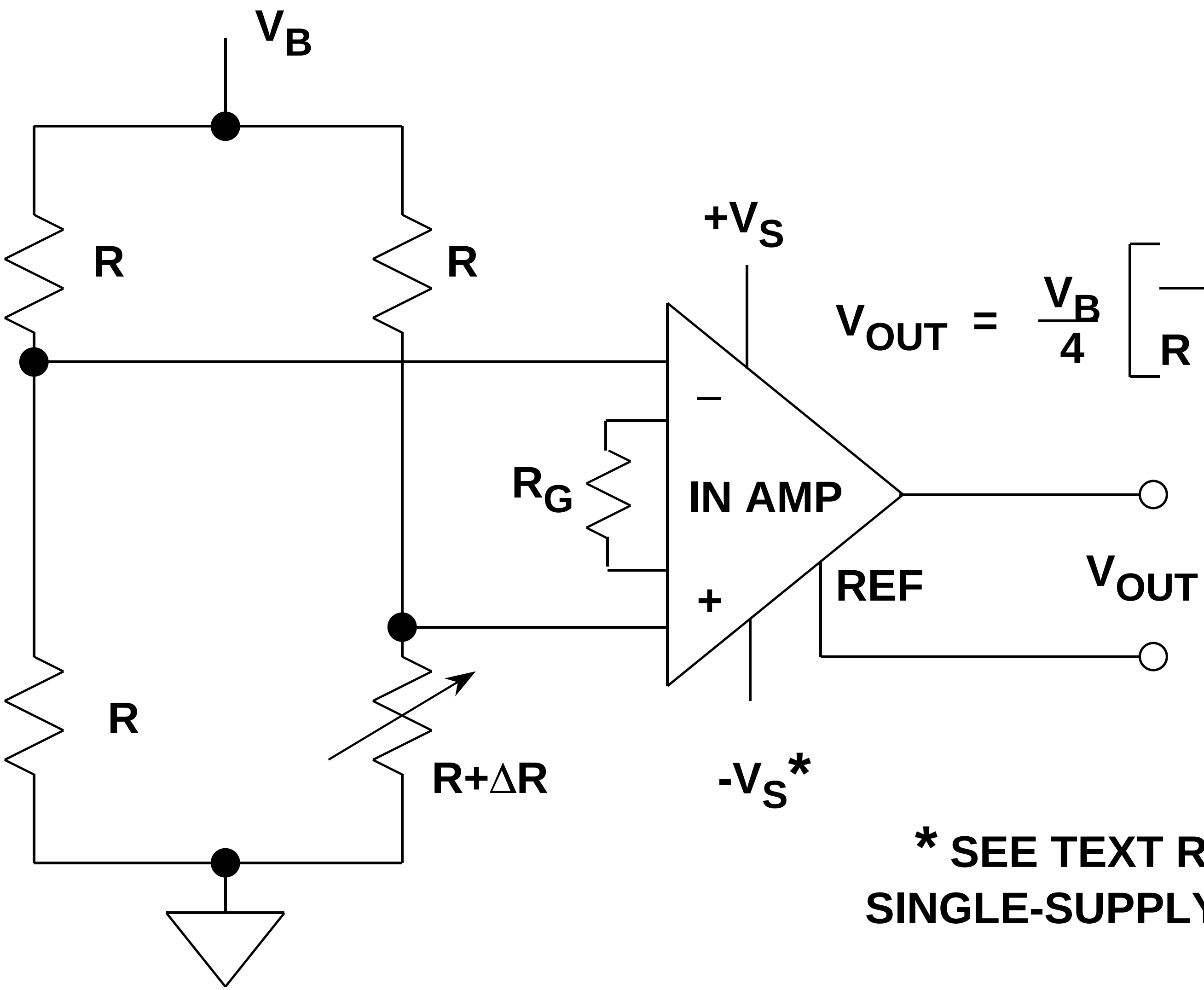
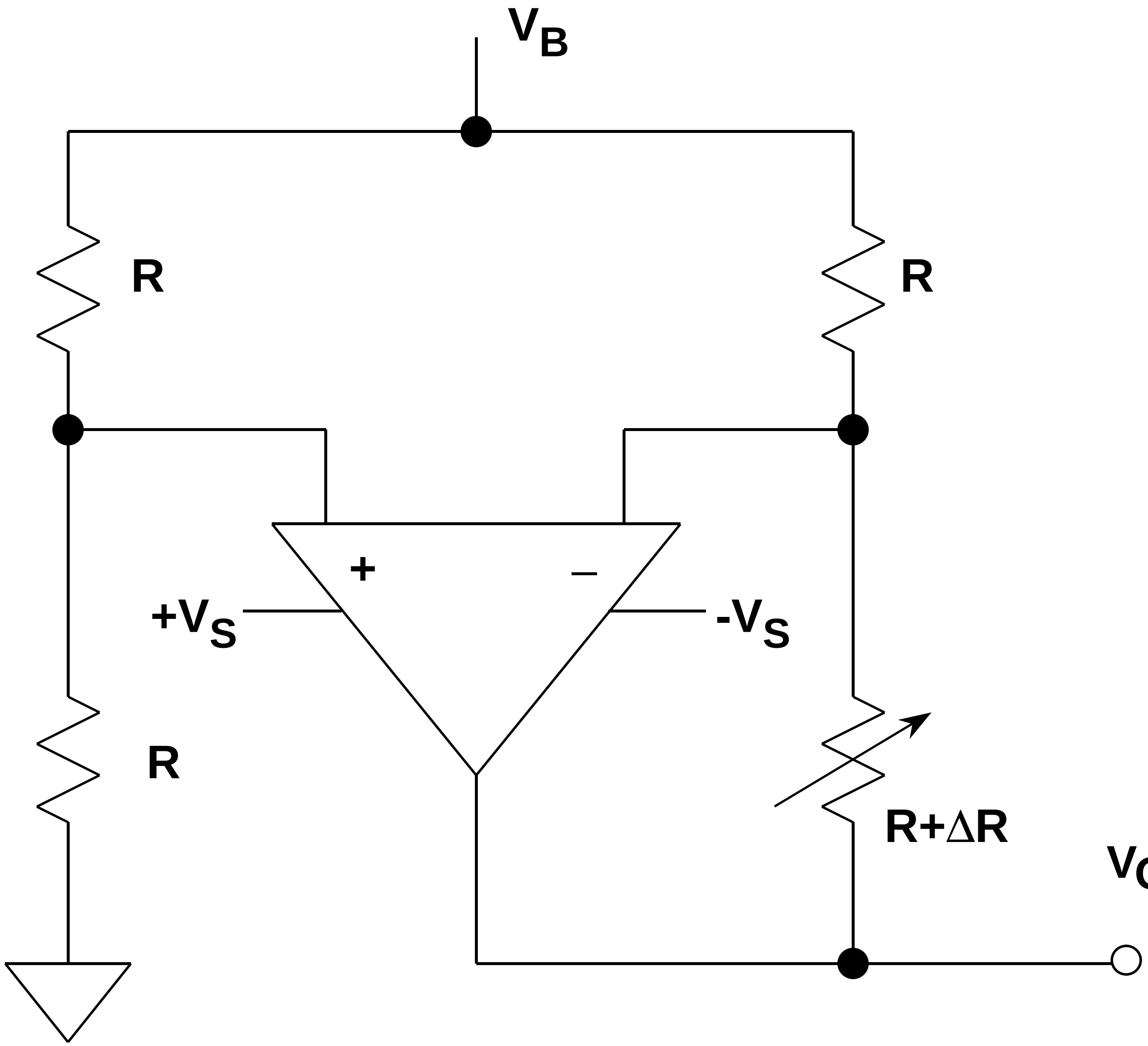
USING AN INSTRUMENTATION AMPLIFIER WITH A SINGLE-ELEMENT VARYING BRIDGE



$$V_{OUT} = \frac{V_B}{4}\left[\frac{\Delta R}{R + \frac{\Delta R}{2}}\right]\left[\text{GAIN}\right]$$

* SEE TEXT REGARDING SINGLE-SUPPLY OPERATION

LINEARIZING A SINGLE-ELEMENT VARYING BRIDGE METHOD 1



$$V_{OUT} = -V_B\left[\frac{\Delta R}{2R}\right]$$

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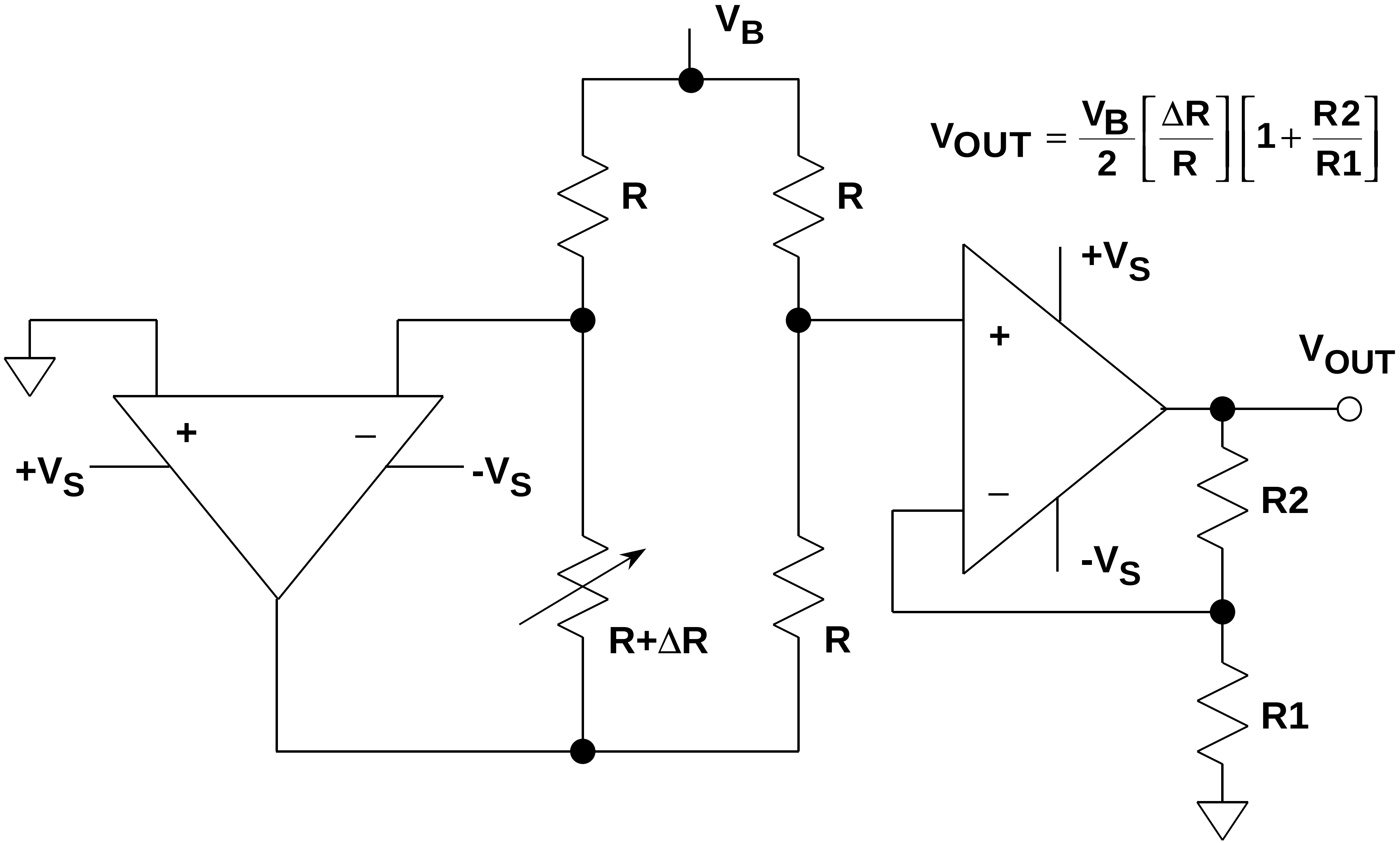
LINEARIZING A SINGLE-ELEMENT VARYING BRIDGE
METHOD 2

$$V_{OUT} = \frac{V_B}{2}\left[\frac{\Delta R}{R}\right]\left[1+\frac{R2}{R1}\right]$$



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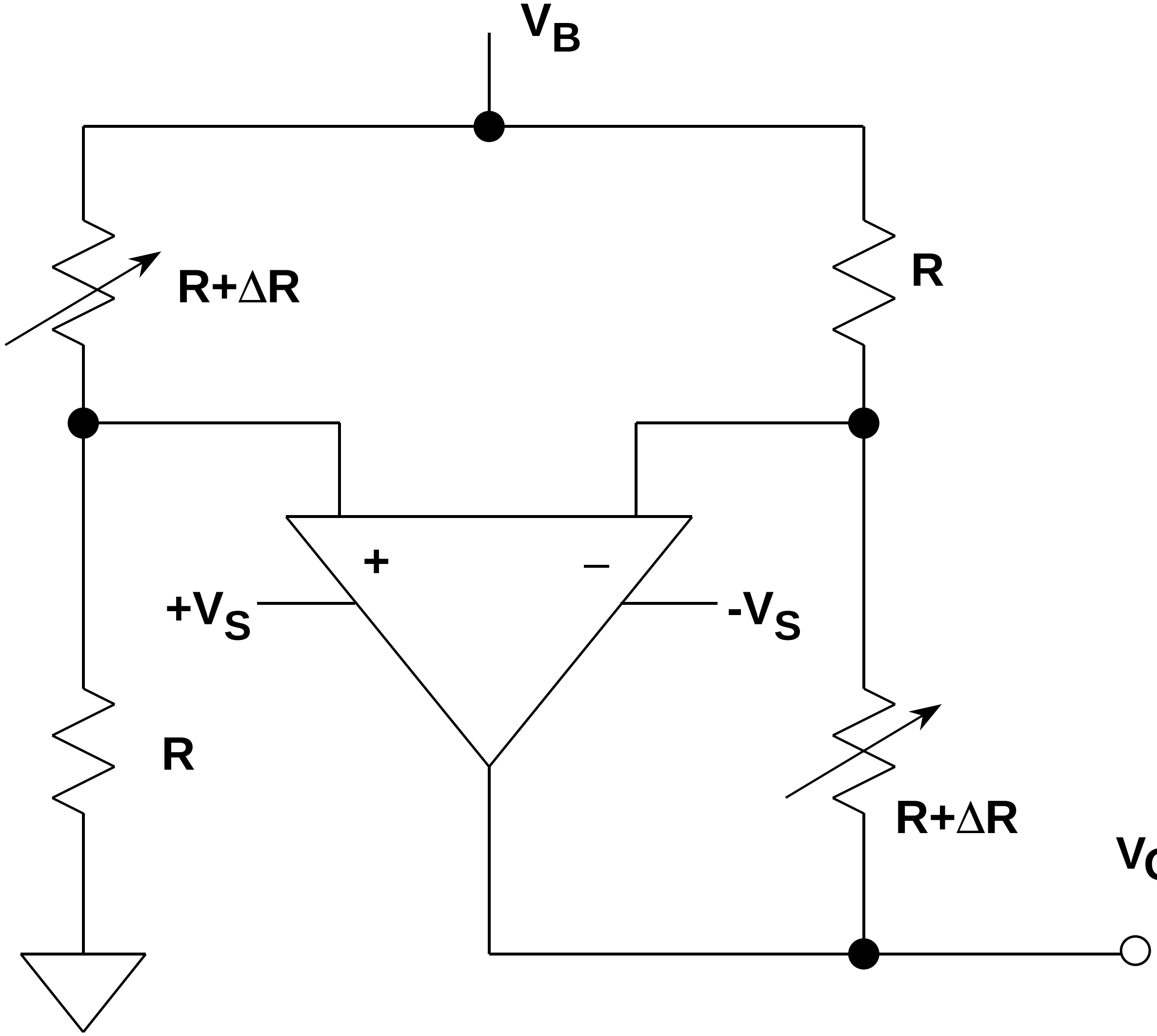
LINEARIZING A TWO-ELEMENT VARYING BRIDGE
METHOD 1 (CONSTANT VOLTAGE DRIVE)



$$V_{OUT} = -V_B\left[\frac{\Delta R}{R}\right]$$

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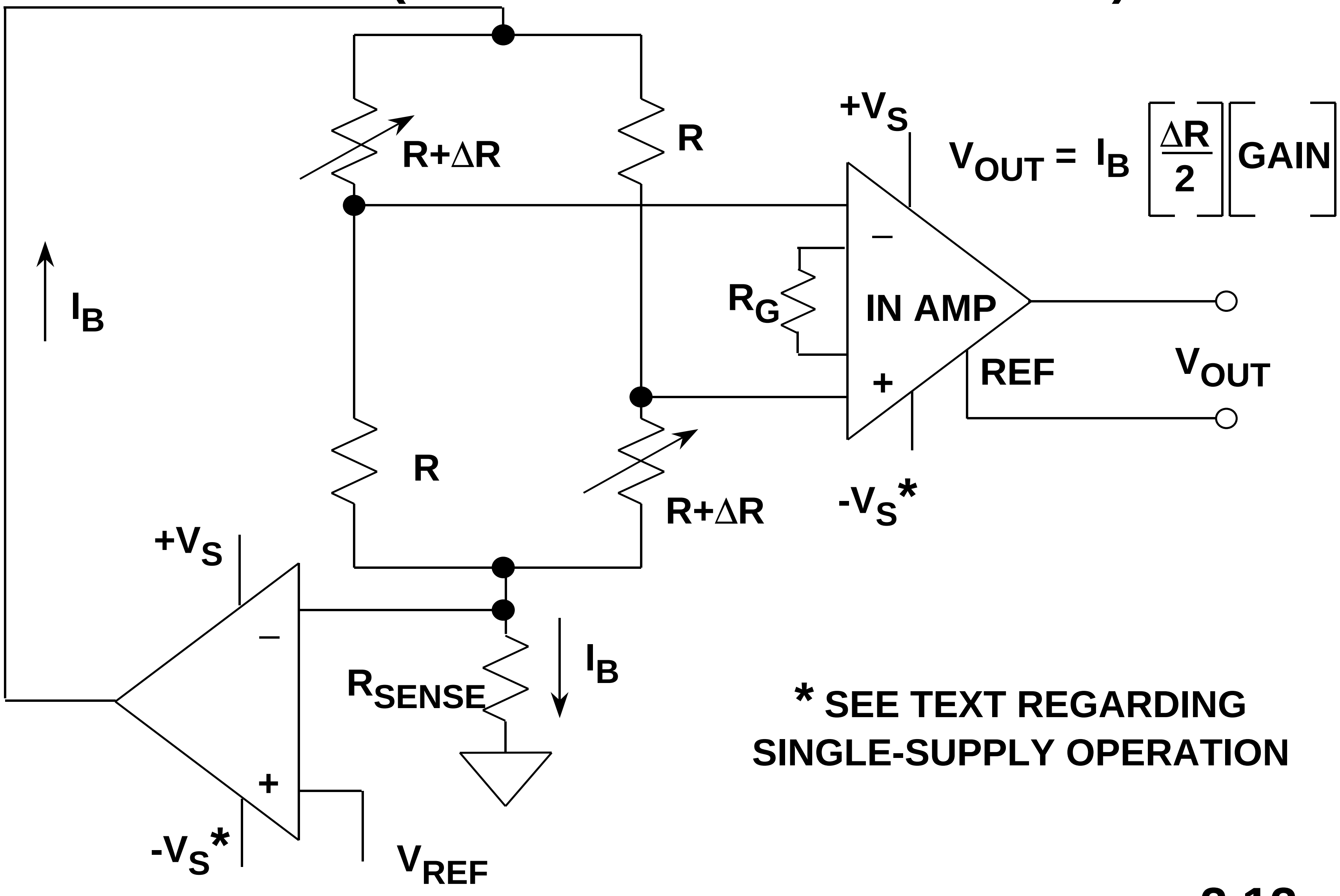
LINEARIZING A TWO-ELEMENT VARYING BRIDGE
METHOD 2 (CONSTANT CURRENT DRIVE)



* SEE TEXT REGARDING SINGLE-SUPPLY OPERATION

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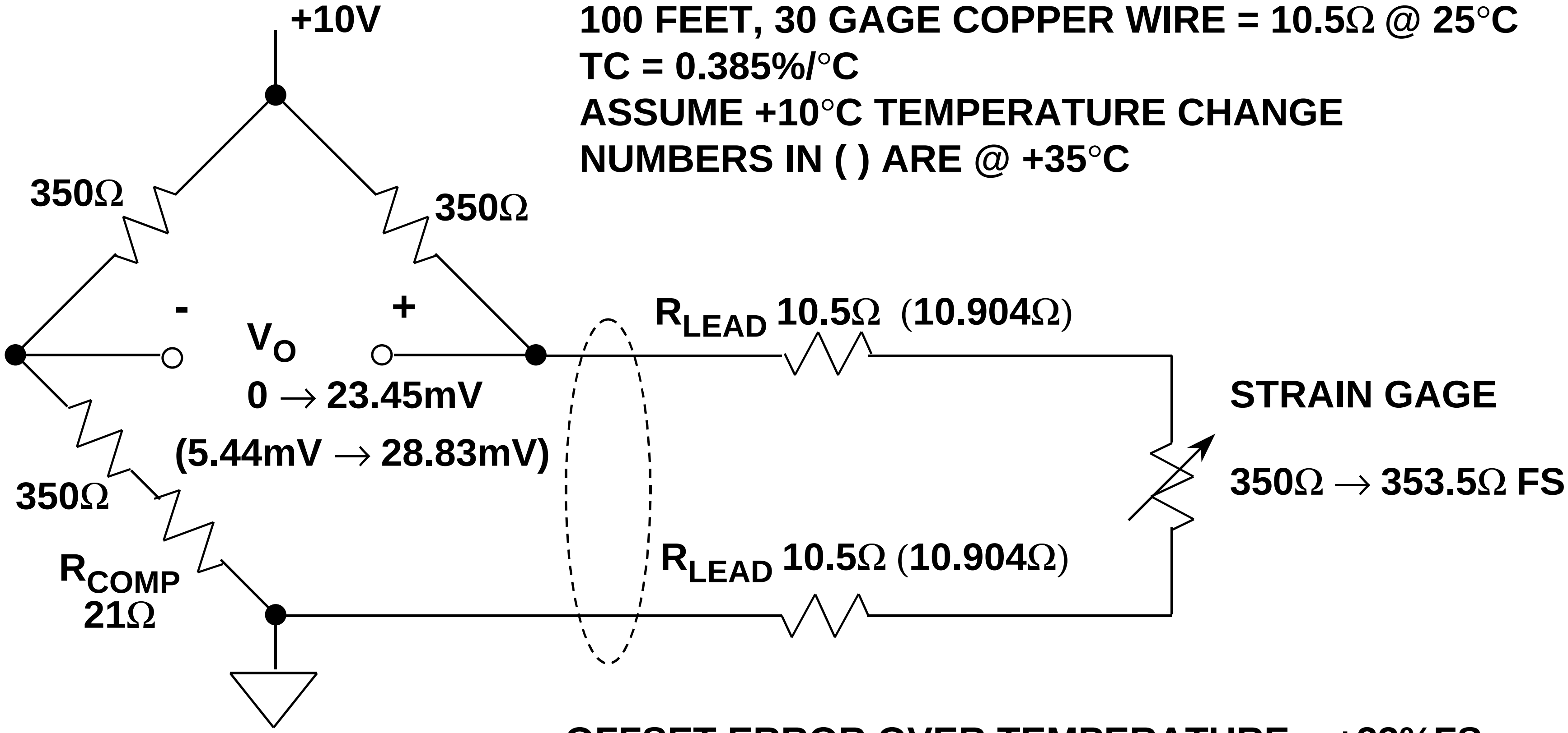
ERRORS PRODUCED BY WIRING RESISTANCE FOR REMOTE RESISTIVE BRIDGE SENSOR

100 FEET, 30 GAGE COPPER WIRE = 10.5Ω @ 25°C
TC = 0.385%/°C
ASSUME +10°C TEMPERATURE CHANGE
NUMBERS IN ( ) ARE @ +35°C

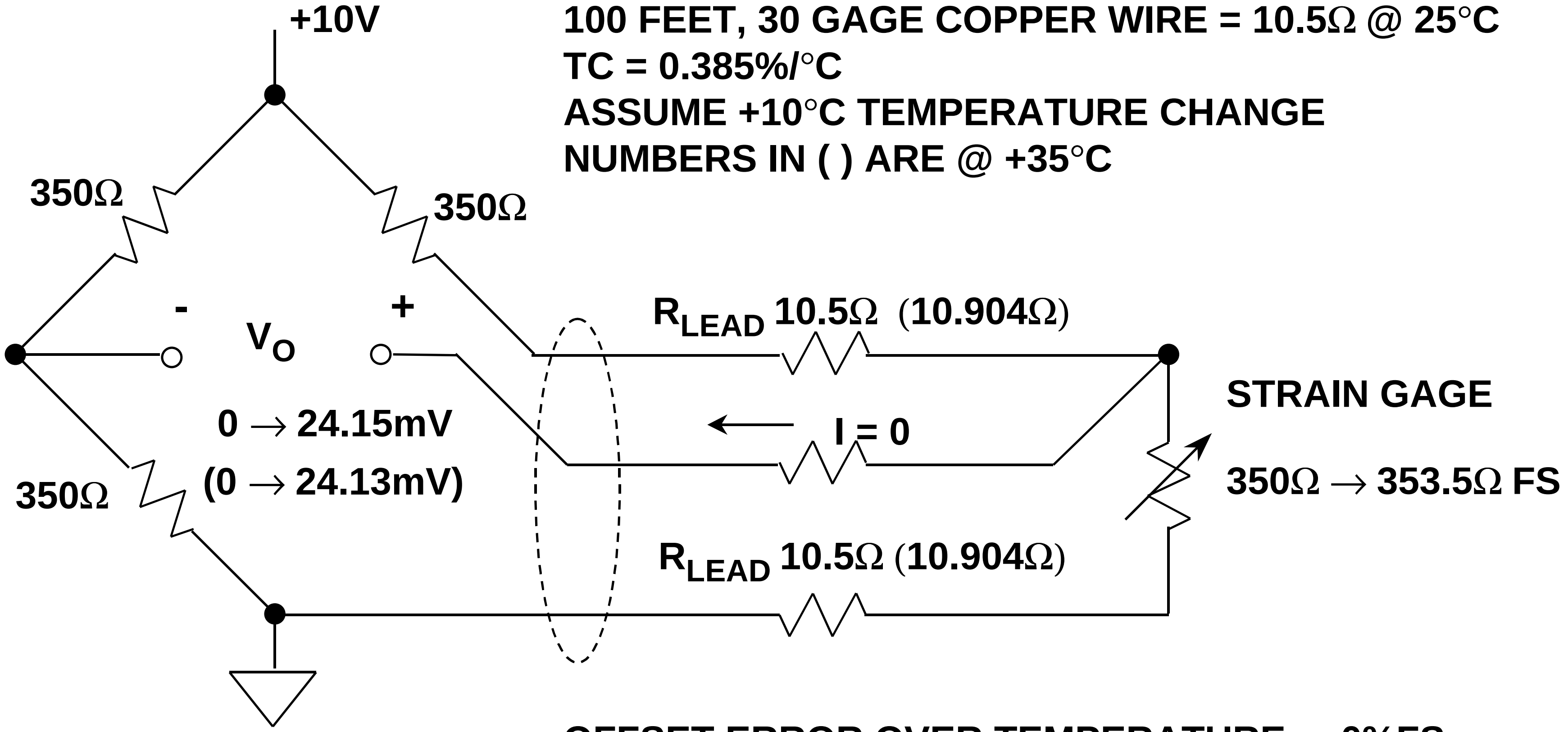


OFFSET ERROR OVER TEMPERATURE = +23%FS

GAIN ERROR OVER TEMPERATURE = –0.26%FS

3-WIRE CONNECTION TO REMOTE BRIDGE ELEMENT (SINGLE-ELEMENT VARYING)

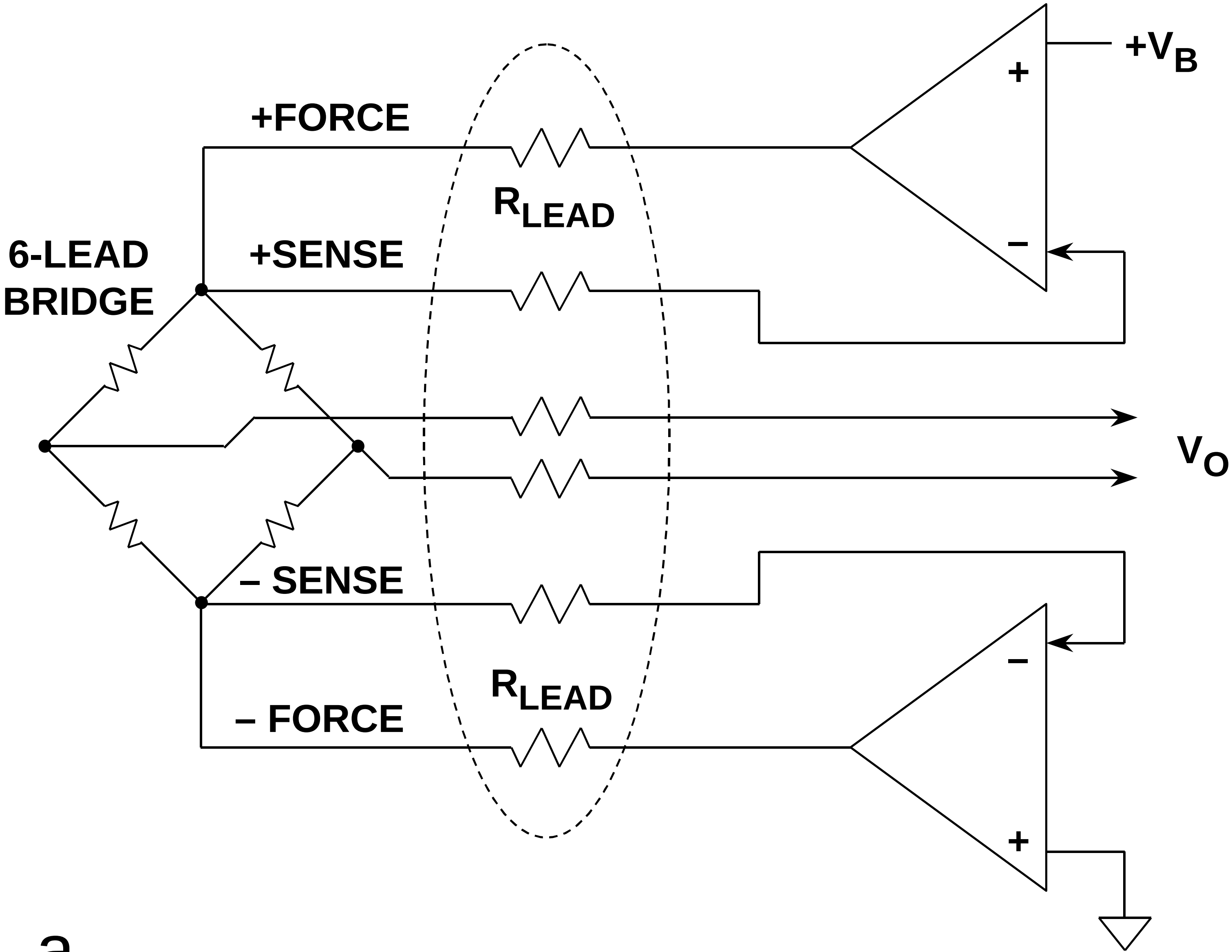
100 FEET, 30 GAGE COPPER WIRE = 10.5Ω @ 25°C
TC = 0.385%/°C
ASSUME +10°C TEMPERATURE CHANGE
NUMBERS IN ( ) ARE @ +35°C



OFFSET ERROR OVER TEMPERATURE = 0%FS

GAIN ERROR OVER TEMPERATURE = –0.08%FS

KELVIN (4-WIRE) SENSING MINIMIZES ERRORS DUE TO LEAD RESISTANCE



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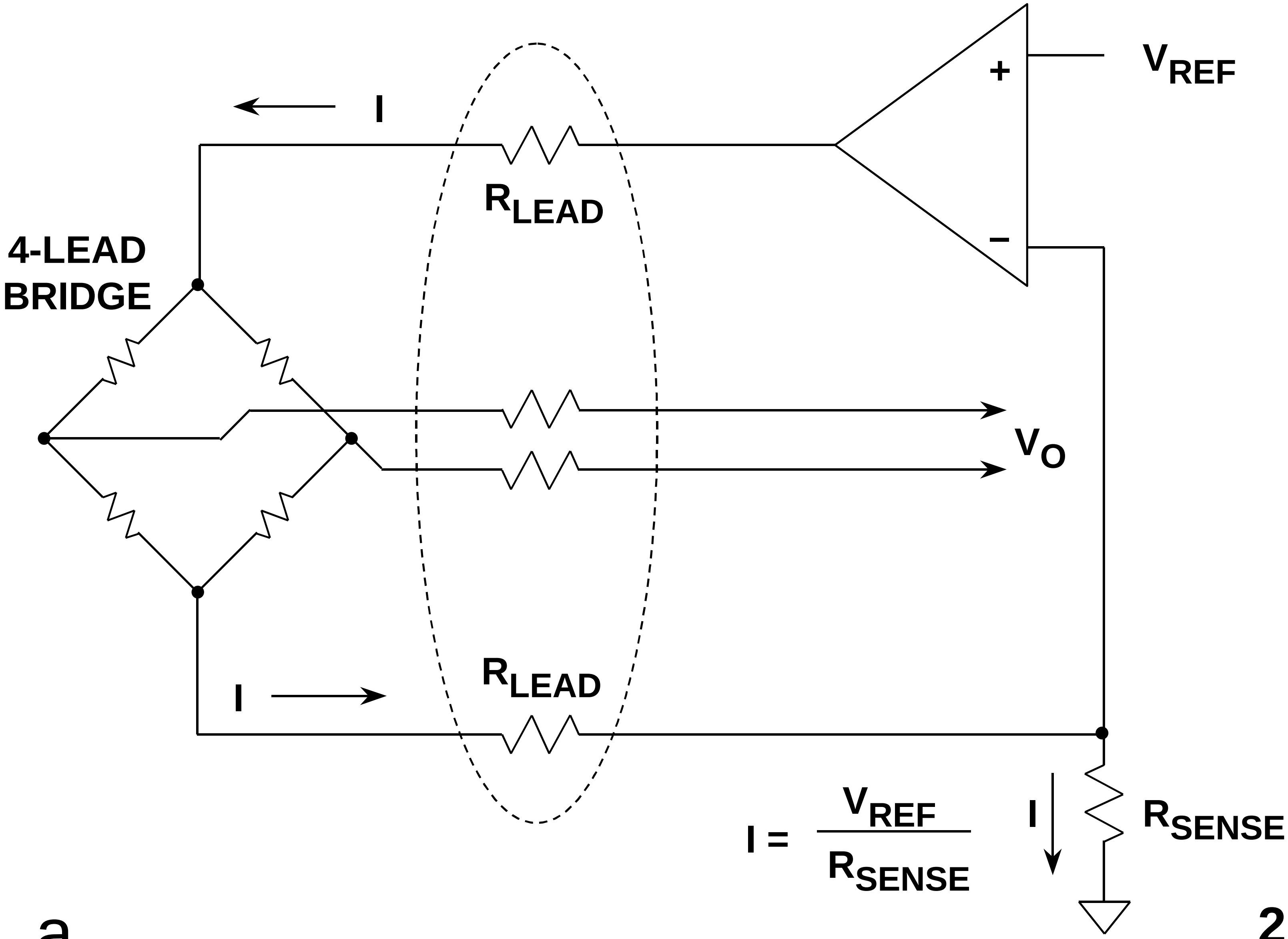
CONSTANT CURRENT EXCITATION MINIMIZES WIRING RESISTANCE ERRORS



$$I = \frac{V_{REF}}{R_{SENSE}}$$

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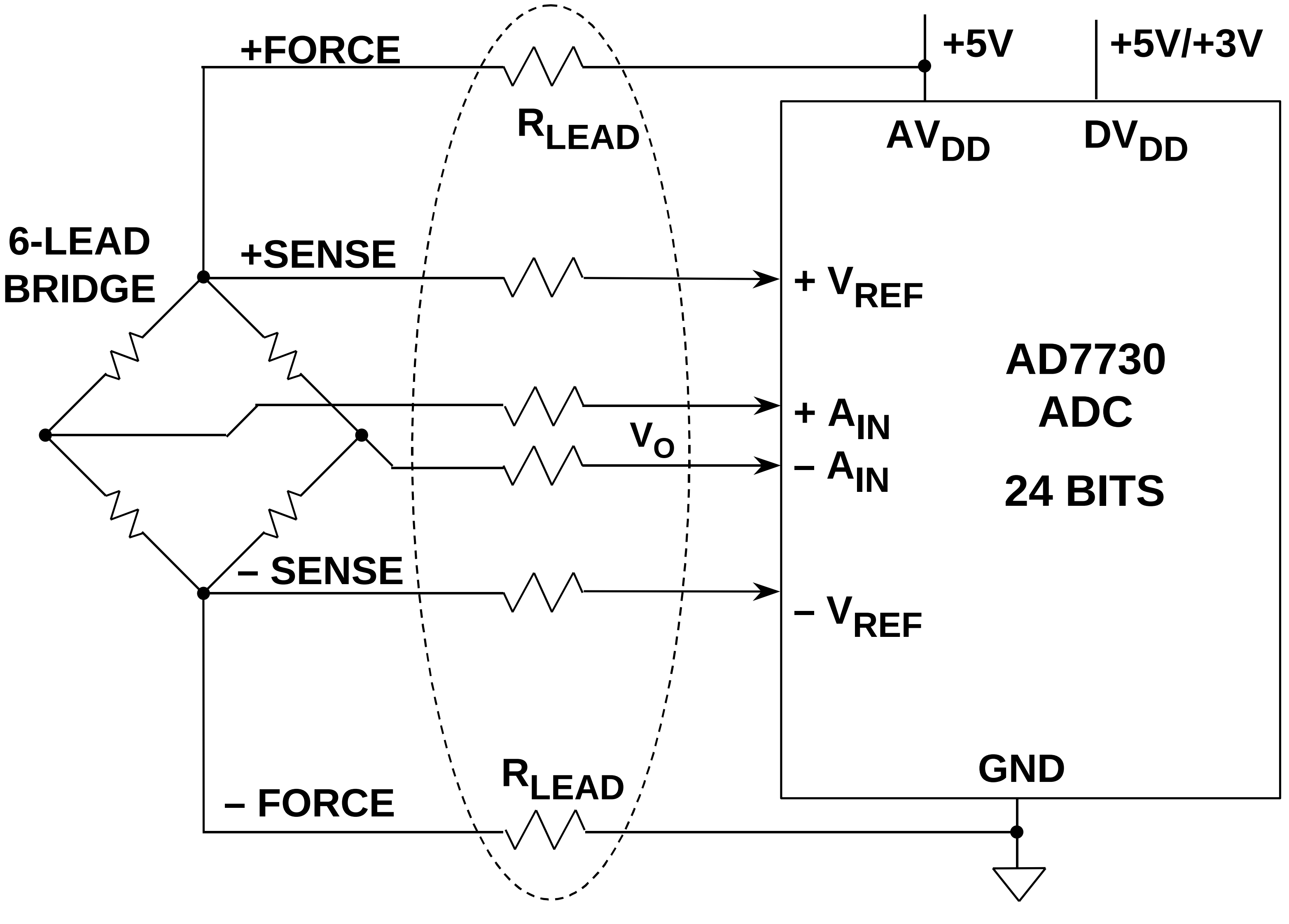
DRIVING REMOTE BRIDGE USING KELVIN (4-WIRE) SENSING AND RATIOMETRIC CONNECTION TO ADC



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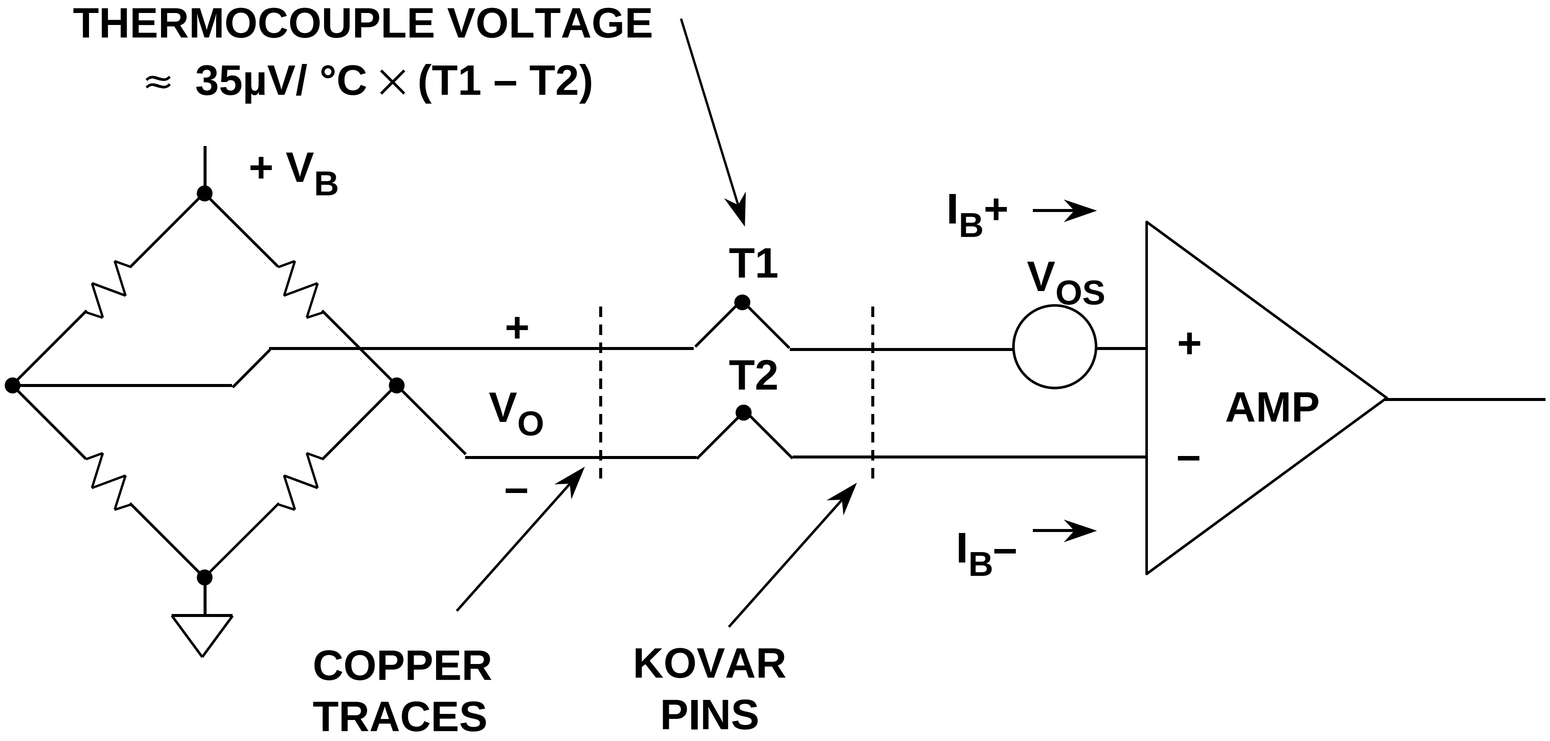
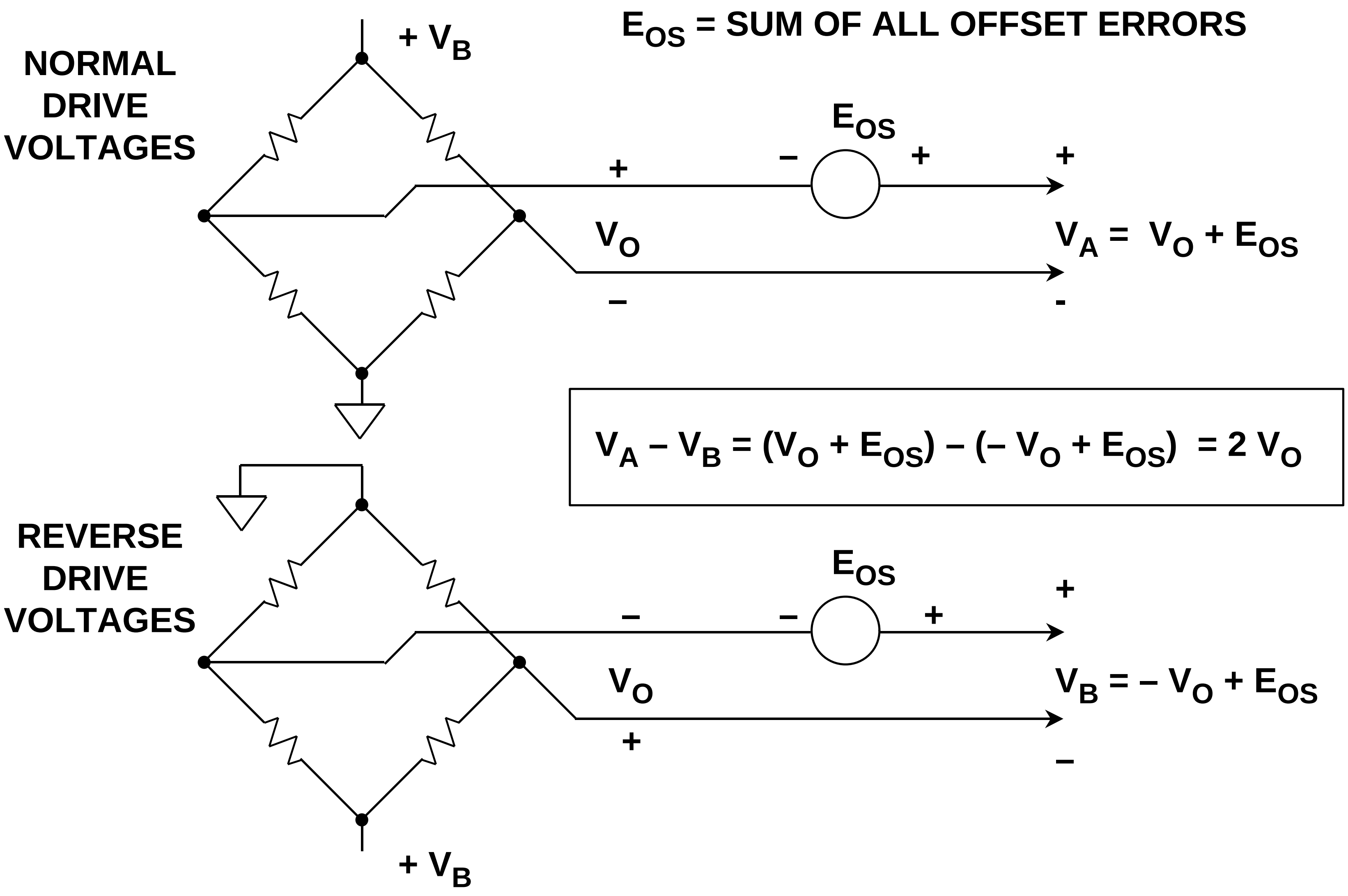
TYPICAL SOURCES OF OFFSET VOLTAGE



AC EXCITATION MINIMIZES OFFSET ERRORS



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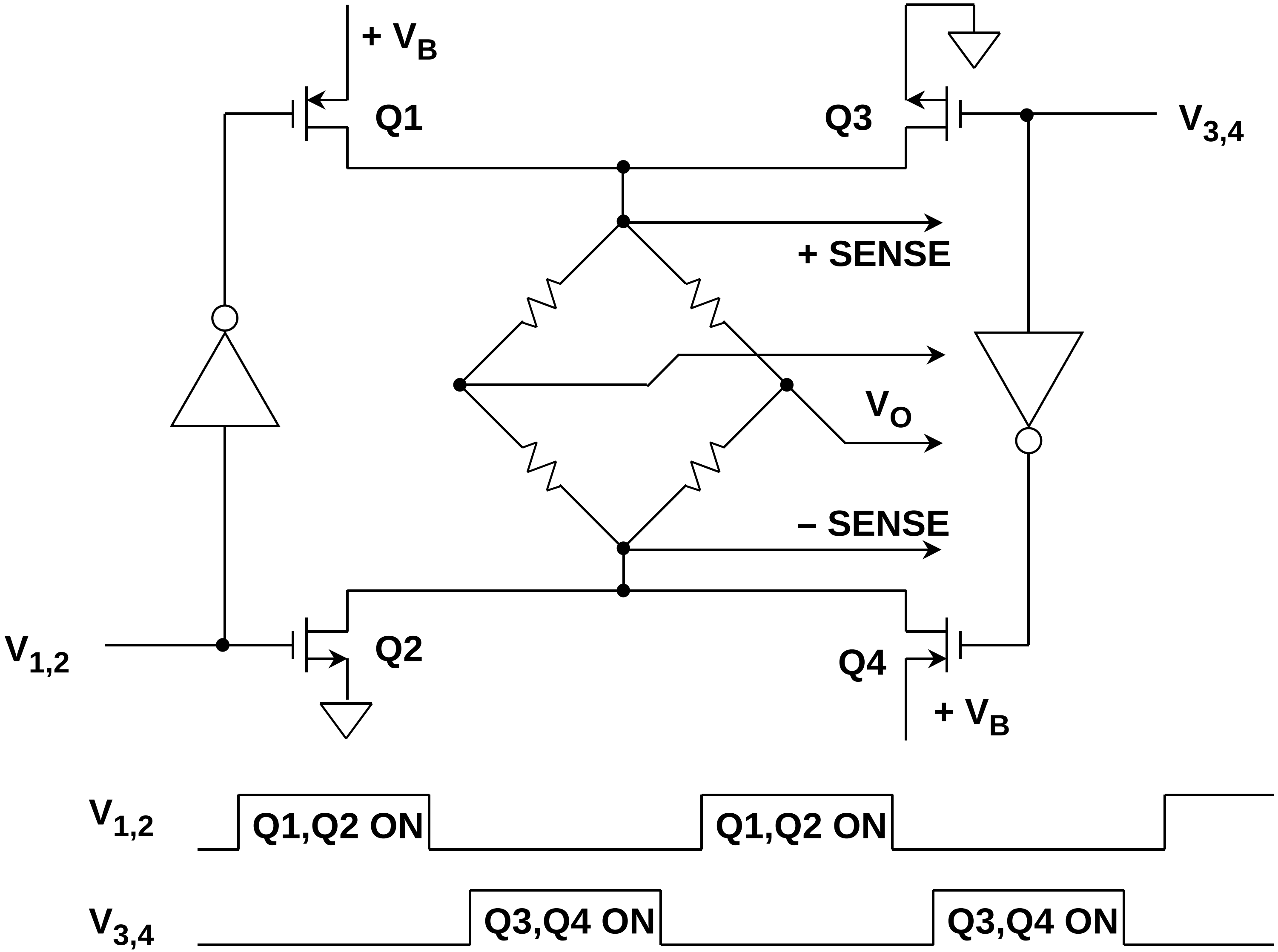
SIMPLIFIED AC BRIDGE DRIVE CIRCUIT



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