

# SENSORES DE POSICIÓN

INEL 5205 - Instrumentación

- Aplicaciones:
  - data de posición para servo-mecanismos, robots de ensamblaje
  - *machine tools*
  - plumilla de una impresora, etc.
- Puede requerir alta precisión
- Métodos:
  - Potenciometros industriales
  - *Linear-variable diff. transformers* (LVDT)
  - codificadores (*encoders*) ópticos



## Industrial Pots

Electrical angle: 318°

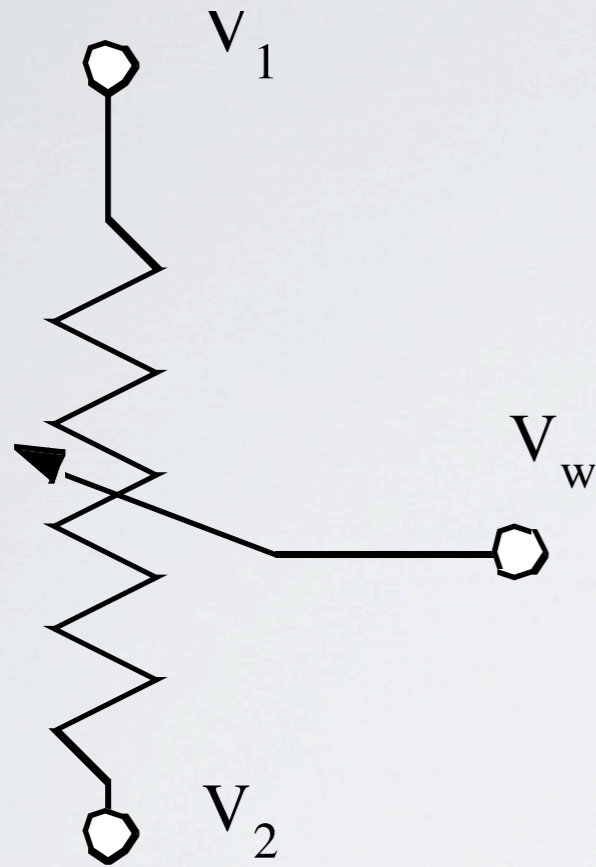
Repeatability: 0.11%



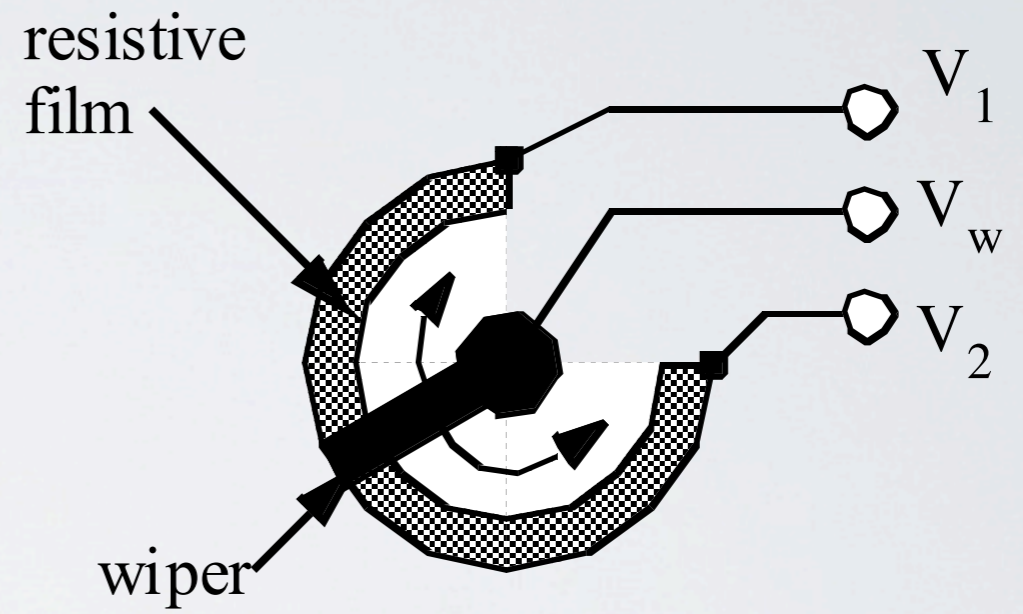
**Application:** Foil packaging machines

**Product:** Sensor potentiometer SP2841

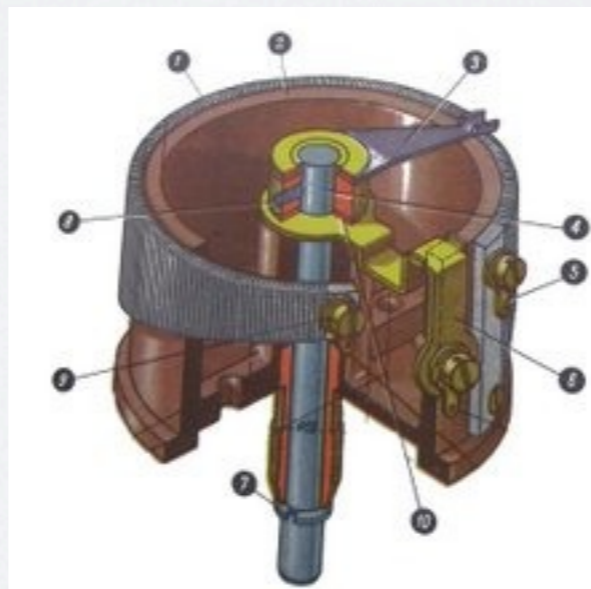
# Potenciometros



schematic

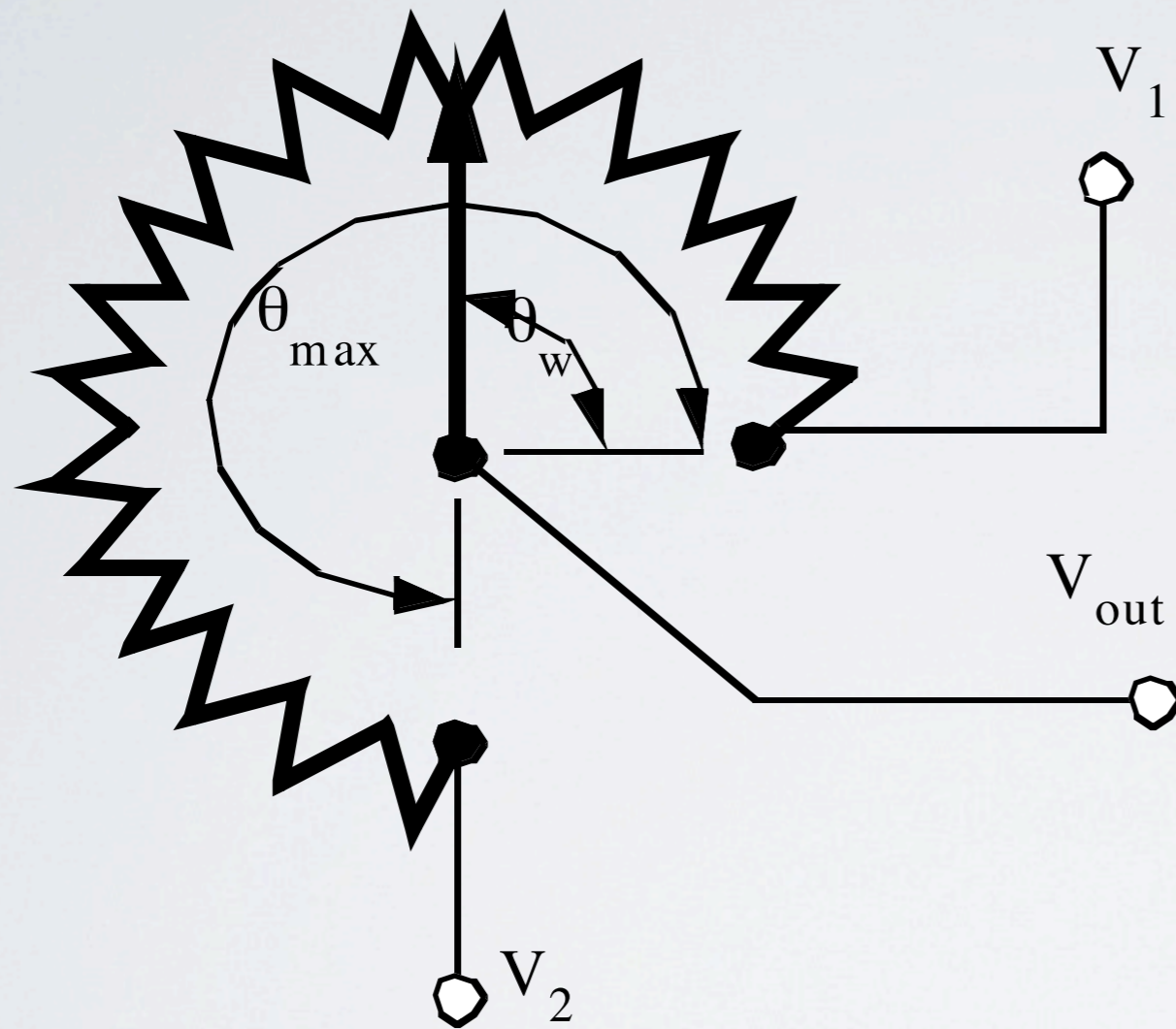


physical

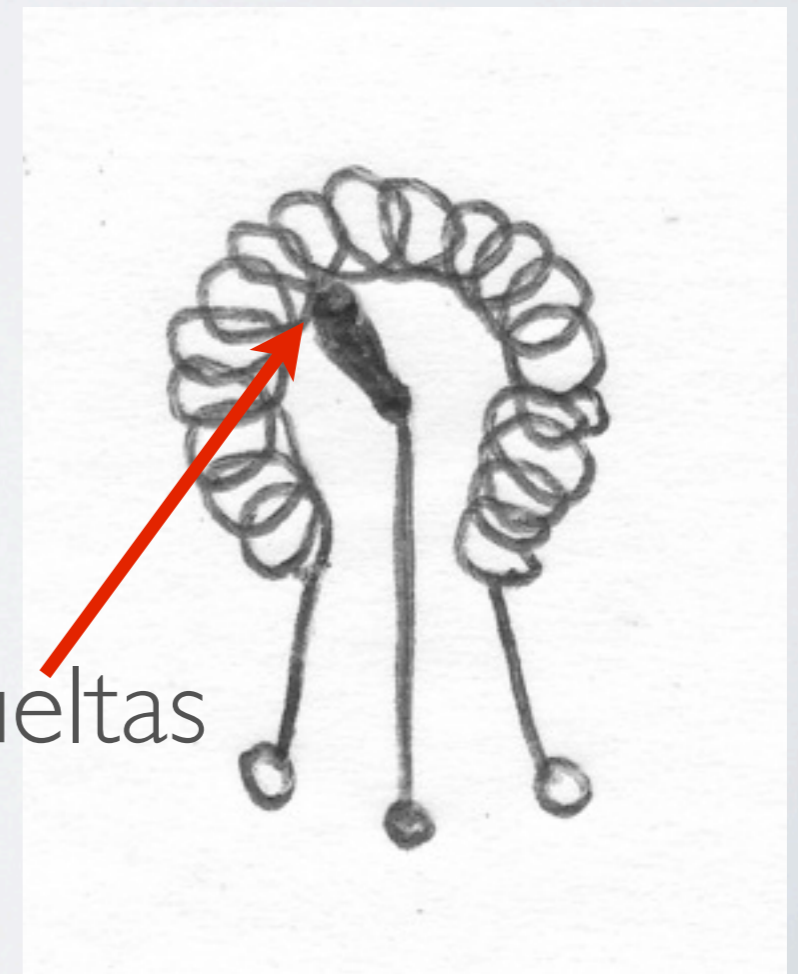


- Requieren un “dead-zone” al final de la vuelta
- Pots de instrumentación: hasta de  $358^\circ$  de rotación útil (versus  $\sim 270^\circ$  de uno normal)
- Hay muchos tipos: “slide-wire”, película de metal, película de carbon, “wire-wound”, película plástica, cermet (mezcla de cerámica-metal)
- “Wire-wound” son comunes para medir ángulo o translación

# Relación de Voltajes



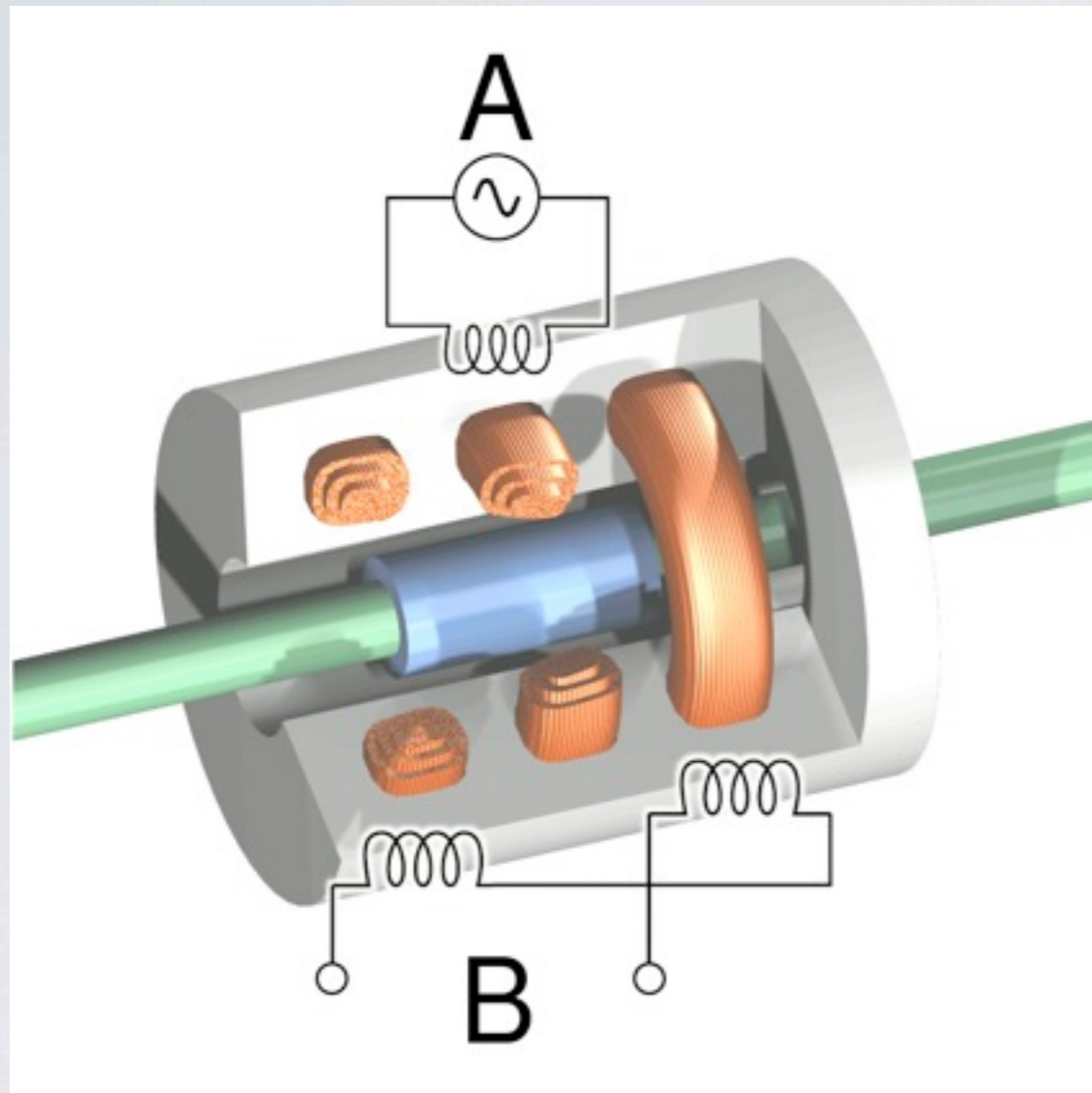
$$V_{\text{out}} = (V_2 - V_1) \left( \frac{\theta_w}{\theta_{\text{max}}} \right) + V_1$$



Half-step - contacto entre dos vueltas

- **Ejemplo:** Considere un potenciómetro tipo w.w. con 100 vueltas, cada una con una resistencia de  $\frac{1}{2}\Omega$ . Determine la fracción del voltaje total que aparece en el wiper cuando esta en (a) la 20<sup>va</sup> vuelta; (b) entre la vuelta 20 y 21; (c) en la 70<sup>va</sup> vuelta; (d) entre la vuelta 70 y 71.
- **Ejemplo:** potenciómetro w.w. con 700 vueltas y rango de  $350^\circ$ . La resolución es  $350^\circ/700$  vueltas =  $\frac{1}{2}^\circ/\text{vuelta}$ . Si un voltaje DC de 10V se conecta al potenciómetro y la resistencia total es  $15\text{k}\Omega$ , la sensibilidad promedio es  $10\text{V}/350^\circ = 29\text{mV}/^\circ$ . El consumo de potencia es  $(10\text{V})^2/15\text{k}\Omega = 670 \text{ mW}$  más la potencia consumida por la carga.

# LVDT

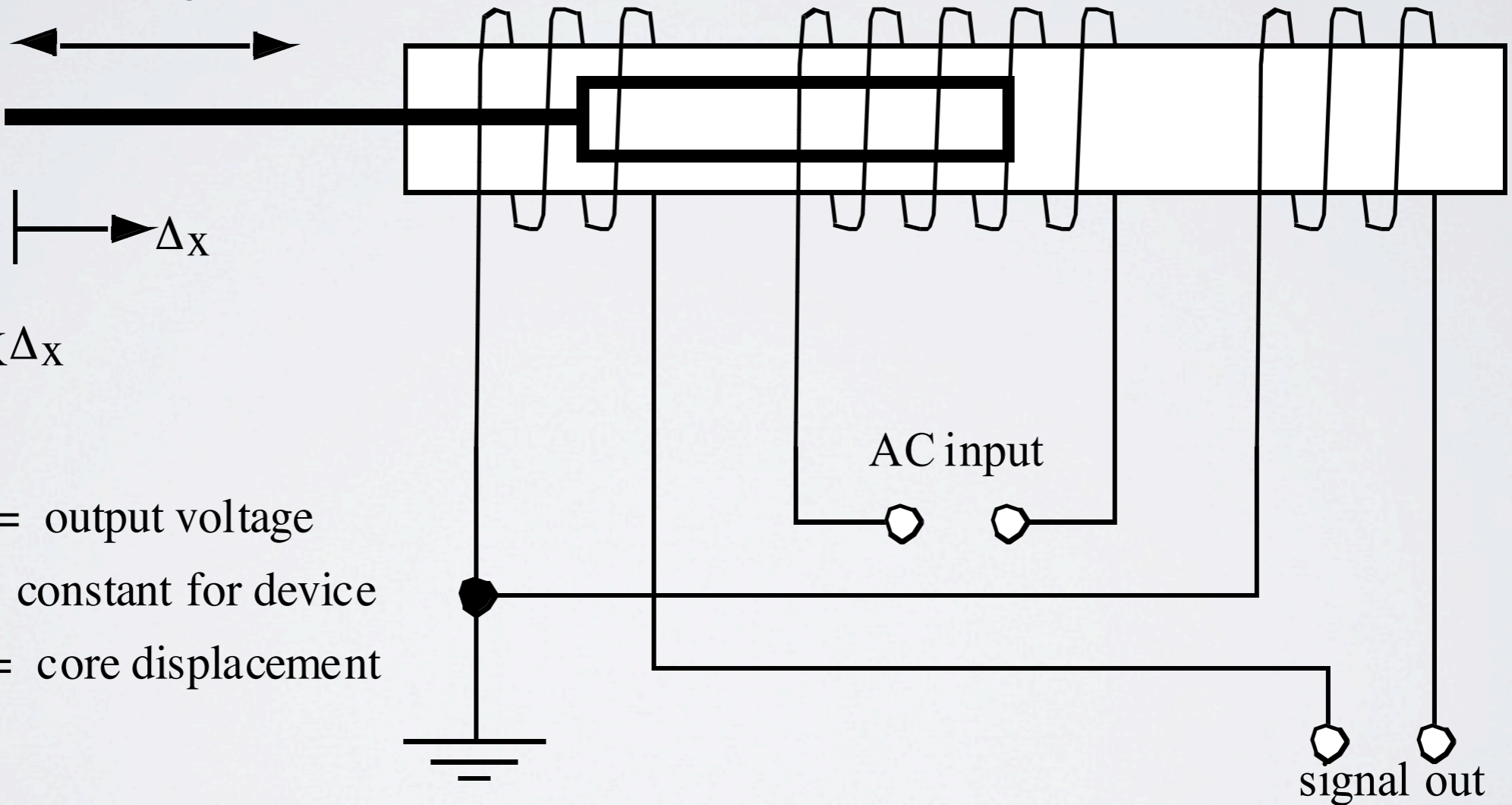


Corriente alterna fluye en la bobina principal *A* e induce corriente en las bobina secundaria *B* que depende de la posición del *core* magnético.

Las bobinas secundarias están conectadas en serie-reverso y producen un voltaje diferencial.

# Linear Variable Differential Transformer (LVDT)

A rod drives  
the sliding core



$$\Delta V = K \Delta x$$

where,

$\Delta V$  = output voltage

$K$  = constant for device

$\Delta x$  = core displacement

# VENTAJAS DE LVDT

- No tiene fricción
- Larga vida mecánica
- Resolución ilimitada (determinada por la electrónica)
- Excitación y salida están eléctricamente aisladas

## Desventaja

- Costoso y requiere electrónica compleja



Figure 6b shows a circuit which does this. Waveforms of operation are given in Figure 6c. In this circuit, Q1 and its associated components from a phase shift oscillator which runs at 2.5 kHz, the manufacturer's specified transducer operating frequency. A1A amplifies and buffers Q1's output and drives the LVDT (waveform A, Figure 6c). Since the transducer's output will vary with drive level, feedback is used to stabilize the 2.5 kHz amplitude. A1C and A1D full wave rectify a sample of the drive waveform. A1C's filtered output is applied to A1D, a servo amplifier. A1D compares A1C's output to the LM329 reference and drives the Q1 oscillator to complete an amplitude stabilization loop. The LVDT's output is amplified by A2C and fed to A2A. A2A is a unity gain amplifier whose sign alternates between "+" and "-". Synchronous switching for A2A comes from C1 (waveform B, Figure 6c), which is driven by the modulation sine wave output via a phase shift network. The phase trim network compensates phase shift in the LVDT and ensures that C1 switches at the zero crossings relative to A2A's output. When C1's output is low, the 2N4393 FET is off and A2A's positive input (waveform C, Figure 6c) receives signal. When the sine wave reverses polarity, C1's output goes high, turning on the FET, which grounds A2A's "+" input. Under these conditions A2A is always switching its amplification's sign from "+" to "-" in synchronism with the sine wave output from the LVDT. A2A's phase sensitive output, in this case positive, appears in trace D, Figure 6c. A2B provides a scaled and filtered DC output. To trim the circuit, set the LVDT to at least 1/2 physical displacement and adjust the phase trim for maximum output indication. Next, adjust the gain trim for the desired circuit output at full-scale LVDT displacement.

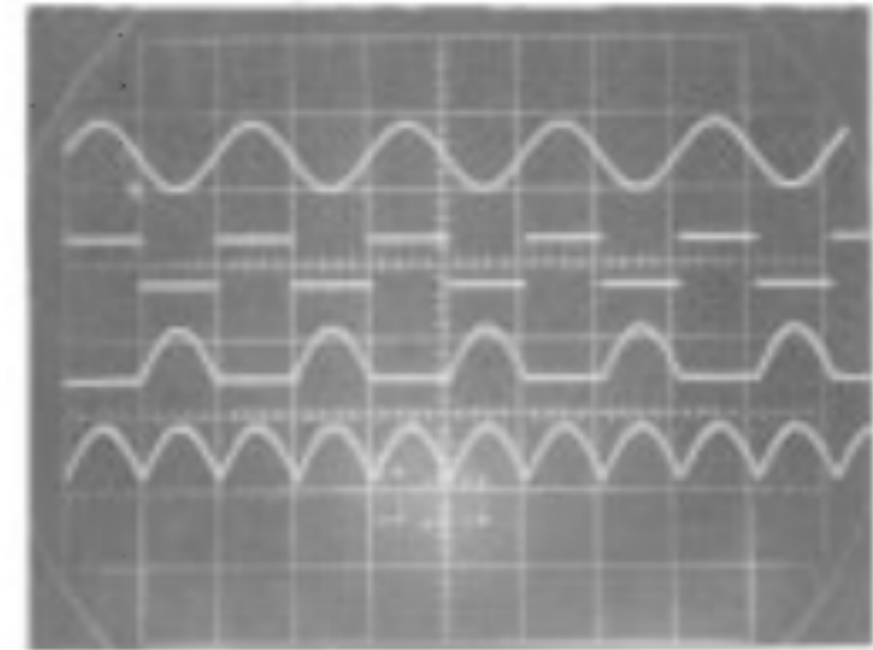
Source: AN-301\_signal\_conditioning.pdf

A = 5V/DIV

B = 50V/DIV

C = 5V/DIV

D = 5V/DIV



HORIZONTAL = 200 μs / DIV

TL/H/5641-12

FIGURE 6c

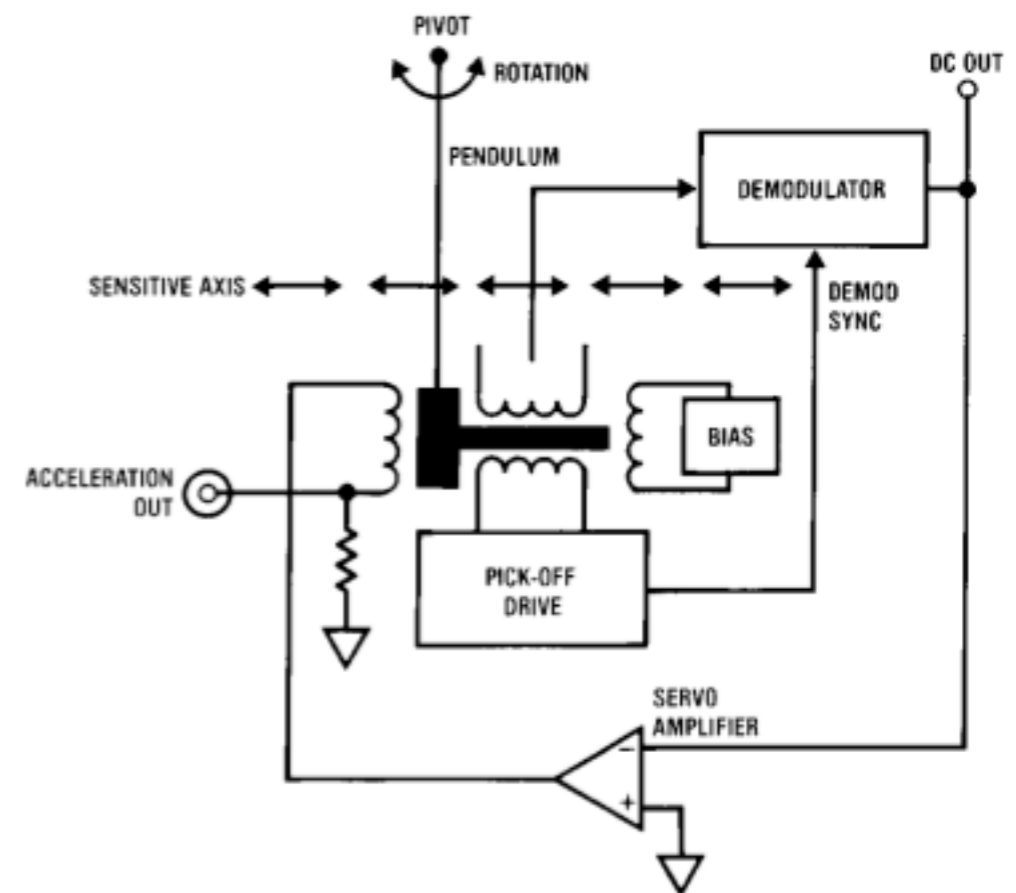
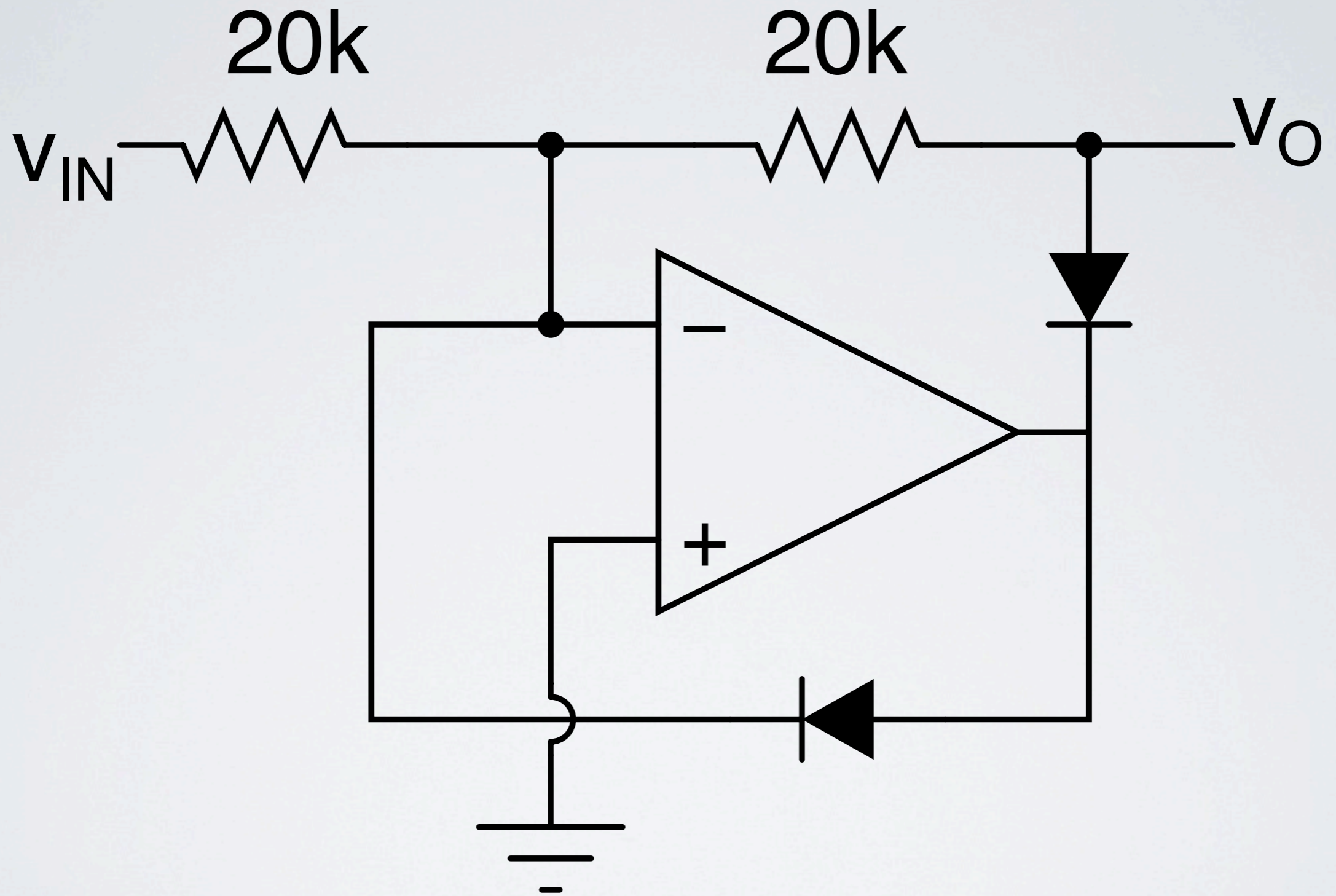
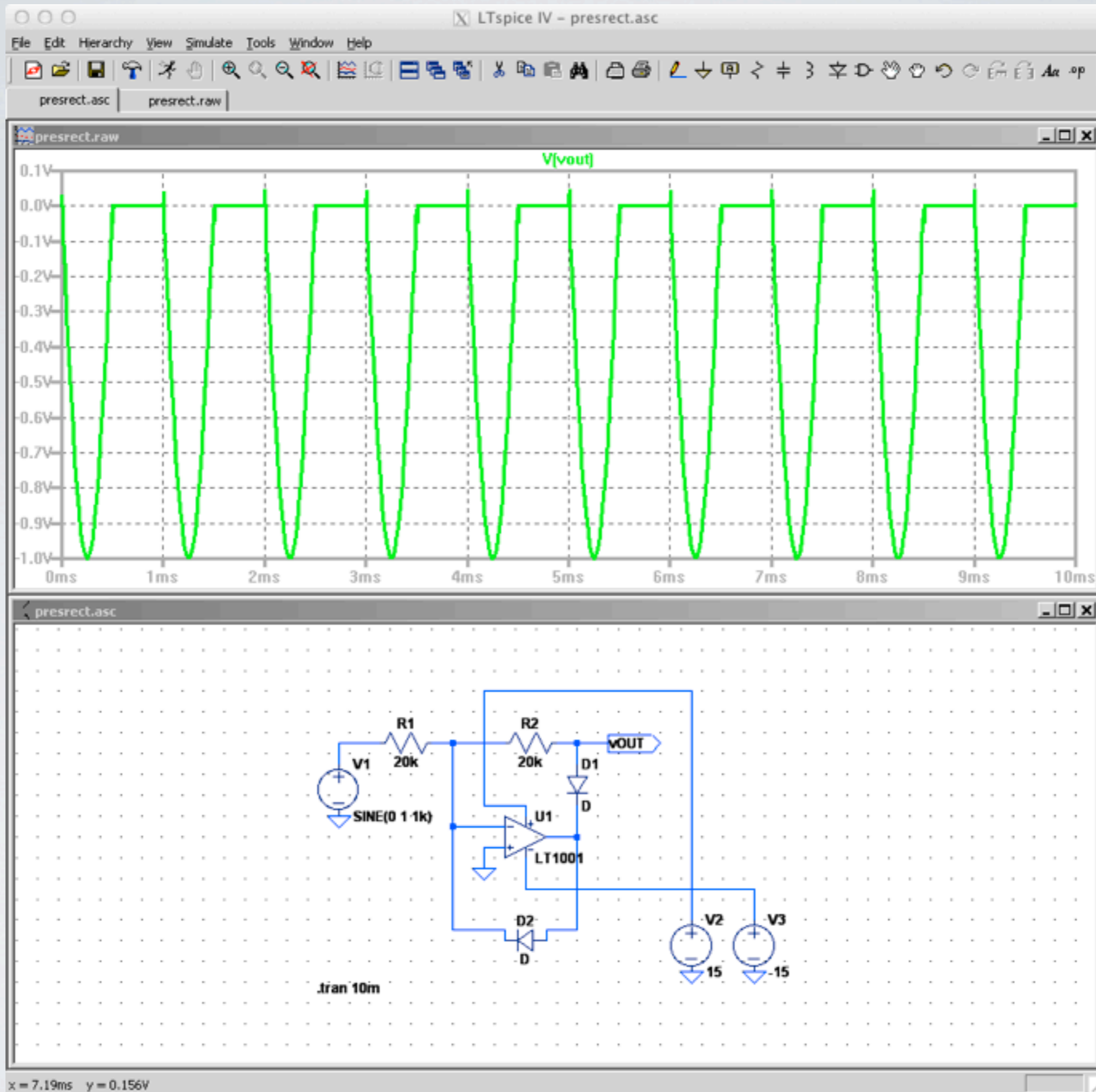


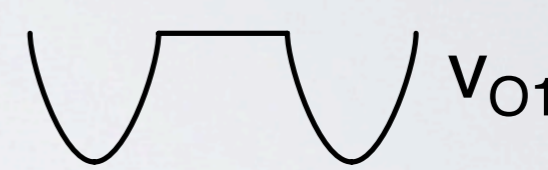
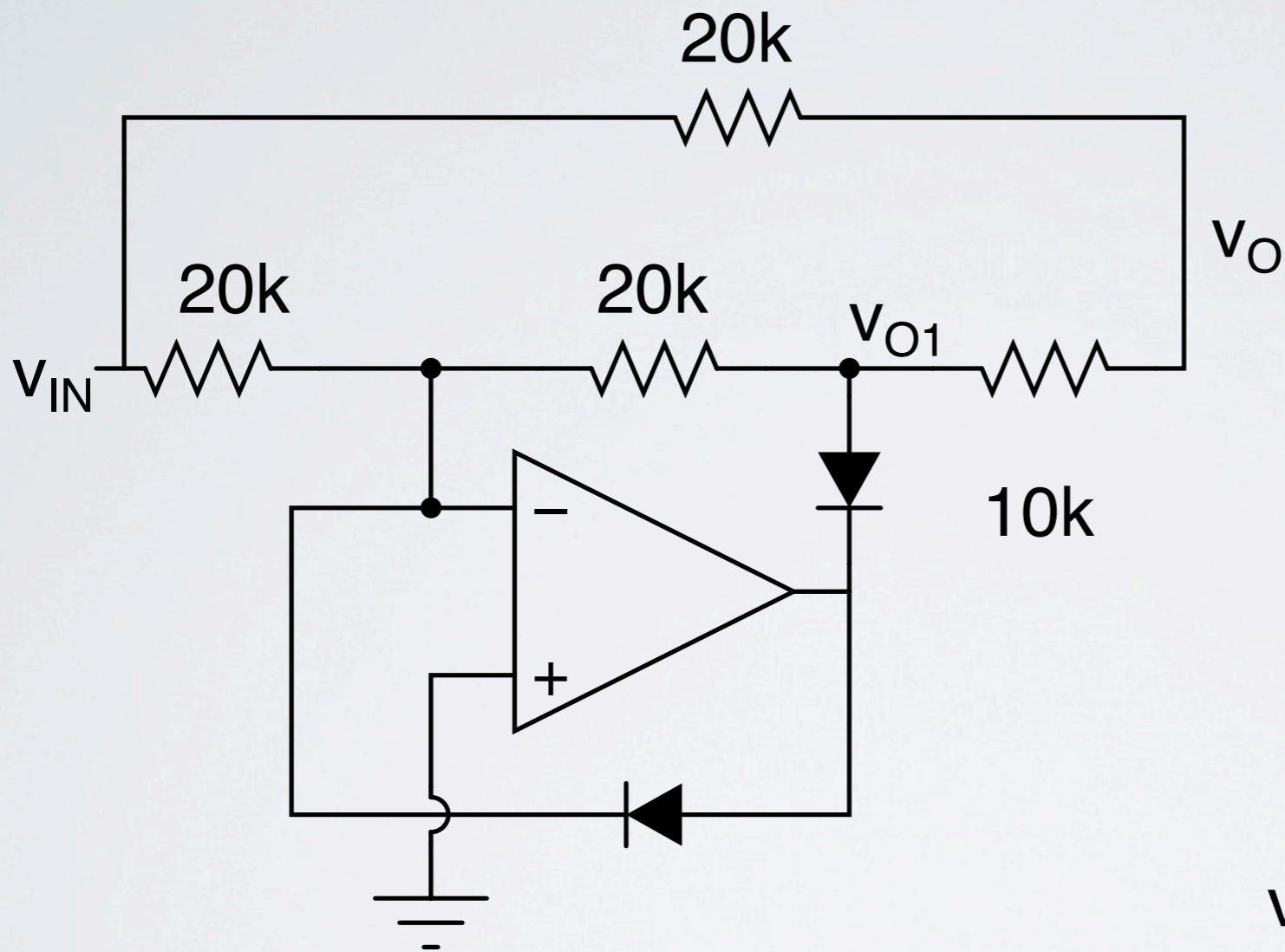
FIGURE 7a

TL/H/5641-11

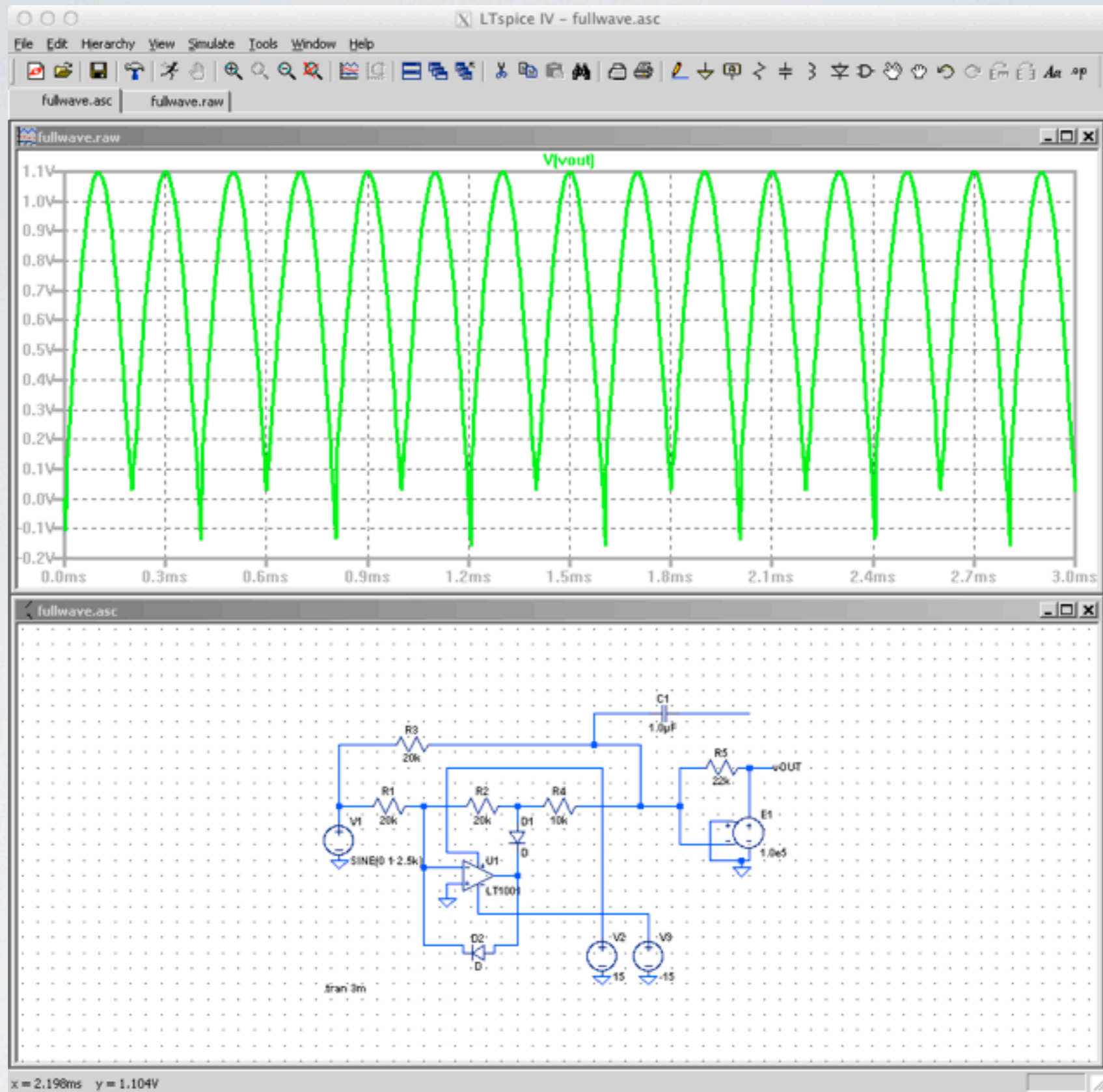




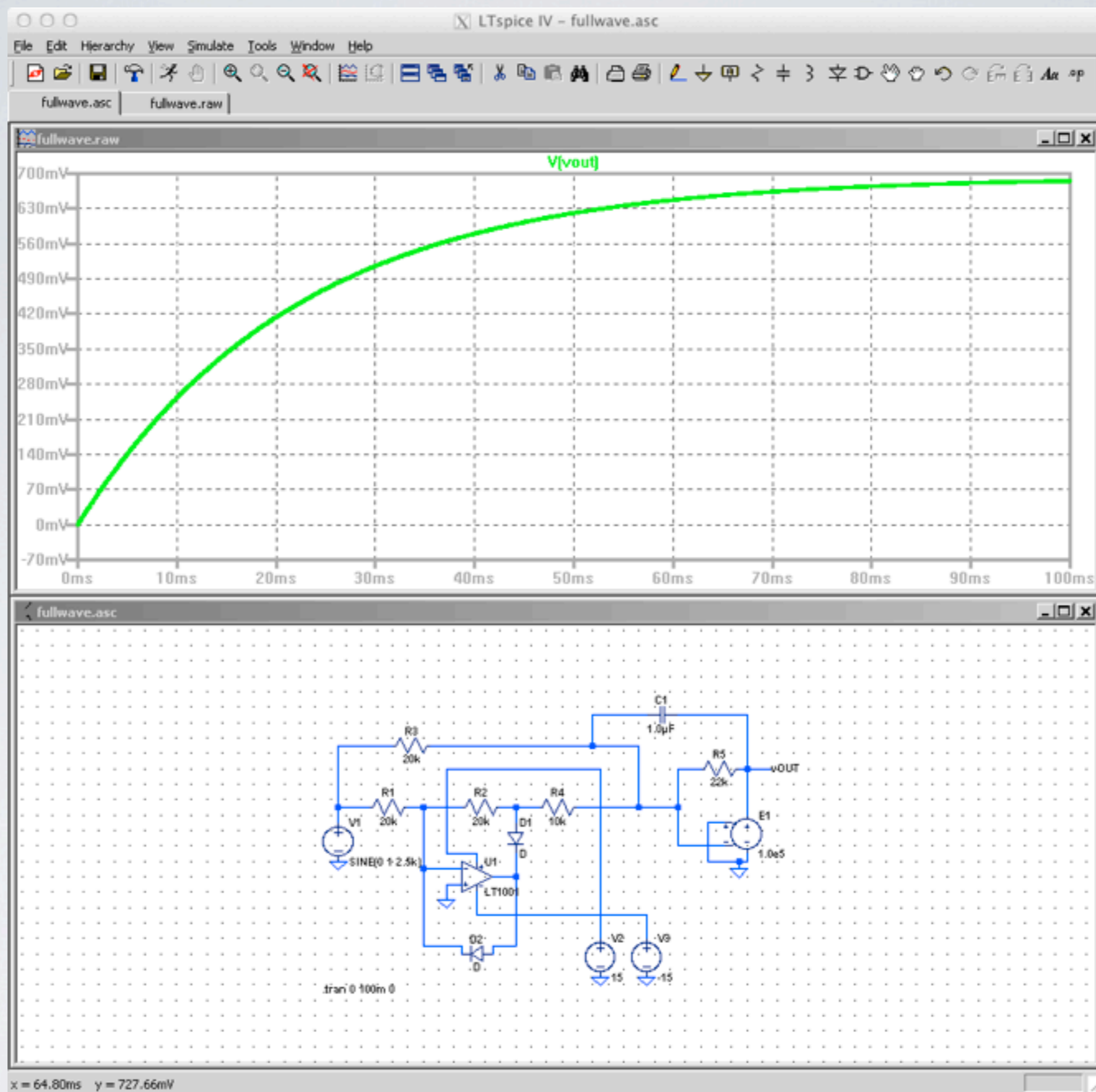
x = 7.19ms y = 0.156V



$$V_O = (1/3)V_{IN} - (2/3)V_{O1}$$

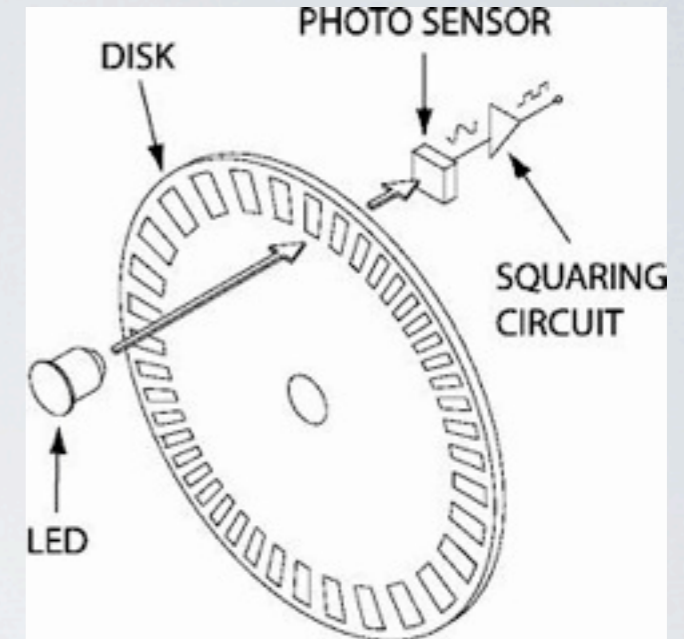
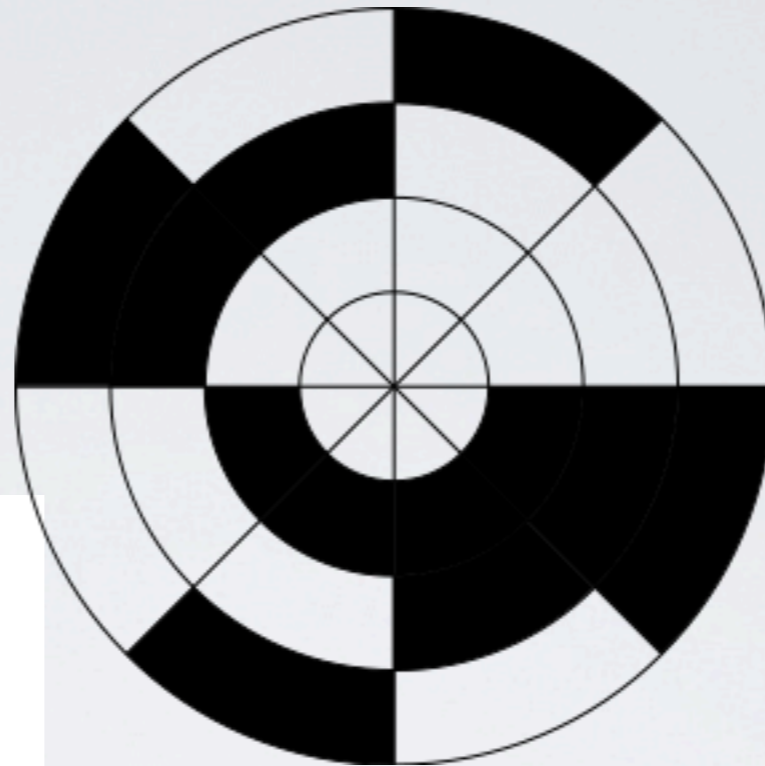


Full-wave without the cap connected



With the cap connected, it works as a magnitude-detector

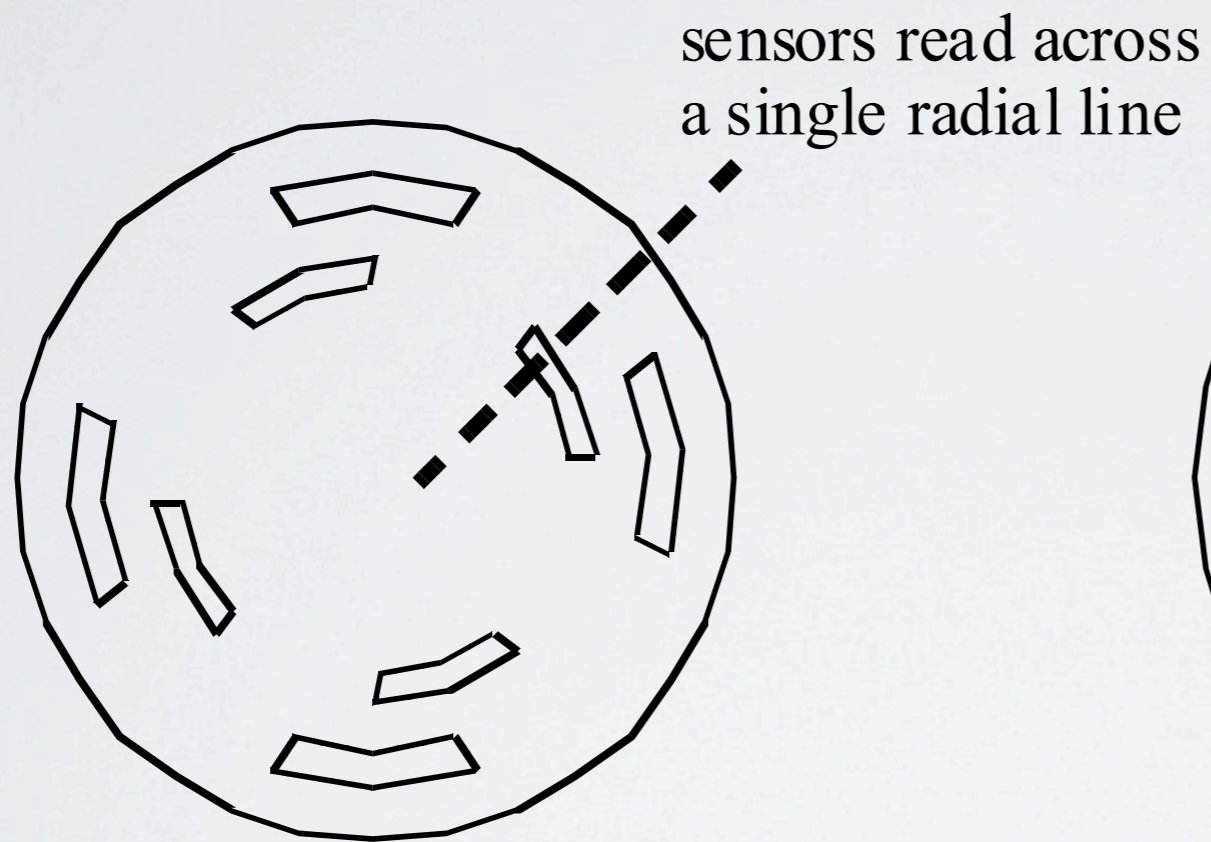
# Codificador óptico



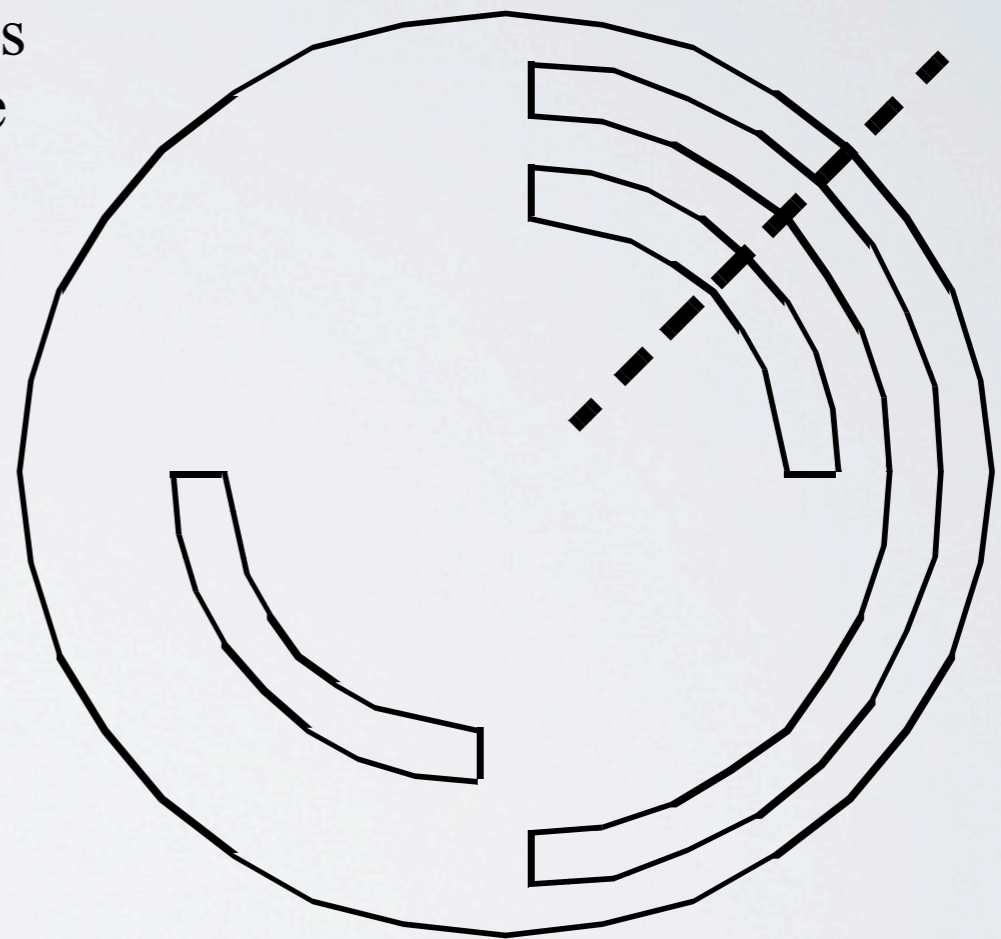
## Ejemplo

- ⇒ codificador de 3-bits
- ⇒ provee 8 angulos distintos
- ⇒ resolución =  $360^\circ/2^N =$   
 $360^\circ/2^3 = 360^\circ/8 = 45^\circ$

# Absolute and Relative Encoders

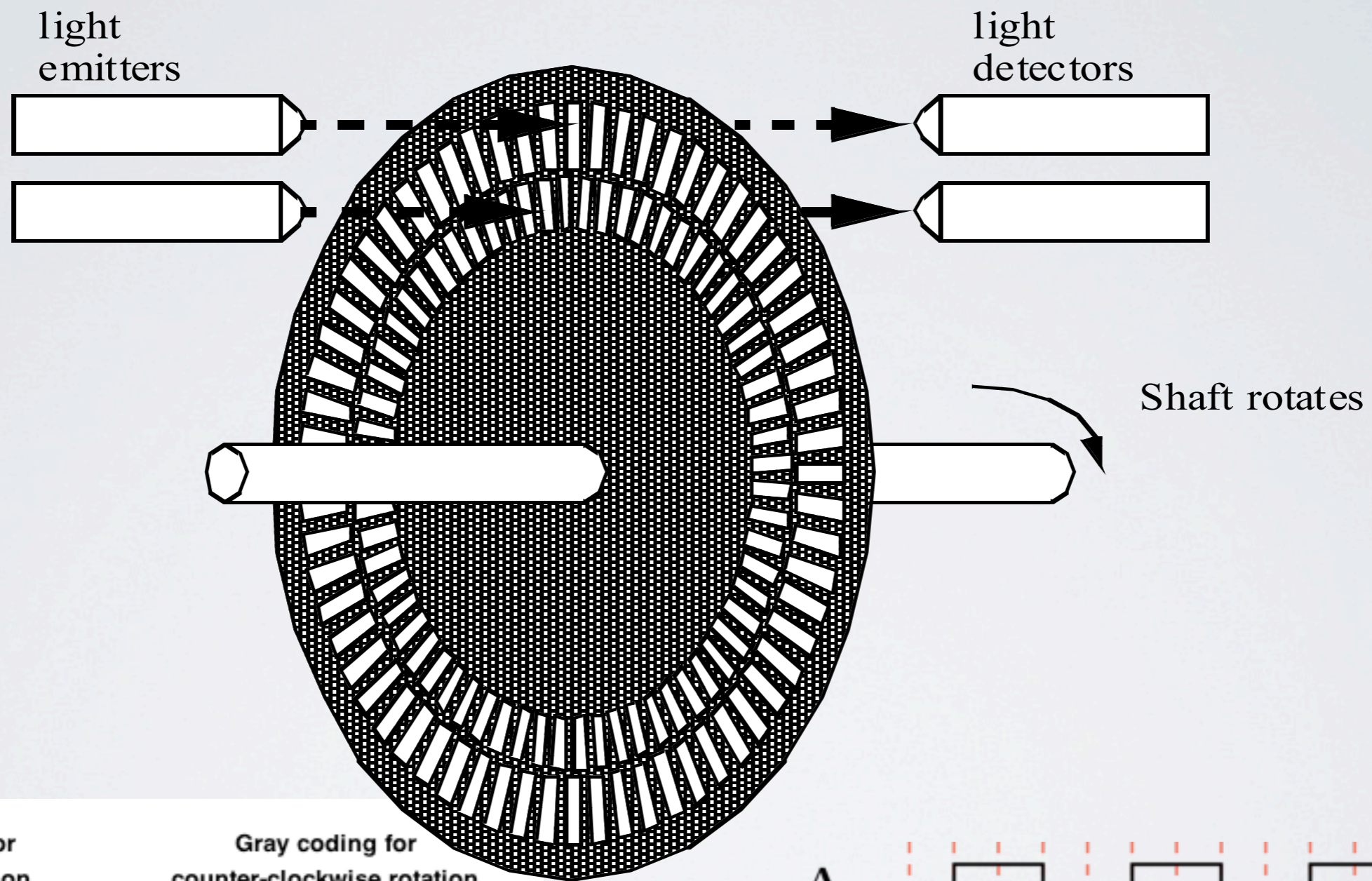


relative encoder  
(quadrature)



absolute encoder

# Codificadores ópticos

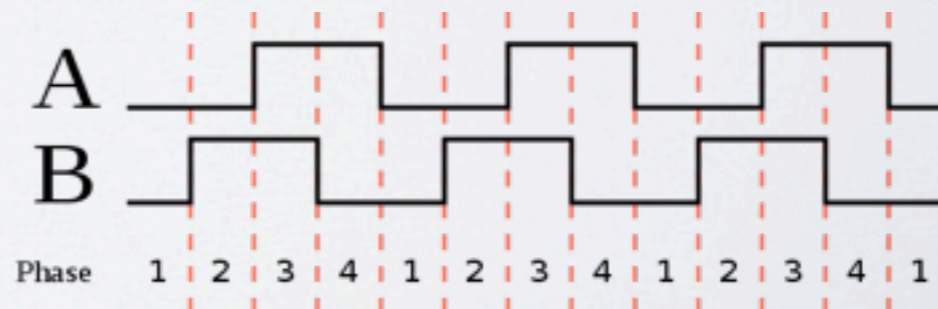


Gray coding for clockwise rotation

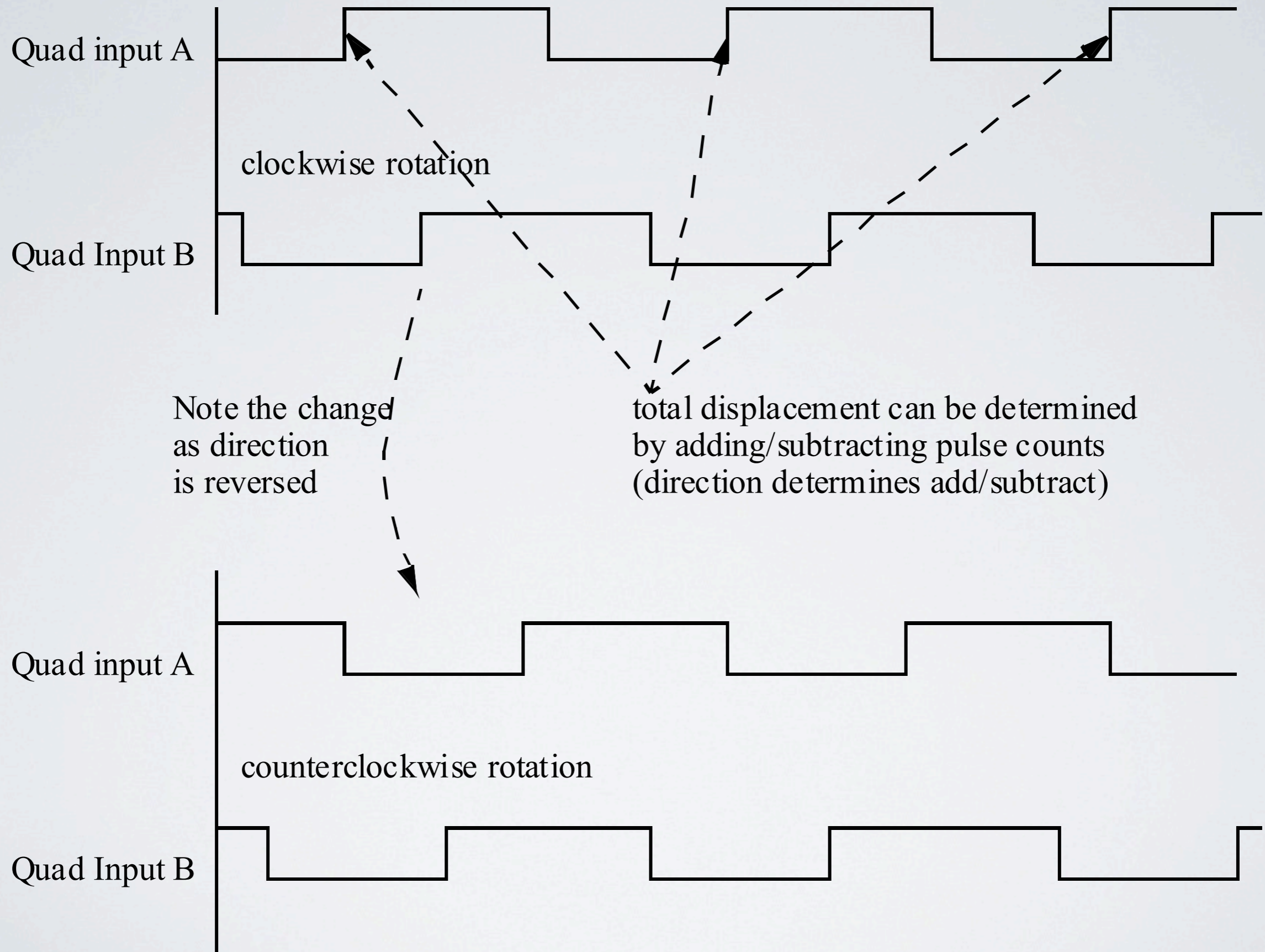
Phase	A	B
1	0	0
2	0	1
3	1	1
4	1	0

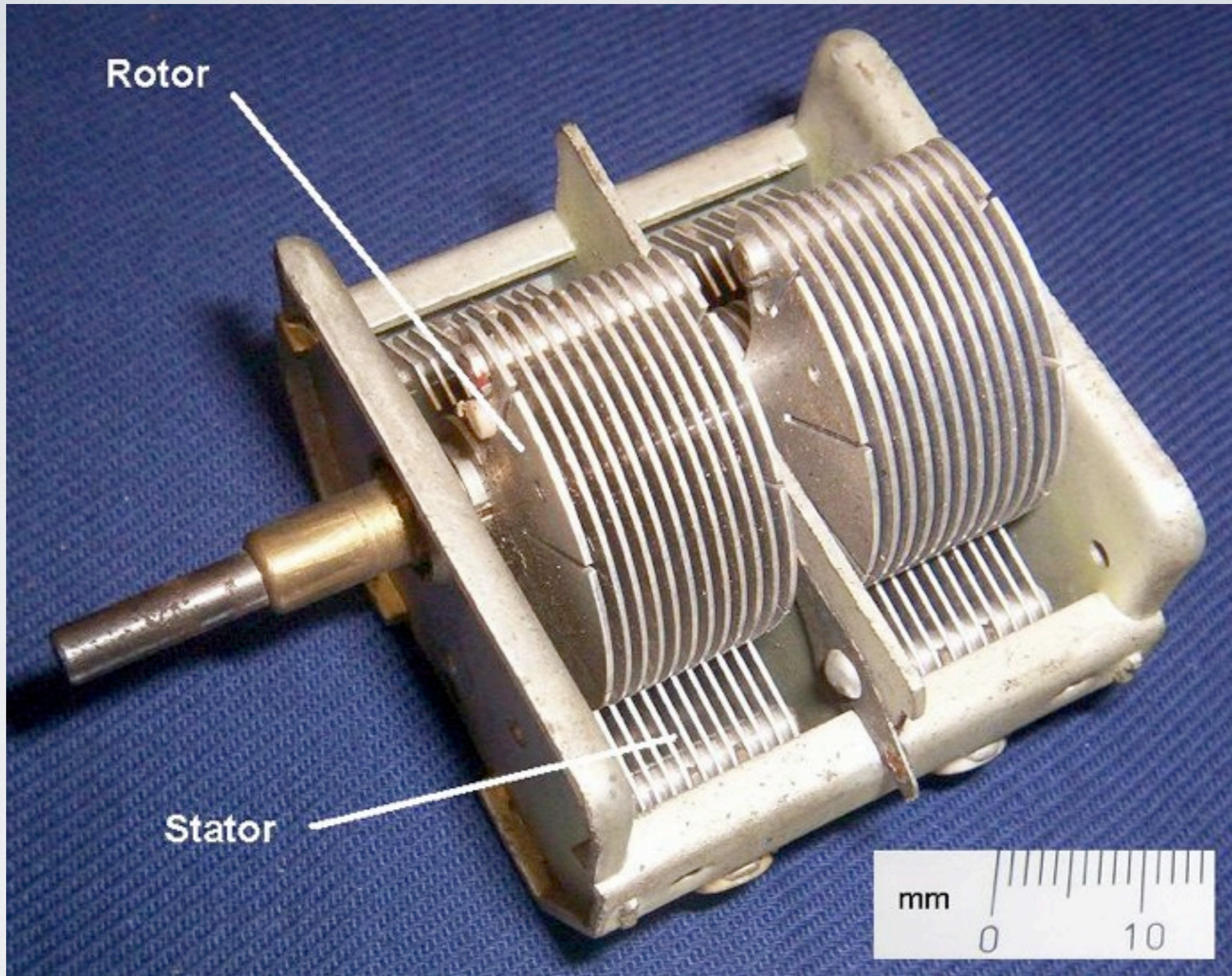
Gray coding for counter-clockwise rotation

Phase	A	B
1	1	0
2	1	1
3	0	1
4	0	0



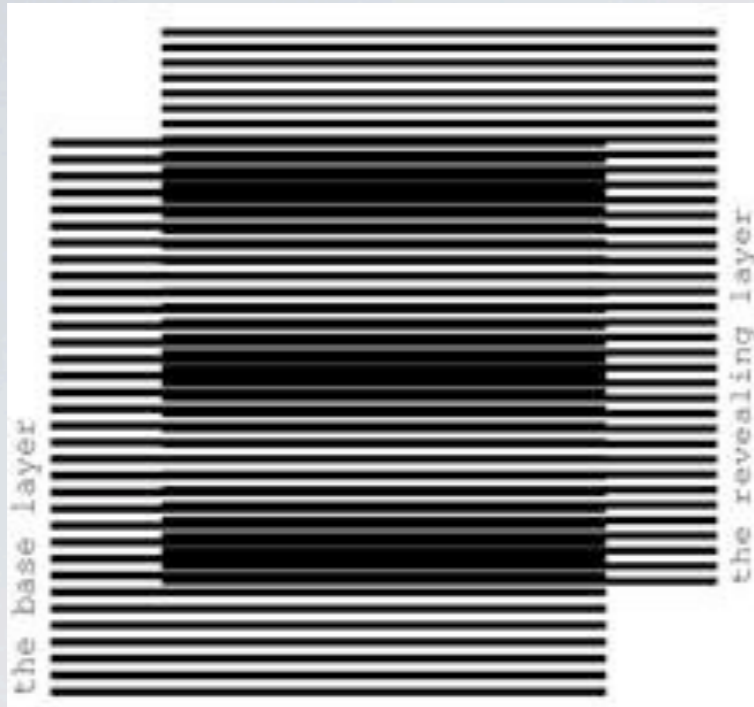
# Quadrature





Variable capacitor

## Patrones de Moiré



$$p_m = \frac{p_b \times p_r}{p_b - p_r}$$

donde

- $p_m$  = periodo del patrón de Moiré
- $p_b$  = periodo de la capa base
- $p_r$  = periodo de la capa “reveladora”