EE 4BD4 Lecture 14

Position and Movement Sensors

Types of Sensors

- Potentiometers and linear resistors
- Capacitive sensors (mm distances, e.g. capacitive microphone)
- Linear variable differential transformer (LVDT)
- Hall Effect sensors
- Optical encoders
- Accelerometers

LVDT

- accurate and reliable method for measuring linear distance.
- LVDTs find uses in modern machine-tool, robotics, avionics, and computerized manufacturing.
- Linearity - typically 0.5% or better.
- Measurement ranges - ±100 μm to ±25 cm.

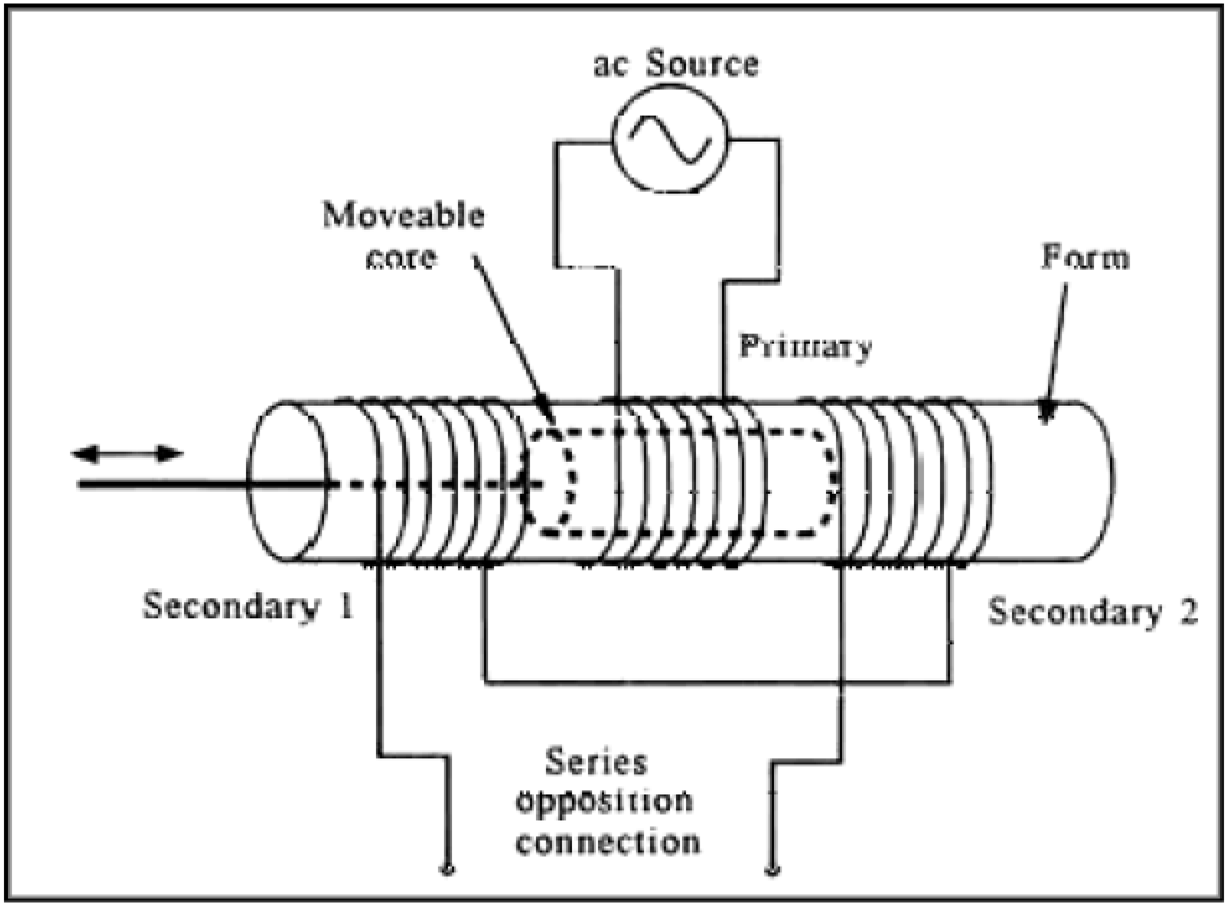


Figure 2. General LVDT Assembly

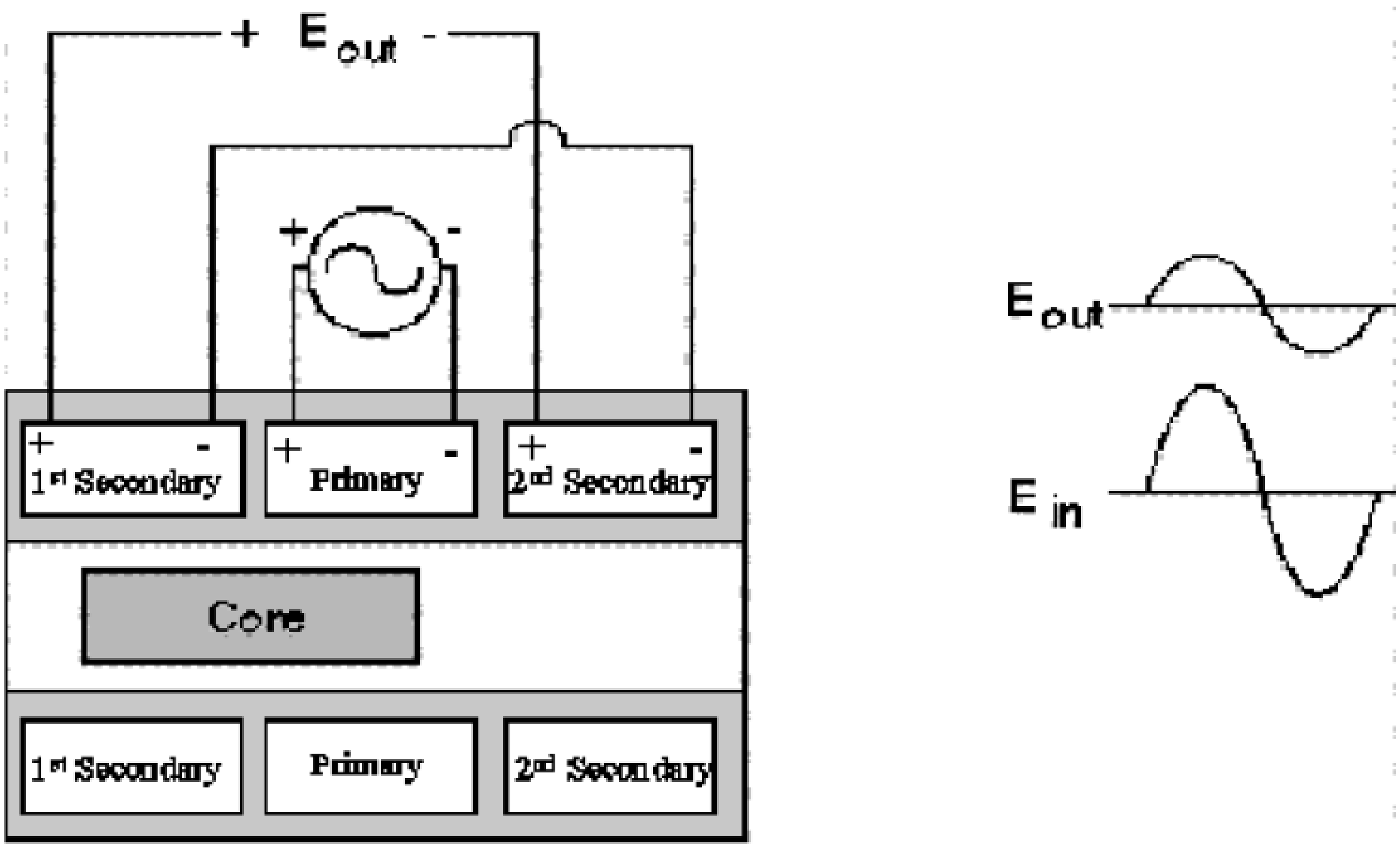


Figure 4. Coupling to First Secondary Caused by Associated Core Displacement

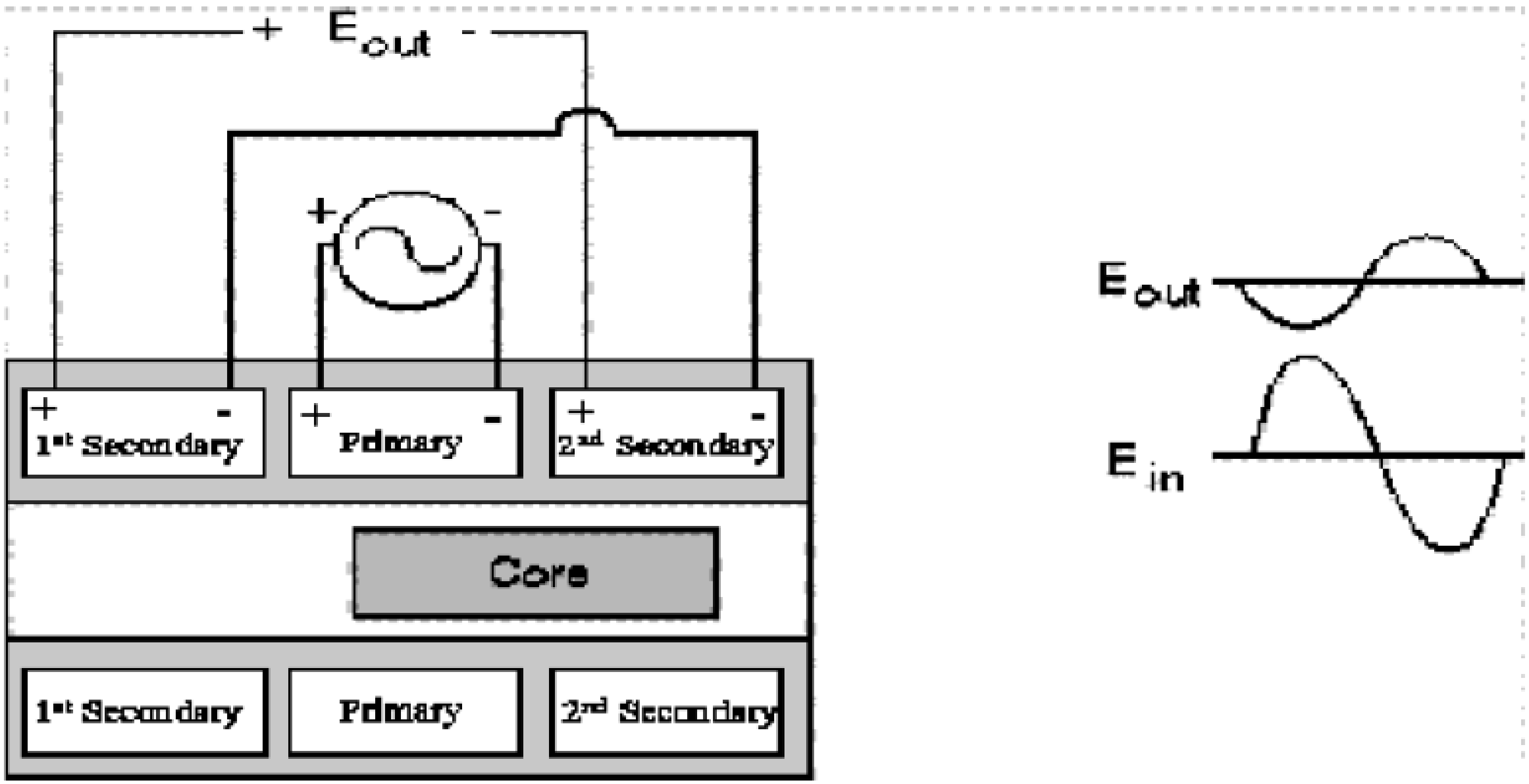
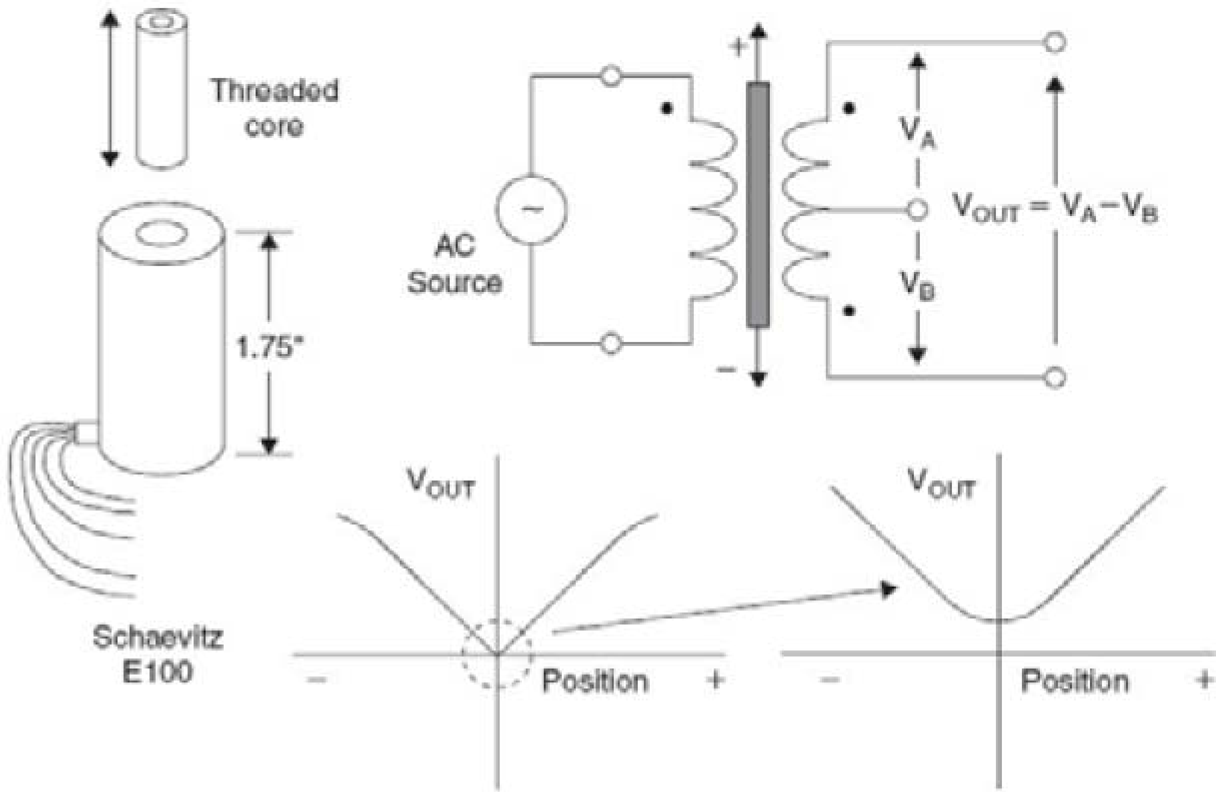


Figure 5. Coupling to Second Secondary Caused by Associated Core Displacement

Basic Approach (not direction sensitive)



Phase –Sensitive Detector for Direction

- Excitation signal between 50 Hz and 25kHz (10 times greater than frequency of movement)

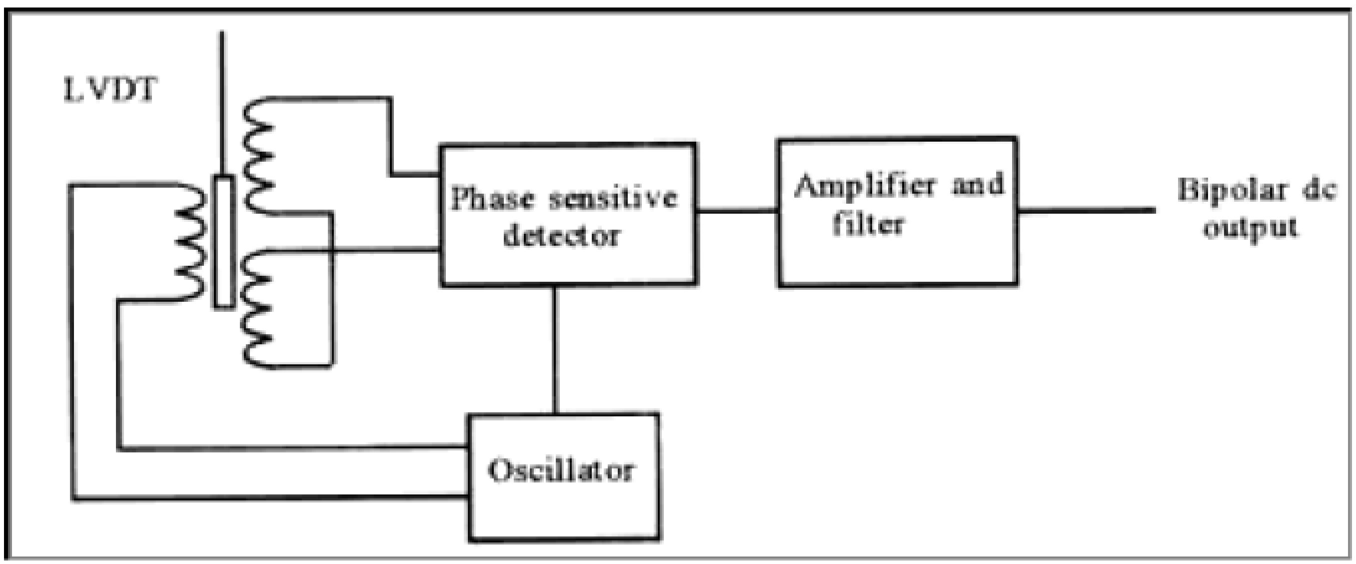
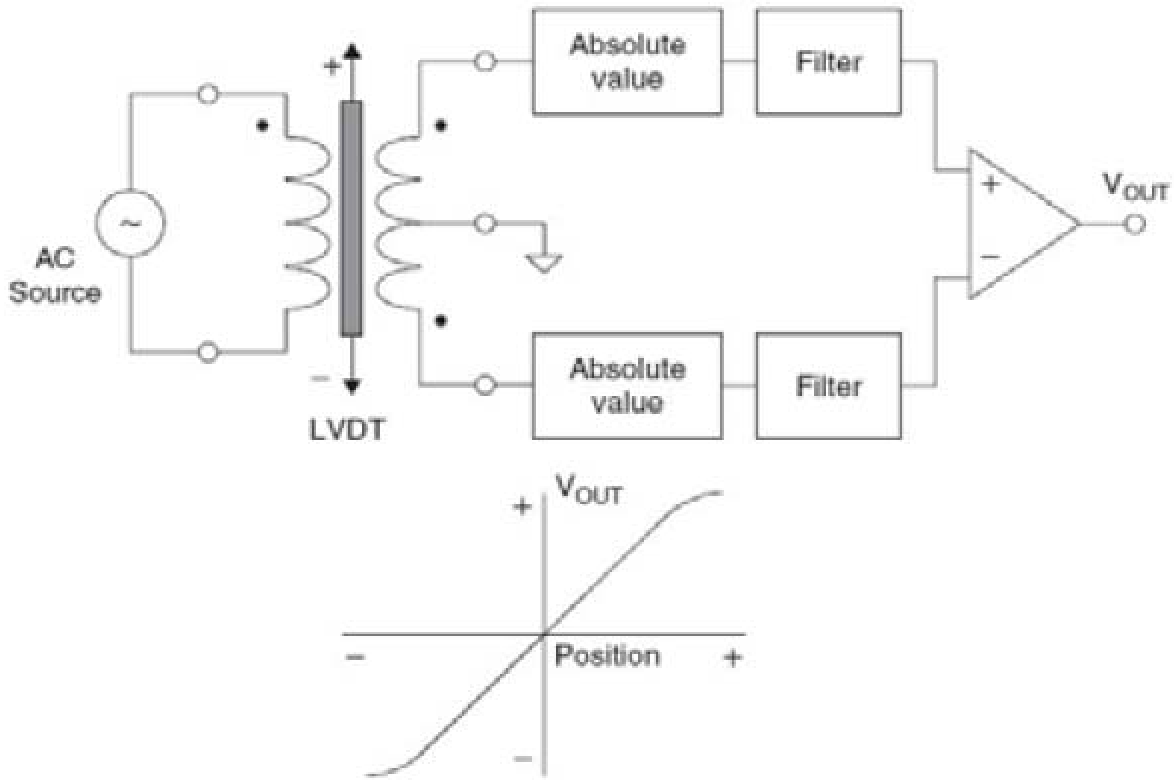
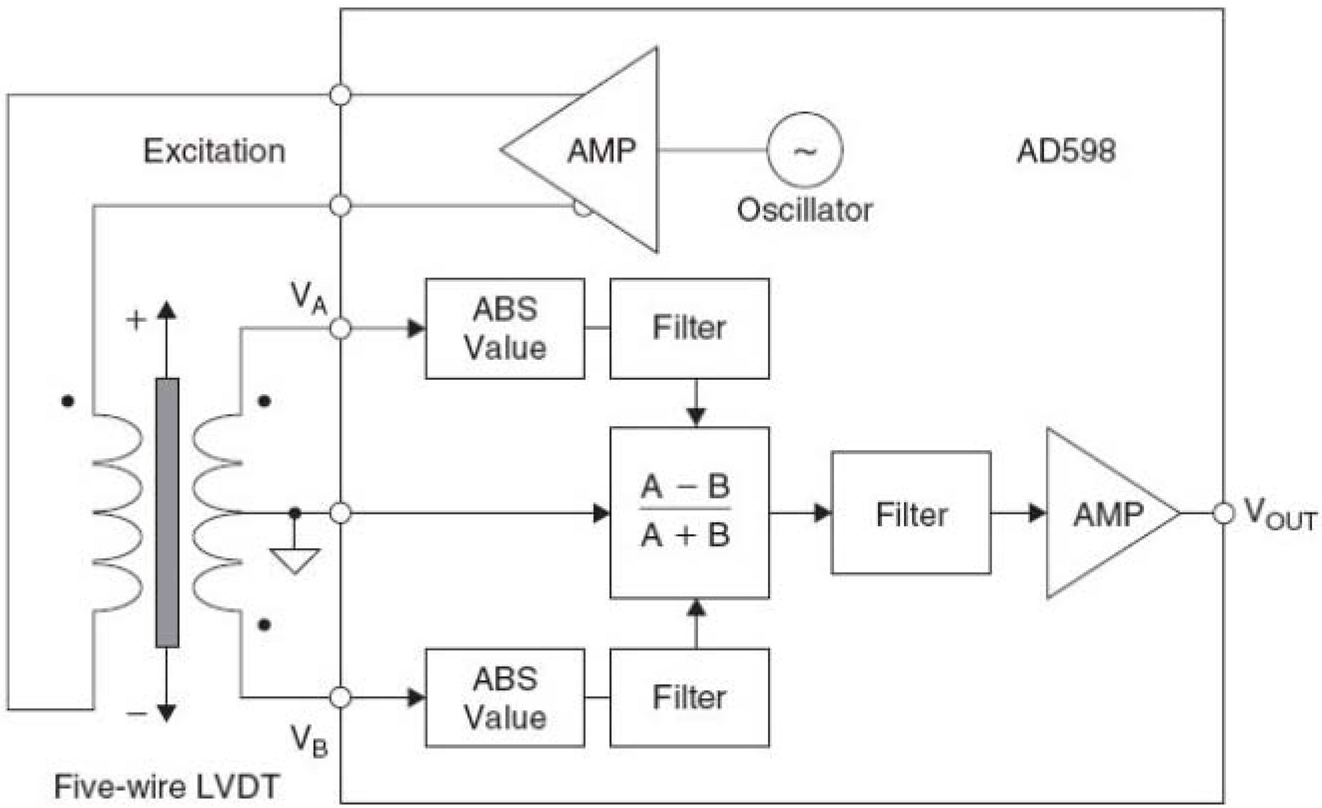


Figure 7. Sophisticated Phase-Sensitive LVDT Signal Conditioning Circuit

Alternate Processing Approach



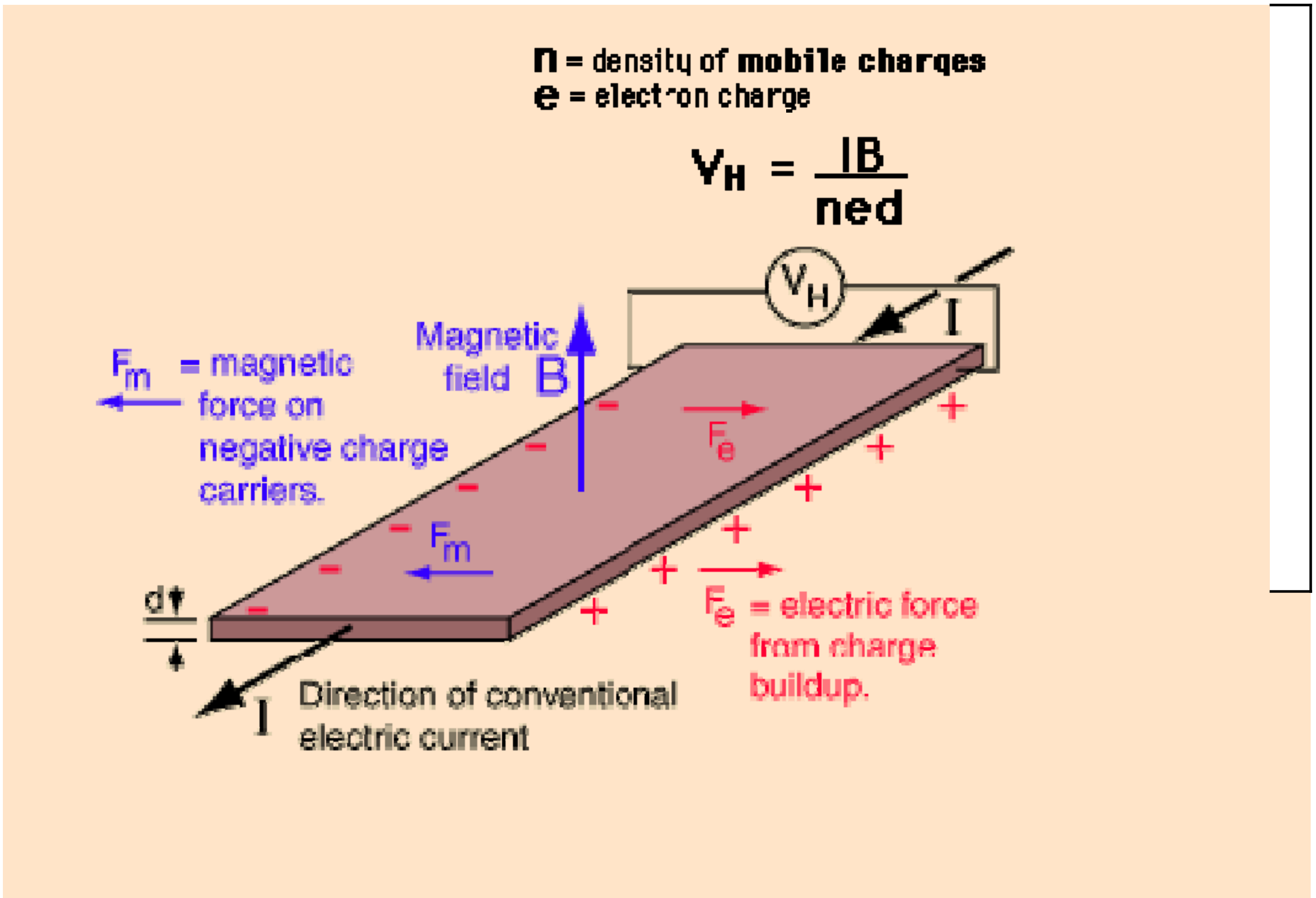
AD598 Signal Conditioner (Simplified)



Hall Effect Sensor

- Transducer that varies its voltage output in response to a magnetic field
- Used for proximity switching, speed detection, positioning applications, tachometer, etc.
- Automotive: ignition timing, tachometer, ABS
- Motors: shaft position in brushless DC motors
- Magnetic source can be permanent magnets
- Sensor coefficients are temperature sensitive (need compensation)
- More reliable than mechanical switch and no bounce
- Switching up to 100 kHz

Hall Effect Voltage V_H



Hall Effect Sensors

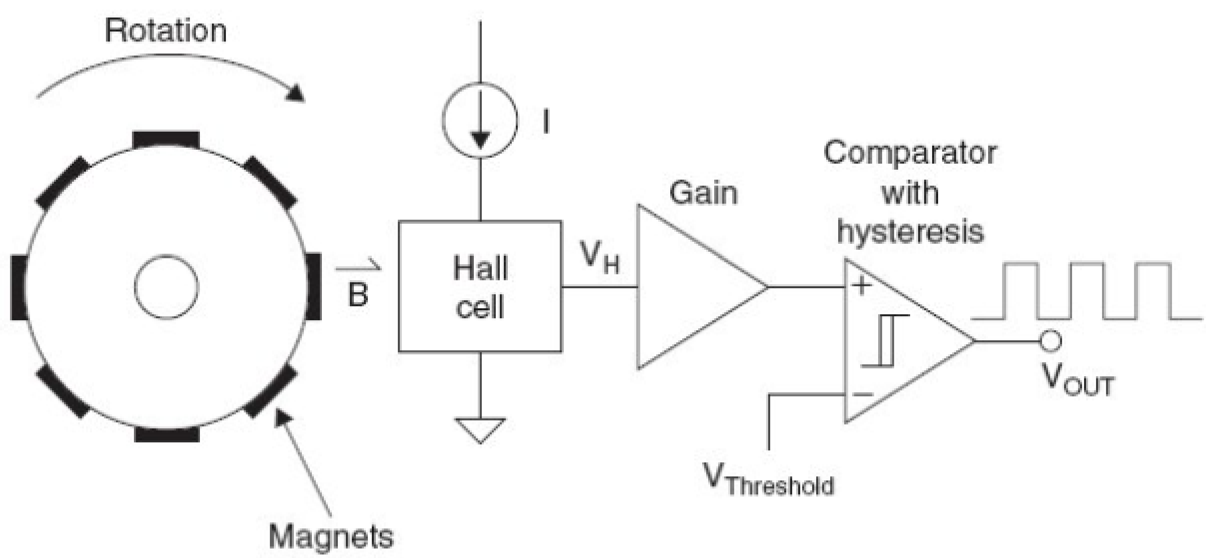
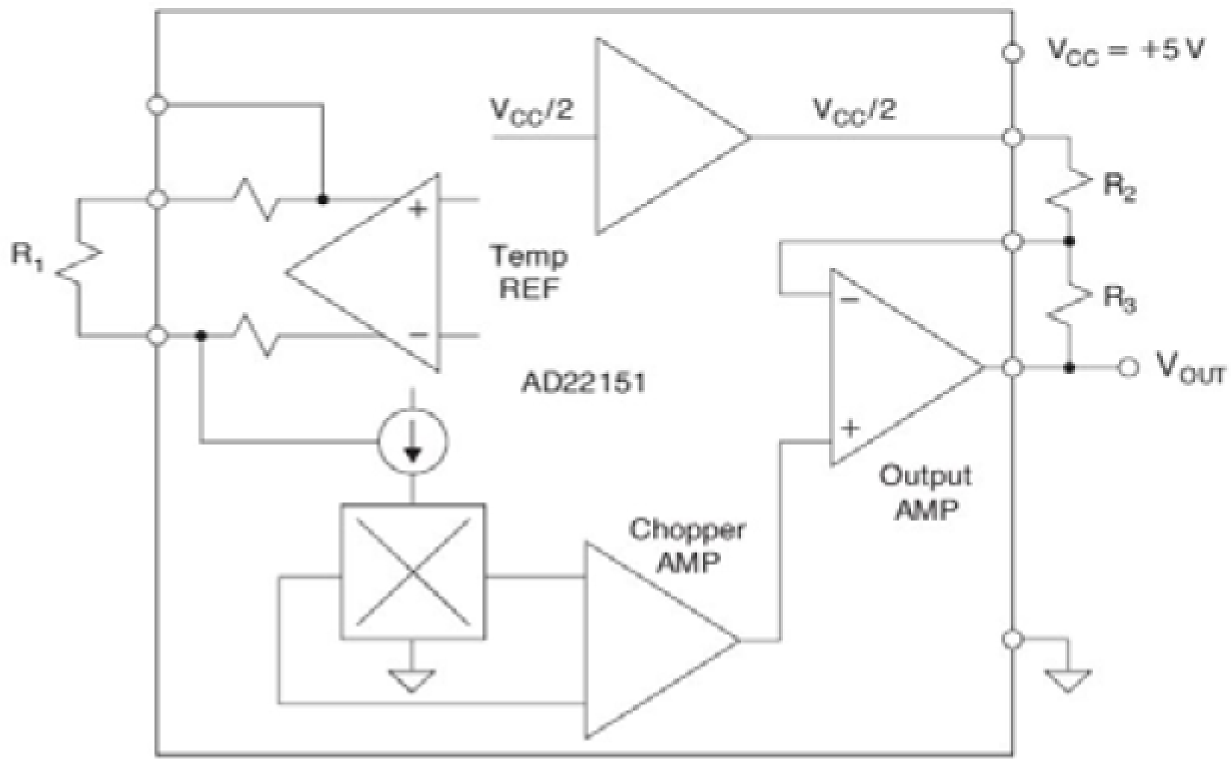


Figure 3-8: Hall Effect sensor used as a rotational sensor

Hall Effect Sensors

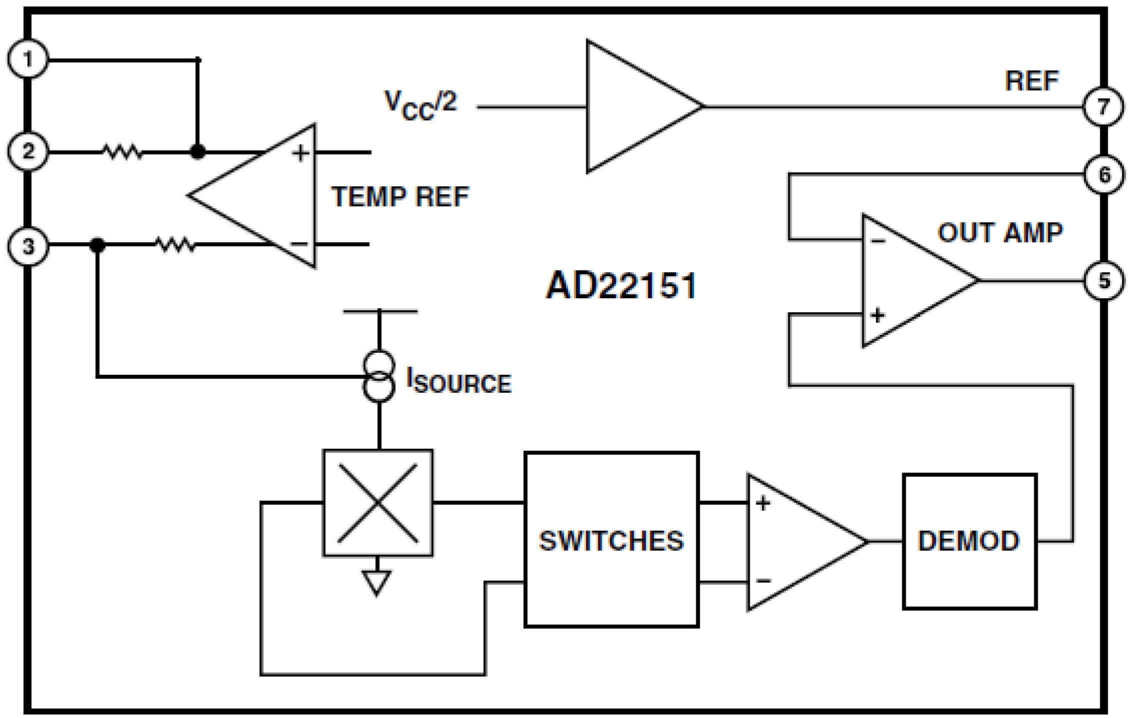


$$V_{OUT} = \left[1 + \frac{R_3}{R_2}\right]\left[0.4\,\text{mV}\right] \Big/ \text{Gauss} \qquad \text{Non-linearity} = 0.1\%\ \text{FS}$$

Figure 3-9: AD22151 linear output magnetic field sensor

Analog Devices Magnetic Field Sensor (Linear output)

FUNCTIONAL BLOCK DIAGRAM



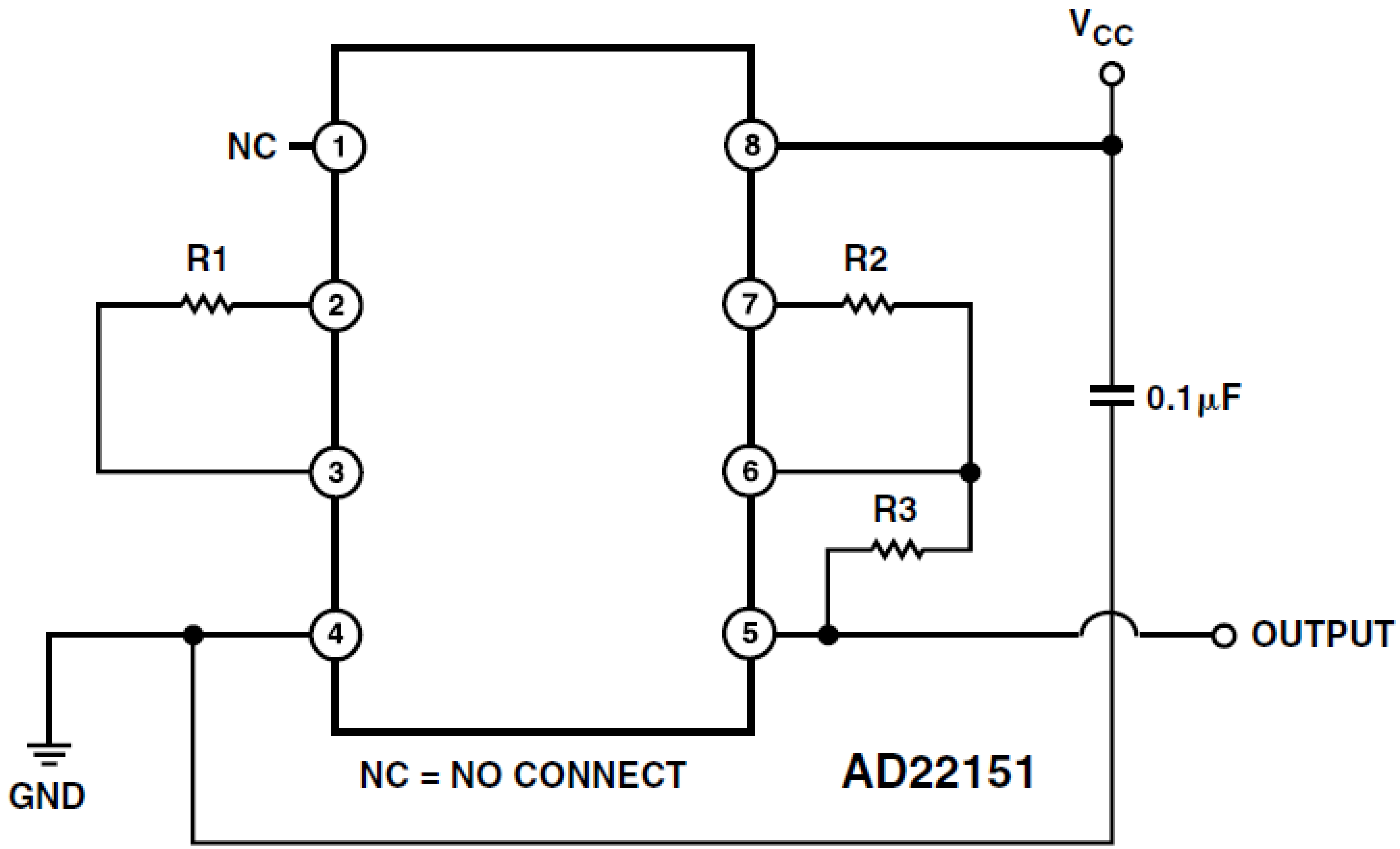


Figure 1. Typical Bipolar Configuration with Low (< –500 ppm) Compensation

Setting Gain of the Chip

GAIN AND OFFSET

The operation of the AD22151 can be bipolar (i.e., 0 Gauss = $V_{CC}/2$), or a ratiometric offset can be implemented to position Zero Gauss point at some other potential (i.e., 0.25 V).

The gain of the sensor can be set by the appropriate R2 and R3 resistor values (see Figure 1) such that:

$$Gain = 1 + \frac{R3}{R2} \times 0.4\, mV / G \qquad (1)$$

However, if an offset is required to position the quiescent output at some other voltage, the gain relationship is modified to:

$$Gain = 1 + \frac{R3}{(R2 \| R4)} \times 0.4\, mV / G \qquad (2)$$

The offset that R4 introduces is:

$$Offset = 1 + \frac{R3}{(R2 + R4)} \times (V_{CC} - V_{OUT}) \qquad (3)$$

Accelerometers and Gyros

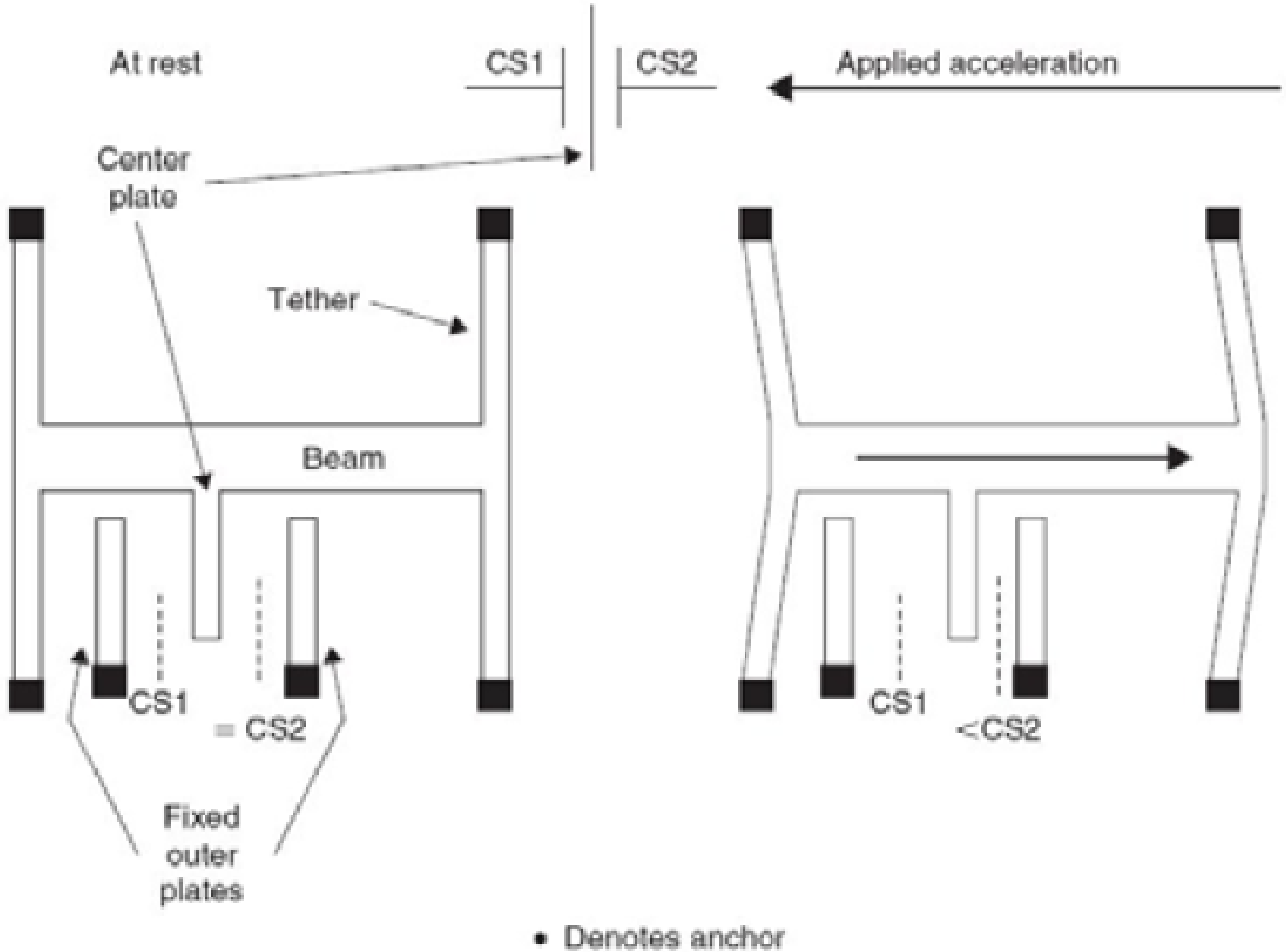


Figure 3-13: ADXL family micromachined accelerometers (top view of IC)

Accelerometers and Gyros

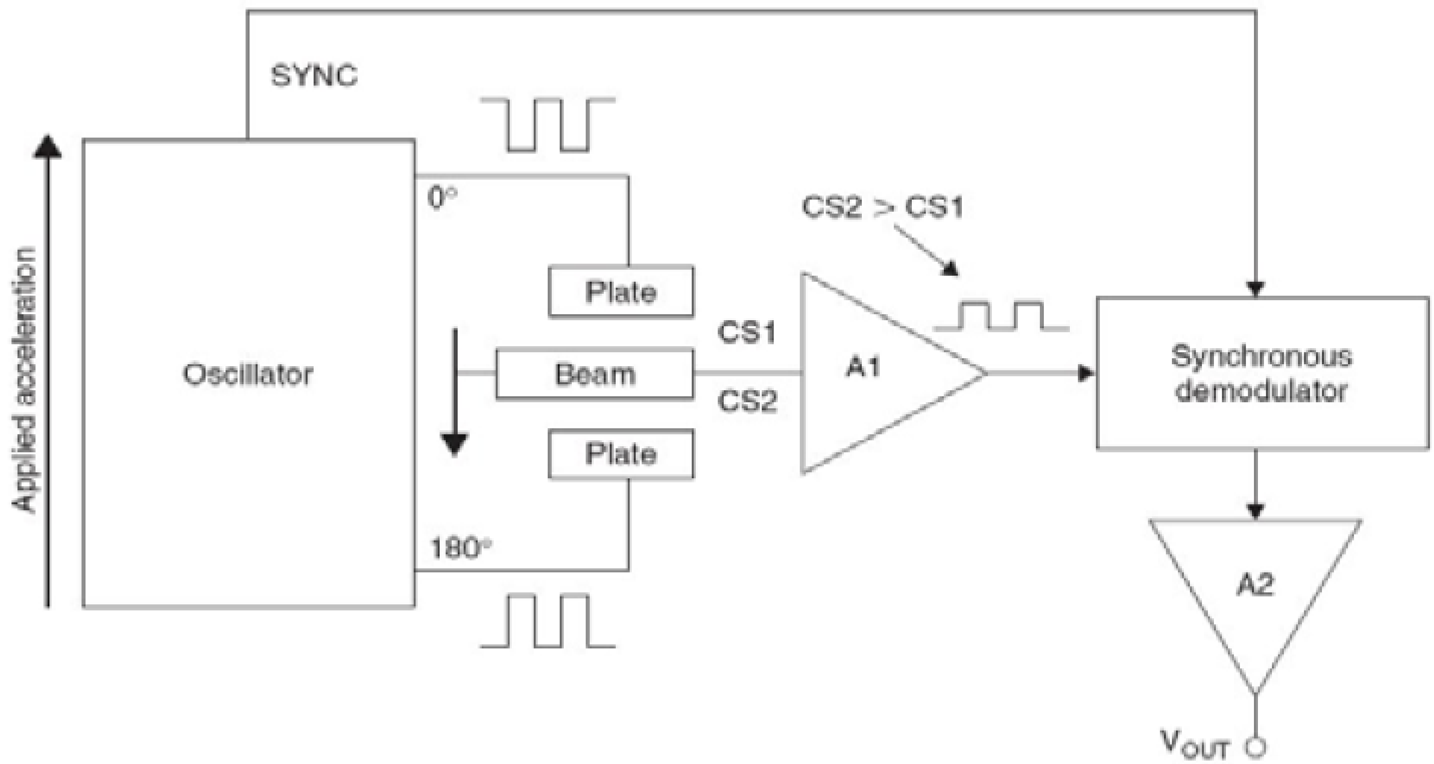


Figure 3-14: Accelerometer internal signal conditioning

Accelerometers and Gyros

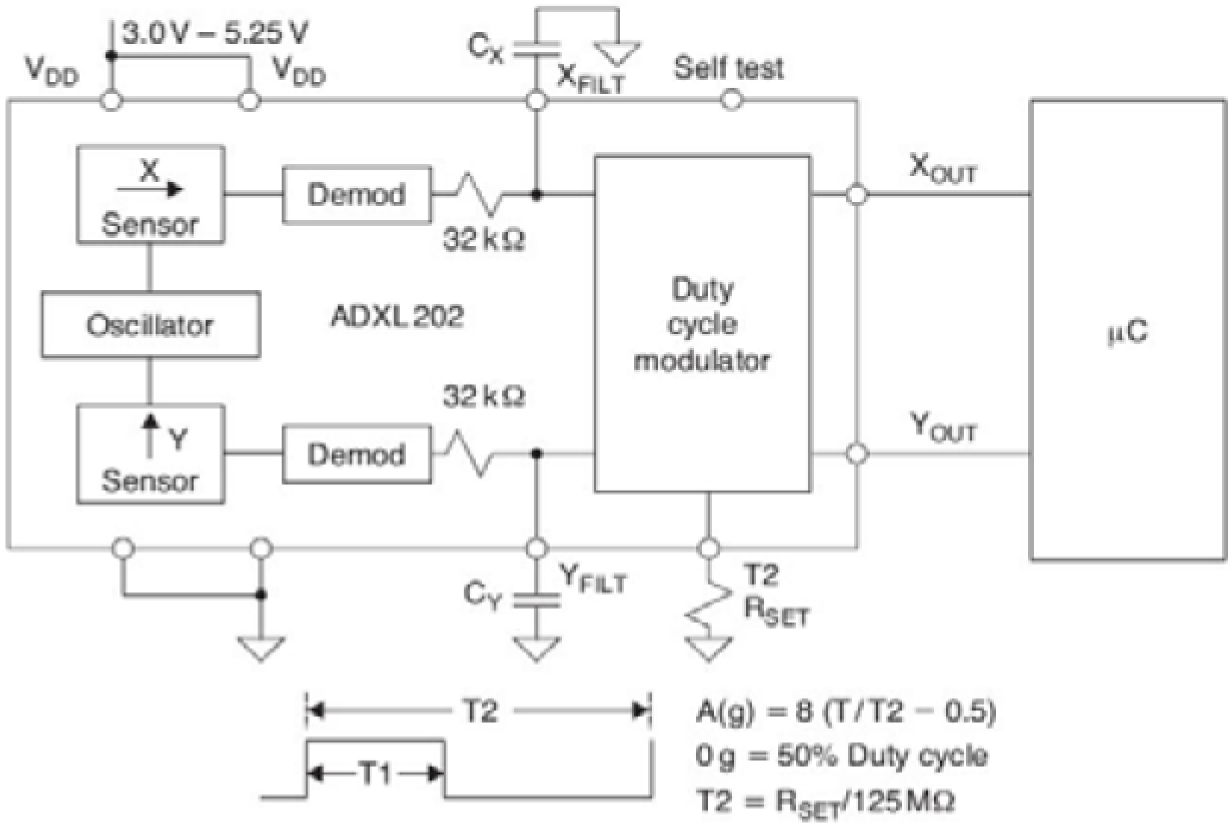
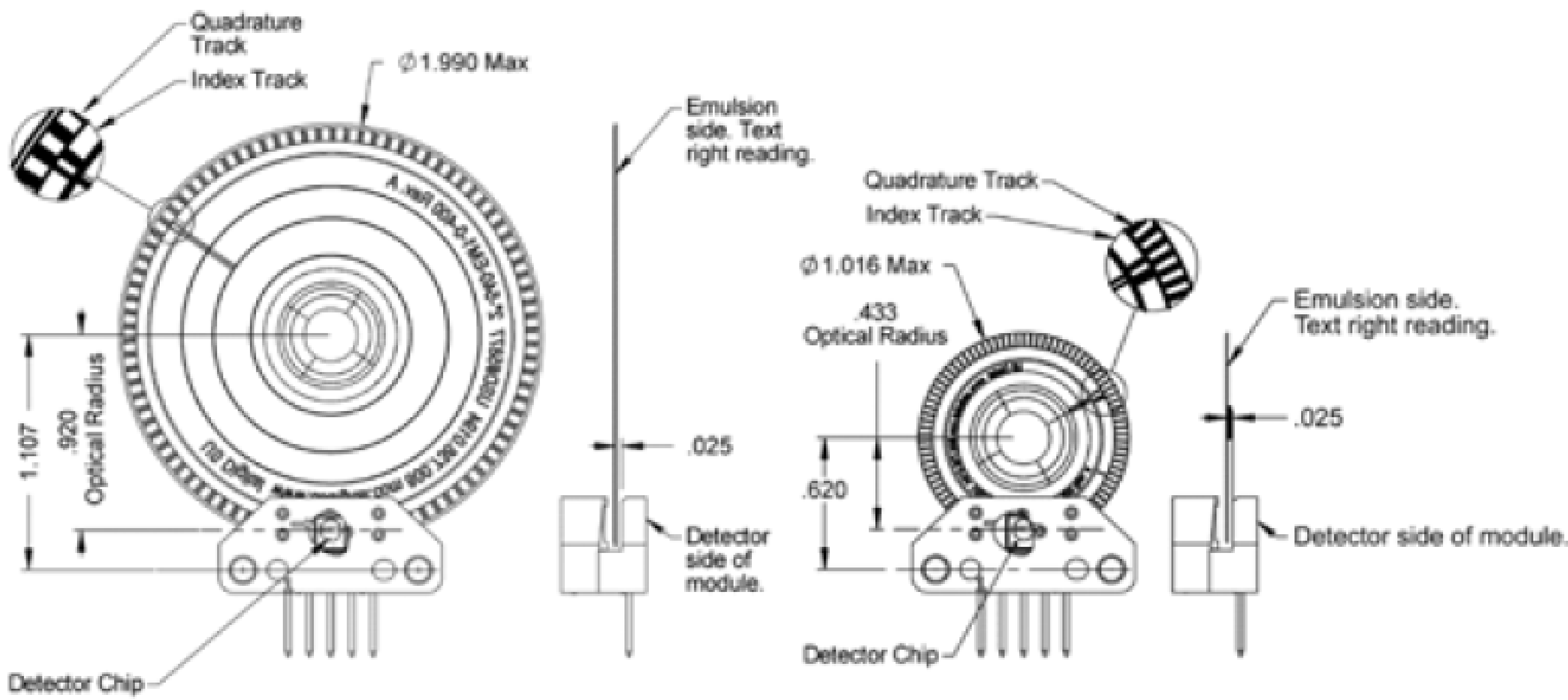


Figure 3-16: ADXL202 ±2 g dual axis accelerometer

Optical Encoders (Rotary)



Optical Encoders (Linear)