Sensor Temperatur
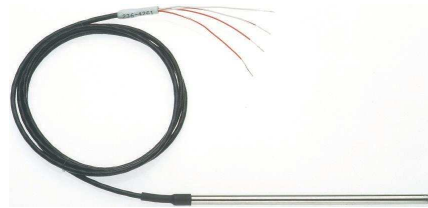
- **Resistive thermometers**
  - Salah satu yang umum menggunakan kawat platinum disebut dengan platinum resistance thermometers or PRT)
  - Karakteristiknya *linear* tapi *sensitivitasnya* rendah

A typical PRT element

A sheathed PRT

- **Thermistors**
  - Terbuat dari bahan dengan koefisien tahanan termal yang tinggi
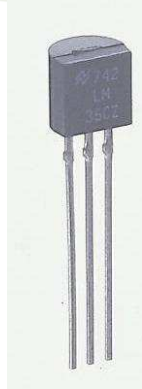 - *sensitive* but highly *non-linear*

A typical disc thermistor

A threaded thermistor

- **pn junctions**
  - Komponen semikonduktor yang digunakan sebagai sensor temperatur
  - *inexpensive*, *linear* and *easy to use*
  - *limited temperature range* (perhaps -50°C to 150 °C) due to nature of semiconductor material
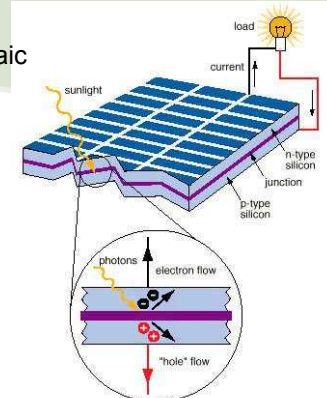
pn-junction sensor
LM 355

Sensor Cahaya (Light Sensors)

Photovoltaic

- **Photovoltaic**
  - Berkas cahaya jatun pada *pn*-junction dan menimbulkan listrik (disebut juga solar cell)
- **Photodioda**
  - Ukuran komponen kecil dan sangat peka, namun tegangan listrik yang dihasilkan tidak linier terhadapa intensitas cahay
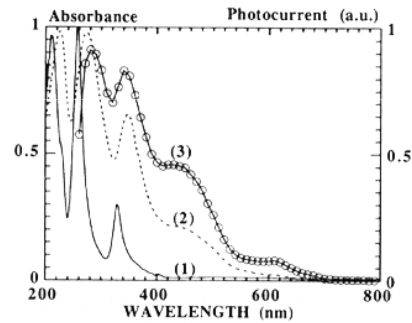
photodioda

Slide 5

- **Photoconductive**
  - Komponen ini tidak menghasilkan listrik tetapi secara sederhana tahanannya berubah terhadap intensitas cahaya.
    Meski namanya conductive tetapi cara kerjanya bersifat resistif bukan sebagai konduktor
- **phototransistor** berperilaku nonlinear seperti photodioda tapi memiliki sensitivitas lebih besar
- **light-dependent resistors (LDRs)** memiliki respon waktu yang lambat

Fig. 1. (1)Uv-visible absorption of C_{60} in solution (hexane), (2)thin film (air exposed) and (3)photoconductivity spectrum (air exposed).
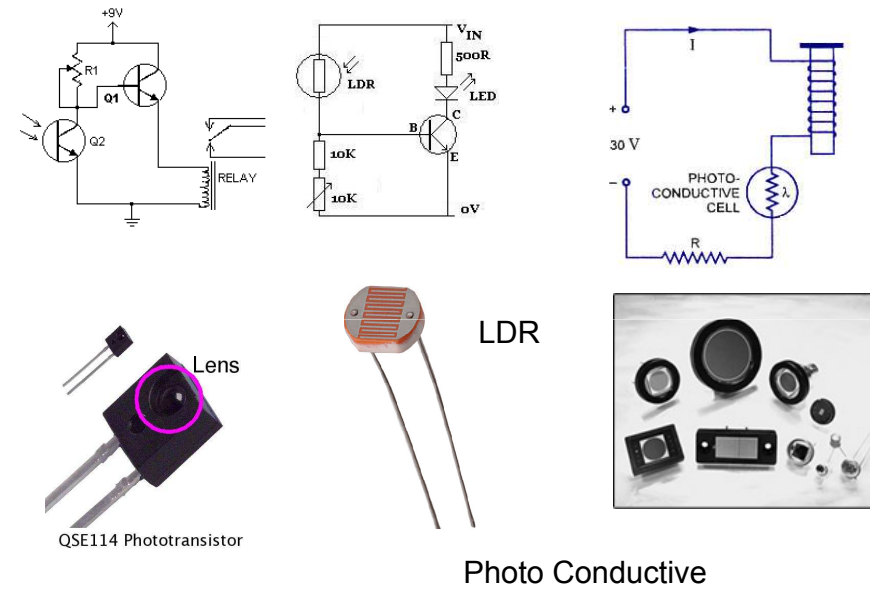
5

Slide 6

LDR

QSE114 Phototransistor

Photo Conductive

Photo Transistor

6

Slide 7

Proximity Sensor

- **Inductive proximity sensors**

  - Kumparan induktansi sangat berpengaruh pada keberadaan bahan ferromagnetik
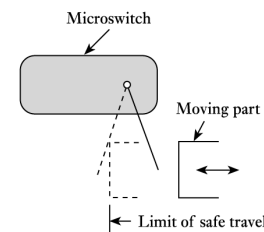 - Proximity (kedekatan) pelat ferromagnetic menentukan induktansi pada kumparan
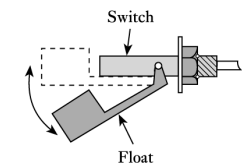

Inductive proximity sensors

7

Slide 8

- **Switches**
  - Merupakan sensor pergeseran (displacement) yang membentuk sinyal digital
  - Beberapa jenisnya : lever or push-rod operated microswitches; float switches; pressure switches; etc.
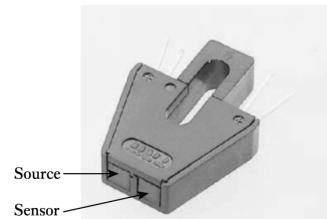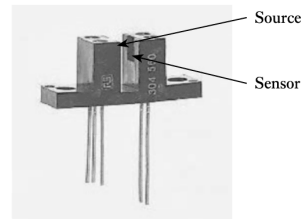

A limit switch

A float switch

8

- **Opto-switches**
  - Terdiri dari sumber cahaya dan sensor cahaya yang disusun dalam satu kesatuan
  - Bekerja menggunakan efek cahaya yang terhalang
  - Dua jenis yang umum adalah reflective dan slotted types
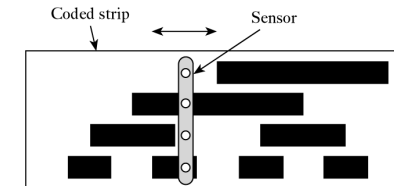
A reflective opto-switch   A slotted opto-switch
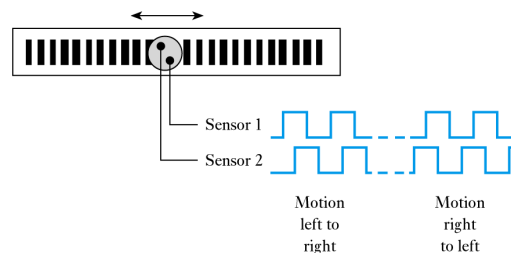
- **Absolute position encoders**
  - a pattern of light and dark strips is printed on to a strip and is detected by a sensor that moves along it
    - the pattern takes the form of a series of lines as shown below
    - it is arranged so that the combination is unique at each point
    - sensor is an array of photodiodes

Coded strip   Sensor

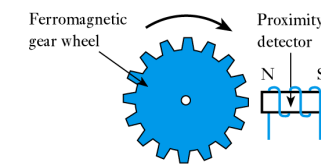- **Incremental position encoder**
  - uses a single line that alternates black/white
    - two slightly offset sensors produce outputs as shown below
    - detects motion in either direction, pulses are counted to determine absolute position (which must be initially reset)
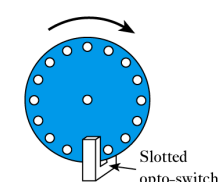
Sensor 1
Sensor 2

Motion left to right   Motion right to left

- **Other counting techniques**
  - several methods use counting to determine position
    - two examples are given below

Ferromagnetic gear wheel   Proximity detector

N S

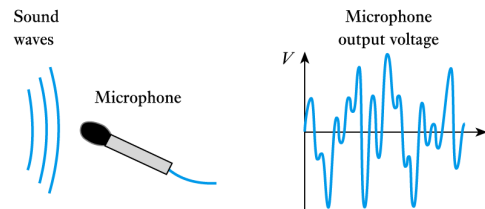Slotted opto-switch

Inductive sensor   Opto-switch sensor

Sound Sensors

- **Microphones**
  - a number of forms are available
    - e.g. carbon (resistive), capacitive, piezoelectric and moving-coil microphones
    - moving-coil devices use a magnet and a coil attached to a diaphragm – we will discuss electromagnetism later

Sound waves

Microphone

Microphone output voltage

V

PRESSURE SENSOR

PRINSIP PRESSURE

- Static Pressure : Fluida tak bergerak / diam
- Dynamic Pressure : Fluida bergerak
- Gauge Pressure : Pg = Pabs – Patm
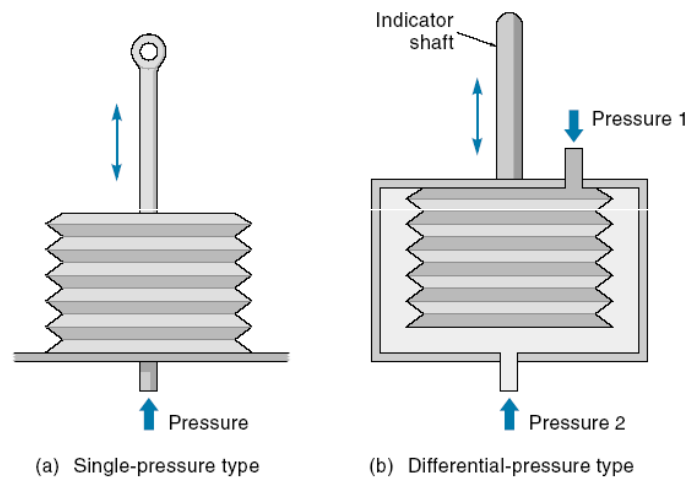- Unit : Satuan-satuan yang terkait ➜ P=F/A
- Head Pressure : P=ρgh; ρ=m/v; P= ρwh

JENIS-JENIS SENSOR

- Bourdon Tubes
- Bellows
- Semiconductor Pressure Sensors
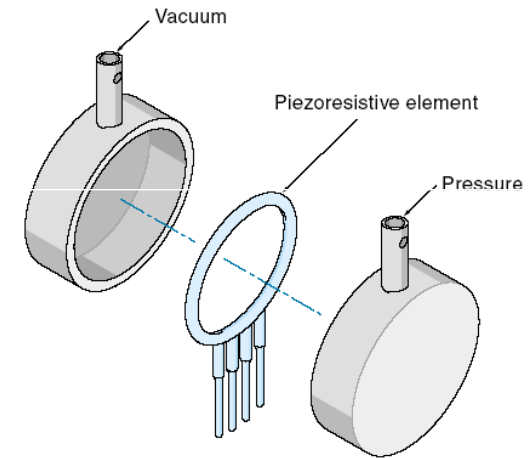
• Bellows

(a) Single-pressure type

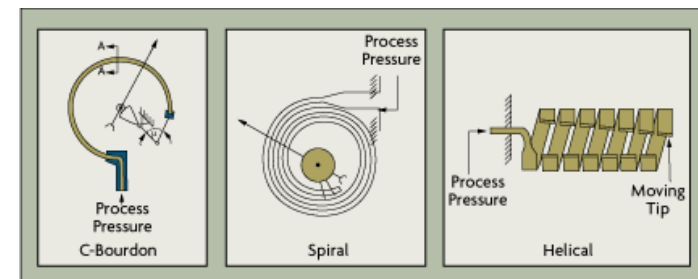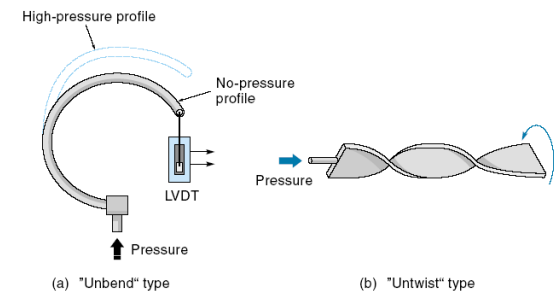(b) Differential-pressure type

• Semiconductor Pressure Sensors

• Bourdon Tubes
Prinsip Kerja

sejenis pipa pendek lengkung , dan salah satu ujungnya tertutup. Jika bourdon tubes diberikan tekanan maka ia akan cenderung untuk "menegang". Perubahan yang dihasilkan sebanding dengan besarnya tekanan yang diberikan.

• Bourdon Tubes

(a) "Unbend" type   (b) "Untwist" type

KELEBIHAN

- Tidak mudah terpengaruh perubahan temperatur
- Baik dipakai untuk mengukur tekanan antara 30-100000 Psi

KEKURANGAN

- Pada tekanan rendah 0-30 psi kurang sensitif dibanding bellows

APLIKASI SENSOR

Sensor tekanan dapat diaplikasikan pada :
1. Pemantau cuaca
2. Pesawat terbang
3. Pengukur tekanan ban
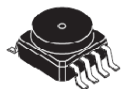4. ketinggian, bisa pada pesawat terbang, roket, satelit, balon udara dll

$$h = \frac{(1 - (P/P_{ref})^{0.19026}) \times 288.15}{0.00198122}\text{an}$$
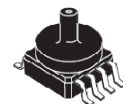
h ketingian, P Tekanan satis and
Pref Tekanan referensi

Pressure sensors-altimeter
MPX4115A(IMU) / MPXA6115A (R-DAS)

SMALL OUTLINE PACKAGE
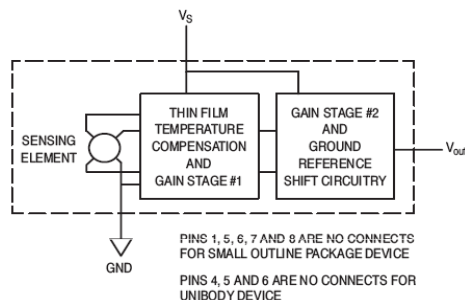
MPXA4115A6U
CASE 482

MPXA4115AC6U
CASE 482A

Figure 1. Fully Integrated Pressure Sensor Schematic

PINS 1, 5, 6, 7 AND 8 ARE NO CONNECTS FOR SMALL OUTLINE PACKAGE DEVICE

PINS 4, 5 AND 6 ARE NO CONNECTS FOR UNIBODY DEVICE

Features
- 1.5% Maximum Error over 0° to 85°C
- Ideally suited for Microprocessor or Microcontroller–Based Systems
- Temperature Compensated from −40° to +125°C
- Durable Epoxy Unibody Element or Thermoplastic (PPS) Surface Mount Package

http://www.freescale.com/files/sensors/doc/data_sheet/MPX4115A.pdf?pspll=1
http://www.eng.hmc.edu/NewE80/PDFs/MPXA6115A.pdf

Pressure sensors-**MPX4115A**

- Pressure units
  - Pascal (Pa)=N/m^2: standard atmosphere P$_0$=101325 Pa=101.325kPa
  - Bar: 1 bar=100 kPa
  - Psi= (Force) pound per square inch: 1 Psi=6.89465 KPa

- MPX4115A measures pressure in the range: 15-115 kPa
- Sensitivity: 45.9mV/kPa (pressure range 100kPa➔ voltage range 4.59V)
- Typical supply voltage 5.1V
- Output analog voltage
  - Offset voltage (V$_{off}$) is the output voltage measured at minimum rated pressure (Typical@ 0.204V)
  - Full scale output (Vfso) measured at maximum rated pressure (Typical@ 4.794 V)

http://www.freescale.com/files/sensors/doc/data_sheet/MPX4115A.pdf?pspll=1

Signal Conditioning Circuitry
- From sensor voltage to ADC on R-DAS

+5V

1
2 MPXA4115A Pressure Sensor
3
4

0.01uF 1uF

470uF

buffer

−
+

1/4
AD8606
(AD8605)
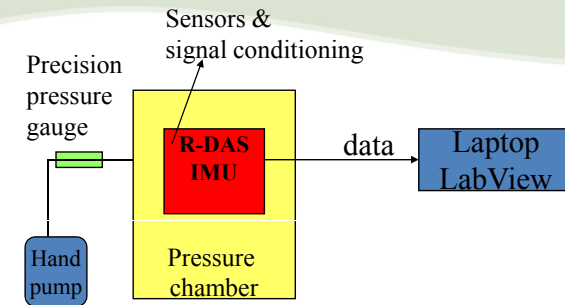
To ADC

• 0.2-4.8V (close to 0-5V in ADC), so no scaling/shifting circuitry is added for easy data processing.
• The input impedance of R-DAS is 1kΩ, so a unity gain   buffer is required for loading.
• Low pass filter before ADC.
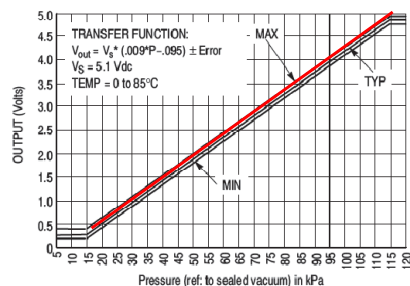• All power supplies should be bypassed to reduce noises.

Measure voltage and pressure in the lab

Sensors & signal conditioning

Precision pressure gauge

R-DAS IMU

data

Laptop LabView

Hand pump

Pressure chamber

• After ADC, the digital readings (0-1024)➔(0-5V) analog voltage
• Pressure reading is in the units of Psi.
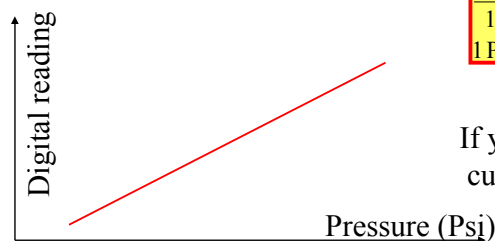• Since everything is linearly scaled, you can choose your calibration curve or units freely.

Calibration curve options

TRANSFER FUNCTION:
$V_{out} = V_S * (.009*P - .095) \pm Error$
$V_S = 5.1$ Vdc
TEMP = 0 to 85°C

MAX
TYP
MIN

OUTPUT (Volts)

Pressure (ref: to sealed vacuum) in kPa

If you want to compare with Manufacture specifications

$$\frac{Digital}{1024} \times 5 = \text{Analog voltage from sensor}$$
1 Psi = 6.89465 kPa

If you want to use you calibration curve to find pressure in field test

Digital reading

Pressure (Psi)

How does pressure (P) relate to altitude (h)?

Assume constant temperature gradient dT/dh, the altitude h is a function of pressure P given by:

$$h = \frac{T_0}{-\left(dT/dh\right)} \cdot \left[1 - \left(\frac{P}{P_0}\right)^{\frac{-\left(dT/dh\right)R}{g}} \right]$$

where
– h = altitude (above sea level) **(Units in feet)**
– P_0 = standard atmosphere pressure= 101325Pa
– T_0 = 288.15K (+15°C)
– dT/dh=-0.0065 K/m: thermal gradient or standard temperature lapse rate
– R = for air 287.052 m²/s²/K
– g = (9.80665 m/s²)

Reference: (1976 US standard atmosphere)
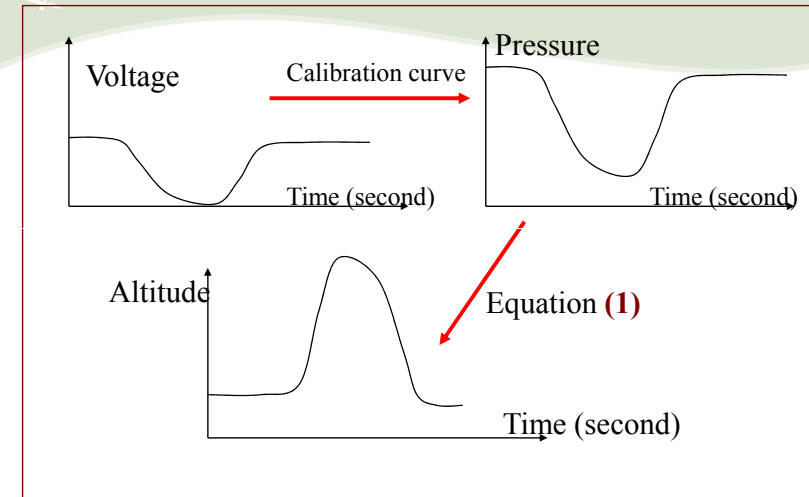
How to relate pressure to altitude?

Plug in all the constants

$$h = 1.4544 \times 10^5 \times \left(1 - \left(\frac{P(\text{kPa})}{101.325\text{kPa}} \right)^{0.1902} \right) \quad \textbf{(1)}$$

- h is measured **in feet.**
- This equation is calibrated up to 36,090 feet (11,000m).
- Reference: http://en.wikipedia.org/wiki/Atmospheric_pressure
- A more general equation can be used to calculate the relationship for different layers of atmosphere

---

It is finally rocket time!

Voltage — Calibration curve → Pressure

Time (second) / Time (second)
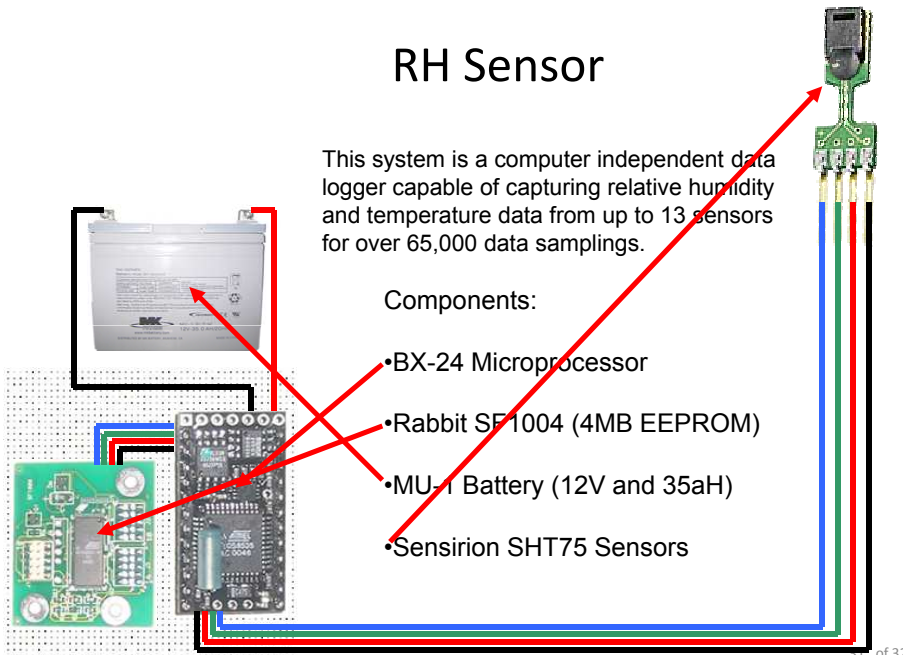
Altitude — Equation **(1)**

Time (second)

RH Sensor

This system is a computer independent data logger capable of capturing relative humidity and temperature data from up to 13 sensors for over 65,000 data samplings.

Components:

- BX-24 Microprocessor
- Rabbit SF1004 (4MB EEPROM)
- MU-1 Battery (12V and 35aH)
- Sensirion SHT75 Sensors