ECE Life Supporting Cabin Research

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Introduction

- **Most important parameters:**
  - Temperature
  - Pressure
  - Oxygen
- **Things to consider:**
  - Sensors
  - Equipment to regulate these factors
  - Reaction of system

- **Other possible passenger issues to consider:**
  - *Humidity*
  - *Air exchange/filtration (dispose of CO2)*
  - *Emergency Escape (into vacuum tube)*
  - *Crash Event*
  - *Positive and negative acceleration limits (More mechanical)*
  - *Light*
  - *Noise*
  - *Motion Sickness*
  - *Motor failure (catastrophic)*
  - *Pod going too fast? (Speed detection)*
  - *Passengers compromising system*

Temperature system

Multiple options for temperature sensing:

- Resistance temperature detector
- Thermocouple
- Semiconductor-based sensor
- Thermistor

Temperature system

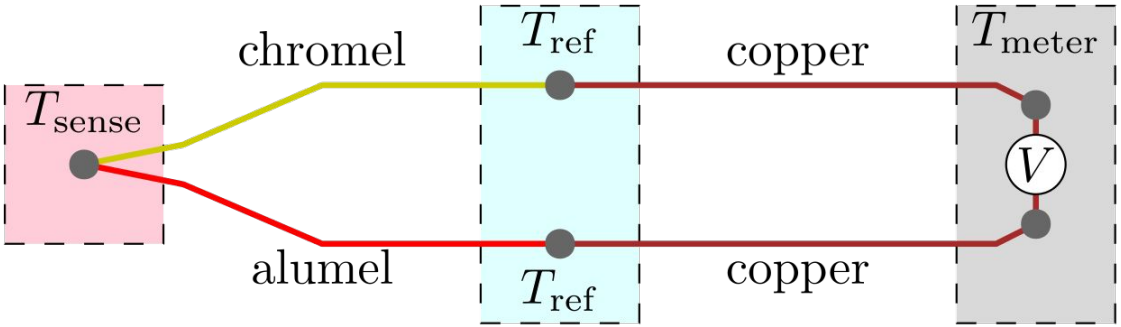
1. Resistance temperature detector (or **resistance thermometer**):

- Exhibits predictable and precise change in resistance in response to temperature changes. As temperature increases, resistance decreases.
- High accuracy, which is due to large changes in resistance per degree Celsius
- However, they exhibit a low operating temperature range (-50°C to 250°C).

Temperature system

2. Thermocouple

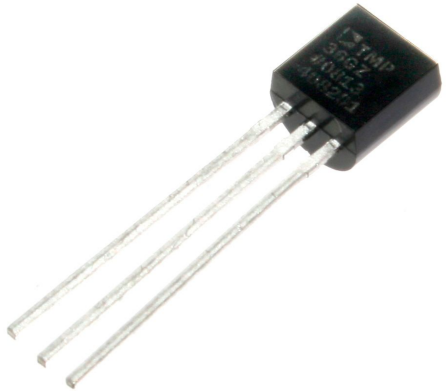
- The voltage at the junction between two different conductors reflects changes in temperature.
- Very high operating range: -200°C to 1750°C
- But low accuracy (anywhere from 0.5°C to 5°C discrepancy)



Temperature system

3. Semiconductor-based sensor

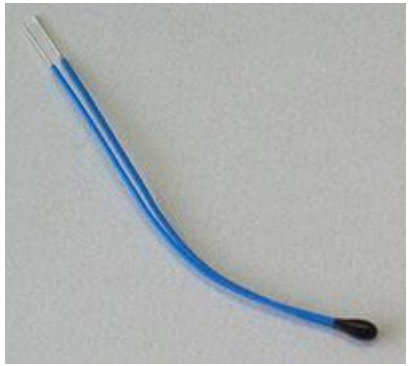
- Changes in current-voltage characteristics reflect changes in temperature in diodes. This is a linear response.
- Disadvantages include a low operating range (-70°C to 150°C), slow responsiveness, and low accuracy (1° C to 5°C discrepancy).



Temperature system

4. Thermistor

- Correlates the resistance of a circuit element to the temperature
- Consist of a film or wire wrapped around a ceramic or glass core
- Thermistors have both very high accuracy and a very wide operating range (-200°C to 600°C).
- However, they are expensive.



Temperature system

The best option would be a **thermocouple** for temperature sensing in a life-supporting pod. A very high operating temperature range is necessary in order to detect extreme temperatures in case a component overheats.

The low accuracy is not a major issue because the main necessity is to detect if a system is getting too hot so that measures can be taken to cool the system down.

Pressure System

Why detect Pressure:

- Lowest tolerable pressure for humans is Armstrong's Limit (61.8 mbar or 0.0618 atm).
  - At this point water boils at the temperature of the human body 37 deg C
- Ideal is 1013.25 mbar = atmospheric pressure at sea level.
  - 21% oxygen partial pressure, at this point, enough oxygen to saturate hemoglobin
- Lowest breathable air pressure is 121.7 mbar
- Less pressure = less oxygen

Pressure System

What Needs to Happen:

- Pump air into cabin after sensing low pressure and out when sensing high pressure.
  - Intake of low pressure from track and regulate it using electronic compressor.
  - Supplemented by air tanks.
  - 2 posterior Overflow valve controlled by pressurization system and by Pod Operators.
    - Slowly open when pressure is high or to exchange air.
    - Close when pressure is low.

Pressure System

Sensing:

- Piezoresistive Pressure Sensor:
  - diaphragm formed on piezo-silicon substrate that flexes with applied positive or negative pressure.
  - Change in structure causes change in Resistance
  - Have a higher gage factor than bonded foil strain gages
  - Significantly higher mv/V sensitivity .(millivolts per Volt output signal)
  - less noisy output signal.

Oxygen System

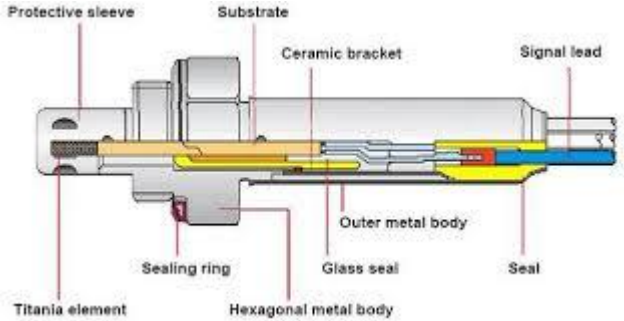
System Behaviour:

- Detect low/high oxygen (Titania Sensor)
- Attempt to regulate through oxygen generation method (Oxygen Candle)
- Time the regulation attempt (Microcontroller)
- Timeout regulation attempt - drop direct oxygen masks (Stored O2)
- Attempt to finish trip (short duration)
- Monitor direct oxygen flow (pressure sensor)
- Oxygen flow failure - emergency stop distress signal (release tube vacuum)

Oxygen Sensor

Titania Sensor

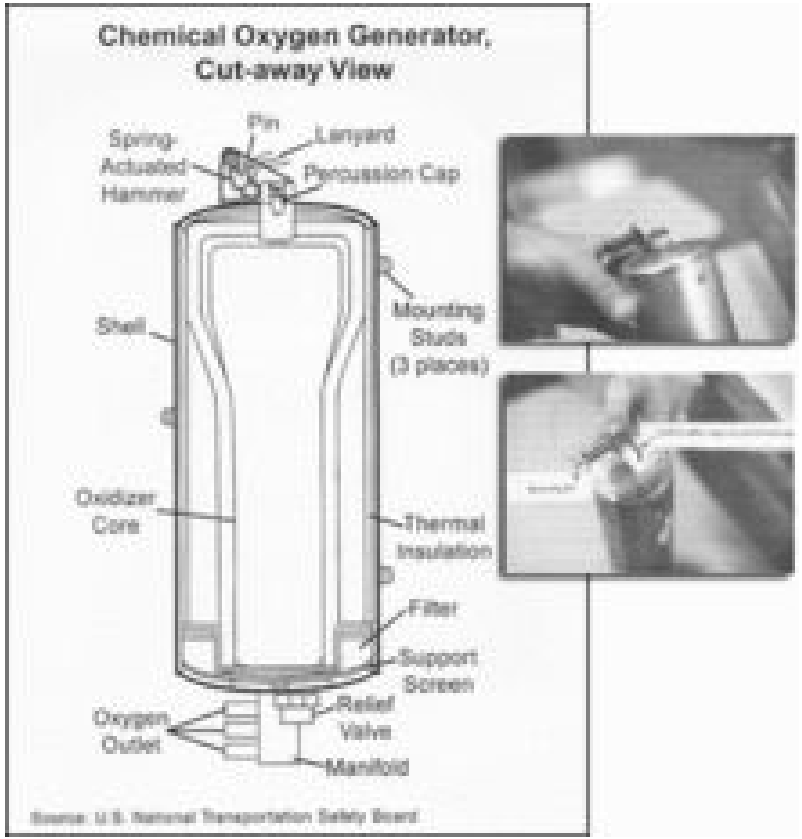
- Dynamic resistance based on partial pressure of O2
- Solid State Semiconductor device
- Small
- High response time
- No reference air - just calibration
- Not vulnerable to water



Oxygen Supply

Oxygen Candle

- Main source of oxygen
- Indefinite shelf life
- Compact
- Smolders at 600° C
- Reaction happens in a controllable unit



Control Unit

Oxygen Supply Controller

- Responds to signal from Titania Sensor
- Can signal stored oxygen or backup candle (Candle failure)
- Timeout feature - if not regulating then drop emergency masks
- Monitor mask oxygen flow for failure
- Send emergency signal to stop and pressurize the tube

Implementation of Life Support Systems to Paradigm’s Pod

Implementation of Life Support Systems to Paradigm's Pod

Important Implementation Aspects

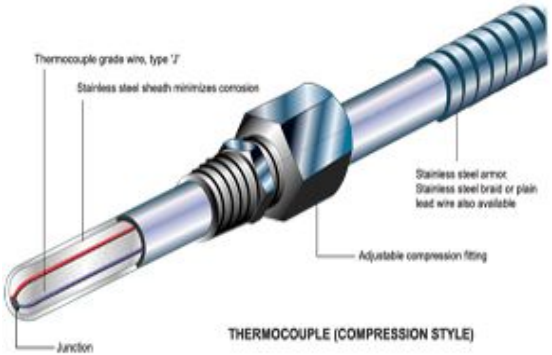
- Scope includes problem detection and system response.
- Redundancy (safety critical system)

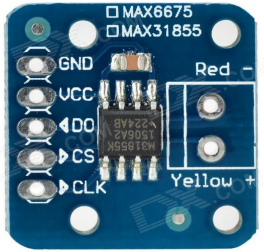
Temperature Sensing - Thermocouple

- K-Type Thermocouples
  - Thermoelectric Effect
- MAX31855
- Use a SPI bus to any MC
- Libraries to interface with MAX

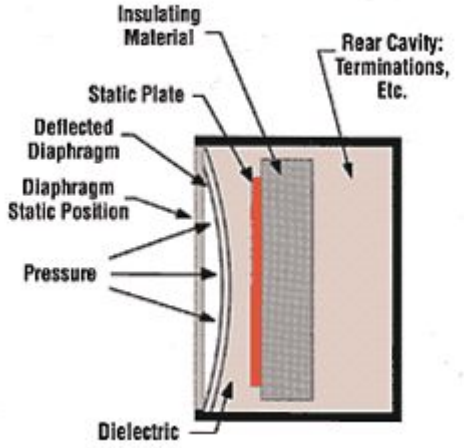
IC already created

Response: Energize Heater

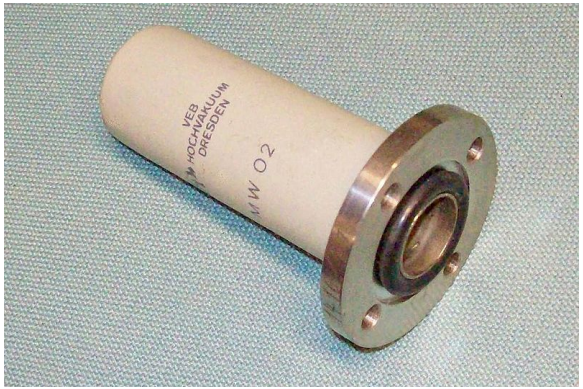




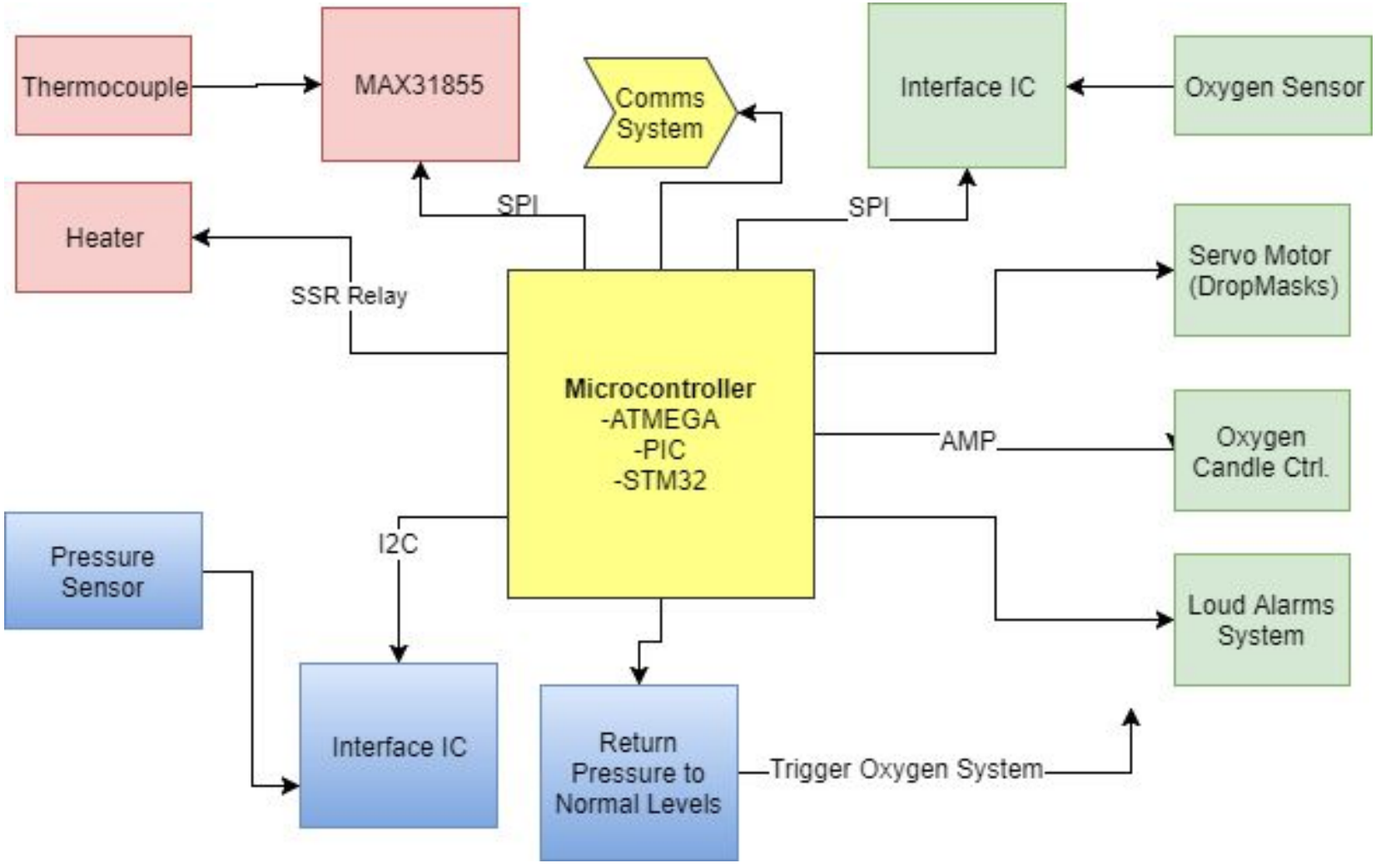
Pressure Sensing



- Piezoresistive and Capacitance Pressure Transducers
  - Changes resistance when strained
  - Generates charge when strained
  - Could be embedded into interior walls
    - Requires simple amp circuit



- Pirani Gauge
  - Alternative or Redundant System
  - Measurement of pressure in Vacuum
    - Pressure is proportional to heat loss time


Thermocouple
MAX31855
Comms System
Interface IC
Oxygen Sensor
Heater
SPI
SPI
Servo Motor (DropMasks)
SSR Relay
Microcontroller
-ATMEGA
-PIC
-STM32
AMP
Oxygen Candle Ctrl.
Pressure Sensor
I2C
Loud Alarms System
Interface IC
Return Pressure to Normal Levels
Trigger Oxygen System

Questions?