

Lecture 6 Interfaces

Interfaces are the various connections of an object to the rest of the world.

Examples: Mechanical interface: size, shape, orientation, viewports, connector locations, mounting holes,

Thermal interface: production or absorption of heat via conduction, radiation, convection

For a collection of subsystems, it is necessary to document these aspects of the subsystems individually. These individual documents comprise an interface control document (ICD) which completely specify the interfaces. The ICD evolves, it is a live document. Each subsystem contributes materials to it. Typically, a systems engineer supervises its content.

This lecture will summarize the contents, illustrate with examples, and introduce grounding and shielding as means of reducing inter-subsystem electrical interference.

ICD contents

I. Introduction

- This explains functions of instrument at a summary level. It does not describe purpose, design trade-offs, history, etc. It addresses the questions: What is the device? What does the device do?
see example from the ICD except packet
(first page in packet)
- A block diagram (2nd page in packet) summarizes the system

II Mechanical Interface

- Exterior drawings show dimensions, shape, mass, special features (3rd page in packet)
- Mounting details
 - drawing of instrument footprint
 - mounting information
 - hole locations
 - fastener types, torques
 - assembly order
 - orientation within mount area, relations to other instruments,
 - field of view, range of motion or other requirements of adjacent clearance

- C. Connector locations
- D. Materials, exterior coatings

III Thermal interface

- A. Required temperature environment (operating, storage)
- B. Heat generation (generally the system power dissipation)
- C. Heat transport
 - a) Radiative interface to surroundings
 - b) conductivity interface to surroundings
 - c) air convection contribution

III Electrical Interface

- A. Power
 - 1. voltages — minimum, typical, maximum cleanliness of voltage (limit on rms noise?, ripple?)
 - 2. currents — typical, maximum, fuse currents at nominal voltage levels. Description of how current requirements vary in time
 - 3. power — total nominal power requirement
- B. Signals
 - 1. Logic inputs (4th page in packet)
 - a) schematic of hardware implementation
 - b) description of voltage levels
 - c) timing diagram with limits on delays, ordering, etc
 - 2. Logic outputs (same as logic inputs)
 - 3. Analog inputs (5th page of packet)
 - a) schematic of hardware implementation
 - b) description of signal voltage limits and impedances
 - c) recommended signal return information
 - 4. Analog outputs same as inputs
- C. Data interface
 - 1. for commands to the subsystem, describe the format of the data and the interpretation of the data. For instance, number of bits in the command, bit ordering, meaning of bit patterns, how the data is synchronized.
 - 2. for commands, describe also relations between commands such as timing, order, incompatibilities

3. For data from the subsystems, describe format and interpretation. This section would also describe converting the data to physical units (calibrations).

D Connectors

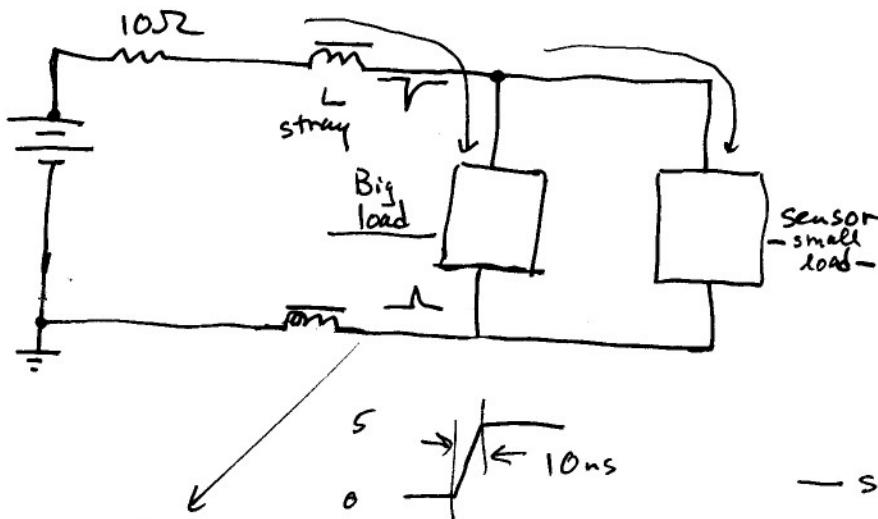
1. Associate named connectors to their function
2. Table of connector pinouts
3. Schematic of what connects to the connector
(6th page of packet)

E. Harnesses

1. Schematic of how connectors are linked by harness
 2. Description of physical layout of conductors
(conductors should be named) For instance, are they twisted bundles? Multi-axial? Is there a capacitance requirement?
 3. Description of conductor size (22 gauge), type (solid, stranded), and insulation.
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Grounding

Example:



— some assumptions —

switching transient: $\frac{5V}{10\text{ns}} \quad 10 \text{ logic gates} \times 2\text{pF/gate} \text{ are switched}$

$$CV = Q = 2 \times 10^{-11}\text{F} \times 5\text{V} = 10^{-10}\text{C}$$

$$I = \frac{10^{-10}\text{C}}{10^{-8}\text{s}} = 10^{-2}\text{A} \quad (10\text{mA})$$

$$X_L = sL = j2\pi f L$$

$$X_C = \frac{1}{sC}$$

$$\begin{aligned} 20\text{ cm of } \#24 \text{ wire} &= 2\mu\text{H} \\ X_L &= 2\pi 10^8 \times 2 \times 10^{-6} = 4\pi \times 10^2 \Omega \\ &\sim 1\text{k}\Omega \end{aligned}$$

Wow! 10mA across 1kΩ!

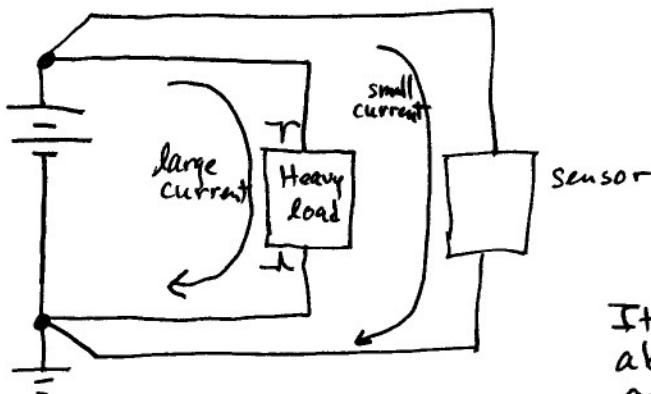
→ Voltage sag (for a short time) ~ 10V

→ Gets into the input circuitry

Power line noise appears due to current transients.

Must control flow of power currents and keep these out of input circuitry, where things are most sensitive.

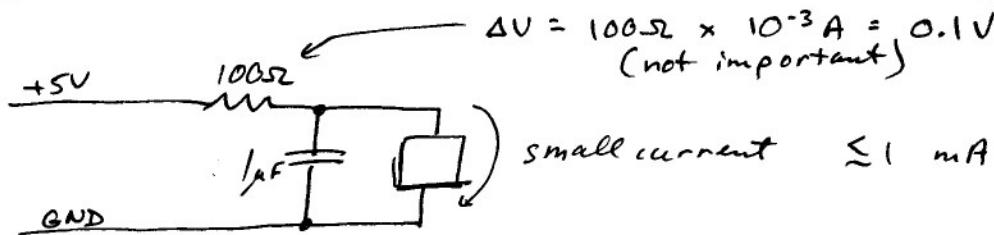
Solutions



Arrange power lines so that large currents are flowing only far away from sensitive electronics.

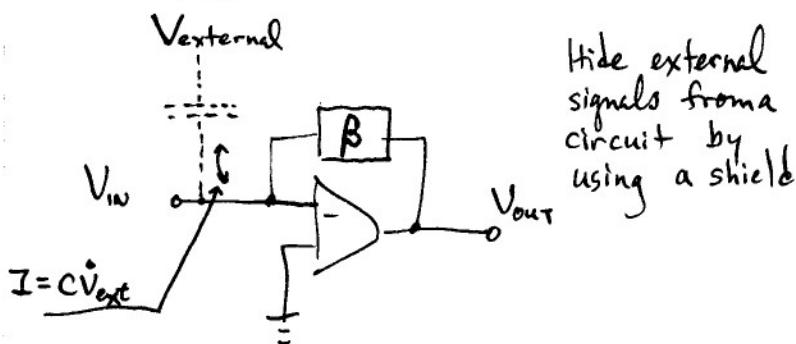
It is important to think about where currents are flowing. Then, control the flow!

Additionally, one can add a low pass filter on the power lines, especially for a low current consuming circuit.

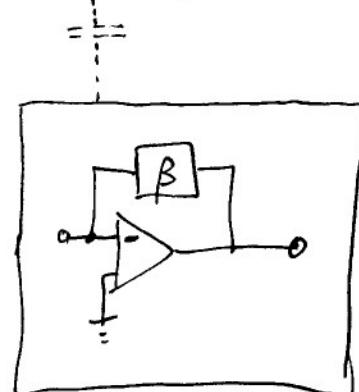


Shielding

Any circuit couples capacitively or inductively to the world. Wiggling voltages outside your circuit can push currents around in your circuit. This is interference.



Hide external signals from a circuit by using a shield

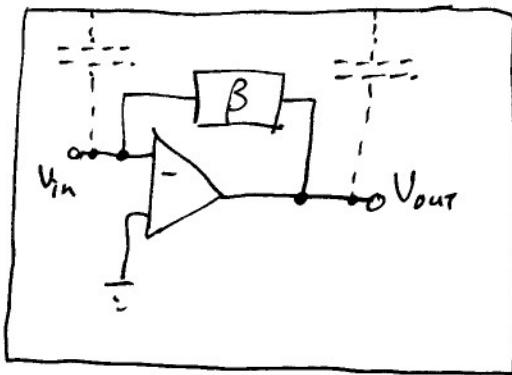


Shield responds to external electric fields, but circuit inside the shield cannot see them.

However, shield introduces a new feedback path

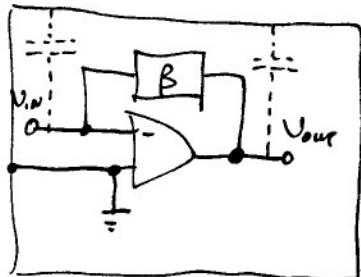
Output and input can be coupled through the shield, which is not directly connected to the circuit.

Problem!



Solution: no floating shields! connect the shield to the circuit to hold the shield at a fixed potential.

Example:



With shield grounded, we remove the feedback path because the shield potential is locked at ground.

It makes a difference where the shield connects to ground in more complicated circuits