Chapter 5 Miscellaneous Aspects for Digital Systems

1. Dependability, Reliability, and Availability

a. Dependability encompass the concept of reliability, availability, safety, performability, maintainability and testability
b. Failure rate of a device (λ)
   i. Circuit (# of gates, # of I/O pins, technology, etc)
   ii. Environmental factors
   iii. Others: e.g., who will do this, how it is documented, with ISO 9000 or not, etc.
c. FIT (Failure in Time Unit): Number of failures in 10^9 hours.
d. Bath Tub Curve for failure rate.

e. Reliability: Conditional probability that the given system still works correctly at time t_1 given the system has been working correctly at t_0
   P {works at t_1 | worked at t_0}
   Normally represented as 0.9999993 = 99.99993% = 0.9_63

f. Mean Time to Failure (MTTF)
   MTTF = 1 / λ
   Example: given the failure rate λ of a digital circuit is 274 FIT, determine the MTTF for the circuit?

g. More commonly used is MTBF: Mean Time Between Failures
   MTBF = MTTF + MTTR
   MTTR: Mean time to repair, MTTR = 1 / μ, where μ is the repair rate

h. When there is no redundancy, every component in the system is critical (must be functioning for the system to function)

Failure rate of the system =

Reliability of the system =

i. If there's redundancy (HW, SW, Information (coding), Time)

Failure rate of the system =

j. For serial system, its reliability is given by

k. For parallel system, its reliability is given by

l. For high redundant system (M-of-N system), its reliability is given by

m. Read from the additional notes about the availability, maintainability and so on.

2. Transmission Line Effort

a. Statement: A transmission line has to be at least miles long (Y/N)?
   No, transmission line not necessary to be a wire miles long!

b. Then, what is a transmission line?
   If the propagation delay of a segment of wire is greater than the transmission time of a pulse to be sent, it can be considered to be a transmission line

c. Results from transmission line effects include
   Ringing, Overshooting, Undershooting, Producing Erroneous Signals

d. Equivalent circuit of a segment of the transmission line

   L: inductance in Henry per unit length of wire
   C: Capacitance in Farads per unit length of wire
      Wire width, thickness, and spacing of conductors and dielectric constant of insulation materials decide the capacitance.

   Time delay per unit length =

   Characteristic impedance Z_0 =

   Reflected voltage V_f =

e. Transmission Line Effect
   Electricity travels roughly half of the speed of light
      1 s light travels 3×10^8 m
      1 ns electricity travels 0.15 m

Assume characteristic impedance Z_0, then we will have

I = , V =

Analysis:
Case 1: Matching Impedance

Case 2: Short Circuit (when Z_0 equals internal resistance of the power source)

Case 3: Short Circuit (Z_0 dose not match internal resistance of the power source)

Case 4: Open Circuit

Case 5: More General Case

3. Noise in Digital Systems

Questions:
* Source of Noises and Types of Noises?
* Effect of Noise on different parts of the system?
* How to design and implement system to control noise?

a. External or Radiation Noise

   i. Electrostatic: Lighting (High Voltage Noise)
      Remedy ➔ Use Aluminum (AL) chassis

   ii. Electromagnetic: High current sources in the vicinity
      Examples: welding machine, current from large motors
      Remedy ➔ Chassis made of high-μ ferromagnetic material

   iii. Shielding

iv. Grounding depends on the frequency of signal

If low frequency signals (< 1 GHz)
Ground only one end of shielded wire.

If high frequency digital system with no amplifier
Ground both ends of shielded wire.

Ribbon caller: use alternative lines as ground in high noise environment

b. Internal Noise
Mainly from the power supply.

FFs, one-shots, high-gain Op amps, Schmidt trigger input, and other regenerative modules are more prone to noise
Transducer producing low strength signals are vulnerable

To get rid of internal noise:

1) Decoupling: use decoupling capacitors
   Across power supply inlet on a PCB
   250 – 2000 µF electrolytic or tantalium and a 0.1 µF disc capacitor in parallel.

   If this is not enough ➔
   Directly across the power supply pins of each critical chips connect to a 0.1 µF disc cap.

2) Grounding
   Very important if unit consist of analog and electromechanical parts

   -- Each subsystem: should have its own (or isolated) power supply. At least have separate voltage regulators chips or DC/DC converters.

   -- Two grounding systems: chassis ground and AC power ground

   -- Use opto-couplers for electromechanical systems (Usually it's a must).

   -- Avoid ground loops, use center point configuration for ground and power lines.