The University of Texas at Arlington

Talking Points - 1
Basics of Electronics

CSE@UTA

CSE 3323 – Electronics for Computer Engineers

Dr. Gergely Záruba

Basics

- Engineering (SI) prefixes (P,T,G,M,k,m,μ,n,p,f,a)
- Electric Potential (difference) {V, ΔV, or U} [V] or [Joules/Coulomb]
- Current {I} [A]
- Water-system analogy
- Electric Power (a.k.a. rate of Work) {P} [W] [Joules/sec]
- Momentary Power consumption, need
- Energy {E} [Ws], [kWh] or [Joules]

Resistance

- For current to flow, a circuit is needed.
- To restrict flow, we need to obstruct it; resistance
- Resistance can be determined by knowing potential difference and flow.
- Ohm's law (Ohm's triangle)
- Power and Ohm's law

3

Resistors

- Symbol
- Resistor materials (wire wound, carbon film, metal film)
- Resistor values (colors)
- SMT resistor markings
- Resistor tolerance
- Resistor series (E12, E24, E48, etc.)
- Resistor heat variation
- Resistor power ratings
- Potentiometers

4

Energy Sources

- Theoretical or ideal:
  - Voltage source or generator (fixed potential difference)
    - Symbols
    - Properties
    - What happens when…
  - Current source or generator (fixed flow)
    - Symbols
    - Properties
    - What happens when…

5

Uncontrolled Energy Sources

- Real:
  - Voltage source
    - Internal resistance
    - Cannot source infinite current
    - Batteries
  - Current source
    - Internal resistance
    - Cannot produce infinite potential
    - Less pervasive

6

Controlled Energy Sources

- Need energy to provide energy
- Power supply.
- Controlled sources control the output to be:
  - Fixed voltage within some current limits
  - Fixed current within some voltage limits
- Controlled voltage source:
  - Needs to break down in voltage as current grows. Most power supplies have a limit.
  - Graph growing load – lowering resistance.
  - Some power supplies cut off entirely if they see too much current.

7

Thevenin-Norton

- This is from the load's perspective; Equivalency calculation requires the load to be the same.
- Thevenin circuit replaces any energy source (or source/resistor combinations) with a single voltage source and internal resistor.
- Norton is the same but with a current generator.
- Looking in – the internal resistor has to be the same. The source potential needs to be recalculated from the source current (and vice-versa) and the load. ($V_T=I_N*R_{NT}$)

8

Resistor-only circuits

- Any resistor only circuit can be recalculated into a single resistor
- One needs to search for parallel and serial resistors inside.
  - Bridge circuits can be troublesome
- Serial resistors add their resistance
  - Kirchoff's laws can be used to show
- Parallel resistors "replus" their resistance
  - Kirchoff's laws can be used to show

Voltage divider

- Any series resistor circuit will divide up the supply voltage between the resistors.
- The potential drop (voltage difference) on a resistor is proportional to its resistance and inversely proportional to the total resistance.
  - Kirchoff's laws to derive
- Thus $U_1=U*R_1/(R_1+R_2)$
- We can use this to create voltages that are less than the supply.

Current divider

- Any parallel resistor circuit divides up the total current among resistors.
- The current flowing on a resistor is proportional to the rest of the resistance and the inversely proportional to the total resistance
- Thus: $I_1=I*R_2/(R_1+R_2)$
- We can use this to “shunt” (reduce current to load) given that there is an internal resistance.

11

Voltage divider in practice

- The internal resistance of a voltage source (and the load) creates a voltage divider.
- Be careful! If using a voltage divider, the load on the divider needs to be known, fixed and determinable.
- What are good values for a voltage divider?
  - Large: no current wasted but very sensitive to load
  - Small: a lot of current wasted but less sensitive to load

12

Measuring Voltage

- Voltage is potential difference.
- Need to measure a difference between two points (two points)!
- We do not need to break the circuit
- However the instrument has an internal resistance, thus it will modify the equivalent resistance (and thus the voltage on the resistor).
- **Observation distorts circuits and measurement data!**

13

Measuring Voltage

- **Observation distorts circuits and measurement data!**
- A good “voltmeter” has a large (optimally infinite) internal resistance.
- An active instrument (outside power), can achieve high internal resistance (n*10MΩ)
- “Old” analog instruments with dials had to move the needle without any outside power (based on current that was flowing through) and thus distorted way more.
- Range (important and can have an effect on the instrument’s internal resistance). Range can be changed by voltage division (serial resistance).
- DC potential is a silent killer!
- Measuring introduces capacitive and inductive load as well – remember for now, we’ll discuss later.

14

Measuring Current

- Need to determine flow.
- Thus need to break the circuit and insert the instrument in a serial fashion.
- **Observation distorts circuits and measurement data!**
- Internal resistance needs to be very low.
- Active instruments can achieve that, but they measure potential difference and thus need a small sensing resistor (the higher amplification the smaller the resistor).

15

Measuring Current

- Old "dial" instruments by nature measure current
- Range can be changed by parallel resistor – shunting the instrument.
- What happens if you forget to change the DVM from voltage to current and you measure current?
- What happens if you forget to change the DVM from current to voltage and you measure voltage?
- Most DVMs have separate inputs for voltage and current.
- If current is large – we could use inductive coupling to measure current (no breakage required); sometimes done, but it's less precise.

16

Measuring Power

- Need to measure (instantaneous) voltage and current.
- Multiply the two – hard in an analog way
- Measuring energy: power times time (running counter, like the energy meter on a house)
- Relatively easy with microcontrollers but need to measure (insert sensing resistor) both voltage and current!

17

D.C. and the rest

- Most everything that we talked about applies to any electric circuit.
- However it applies during any infinitesimally small point in time only if anything inside the circuit changes.
- D.C. (direct current) usually means, that the source never changes, and thus time does not matter.
- In reality D.C. is the “average” current or “average” voltage in the circuit.
- D.C. sometimes refers to very slowly changing voltage (but then what is slow? 1Hz? 0.1Hz?)

18

D.C. and the rest

- D.C. is uninteresting. The only purpose of it is to power things up.
- Things become interesting once we represent signals with voltages, thus when we **introduce time.**
- A.C. stands for alternating current. People sometimes refer to a potential that is changing as A.C. as long as it is changing.
- We will distinguish between pure A.C. (sinusoidal potential and current) and signal (changing potential and current that is changing with some interesting, e.g., physical quantity).
- A general signal graph – show A.C. and D.C. (the average (over what epoch?)) component