Basic Electrical Measurements

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Example: first order system RC circuit

- How to present measurement results?
- What instruments to use?
- How to set up test?
- Any limits?
Example: first order system RC circuit

Power supplies
Function generators

Breadboard

Multimeters
Oscilloscope
DAQ

E80 Lecture 4.3: Basic Electrical Measurements
How to present measurement results?
Time-Domain Plots

V\text{in} (V)

V\text{out} (V)

Time (sec)
How to present measurement results?
Frequency-Domain (Bode) Plots

\[ L_m = 20 \log_{10} \left( \frac{V_{\text{out}}}{V_{\text{in}}} \right) \]

\[ \text{Phase} = \frac{\Delta t}{T_o} \times (360^\circ) \]
Data Organization

$V_{\text{out}} (V)$

$V_{\text{in}} (V)$

Time (sec)

$L_m = 20 \log_{10} \left( \frac{V_{\text{out}}}{V_{\text{in}}} \right)$

$\text{phase} = \frac{\Delta \theta}{T_o} \times (360^\circ)$

How many data points to take?
Useful data analysis tool?
DAQ and LabVIEW (automation)?
Instrumentation

- Instruments that **GENERATE** signals
  - Signal generator (AC or DC)
  - Power supply (DC)

- Instruments that **MEASURE** signals
  - Multimeter (AC/DC voltage/current, resistance)
  - Oscilloscope (AC)
  - DAQ

- Wires and cables that **CONNECT** the instruments

- **BREADBOARD**
Function Generator

- Waveforms: Sine, square, triangle, sawtooth
- AC signal
- Parameters: Amplitude (Vpp), Frequency (Hz), Out Term (High-Z or 50 Ω)
Power Supply

- **DC**
- **COM** = common reference node of circuit
- ̅= earth ground
Multimeter - Voltage

Measuring V:

- Connect in parallel with C.U.T
- Internal resistance of VM should be large, 10MΩ for Elenco
- DC vs. AC (RMS for sinusoid)
- Range
Multimeter - Current

Measuring I:

- Connect in series with the C.U.T.
- Internal resistance of AM must be very small, can be ignored.
- DC vs. AC (RMS for sinusoid)
- Range

E80 Lecture 4.11: Basic Electrical Measurements
Measuring R:

- Connect across R (isolated from other circuits)
- ΩM has internal battery, so should not connect to active circuits such as power supply
Multimeter – Digital vs. Analog

- Analog meter (less precision in VM due to lower input resistance)
- Digits vs. needle position
- Higher performance: precision, true RMS reading

Simpson 260

HP34401A (in E80/VLSI lab)
Oscilloscope: Voltage Measurement (Time domain)

- Graphical display of electrical signal: y-axis represents voltage, x-axis represents time
- New oscilloscopes have a built-in signal generator!
Oscilloscope Probe

- Oscilloscope: 1MΩ input resistance
- 10x probe: **Improved input impedance by a factor of 10 not only for low frequency but also for high frequency**
- Signal reading on 10x probe is 1/10 of the signal at probe tip
- Oscilloscope bandwidth 60MHz
- Tuning of 10x probe (for instructions, see BEM guide)
Use long busses for power and ground:
Don’t use them for signals

Color-code wires:
Red = V+ power
Black = V- or ground
White or Blue = signal

Keep components close to the board:
Trim resistors, capacitors, wires

Check individual components before constructing the circuit
Pay Attention to Details and Practice

http://makezine.com/2010/03/22/improving-breadboard-layout-through/

E80 Lecture 4.17: Basic Electrical Measurements