

# Resistors and simple network analysis

Eugeniy E. Mikhailov

The College of William & Mary



Lecture 01

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## Analog Electronics goals

Major time spending for experiment preparation goes to design, construction and interfacing different electronics components. Often a commercial circuitry is not available or it has to be matched with electronics front-ends (responsible for collecting usually weak signals) or back-ends (which do general purpose processing). To perform above tasks we need:

- Learn basic discrete components
  - resistors, capacitors, inductors.
  - diodes, photo-diodes, transistors, FETs.
  - Op-amps, comparators.
- Multimeters, oscilloscopes, function generators.
- Breadboards and soldering irons.
- Modern circuit design and lay-out software.
- Master their usage

As result we will be capable to build simple yet capable electronics circuits

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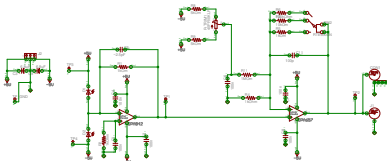
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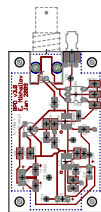
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## From schematic to the board layout

Schematic



Board layout



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## Contact info

### Instructor: Eugeniy E. Mikhailov

- Office: Millington 251
- Lab: Small 022
- Phones: 221-3571 (office), 251-3560 (lab)
- Email: eemikh@wm.edu
- Web: <http://physics.wm.edu/~evmik/>
- Office Hours:
  - M 14:05-15:00
  - T 09:00-10:00
  - W 09:00-10:00
  - and by appointment.

T.A. lab book grader: Austin Ziltz

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## Evaluations

Your final grade for the course will be determined from the following grading weight distribution:

- Notebooks/Lab: 40% (design exercises 15%, lab 25%)
- Quizzes: 10%
- Participation: 5% (**being in class is not enough**)
- Midterm: 20%
- Final: 25%

Most labs will include a design component. **The designs must be prepared prior to attending a lab.** I will check preparation of the design exercise at the beginning of each lab. **An unprepared/incomplete design exercise will have up to 50% penalty.**

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## Grades table

Grade	Score	Grade	Score	Grade	Score
		A	94-100	A-	90-93
B+	87-89	B	84-86	B-	80-83
C+	77-79	C	74-76	C-	70-73
D+	67-69	D	64-66	D-	60-63
F	<60				

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## Exams

### Midterm test

There will be a 1 hour midterm test in lab on February 23-24. There will be a lab session after the midterm.

### Final exam

There will be a final exam on May 5 (2:00pm - 5:00pm) covering all course materials.

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## Lab books

Your lab book is the primary record of your work and data.

- What you did.
- How you did it (e.g. circuit diagrams).
- How you made measurements (which test equipment and how it was connected).
- Your data and enough information to tell us what that data is.
- What you observed.
- Your calculations and analysis (including scratch work).
- Plots.
- Answers to questions and justifications for your answers.

Diagrams, data, graphs, and other notes on separate pieces of paper should be glued, taped, or stapled into the lab book.

**If something falls out of the lab book during reading, shaking, transporting, it is not the part of the log book and will be discarded.**

The lab book will be graded primarily on completeness and to a lesser extent on neatness.

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## Due days

Lab books are due by 5pm on next day after lab (i.e. Thursdays for the Wednesday section and Fridays for the Thursday section) and will be returned by the next lab period. Reports are due in class the following week.

Late reports or logbooks will have points deducted. If you know you will have a problem getting the report on time please send me an email as soon as you can to let me know about your situation.

### Illness

Please notify the instructor if you are ill, so that arrangements can be made to make up missed labs.

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## Weekly topics

Week 0: 1/17	NO CLASS
Week 1: 1/24	DC Circuits Basics.
Week 2: 1/31	Kirchhoff's Law's and Thevenin's Theorem.
Week 3: 2/07	Capacitors, Inductors, and Complex Impedance.
Week 4: 2/14	Passive Filters and Transmission Lines
Week 5: 2/21	Diodes. <b>MIDTERM TEST</b> during labs time
Week 6: 2/28	Transistors 1: BJTs
Spring Break	NO CLASS
Week 7: 3/14	Transistors 2: More BJTs
Week 8: 3/21	Transistors 3: FETs
Week 9: 3/28	Op-Amps 1: Introduction to Op-Amps
Week 10: 4/4	Op-Amps 2: detectors, filters, power amplifiers
Week 11: 4/11	PID Control Theory
Week 12: 4/18	Electronic Circuit Design Tools
Week 13: 4/25	Comparators
Week 14: 5/05	<b>FINAL EXAM</b> Thursday May 5, 14:00-17:00

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## Basic blocks

### Voltage (V)

Short for electrical potential difference  
Potential energy divided by charge ( $V = E/Q$ )  
Derived Unit: J/C  
SI unit: V (Volt)

### Current (I)

Rate of flow of electric charge ( $dQ/dt$ )  
SI unit: A (Ampere)

### Power (P)

Energy per time ( $dE/dt$ )  
In electronics:  $P = VI$   
SI unit: W (Watt)

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## Electrical resistance

### Resistance (R)

Different objects have different current passing through when the same voltage difference is applied.  
Which indicates: they have different electrical resistance.  
SI unit:  $\Omega$  (Ohm)

### Ohm's law

$$I = \frac{V}{R}$$

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# Resistors

## Standard leaded

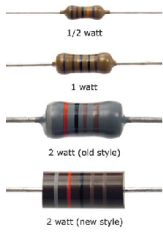


Image from [www.audionote.co.uk](http://www.audionote.co.uk)

## Power

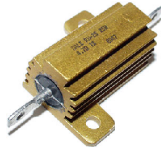


Image from [www.dansdata.com](http://www.dansdata.com)

## Surface mounted



Image from [www.seed-solutions.com](http://www.seed-solutions.com)

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# Resistor color code

4-Band-Code

COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

5-Band-Code

Electronic Express/RSR  
<http://www.elexp.com>

1-800-972-2225  
In NJ 732-381-8020

# Resistors usage

- current limiters
- fix voltage from a current source (exotic use)
- generate heat
- fuse (non standard use)
- lowering the voltage of the source (i.e. voltage dividers)

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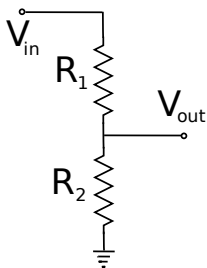
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# Unloaded voltage divider



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2}$$

## Notes

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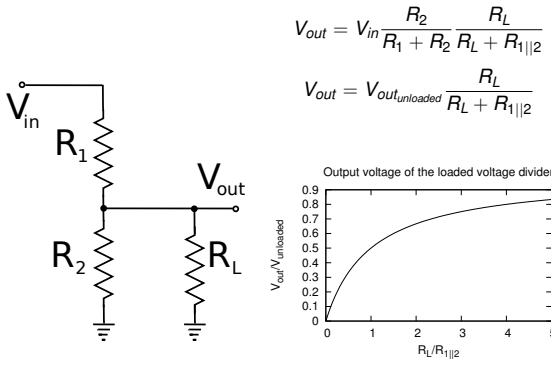
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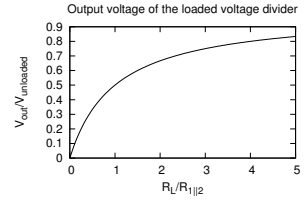
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# Loaded voltage divider



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2} \frac{R_L}{R_L + R_1 || R_2}$$
$$V_{out} = V_{out,unloaded} \frac{R_L}{R_L + R_1 || R_2}$$



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