CIRCUIT DIAGRAMS AND COMPONENT DRAWINGS

BASIC MULTIMIETER OPERATION

BASIC MULTIMETER INFORMATION

Multimeter is a measuring instrument. It can be used to measure voltage, current and resistance.

An analog meter (Figure a) moves a needle along a scale. The function of the meter can be changed by switching the dial. Analog multimeter shown in the figure is cheap but difficult for beginners to read accurately.

Most modern multimeters are digital. Similar to analog ones, digital multimeter (Figure b) has a dial to select its function. However, instead of having to interpret the reading of an analog scale, the data is shown directly in digital format on the LCD display. In addition, the units are also shown.

Multimeter will be used in several labs, and important for checking circuit when doing your final project. Digital multimeters will be provided by the lab. A check out form must be approved and signed by a TA or instructor of this class before you can get a multimeter in the lab.



BASIC MEASUREMENT PROCEDURES

- 1. Before using the multimeter, estimate the value you will measure, make sure it is within the range that the multimeter can measure or withstand.
- 2. Choose to the function you want to use by switching the dial. Turn on the power.
- 3. When measuring voltage, connect the BLACK probe (COM) to the ground (0V), and the RED probe to the nod you want to check. When measuring resistor, first make sure the resistor is not connected to any other component or power supply, then connect the probes to the two ends of the resistor.
- Two alligator clips are supplied with probes. For your safety, alligator clips <u>MUST</u> be used when measuring any voltage more than <u>36V</u>. They can also be used to free your hands by clipping the probes onto the circuit. Put the alligator clips back in the box after each use.
- 5. Read the data on the LCD display, remember the units.
- 6. Turn off the power after you finish.

MULTIMETER TROUBLESHOOTING

- 1. Is the BLACK probe in the COM plug?
- 2. Is the RED probe in the correct plug?
- 3. Is the function dial turned to the correct position?
- 4. Is the power of the multimeter on?

BASIC OSCILLOSCOPE OPERATION

BASIC MEASUREMENT PRINCIPLES

The oscilloscope (O-scope) is a valuable tool for both diagnostic and measurement purposes. It displays a <u>voltage vs. time</u> plot. The voltage displayed is determined as the difference between the <u>measured voltage</u> and the <u>reference voltage</u>.

Both the measured and the reference voltage are determined from the <u>probe</u>. Although there are many types of probes, they all have three basic components: a measured voltage lead, a reference voltage lead, and a connection to the oscilloscope. To measure a voltage, or <u>potential difference</u>, with the oscilloscope, one must do three things:

- 1) Establish a reference. This is done by attaching the reference lead of the probe to the desired potential. For our purposes we will always use ground (0V) for our reference.
- 2) Measure the voltage. This is done by placing the measuring lead of the probe to the potential to be measured.
- 3) Display the measurement properly and interpret the results.

The first two aspects are relatively straightforward. They involve physical placement of the probe leads. The third aspect of oscilloscope use is critical; to be a useful tool, <u>the oscilloscope must be configured</u> such that the user knows the voltage vs. time profile.



In the EMCH367 lab, you will be using the analog Tektronix 2225 O-scope, which can display 2 channels, as indicated in the above figure. The voltage (vertical) scale for each channel can be set separately, using the appropriate knobs. You can display the channels separately or together, or perform basic arithmetic operations on the signals (addition, inversion). The time (horizontal) scale can display from .05µs to 0.5s per division, with 10 horizontal divisions. Results that the maximum wavelength able to be displayed is 10x0.5s=5s, corresponding to a minimum frequency of 0.2Hz.

If you have doubts about the proper functioning of one of the O-scope channels or the probes, you can ask a TA for help, or check yourself, using the following procedure: a) hook up the probe corresponding to the supposedly bad channel to the "Probe adjuster" pin; b) set the timescale to .5ms; c) if the probe you use is 1X, set the appropriate voltage scale to 0.5 V; if the probe is 10X, set the voltage scale to 50mV; d) set the "Trigger Source" on the tested channel; e) use the vertical and horizontal adjuster to clearly see the signal on the O-scope display. If the equipment is in good condition, you should see a square wave with the half-wavelength equal to a horizontal division, and the height equal one vertical division.

Trigger

Most of the measurements made in this course will have fairly long time periods with respect to the capability of the oscilloscope to measure it, but more importantly, with respect to your eyes' ability to interpret the plots. In some cases, though, the use of a <u>trigger</u> function of the oscilloscope is very useful. A trigger is used when the signal to be measured is very rapid, difficult to measure, or occurs sporadically. In essence, the trigger is a separate probe, which looks for a <u>pulse</u>, or a transition of the voltage from one state to another. Once the oscilloscope trigger probe detects a pulse, the oscilloscope knows that the signal of interest is going to follow along the measuring probe. Then, the pulse can be displayed along with the signal to give a point of reference. You will use the trigger function in Lab 4, Serial Communications.

OSCILLOSCOPE TROUBLESHOOTING

- 1. If the oscilloscope image is not what you think it should be, consider the following:
- 2. Make sure the oscilloscope power is on.
- 3. Make sure that the intensity is not turned all the way down.
- 4. Make sure the probe is plugged into the oscilloscope.
- 5. Make sure you are measuring the proper voltage (What is the probe touching?).
- 6. Make sure you have the proper reference voltage (Where is the reference wire?).
- 7. Make sure you are displaying the signal from your probe channel.
- 8. Make sure the voltage is set for the proper scale for your probe (most lab probes are 10x).
- 9. Make sure the oscilloscope is set to measure a DC voltage.
- 10. Use the beam find function to verify that the beam is on the screen. Adjust the horizontal and vertical position if it is not.
- 11. Make sure the calibration knobs are properly set. The knobs should be turned counter clockwise till they "click".
- 12. If you are using the trigger function, make sure the trigger is properly set.
- 13. Adjust the time scale.

RESISTORS

CHART TO READ RESISTORS

R = (First Digit)(Second Digit) x (Multiplier) ± (Tolerance)

R = (First Band)(Second Band) x (Third Band) ± (Fourth Band)

Color	1 Band	2 nd Band	3 rd Band				
Black	0	0	1 (10 ⁰)				
Brown	1	1	10 (10 ¹)				
Red	2	2	100 (10 ²)				
Orange	3	3	1k (10 ³)				
Yellow	4	4	10k (10 ⁴)				
Green	5	5	100k (10 ⁵)				
Blue	6	6	1M (10 ⁶)				
Violet	7	7	10M (10 ⁷)				
Gray	8	8	100M (10 ⁸)				
White	9	9					
Fourth Band Represents Tolerance							
Silver	10%	Gold	5%				



A quick reference for retrieving the resistance of a particular resistor, based on the color code: http://www.electrician.com/resist_calc/resist_calc.htm

RESISTORS AVAILABLE IN THE EMCH 367 LA	٩B
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10 Ω	22 Ω	47 Ω	56 Ω	100 Ω	200 Ω	220 Ω	470 Ω	680 Ω	10 Ω, 5 W
1 kΩ	1.8 k Ω	$2.2 \ k\Omega$	4.7 kΩ	5.6 kΩ	6.8 kΩ	8.2 kΩ	10 k Ω	16 k Ω	22 kΩ
27 kΩ	56 kΩ	100 kΩ	220 kΩ	470 kΩ	680 kΩ	820 kΩ	1 MΩ	4.7 MΩ	10 MΩ

A selection of variable resistors (potentiometers or "pots") is also available.

EMITTER-DETECTOR



OPEN COLLECTOR COMPARATOR



LM2901 Open Collector Comparator Unless labeled all resistors are 1k. (+) are inputs (-) are reference voltages (0) are ouputs

This configuration gives +5V if the input voltage is greater than or equal to 2.5V, and 0V if the input is less than +2.5V. The operating parameters can be changed by changing the reference voltage.

OPEN COLLECTOR BUFFER

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OP AMP



LM1458 Dual Operational Amplifier

POWER TRANSISTOR



PORT PROTECTION

GENERIC INPUT TO MICROCONTROLLER PORTS



Potentiometer Input to Port E. Diodes are 1N4001.



Generic Input to Any Microprocessor Port. Diodes are 1N4001.

PORT A PROTECTION



Port A protection. This circuit protects the three input captures and four output compares of Port A. Unless specified all resistors are 1k. Diodes are 1N4001.

OPTOISOLATOR (OPEN COLLECTOR)



PS2501 Open Collector Optoisolator