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# APPENDIX A

## LTSPICE

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## Useful Links & References

<http://www.ece101.com/2010/01/an-introduction-to-LTspice/>

- Has video tutorial for LTspice dealing with an inverting amplifier

<http://denethor.wlu.ca/LTspice/>

- Very thorough tutorial of basic operations in LTspice (with screenshots)

[http://highered.mcgraw-hill.com/sites/0073106941/student\\_view0/lt\\_spice\\_instructions\\_and\\_support\\_files.html](http://highered.mcgraw-hill.com/sites/0073106941/student_view0/lt_spice_instructions_and_support_files.html)

- Download contains a long powerpoint that is useful at first; gets more complicated at end

<http://claymore.engineer.gvsu.edu/~steriana/Videos/>

- Contains 2 video tutorials for LTspice; one basic, one dealing with models

<http://ece.sdsmt.edu/ee221/Intro%20to%20LTspice.pdf>

- Shorter tutorial, has lots of screenshots though (very simple, easy to follow)

<http://home.zcu.cz/~panek50/TE1/Introduction%20to%20SwitcherCAD.pdf>

- Quick PDF with basic operations

<http://www.linear.com/designtools/software/LTspiceGettingStartedGuide.pdf>

- Guide distributed by company which has good information

## I. DOWNLOADING LTSPICE

1. Go to this website: <http://www.linear.com/designtools/software/>
2. Click the link titled "Download LTspice IV."
3. It isn't necessary to register for an account with the site.
4. Save the file to your computer and finish the download.

## II. TYPES OF SOURCES

1. Voltage sources can be configured in many different ways in LTspice. In order to change one, right clicking on the source will bring up a window titled "Independent Voltage Source". (You might need to click "Advanced" to see these options )
  - a. (none) – This is the basic DC voltage source, simulating a simple battery. On the side of the window you can adjust the DC value to whatever voltage necessary.

- b. PULSE – This source defines a voltage with pulse characteristics. This is generally used for a transient circuit simulation in order to make a voltage source act like a square wave source. (\*Note: Never use it for a frequency response study, because the probe plot will give inaccurate results.) The adjustable values are as follows:
  - Vinitial is the value when the pulse is not “on.” So for a square wave, the value when the wave is “low” and this can be zero or negative depending on what is needed.
  - Von is the value when the pulse is turned “on,” and can also be zero or negative.
  - Tdelay is the time delay (default units are seconds), and may be zero but not a negative value.
  - Trise is the rise time of the pulse (default units are seconds). It may be zero, but using zero can cause convergence issues in some transient analysis.
  - Tfall is the fall time of the pulse (in seconds).
  - Ton is the pulse width (the time in seconds that the pulse is fully on).
  - Tperiod is the period (the total time in seconds of the pulse).
  - Ncycles is the number of cycles of the pulse that should happen (use zero if you want ongoing pulses).
  
- c. SINE – This is the AC voltage source, and defines a sinusoidal voltage. There are two possible ways to analyze the source (AC analysis and transient analysis), which two sets of parameters that can be changed.
  - AC Amplitude is the RMS value of the voltage.
  - AC Phase is the phase angle of the voltage.
  - DC offset is the DC offset voltage (should be zero if you need a pure sinusoid).
  - Amplitude is the undamped amplitude of the sinusoid.
  - Freq is the sinusoid frequency in Hz.
  - Tdelay is the time delay (in seconds, set to zero for normal sinusoid).
  - Theta is the damping factor, should be set to zero for a normal sinusoid (this is not the phase angle). Used to apply an exponential decay to the sinusoid.
  - Phi is the phase advance in degrees (set to 90 if you need a cosine wave form).
  - Ncycles is the number of cycles of the pulse that should happen (again, use zero if you want ongoing pulses).
  
- d. EXP – This is an exponential independent source that defines a voltage with exponential rise time and exponential fall time.
  - Vinitial is the initial voltage
  - Vpulsed is the pulsed value.
  - Rise Delay is the time delay before the rise of the exponential function.
  - Rise Tau is the rise time constant.
  - Fall Delay is the time delay before the fall of the exponential function.
  - Fall Tau is the fall time constant.

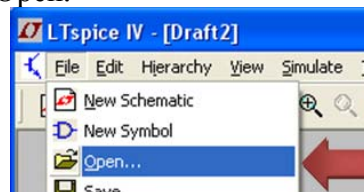
- e. SFFM – This stands for “Single Frequency FM.” It represents a single-frequency voltage source whose frequency modulated output voltage value is independent of the current through the source.
  - DC offset is the magnitude of the time-independent part of the output voltage.
  - Amplitude is the magnitude of the sinusoidal part of the output voltage.
  - Carrier Freq is the frequency of the carrier wave. It may be zero, but cannot be negative.
  - Modulation Index is the amount by which the modulated signal varies around its unmodulated level. It may be zero, but cannot be negative.
  - Signal Freq is the frequency of the modulated signal. Value must be greater than or equal to zero.
- f. PWL – This is a piece wise linear function that can be used to create a waveform consisting of straight line segments drawn by linear interpolation between points that you define (as many points as you want can be used). The structure for this source is flexible and has a variety of parameters to choose from. However, there are some requirements:
  - Two-dimensional points consisting of a time value and a voltage.
  - Time values must be in ascending order (however, intervals between the values don’t need to be regular).

## 2. Current Sources

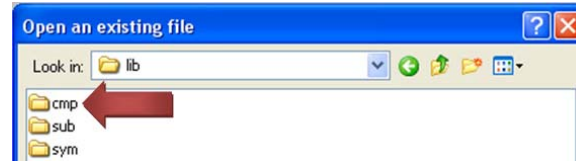
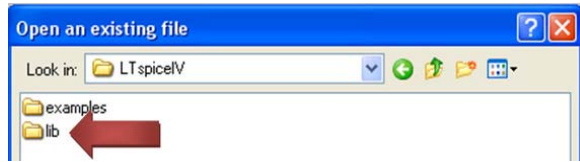
There exist current sources for all of the aforementioned voltage sources. The difference is that they produce current instead of voltage, and that you have to be aware and careful of the direction of the current arrow and the resulting polarities.

## III. ADDING NEW MODELS TO LTSPICE

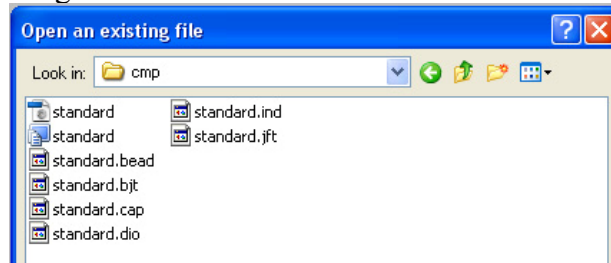
1. Here is an example to add a diode. Other components are added the same way.
2. First start by clicking the “File” menu, and “Open.”



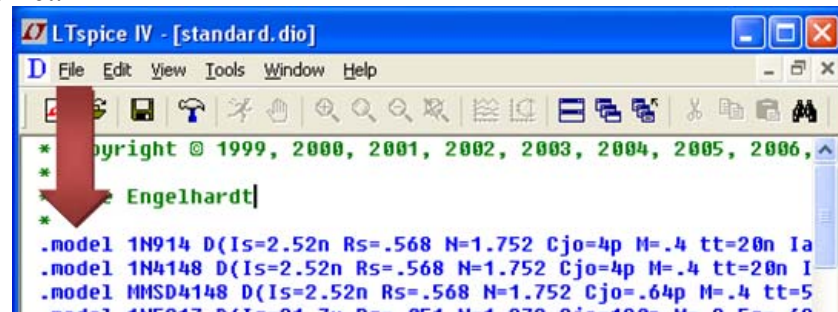
3. Look in the LTspice folder, and click the folder called “lib.” It contains the symbol libraries.



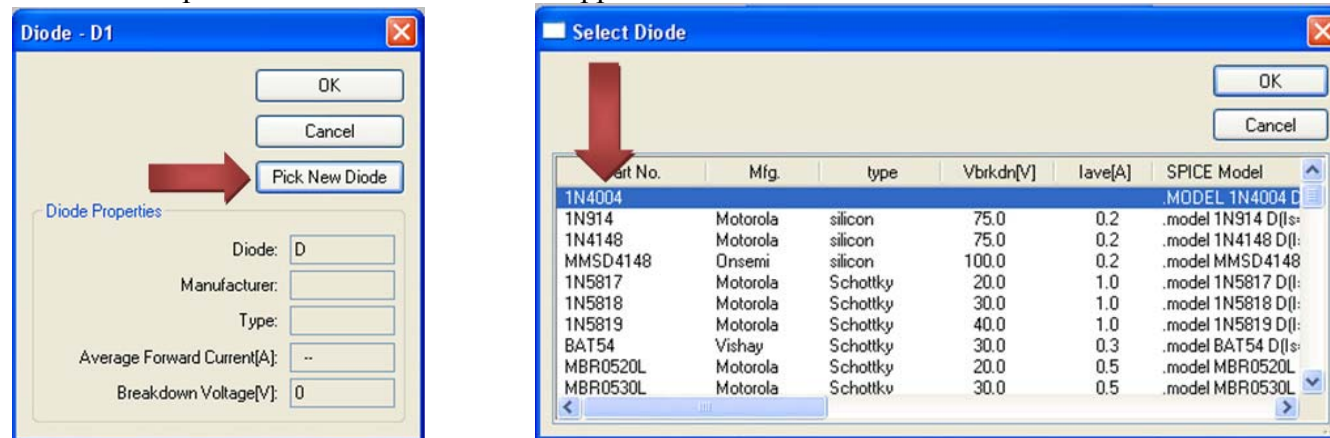
4. Select the folder titled “cmp” and change the “Files of type:” option at the bottom of the window to “All Files (\*.\*)”. You will then see a few files that begin with “standard.”



5. Choose and open what kind you need from these standard devices:
  - Standard.bjt – contains the bipolar junction transistors (BJTs)
  - Standard.dio – contains the diodes
  - Standard.cap – contains the capacitors
  - Standard.ind – contains the inductors
  - Standard.jft – contains the junction gate field-effect transistors (JFETs)
  - Standard.bead – contains the ferrite beads
6. Add a line with the “.model” line for the device you are adding to the end of the file. Now it should show up in the LTspice lists, and you should be able to pick it as though it was one of the pre-existing models. You can find the model spice netlist on the internet.



- In order to find your newly added model for use in your LTspice circuit, place the basic symbol for the component you want. Then, right click the part, and a window will pop up that contains the option to “Pick New Diode,” and then select the correct part number from the list that appears.



## IV. SIMULATION

- Go to Simulate Menu in the tool bar and click on the “Edit Simulation CMD”.
- Select the type of simulation desired and make sure to place the spice directives on the schematic (See below for description of types of simulation)
- Then click on “Run”. (If errors appear then correct and rerun.)

## V. SIMULATION COMMANDS

- DC Operating Point
  - This is the most basic and commonly used analysis.
  - It does not give any plots but it is still very powerful.
- Transient
  - It is used to observe various values of your circuit over time.
  - The ratio of Stop Time: Maximum Timestep determines how many calculations LTspice must make to plot a wave form. LTspice always defaults the start time to zero seconds and goes until it reaches the user defined

final time. Determine what timestep you should use before running the simulation. If you make the timestep too small the probe screen will be cluttered with unnecessary points making it hard to read, and all calculation performed by LTspice will take much longer to complete if you set the timestep too high, you might miss important phenomenon that are occurring over very short periods of time in the circuit. Therefore, play with step time to see what works best for your circuit.

3. AC Analysis
  - a. Allows plotting magnitude and/or phase versus frequency for different inputs of signals.
4. DC Sweep
  - a. Allows different types of sweeps of voltage, current and temperature to see how the circuit reacts.
  - b. For all sweeps make sure to specify a start, stop and the number of points you wish to plot.
5. Noise
  - a. This simulation allows for the creation of noise either as an input or output
6. DC Transfer
  - a. Finds small DC signal transfer function of a node voltage or branch currents due to small variations of independent sources.

## VI. GENERAL TIPS AND HINTS

A. Changing Part Values: "M" and "m" are interpreted the same by SPICE, because it is case insensitive. Putting 10m and 10M for a resistor value will have the same effect, giving it a value of 10 milliohms. Also, don't enter "1F" for a capacitor, because this will read as a femto-farad. To avoid this, reference the following information:

- |                         |                         |                          |
|-------------------------|-------------------------|--------------------------|
| - T = terra = $10^{12}$ | - K = kilo = $10^3$     | - N = nano = $10^{-9}$   |
| - G = giga = $10^9$     | - M = milli = $10^{-3}$ | - P = pico = $10^{-12}$  |
| - MEG = mega = $10^6$   | - U = micro = $10^{-6}$ | - F = femto = $10^{-15}$ |

B. LTspice Leading characters

“A” - Special functions device

“B” - Arbitrary behavioral source

“C” - Capacitor

“D” - Diode

“E” - Voltage dependent voltage source

“F” - Current dependent current source

“G” - Voltage dependent current source

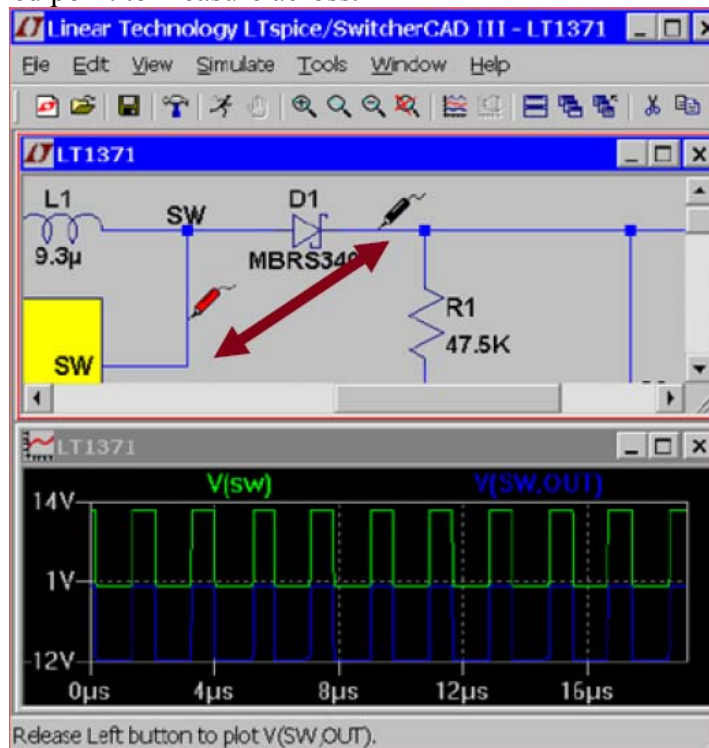
“H” - Current dependent voltage source

“I” - Independent current source

“J” - JFET transistor

“ <b>K</b> ” - Mutual inductance	“ <b>U</b> ” - Uniform RC-line
“ <b>L</b> ” - Inductor	“ <b>V</b> ” - Independent voltage source
“ <b>M</b> ” - MOSFET transistor	“ <b>W</b> ” - Current controlled switch
“ <b>O</b> ” - Lossy transmission line	“ <b>X</b> ” - subcircuit invocation
“ <b>Q</b> ” - Bipolar transistor	“ <b>Z</b> ” - MESFET transistor
“ <b>R</b> ” - Resistor	“ <b>*</b> ” - Comment
“ <b>S</b> ” - Voltage controlled switch	“ <b>+</b> ” - Continuation of prior line
“ <b>T</b> ” - Lossless transmission line	“ <b>.</b> ” - Simulation directive

- C. The auto-generated SPICE netlist is located in the View menu.
- D. To set a component to a specific manufacturer right click on the component and then click “Select Component Type”.
- E. Finding a voltage difference across two points can be achieved by simulating the design. Then using the red probe, left click, hold, and drag to desired point to measure across.





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## **APPENDIX B**

### **Total Harmonic Distortion**

## SIMULATE TOTAL HARMONIC DISTORTION USING LTSPICE

1. Setup a transient analysis with the analysis time a multiple of your signal generator's period
2. Add **.four** command using the "SPICE directive" button. `.op`

Syntax: `.four <frequency> [Nharmonics] [Nperiods] <datatrace1> [<data trace2> ...]`

**Note:** The frequency in **.four** command is the same as the frequency of an input source. For example, if your signal generator is set to 1kHz and you want to watch the node named "out." The command would be:

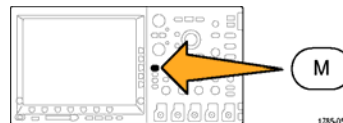
Example: `.four 1kHz V(out)`

3. After running the simulation, you can see the results of THD using *View >> SPICE error log*

## MEASURE TOTAL HARMONIC DISTORTION WITH DPO4034 OSCILLOSCOPE

After acquiring the output signal from your circuit, follow the procedure below in order to calculate the Total Harmonic Distortion;

1. Push **Math**



2. Push **FFT**



3. Push the side-bezel menu **FFT Source** repeatedly for the channel with reference waveform to be analyzed (your output waveform).
4. Push the side-bezel **Vertical Units** button repeatedly to select **dBV RMS**.
5. Push the side-bezel **Window** button repeatedly to select **Hanning** window choice.
6. Push the side-bezel **Horizontal** button. Use knob **a** and **b** to pan or zoom the FFT display on screen. Below is the example screen after step 1-5.

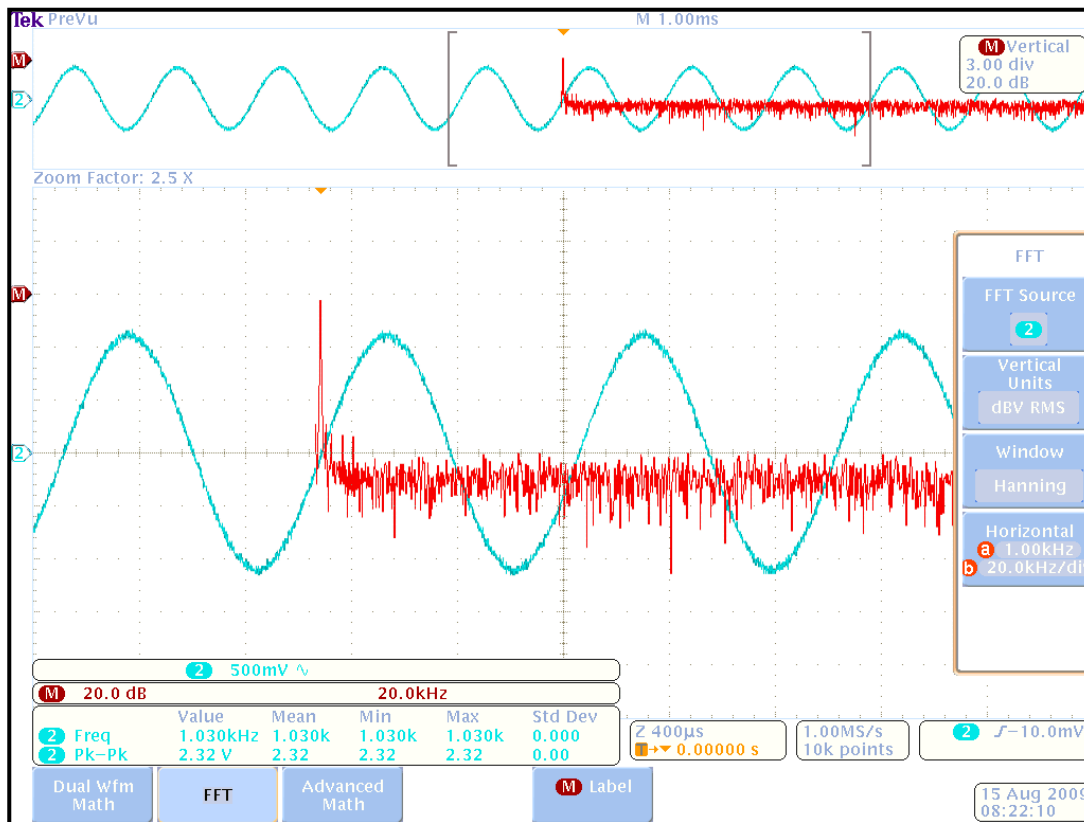
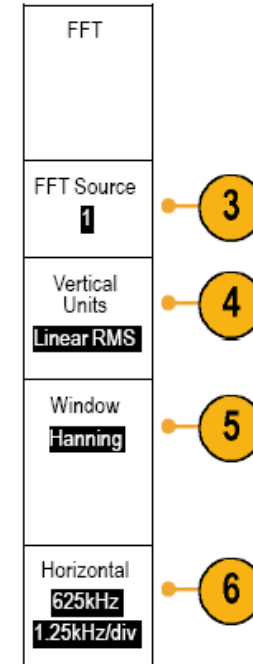


Figure Display Output Waveform and the Result of *Math/FFT* Function

7. Save your waveform in **.csv** format.
8. Import the data to your computer.
9. Choose the harmonic frequency and convert the data in dB to power using the equation below;

$$Power = 10^{\left(\frac{dB}{20}\right)}$$

Example:  $P_1 = 10^{\left(\frac{-17.9156}{20}\right)} = 0.1271$

4.20E+02	-45.0688
4.50E+02	-24.15
4.80E+02	-21.0344
5.00E+02	-17.9156
5.20E+02	-20.8281

10. Use equation below to determine THD;

$$\% THD = \left( \sqrt{\frac{(P_2 + P_3 + P_4 + \dots + P_n)}{P_1}} \right)$$

**Note:**  $P_n$  = the  $n^{th}$  power harmonic, where the fundamental harmonic is at  $n=1$ .



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## **APPENDIX C**

### **Presentation Pointers**

## SECTION OVERVIEW

The purpose of any form of technical communication is to inform, not impress. Classes that need students to give a technical presentation, actually require one that falls in the genre of formal presentation. This document falls in the same genre too. In addition, there is sometimes the requirement for the student to submit the written matter of that presentation in hard or soft copy. This document is therefore intended to help you with some basic tips to refine the outlook of a technical presentation, both for the presenter as well as for the presenter's document. Use them as guidelines and the result will be a well-prepared, well-presented, professional presentation.

## OBJECTIVES

Any formal presentation has the following key features presenters need to focus on:

- Writing the document to be submitted for the presentation.
- Outline of the presentation content/ slides.
- Communicating effectively through presentation media.
- Dressing appropriate and using the correct body language for the presentation.

## Writing the document to be submitted for the presentation

The tips for the written material (that you would submit at the end of the lab) include:

- Outline of the document content.
- Content of the document.
- Language of the written document.

### ***Outline of the document content***

The outline of the document (i.e. introduction/ body of the document/ conclusion), are explained later in this document under the section: *Outline of the presentation content*.

### ***Content of the document***

The content of the document would be similar to what you present in class. The following are some quick tips to start you on the content of the document, as well as on the slides:

1. Make a rough draft: Write down a synopsis of your goals, which would essentially be the purpose of the document.
2. Research the goals: Use reliable Internet resources/ the Library/ conduct surveys or interviews and get valid information to support your goals.

3. List five important facts: Depending on the length of the document, select any five goals/ concepts on which to focus the basis of your document, and arrange them in order of chronology/ priority.
4. Add appropriate visuals: A picture is worth a thousand words. Any part of the document text that can be replaced/ enriched with a visual will create more impact than just plain-text.
5. Cite all your resources: Check all author-date citations and all entries in the reference list for both accuracy and conformance to the format being imposed for your document.
6. Proofread: Use the spell-checker and/ or have a friend peer-edit the document before submission.

### **Language of the written document**

Each document has a voice. Here are a few tips to observe, in order to ensure the language is not offensive or ambiguous:

1. Use a clear and informal style, avoiding unnecessary jargon and acronyms. Acronyms can be used when it is understood by both the audience and the reader.
2. Preferably, use first person and active voice.
3. Avoid language which might be construed as sexist/ racist/ politically incorrect.
4. Analyze the audience (international/ multi-cultural/ academic diversity). For an in-class, technical presentation/ submission, the presenter typically does not need to worry about the nature of the audience, but this is a handy tip that most presenters tend to overlook.

### **Outline of the presentation content/ slides**

These tips are of great importance to forming a powerful outline for any technical document and/ or presentation slides:

1. **Start with a welcome-slide** – The first slide welcomes the audience, (and it is worthwhile to make a mention of notable attendees), and then introduce yourself. (This would conform to the cover-page of your written document).
2. **Spell out your conclusion or summary first** – Most people attending a presentation will "remember" no more than five concepts. Ideally, the presenter should have a list of the five most important points/ concepts/ facts that should be remembered. This introduction with the concepts should spell out the agenda for your presentation. Giving your audience a framework of understanding at the beginning allows them to easily integrate information into their knowledge, because they already have a 'place to put that information.'
3. **Highlight the main concepts, using visuals and minimum text.**
  - a) Use an 18-point (or higher) font size for your slides. Also, use an appealing but light-and-bright solid background color for the slides.
  - b) From the above-mentioned five primary concepts, allocate an average of two slides of text to each main concept.
  - c) Have about four to five key points for each concept.
  - d) Write these key points briefly in short one-liners, and elaborate on the points in the speech instead.



- e) About three visuals for the entire presentation should be sufficient, as long as they give appropriate and complete backing to the associated content.
  - f) Too much information, small-size text, and unclear visuals renders the presentation less effective in terms of message-delivery.
4. **Citation** – Cite any sources for visuals/ text, by mentioning it verbally or including it on the slide,, in a smaller footer area..
  5. **Strong conclusion** – Make the closing short and sweet. Re-iterate the three dimensions of your message (what, why and how) in a powerful one-slide finale to the presentation. A good rule of thumb is to use 10-15% of your time for the opening and 5-10% for the closing.
  6. **Question time** – Make the discussion open to questions from the audience after your closing. Answer the questions as briefly and concisely as you can. It is best to paraphrase the question before answering it, to clarify it in your mind and to make sure you understand the question. If you don't know the answer, say so. Do not try to make up an answer.

### Communicating effectively through presentation media

To make your presentation more than just a stand-up speech with the whiteboard and markers as your tools, add pizzazz to your presentation by taking advantage of the multimedia tools. **Confirm with your professor/ TA as to what multimedia will be available for that day/ classroom.** Any of the following will make your presentation more effective:

If a computer will be available for your presentation, digital slides maybe a good choice for your presentation. However, make an intelligent decision because if slides are not needed or are an ‘overkill’ for your presentation, do not endanger your presentation by using them.

If you do decide to make digital slides, bear these guidelines in mind:

- **Use Microsoft PowerPoint or even Adobe PageMaker:** These **are** ideal for adding color, background theme, convenience and dynamic appeal to your presentation.
- Read and use the tips mentioned in the previous section, “Outline of the presentation content/ slides”, to create your PowerPoint slides.
- **Confirm with your professor/ TA regarding what storage media (i.e. USB mass storage removable disk, CD, etc) you can use, and/ or if you can bring your own PC-notebook, or if there is wireless network access, with which to launch your PowerPoint presentation.**
- Allow the audience at least half to one minute to read a slide with important, concise, bulleted points and stress or elaborate on them verbally.
- Do not read your slides for your audience, because they can usually do that themselves. Instead, use your time to maximize impact by elaboration or descriptions and examples.

## Dressing right and using the right body language for the presentation

The document and slides are not the only aspects for the presentation. In order to be effective in delivering the message, the presenter needs to bear in mind a few key-points as well. This has to do with dressing appropriately and using the right body language.

The ideal way to present yourself successfully is to use the three main components of person-presentation, commonly called **the three Vs: Visual, Vocal, and Verbal**.

### Visual

The first thing your audience members see is your appearance. Your body language will also send the audience a message. Before you get a chance to say a word, some of them will already have judged you based solely on how you look. Your visual outlook therefore comprises of your *attire* and *body language*.

Tips for presentable *attire*:

- You can never be faulted for looking "too professional," even if the audience is dressed down.
- Formal clothing makes the audience accord you respect.
- Comfortable clothing helps the presenter to move around easily.
- Be certain that your outfit and accessories do not detract the audience from your presentation.
- Avoid anything that makes noise or looks flashy, like jangling bracelets or earrings.
- Avoid having money and keys in the pockets, especially if you have a tendency to put your hands in the pockets.

Tips for using the right *body language*:

- Do not cross your arms or fidget.
- Use gestures to emphasize points, but be careful not to flail your arms around.
- The most effective stance is a forward lean, not swaying back and forth or bouncing on your feet.
- Make regular eye contact with audience members, holding the connection to complete an idea. Look around with a panoramic view while you speak. Effective eye-contact helps draw listeners into your speech.
- Nodding to emphasize a point also helps make a connection with the audience. If you nod occasionally, audience members will too -- creating a bond.

### Vocal

If you have ever listened to people speaking in a monotone, or too softly, you know how difficult it is to pay attention. There are six *vocal cues* to remember: pitch, volume, rate, punch, pause, and diction.

- Pitch and volume: It is very important to speak loud, clearly and enunciate. When you look down, your voice drops.
- Rate: If you rush your delivery, the audience will have to work too hard to pay attention. Vary your tone and speed and tailor your delivery rate to accommodate any regional differences. Keep your chin up while speaking, and do not bury it in note-cards.
- Punch and pause: Emphasize or "punch" certain words for effect, but do not forget to incorporate pauses to give the audience time to let important points be understood.
- Diction: Proper diction is also essential; if you are not sure how to pronounce a word, look it up or do not use it.

### Verbal

There are three verbal *communication rules* to remember:

- Use descriptive and simple language.
- Use short sentences.
- Avoid buzz-words and jargon.

Video-tape your presentation or practice in front of a friend. Watch your expressions, body language, vocal and verbal delivery, and your confidence level. See if you have smiled enough and in appropriate places.

## CONCLUSION

As with most documents, this document re-caps the main points to remember for the final presentation:

- **Know the purpose, audience, and logistics** (such as time-limit for presentation, whether each member talks or just a team representative talks, and the visual equipment available for the presentation).
- **Prepare and research adequately** (with an opening that creates impact, and a closing that ends with strength).
- **Create a user-friendly draft** (that makes use of the available multimedia, such as PowerPoint presentation).
- **Most important of all: PRACTICE WELL prior to giving your presentation.** (Video-tape yourself or envision a set-up similar to the presentation while practicing the speech delivery).
- **Arrive early** (to meet up your team, check that the visual equipment works, go over the slides).
- **Apply the delivery techniques** as a presenter (visually, verbally and vocally).
- **Handle questions and answers with tact.** (Stick to the time-limit, so that there is time for the Q&A session).
- **Be confident** (especially after you have read and applied the above techniques for an excellent presentation)!

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## REFERENCES

Following is a list of sources that were referred to extensively, in the making of this document. You are encouraged to refer to these sites, for more presentation pointers, apart from those outlined in this document.

1. Society for Technical Communication  
<http://www.stc.org/>
2. The Art of Communicating Effectively  
<http://www.presentation-pointers.com/>
3. National AV supply  
<http://www.nationalavsupply.com/>
4. Chicago Manual of Style  
<http://www.libs.uga.edu/ref/chicago.html>



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## **APPENDIX D**

### **Suppliers**

This section has a list of our suppliers:

<b>DigiKey</b>	701 Brooks Ave. South Thief River Falls, MN 56701-0677 (800) 344-4539 <a href="http://www.digikey.com">http://www.digikey.com</a>
<b>Mouser Electronics</b>	1000 N. Main Street, Mansfield, TX 76063 (800) 346-6873 <a href="http://www.mouser.com">http://www.mouser.com</a>
<b>Allied Electronics</b>	6700 SW 105th St, Suite 106 Beaverton, OR 97008 (800) 433-5700 <a href="http://www.alliedelec.com">http://www.alliedelec.com</a>
<b>TekBots</b>	220 Owen Hall Oregon State University Corvallis, OR 97331 tekbots_support@eecs.oregonstate.edu <a href="http://eecs.oregonstate.edu/tekbots">http://eecs.oregonstate.edu/tekbots</a>
<b>Solarbotics</b>	179 Harvest Glen Way N.E. Calgary, Alberta, Canada T3K 4J4 (866) B-ROBOTS <a href="http://www.solarbotics.com">http://www.solarbotics.com</a>
<b>McMaster-Carr</b>	P.O. Box 7690, Chicago, IL 60680-7684 (562) 692-5911 <a href="http://www.mcmaster.com">http://www.mcmaster.com</a>
<b>Jameco Electronics</b>	1355 Shoreway Rd, Belmont, CA 94002 (800) 831-4242 <a href="http://www.jameco.com">http://www.jameco.com</a>