**SAFETY PRECAUTIONS**

**1 Why is safety important?**

Attention and adherence to safety considerations is even more important in a power electronics laboratory than it’s required in any other undergraduate electrical engineering laboratories. Power electronic circuits can involve voltages of several hundred volts and currents of several tens of amperes. By comparison the voltages in all other teaching laboratories rarely exceed 20V and the currents hardly ever exceed a few hundred milliamps.

In order to minimize the potential hazards, we will use dc power supplies that have output voltage in the range of 40-50V and will have maximum current ratings less than 5-10A. However in spite of this precaution, power electronics circuits on which the student will work may involve substantially larger voltages (up to hundreds of volts) due to the presence of large inductances in the circuits and the rapid switching on and off of high current in the inductances. For example a boost converter can have an output voltage that can theoretically go to infinite value if it is operating without load. Moreover the currents in portions of some converter circuits may be many times larger than the currents supplied by the dc supplies powering the converter circuits. A simple buck converter is an example of a power electronics circuit in which the output current may be much larger than the dc supply current.

**2 Potential problems presented by Power Electronic circuits**

* Electrical shock may take a life.
* Exploding components (especially electrolytic capacitors) and arcing circuits can cause blindness and severe burns.
* Burning components and arcing can lead to fire.

**3 Safety precautions to minimize these hazards**

**3.1 General Precautions**

* Be calm and relaxed, while working in Lab.
* When working with voltages over 40V or with currents over 10A, there must be at least two people in the lab at all times.
* Keep the work area neat and clean.
* No paper lying on table or nearby circuits.
* Wear safety glasses when working with the circuit at high power or high voltage.
* Use rubber floor mats (if available) to insulate yourself from ground, when working in the Lab.
* Be sure about the locations of extinguishers and first aid kits in lab.
* A switch should be included in each supply circuit so that when opened, these switches will de-energize the entire setup. Place these switches so that you can reach them quickly in case of emergency, and without reaching across hot or high voltage components.

**3.2 Precautions to be taken when preparing a circuit**

* Use only isolated power sources (either isolated power supplies or AC power through isolation power transformers). This helps using a grounded oscilloscope and reduces the possibility of risk of completing a circuit through your body or destroying the test equipment.

**3.3 Precautions using the oscilloscopes and multi-meters**

* Oscilloscopes are among the most expensive instruments in the lab. Be careful when working with one.
* Be aware that the ground clips of the probes for all the 4 channels are internally connected to each other and to safety ground.
* Be extremely careful when making multiple measurements simultaneously. Use isolated probes available.
* Make sure the multi-meter is set to proper mode for the measurement being made. Never put in current mode for any other measurement

**3.4 Precautions to be taken before powering the circuit**

* When connecting the power supply and load to the experimental board, the sequence of the connection to be made is from the load to the power supply, which helps to avoid any floating wire or connector to be charged or shorted to each other. Never let connection wires connected to the power supply or the out put port of the experimental board to be floating.
* Check for all the connections of the circuit and scope connections before powering the circuit, to avoid shorting or any ground looping, which may lead to electrical shocks or damage of equipment.
* Check any connections for shorting two different voltage levels.
* Check if you have connected load at the output.
* Double check your wiring and circuit connections. It is a good idea to use a point-to-point wiring diagram to review when making these checks.

**3.5 Precautions while switching ON the circuit**

* Apply low voltages or low power to check proper functionality of circuits.
* Once functionality is proven, increase voltages or power, stopping at frequent levels to check for proper functioning of circuit or for any components is hot or for any electrical noise that can affect the circuit’s operation.

**3.6 Precautions while switching off or shutting down the circuit**

* Reduce the voltage or power slowly till it comes to zero.
* Switch of all the power supplies and remove the power supply connections.
* Let the load be connected at the output for some time, so that it helps to discharge capacitor or inductor if any, completely.

**3.6 Precautions while modifying the circuit**

* Switch off the circuit as per the steps in section 3.5.
* Modify the connections as per your requirement.
* Again check the circuit as per steps in section 3.3, and switch ON as per steps in section 3.4.

**3.7 Other Precautions**

* No loose wires or metal pieces should be lying on table or near the circuit, to cause shorts and sparking.
* Avoid using long wires, that may get in your way while making adjustments or changing leads.
* Keep high voltage parts and connections out of the way from accidental touching and from any contacts to test equipment or any parts, connected to other voltage levels.
* When working with inductive circuits, reduce voltages or currents to near zero before switching open the circuits.
* BE AWARE of bracelets, rings, metal watch bands, and loose necklace (if you are wearing any of them), they conduct electricity and can cause burns. Do not wear them near an energized circuit.
* Learn CPR and keep up to date. Your can save a life.
* When working with energized circuits (while operating switches, adjusting controls, adjusting test equipment), use only one hand while keeping the rest of your body away from conducting surfaces.

**4 Top 21 Safety Precautions To Follow**

**Rule no. 1**

Avoid contact with energized electrical circuits. Please don’t make fun of this rule if you already know this (and you probably already know if you are reading these lines) and remember that if something bad occurs – you probably won’t have second chance. That’s not funny.

**Rule no. 2**

Treat all electrical devices as if they are live or energized. You never know.

**Rule no. 3**

Disconnect the power source before servicing or repairing electrical equipment.

**Rule no. 4**

Use only tools and equipment with non-conducting handles when working on electrical devices.

**Rule no. 5**

Never use metallic pencils or rulers, or wear rings or metal watchbands when working with electrical equipment. This rule is very easy to forget, especially when you are showing some electrical part pointing with metallic pencil. Always be aware.

**Rule no. 6**

When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves, protective clothes and shoes with insulated soles. Remeber: gloves, clothes and shoes. Safety clothes, gloves and shoes

**Rule no. 7**

If it is safe to do so, work with only one hand, keeping the other hand at your side or in your pocket, away from all conductive material. This precaution reduces the likelihood of accidents that result in current passing through the chest cavity. If you ever read about current passing through human body you will know, so remember - work with one hand only. If you don't clue about electric current path through human body, read more in following technical articles:

Do You Understand What Is Electric Shock?

What psychological effect does an electric shock?

**Rule no. 8**

Minimize the use of electrical equipment in cold rooms or other areas where condensation is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.

**Rule no. 9**

If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment.

Very logical. NEVER try to remove water or similar from equipment while energized. Afterall, it's stupid to do so.

**Rule no. 10**

If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt. Tricky situation, and you must be very calm in order not to make the situation even worse. Like in previous rules - Always disconnect the power FIRST.

**Rule no. 11**

Equipment producing a "tingle" should be disconnected and reported promptly for repair.

**Rule no. 12**

Do not rely on grounding to mask a defective circuit nor attempt to correct a fault by insertion of another fuse or breaker, particularly one of larger capacity.

**Rule no. 13**

Drain capacitors before working near them and keep the short circuit on the terminals during the work to prevent electrical shock.

**Rule no. 14**

Never touch another person's equipment or electrical control devices unless instructed to do so. Don't be too smart. Don't try your luck.

**Rule no. 15**

Enclose all electric contacts and conductors so that no one can accidentally come into contact with them. If applicable do it always, if not be very carefull.

**Rule no. 16**

Never handle electrical equipment when hands, feet, or body are wet or perspiring, or when standing on a wet floor. Remeber: Gloves and shoes

**Rule no. 17**

When it is necessary to touch electrical equipment (for example, when checking for overheated motors), use the back of the hand. Thus, if accidental shock were to cause muscular contraction, you would not "freeze" to the conductor.

**Rule no. 18**

Do not store highly flammable liquids near electrical equipment.

**Rule no. 19**

Be aware that interlocks on equipment disconnect the high voltage source when a cabinet door is open but power for control circuits may remain on. Read the single line diagram and wiring schemes - know your switchboard.

**Rule no. 20**

De-energize open experimental circuits and equipment to be left unattended.

**Rule no. 21**

Do not wear loose clothing or ties near electrical equipment. Act like an electrical engineer, you are not on the beach.