THE UNIVERSITY OF
NEW SOUTH WALES

SCHOOL OF
ELECTRICAL ENGINEERING & TELECOMMUNICATIONS

LABORATORY SAFETY MANUAL

FOR UNDERGRADUATE STUDENTS

2005

Introduction

School UG Laboratory Safety Manual

The aim of this manual is to acquaint students with laboratory safety requirements in the School. All students are required to have a basic knowledge of laboratory safety.

This manual will provide you with information on safety procedures, Standards and guidelines for all laboratory activities conducted in the School of Electrical Engineering and Telecommunications.

Students must read and understand the material contained within this manual. It will provide you with an awareness of the potential hazards and risks that may be present in any laboratory work that you undertake during your undergraduate course.

The first four chapters cover general laboratory regulations and safety procedures. The following chapters (5 – 11) cover in detail potential electrical and other specific hazards present in the Undergraduate teaching laboratories. Students should take special note of the safety measures applicable to their experiment work.

Students should also read the section on risk assessment procedures so as to gain a better understanding of risk identification.

The School has a good safety record due to our dedicated laboratory staff, and we hope to keep this up with full co-operation from all students and staff.

Please sign the declaration form at the back of the safety manual to demonstrate that you have read and understood the material.

Lydia Aristuti & Jacinta Xiujun Goh,
T R Blackburn
2003

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1

Students' Legal Rights and Obligations

Every student has the right to work in a safe and healthy environment. The School has the responsibility to provide this in accordance with the New South Wales Occupational Health and Safety Act, 2000. This act requires the University, through its Occupational Health and Safety procedures and through the School OHS committee, to ensure that safety measures are implemented, and that adequate and necessary steps have been taken to prevent and/or minimize risks or accidents. The Regulations further require that the School takes steps to ensure that students are aware of any potential hazards and that the laboratory regulations are adhered to by both staff and students.

The students, in turn, have the obligation to follow safety procedures and the safety guidelines that are set out in this manual. Failure to abide by these regulations may result in personal injury or risk of injury to others. This constitutes misconduct, and may involve students being given a warning, expelled from the laboratory and other laboratory courses or, in the worst case, being expelled from the University.

2

Laboratory Safety Regulations

The following are basic safety regulations applicable to all laboratories in the School. They are necessary both for your safety, for the safety of other people in the laboratory and for the smooth operation of the teaching laboratories.

These regulations MUST be adhered to at all times.

1. **By law, bare feet and exposed, open footwear (e.g. sandals or thongs) are not permitted within laboratory areas.**

   Students should wear enclosed footwear with gripping soles to protect themselves from possible electric shock, slippery floors and dropped objects.

2. **Food and drink are not to be consumed at any time within a laboratory.**

   Accidental spillage of food or drinks on bench tops might cause a short circuit or malfunction of electrical equipment.

3. **Students must store their bags under the benches at all times.**

   The bench tops should be cleared of bags or any clutter to allow for more spacious workable areas, and to avoid unnecessary contact with electrical equipments, such as cables and wires, that might lead to any accidents. Aisles must also be kept clear to allow unimpeded passage.

4. **Students should clean and tidy benches up when they have finished their experiments and return their leads before they leave the laboratory.**

   The next person using the laboratory should have a clean and tidy work area.

5. **Under no circumstance is 240V 50Hz mains power to be used for any purpose, other than that approved by the School of E E & T.**

   Two types of general power outlets (GPOs) are used in the laboratories. Earthed GPOs are normally used. The other type is an isolated, non-earthed outlet, which should not be used unless your experiment has special requirements for them. Equipment must be connected to the correct outlet for their specification. The wiring of the 240V plug or any other internal wiring of equipment should not be interfered with. Please consult a laboratory staff or demonstrator if necessary.

6. **Report any faulty equipment to laboratory staff and obtain a properly functioning unit.**

   Faulty laboratory equipment might pose danger to laboratory users if operated unknowingly. It may result in personal injury or malfunction of other equipment.

7. **Tampering with or removal of any laboratory equipment is forbidden.**

   Tampering with any laboratory equipment may cause the malfunction of equipment, or personal injury.

8. **Students are expected to conduct themselves in a reserved manner at all times. Noise is to be kept to a minimum: it is a teaching environment.**

   Excessive noise might be disturbing to other laboratory users and disrupt their concentration in performing their tasks.

9. **Work that is not specifically associated with a School subject may only be carried out with the prior approval of the laboratory staff.**

   Please consult laboratory staff if working on other subjects, especially if they require the usage of any laboratory equipment. Work can only be carried out under appropriate supervision.

10. **Mobile phones are not to be operated at any time within a laboratory.**

    Mobile phones might cause disturbance to other laboratory users, and also cause signal interference.

11. **Students who fail to abide by these regulations will be told to leave the laboratory.**

    This is necessary to keep order in the laboratory.

3
Emergencies

3.1 WHAT TO DO IN AN EMERGENCY?

STAY CALM … DO NOT PANIC!

3.1.1 EMERGENCY CONTACTS

In the event of any emergency, including Fire, Ambulance and Police requirements,

Dial: extension 56666,

from any lift phone in the University, or use the University Help Points.
This is the UNSW security Office: it is accessible from any telephone on campus

Alternatively use **Free call: 1800 626 003**,

Carefully describe the following details of the emergency:

- Location
- Type of emergency
- Your name and contact number

3.1.2 DISCOVERY OF FIRE OR OTHER EMERGENCY

1. Activate fire alarm by ***breaking glass alarm***.

2. Close doors that may restrict emergency, ***but only if it is safe to do so.***

3. Notify campus services security on **extension '56666'**.

4. Give the following information:
   (i) Your name and location (e.g. campus, building, floor, room, area, etc.)
   (ii) Type of emergency (e.g. fire, chemical spill, etc.)
   (iii) Severity of the situation

5. Tackle the situation ***only if trained in appropriate emergency procedures***.

3.1.3 EMERGENCY EVACUATION PROCEDURES

In the event of an emergency requiring evacuation of the building, the loudspeakers in the building will broadcast an evacuation alarm. When this occurs Floor Wardens in the building will provide guidance in the evacuation procedure. The evacuation procedures are detailed below.

Step 1 – Act on instructions from the Wardens.

Step 2 – Leave the building by the nearest Exit.

Step 3 – *Do not* delay to collect personal possessions.

Step 4 – *Do not* run, push or overtake.

Step 5 – <u>*Do not* use the lifts.</u>

Step 6 – Proceed to the nearest external assembly area.

Step 7 – *Do not* re-enter the building *until* advised.

3.1.4 EMERGENCY ASSEMBLY AREA

In the event of an emergency which requires evacuation of the building, proceed calmly out of the building by the closest exit, and assemble in the specified assembly areas. These are:

- Library Road and
- The main entrance to the E E & T Building.

3.1.5 SECTOR EMERGENCY CONTROL OFFICER

The Sector Emergency Control Officer for the Electrical Engineering Building (G17) is available on ext 56666,

3.2 LABORATORY EMERGENCY FACILITIES

3.2.1 FIRST AID

The First Aid Officers for the Electrical Engineering Building (G17) are:

Richard Tuck and Jim Sullivan

Room: G17A
Telephone: Ext.54005

3.2.2 FIRE EQUIPMENT

All laboratories in the Electrical Engineering Building are equipped with carbon dioxide extinguishers. Carbon dioxide extinguishers and fire hose reels are also located in the corridor foyer areas on every level.

3.2.3 FIRE ALARMS

Fire alarms are located in the corridors on every level.

To activate the fire alarm, break the glass and push the switch.

3.2.4 ACCIDENT REPORTING

For the safety of oneself and that of others in the building, please report any accidents as soon as possible, to the first aid officers, Richard Tuck, or Jim Sullivan.

4

The Six-Step Safety Method

There are six steps that should be taken by individuals to ensure safety in the laboratories (See Cadick 1994, pp3.1 - 3.3).

1 THINK – BE AWARE

Persons must be aware of any potential hazards in the laboratory at all times. Risk assessment should be performed before starting on any experiment.

2 UNDERSTAND YOUR PROCEDURES

Be familiar with all safety procedures as outlined by the School of Electrical Engineering and Telecommunications.

3 FOLLOW YOUR PROCEDURES

All safety procedures should be followed closely at all times.

4 USE APPROPRIATE SAFETY EQUIPMENT

Appropriate safety equipment must be used when there is a possibility of accidents, such as electric shock, arcs or electrical fires.

5 ASK IF YOU ARE UNSURE

Always ask questions or seek advice from laboratory staff if you are unsure of what to do in any particular situation.

6 DO NOT ANSWER IF YOU DO NOT KNOW

Do not answer any safety-related questions if you are unsure of the answer.

5
Electrical Hazards for Undergraduate Teaching

5.1 ELECTRIC SHOCK

5.1.1 DEFINITION AND DESCRIPTION

Electric shock is the physical stimulation that occurs when electric circuit passes through the body. The effect that electric shock has on the body depends on the magnitude of the current flow, the body parts through which the current flows, and the general physical condition of the person being shocked *(Cadick 1994, p1.1).*

5.1.2 CAUSES OF ELECTRIC SHOCK

1. **Exposed Live Conductors** [see Figure 5.1]

   An exposed conductive part is referred to as the metalwork surrounding electrical equipment. According to Adams (1994, p.24), there are two types of contact that cause electric shock.
   The first one is **indirect contact**, where the shock is received from live metalwork casing. This occurs when there is a partial elevation of voltage during the passage of an electrical fault current to earth, or a full elevation when the casing is not earthed. [Fig 5.1(b)]
   The other type of contact is **direct contact**, where the shock is received from exposed energized parts which are normally at live voltage. [Fig 5.1(a)]

   Electric shocks might occur without the presence of fault current. Some examples given by Adams (1994, p.24) are:

   - Direct contact by touching the line and neutral or two phases of an energized supply. This is a highly unlikely incident.
   - Direct contact with a live conductor when any part of the body is connected to earth.
   - Indirect contact with an unearthed casing comprising of an earth fault.

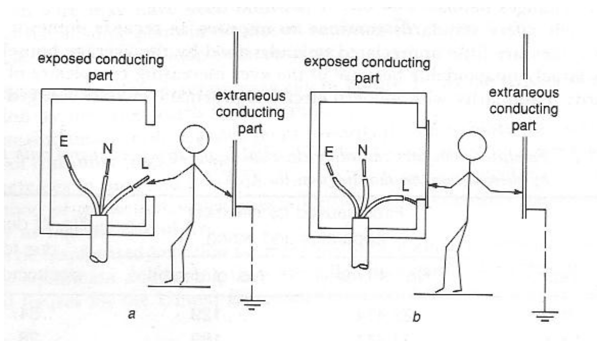


Figure 5.1: Electric shock from exposed conductors
(a) . Direct contact (b). Indirect contact (Adams 1994, p.24)

2. **Improper Equipment Earthing**

The purpose of equipment earthing is to ensure that all exposed metal equipment surfaces will be maintained at substantially earth potential [equipotential bonding], even during a fault condition when substantial current flows to earth.

If the equipment is properly earthed, the circuit overcurrent protection device will trip in the case of a low-resistance internal fault to an exposed metal surface. This will remove the hazard. In case of a fault with high internal resistance, equipment earthing will keep the exposed metal surfaces at or near earth [safe] potential.

Without proper equipment earthing, both low- and high-resistance faults will energize the exposed metal parts to significant voltage levels, thereby causing the potential for serious electric shock if persons are in contact with the metal parts.

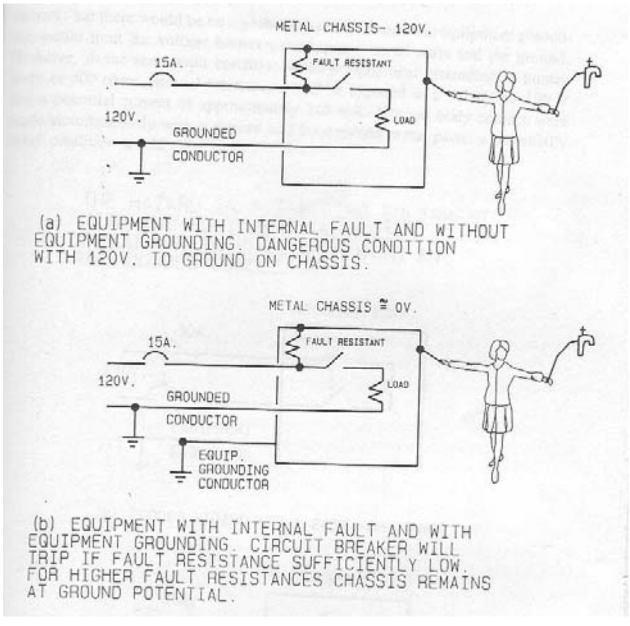


Figure 5.2: Importance of equipment grounding and internal fault resistance in electric shock cases (Greenwald 1991, p.44)

3. **Electric Currents Involving Water**

   Electric shocks might occur when an individual is in water and electric currents are present (Dalziel 1966 in Greenwald 1991, p47). This is due to the energized conductor being exposed to the water. While water is not a good electrical conductor, it does nevertheless conduct some current and its danger is that can spread over large surface areas of the body and thus diminish contact resistance with the skin. It can also cover insulating surfaces and make them live. The factors which will determine the current flow in such cases are:

   - The shape and size of the conductor – water contact surface,
   - The shape and size of any insulating object covered with water
   - The conductivity of the water, and
   - The resistance in the current path to earth

   When water is present its relatively poor conductivity may mean that there exists a reasonably high resistance to earth. This can limit the current magnitude and thus any circuit overcurrent protection may not operate.

   A residual current device (RCD) or earth leakage circuit breaker de-energizes wet equipments if there is a path to earth, hence preventing electrocution. Equipment earthing also prevents electrocution, as the earthed exposed metal parts would tend to reduce the current flow in the water to earth.

5.1.3 EFFECTS OF ELECTRIC SHOCK

Depending on the current path through the body and the magnitude and duration of current transmitted, electric shock may have the following effects on the human body:

1. **Damage and burns to tissue**

   Electric current can result in severe tissue damage through burning. They are mostly third-degree burns, as the burning occurs from the inside of the body where the growth centres are destroyed. If vital internal organs are involved, the burns can be fatal.

2. **Involuntary muscle contraction**

   Involuntary muscular contraction is an effect of the current. At low currents the contraction may cause the “no-let go” effect where the hand is unable to release a live conductor when grasped. If the lung muscles are affected, respiration might stop and asphyxiation occurs.

3. **Ventricular fibrillation**

   The last of the body's muscles to be affected are the heart muscles. If the heart is affected, ventricular fibrillation or irregular heartbeats can occur and result in electrocution.

5.1.4 EFFECTS OF ALTERNATING CURRENT IN THE RANGE OF 15 – 100 Hz

1. **Threshold of perception**

   The threshold of perception is the minimum value of current that causes any sensation for the person through which it is flowing (AS 3859:1991, p11). Some factors that affect the threshold of perception are: contact area, conditions of contact (dry, wet, pressure, temperature), and physiological characteristics of individual.

   The general accepted value is 0.5 mA, independent of time.

2. **Threshold of let-go**

   This is the maximum value of current at which a person holding electrodes can let go of the electrodes (AS 3859:1991, p.11). Threshold of let-go depends on: contact area, shape and size of electrodes, and physiological characteristics of individual.

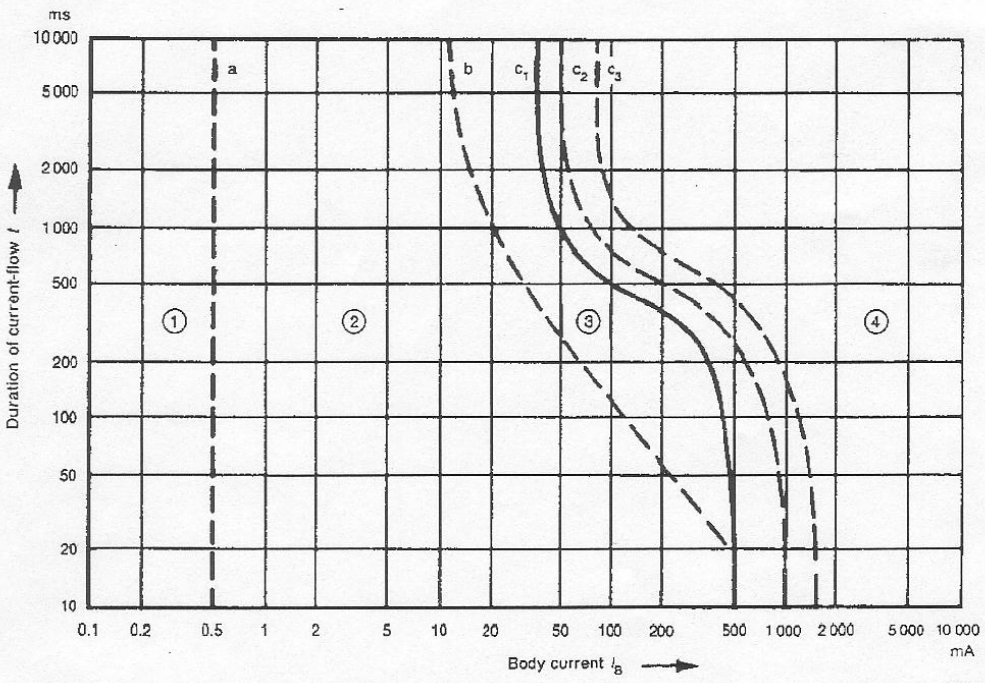
   The general accepted value is 10 mA.

3. **Threshold of ventricular fibrillation**

   This is the minimum value of current that causes ventricular fibrillation (AS 3859:1991, p.11). It depends on physiological factors, such as anatomy of the body, state of cardiac function, as well as electrical factors, for example contact area, duration and pathway of current flow and type of current.

   Above 500 mA, fibrillation may occur for shock duration below 0.1 s. It may also occur for current magnitude of several amperes, if the shock falls inside the vulnerable period. Reversible cardiac arrest may result when shocks last longer than one cardiac cycle.

Below is the graph of time/current zones of the effects of ac currents (15 – 100 Hz) on persons.



Notes 1. – As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path "left hand to feet". For other current paths, see Clause 5 and Table III.

2. – The point 500 mA/100 ms corresponds to a fibrillation probability in the order of 0.14%.

Figure 5.3: Time/current zones of alternating currents (15 – 100 Hz) on persons (Standards Australia 1991, AS 3859:1991, p.15)

Zones	***Physiological effects***
Zone 1	*Usually no reaction effects*
Zone 2	*Usually no harmful physiological effects*
Zone 3	*Usually no organic damage to be expected.* *Likelihood of muscular contraction and difficulty in breathing, reversible disturbances of formation and conduction of impulses in the heart, including atrial fibrillation and transient cardiac arrest without ventricular fibrillation increasing with current magnitude and time.*
Zone 4	*In addition to the effects of Zone 3, probability of ventricular fibrillation increasing up to about 5% (curve c_2), up to about 50% (curve c_3), and above 50% (beyond curve c_3). Increasing with magnitude and time, patho-physiological effects such as cardiac arrest, breathing arrest, and heavy burns may occur.*

Table 5.1: Psychological effects of a.c. currents (15 – 1000 Hz) in various zones (Standards Australia 1991, AS 3859:1991, p.15)

5.1.5 EFFECTS OF DIRECT CURRENT

1. **Threshold of perception**

   Some factors that affect the threshold of perception are: contact area, conditions of contact (dry, wet, pressure, temperature), duration of current flow, and physiological characteristics of individual. With direct current, during the current flow at the threshold, only making and breaking of current is felt (AS 3859:1991, p.18).

   The normal value of threshold of perception is 2 mA.

2. **Threshold of let-go**

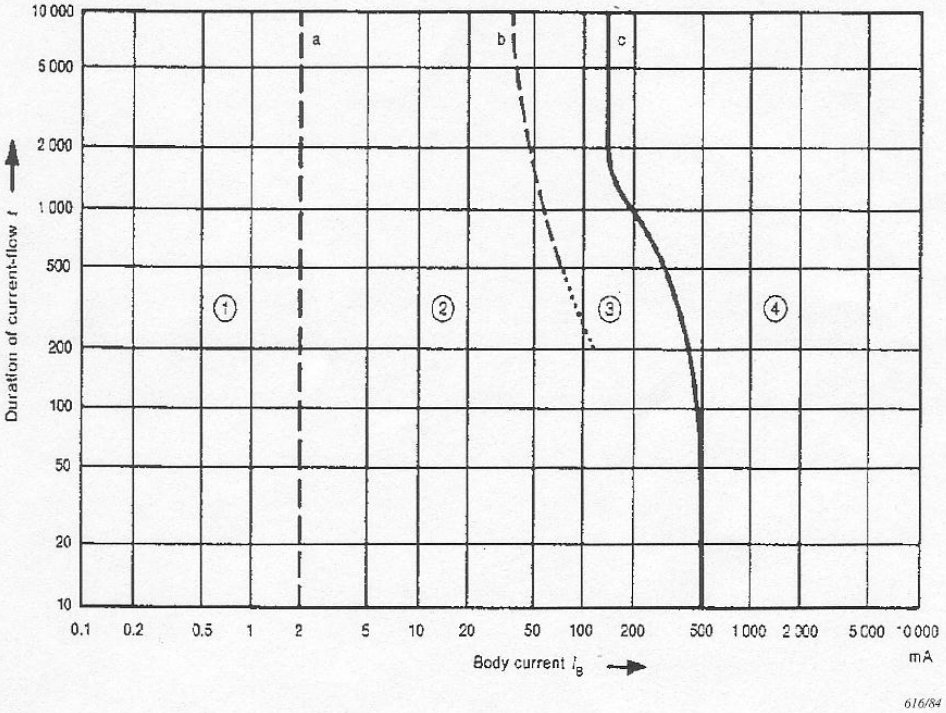
   There is no definable value of threshold of let-go for DC current below 300 mA. Again, only making and breaking sensation is felt and it leads to painful muscle contraction. Above 300 mA, let-go is only possible after several seconds or minutes of shock duration.

3. **Threshold of ventricular fibrillation**

   It depends on physiological factors, such as anatomy of the body, state of cardiac function, as well as electrical factors, for example duration and pathway of current flow, and type of current. The threshold of fibrillation for d.c. is several times higher than a.c. for shock duration longer that the cardiac cycle. If the shock duration is shorter than 200 ms, the threshold of fibrillation for d.c. is approximately the same as for a.c., measured in rms value.

4. **Other effects**

   When the flow of current is below 300 mA, a warm sensation is felt in the extremities. If there is transverse currents up to 300 mA flowing through the body for several minutes, as time and current increases, might cause reversible cardiac dysrhythmias, current marks, burns, dizziness, and unconsciousness. Unconsciousness occurs frequently when the current is above 300 mA.



Notes 1. — As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to feet and for rising current.

2. — Boundary between Zones 2 and 3 unknown for times less than 500 ms.

Figure 5.4: Time/current zones for direct currents (Standards Australia 1991, AS 3859:1991, p.19)

Zones	***Physiological effects***
Zone 1	*Usually no reaction occurs.*
Zone 2	*Usually no harmful physiological effects.*
Zone 3	*Usually no organic damage to be expected. Increasing with current magnitude and time, reversible disturbances of formation and conduction of impulses in the heart are likely.*
Zone 4	*Ventricular fibrillation likely. Increasing with current magnitude and time, other patho-physiological effects, for example heavy burns are to be expected in addition to the effects of Zone 3.*

Table 5.2: Psychological effects of d.c. currents (Standards Australia 1991, AS 3859:1991, p.19)

5.1.6 PROTECTION MEASURES

1. **Fuses and Circuit Breakers**
   A fuse or a circuit breaker protects a circuit from failure of the insulation of an unearthed conductor. It trips when the fault current exceeds the trip setting limit, and disconnects the power, thereby minimizing the hazard.

   Fuses and circuit breakers are overcurrent protective devices and do not protect against electric shock because their tripping current is almost always orders of magnitude greater than the current levels that can cause electrocution. Overcurrent protection will only protect equipment.

2. **Residual Current Devices (Safety switches)**
   A residual current device (RCD) –commonly known as a “safety switch” - is a device incorporating a means for detecting a residual (or earth leakage) current, with an associated means of isolating the circuit if the residual current exceeds the trip level, which is normally 30 milliamps..

   RCDs monitor the balance between the load current and the return current in the load. The RCD has a miniature core balance relay to detect earth leakage. RCDs are designed with an integral circuit breaker that also protects against overloading, short circuit and earth leakage currents.

   RCDs do not prevent electric shock, however they respond rapidly to earth leakage current through the body and are designed to trip the supply before fibrillation has time to set in. The general rating of an RCD at 30 mA will provide a high level of protection against ventricular fibrillation.

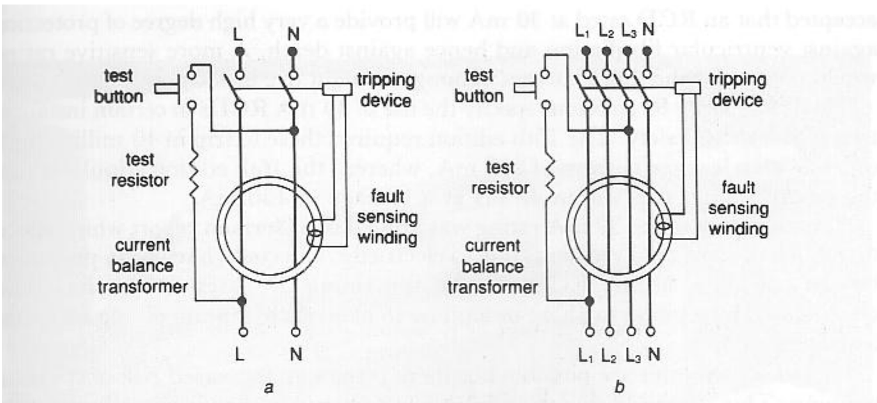


Figure 5.5: Diagrams showing the principle of the RCD to detect fault and leakage currents to earth and interrupt the supply
(a) single-phase unit
(b) three-phase unit **(Adams 1994, p.29)**

****** Note that RCDs are not able to provide universal protection against electric shock. They only work in situations where the electric shock current flows to earth through the body. If a person is connected between the active and neutral, with no earth current leakage, the RCD will not operate and will not provide protection in such electric shock situations.**

3. **Protective Earthing**

The resistance to earth from protective earthed parts in equipment must be low enough to allow sufficient fault current to flow to earth, thus ensuring that the overcurrent protection device in the final sub-circuit or fixed wiring opens quickly during insulation failure.

The purpose of a protective earthing conductor is to make sure that any leakage current from the live parts within the equipment flows harmlessly, via a low resistance path, to earth. (AS 2243.7:1991, p.9)

4. **Double Insulation**

All live circuits must be insulated from earth and all earthed external connections. The purpose of double insulation is to minimize the possibility of an earth fault loop. Double insulation is commonly found in popular devices such as power tools and shavers. Double insulation implies that there are two physically separated insulations. The functional insulation is necessary for the proper operation of equipment, whereas the protecting insulation protects against electric shock when the functional insulation fails to work (Greenwald 1991, p.25). Double-insulated equipment is not earthed because of the two levels of protection provided by the insulation.

However, electrocutions may still occur with double insulation especially if the equipment is used near water, or if there are plug or flexible cord faults.

5. **Extra-Low Voltage Operation**

Extra-low voltage is defined to be voltages not exceeding 50 V AC or 120 V ripple-free DC (AS/NZS 3000: 2000, p.27).

In general, extra-low voltages are considered relatively safe for direct contact. However, if the condition of the room changes, such as increased humidity or a wet environment, contact resistance is decreased and this increases the probability of an electric shock even at very low voltage levels.

6

Specific Hazards

6.1 RADIOLOGICAL AND FIELD EFFECTS

All electromagnetic radiation can be harmful if it exceeds a certain field strength. Some effects of radio frequency and microwave radiation are listed in the following (UNSW - ELEC3017 Electrical Engineering Design lecture notes on safety):

1. Radiated energy can cause damage to areas of low blood supply in the body.

2. Microwave energy above 3,000 MHz is reflected or absorbed by the skin. A warning of excessive exposure is provided when the body feels a warm sensation.

3. Electromagnetic radiation energy below 3,000 MHz is absorbed below the skin without a significant temperature increase.

4. Energy in the range of 1,000 – 10,000 MHz can cause eye cataracts, with the critical frequency being about 3,000 MHz.

6.2 MECHANICAL PROBLEMS

Faulty laboratory equipment might pose a danger to laboratory users. Such equipment should be clearly marked and taken out of the laboratory for service or repair. Further use of such equipments may cause harm to other people or other equipment.

7

Laboratory Equipment: Use and Safety

7.1 WORKING ON LIVE EQUIPMENT

All voltages are potentially hazardous since contact with any live parts might allow substantial amounts of current to pass through the heart. This can be fatal.

Work on live equipment is only permitted if there is no other alternative and supervision is compulsory.

According to AS2243.7: 1991 (p.16), some precautions to take when working with live equipment are:

- Never work alone on live equipment.
- Use only tools and test probes with insulated handles.
- Work one-handed, keeping the other hand in your pocket.
- Use earth-leakage core-balance protection. This is mandatory.
- Avoid contact with any earthed metal in the vicinity of the equipment.
- Stand on an insulating mat, and wear insulated gloves.
- Use prominent warning signs and barriers if equipment with exposed live terminals is energized.
- If components must be touched, e.g. when a motor is being checked for overheating, use the back of the hand so that involuntary muscle contraction does not prevent withdrawal should the casing be alive.

7.2 LABORATORY EQUIPMENT SAFETY

Laboratory equipments, such as oscilloscopes, oscillators, are designed to be safe if they are used in compliance with the manufacturer’s operational guide. However, there is added risk if the equipment is modified to accommodate a particular experiment, for example, if the earth in the oscilloscope is removed to prevent an earth loop in measurement.

7.3 REPORTING FAULTY/DAMAGED EQUIPMENT

Faulty or damaged equipment is potentially hazardous, and must be reported immediately to laboratory staff. Faulty equipment must be clearly tagged and taken out of service for repair.

8

Laboratory Safety Equipment

The equipment detailed below is used only where needed. They do not apply to all laboratories. You must determine whether the area of work in is a hazardous area.

8.1 HEAD AND EYE PROTECTION

1. **Safety Glasses, Goggles, and Face Shields**

   During exposure to electric arcs, safety glasses and goggles reduce the ultraviolet light intensity while flash suit face shields provide excellent face protection from molten metal and plasma cloud, thereby reducing the risk of injury and blindness. Also when working with lasers, laser safety goggles must be used to prevent eye damage.

Some situations where the use of head and eye protection is required include:

- Working on switchgear, closed to exposed energized conductors
- When Rules or Standards require the use of eye protection
- Working with lasers
- Anytime there is a danger of head, eye, or face injury from electric shock, arc, or blast

8.2 RUBBER-INSULATING EQUIPMENT

Rubber-insulating or similar equipment should be used when there is a risk of electric shock, or when working near energized conductor. Some examples of rubber insulating equipment are rubber gloves, sleeves, line hose, blankets, covers, and mats.

8.3 HOT STICKS in High Voltage Laboratories

Hot sticks are poles made of insulating materials. They consist of tools and/or fittings, which allow users to control energized conductors and equipment from a safe distance. They can be used when there is a possibility of electric shock, arc, or blast.

Some situations where the use of hot sticks is required include:

- Voltage measurement
- Any repairs or modifications to energized equipment
- Application of safety earths

8.4 INSULATED TOOLS

Insulated tools are standard hand tools with a complete covering of electrical insulation, leaving only a minimum amount of metallic work surface. They are used to prevent shock or arc when the user is in contact with an energized conductor.

8.5 DANGER AND OUT OF SERVICE TAGS

There are two types of tags suitable for use as an electrical hazard warning.

- **Danger tags**
  They are used on energized equipments, which could cause harm to users.

- **Out of service tags**
  They are used to isolate a faulty piece of equipment. They are also known as Warning or Fault tags.

8.6 LOCK-OUT AND PERMIT SYSTEM

There are two additional safety precautions that may be applied in the high power electrical laboratory or when using Class 3B and Class 4 lasers.

- **Lock-out System**
  The lockout system provides extra security above the tagging system. The equipment is modified such that a lock or interlock is incorporated in the main control mechanism of the equipment.

- **Permit System**
  The permit system is implemented in hazardous areas. Students are required to obtain permission to carry out their experiments in these areas. The permit consists of details such as authority of issue, period of effect (time and date of issue and cancellation), details of the task, precautions to be observed, and authority for cancellation. Students working under a permit have to sign on upon entering and sign off upon leaving.

8.7 SEGREGATION OF HIGH-VOLTAGE AND OIL-INSULATED HIGH-POWER ELECTRICAL EQUIPMENT

In the high-voltage electrical laboratory, equipment operating at voltages up to 400 kV is segregated in an enclosure. These equipment items have a higher risk of electric shock and also a higher probability of fires and explosion when there is an electrical failure from oil-insulated equipment.

9

Recent “Incidents” within the School

Fortunately, there have not been any accidents to date in the School of Electrical Engineering and Telecommunications.

However, here are two cases of near-accidents in the Undergraduate laboratories that should be noted.

- Some students connected their breadboard circuits directly to the 240 V mains.

  Students should take extra care when using breadboards. Under no circumstances should breadboards be connected to the 240 V mains power supply. They should only be connected to 30 – 50 V power supplies.

- ELEC3017 Electrical Engineering Design students connected their prototype to the 240 V mains without ensuring the safety of their design.

  When designing and building your own circuit, extra precautions should be taken so that the circuit is safe to operate.

In the above two cases, laboratory demonstrators and staff were able to intervene in time and prevent any mishaps that may have occurred.

10

Risk Assessment

10.1 RISK ASSESSMENT OBJECTIVES

Risk assessment needs to be done before every experiment and particularly before connecting the equipment to the power supply.

Risk assessment is essential in helping to keep a safe and healthy workplace. It involves identifying significant hazards and making sure that proper precautionary steps are taken to minimize the risks.

10.2 RISK ASSESSMENT PROCEDURE

The flowchart on page 27 outlines the procedure for risk analysis.

(Source: AS3931: 1998 Risk Analysis of Technological Systems – Application Guide)

10.2.1 SCOPE DEFINITION

This involves describing the problems that originated the risk analysis. You must identify safety, technical, environmental, legal, organisational, and human factors that contribute to the system being analysed. State the assumptions and constraints, and recognize the decisions that have to be made in regard to the problems.

10.2.2 HAZARD IDENTIFICATION

Hazard identification includes identifying and taking corrective actions to eliminate or reduce as far as possible the hazards.

10.2.3 RISK ESTIMATION

In the risk estimation step, all factors of concern of the identified hazards are examined and a measure of the level of the risks being analysed is produced. Risk estimation consists of the following procedures: frequency analysis, consequence analysis, and risk calculations.

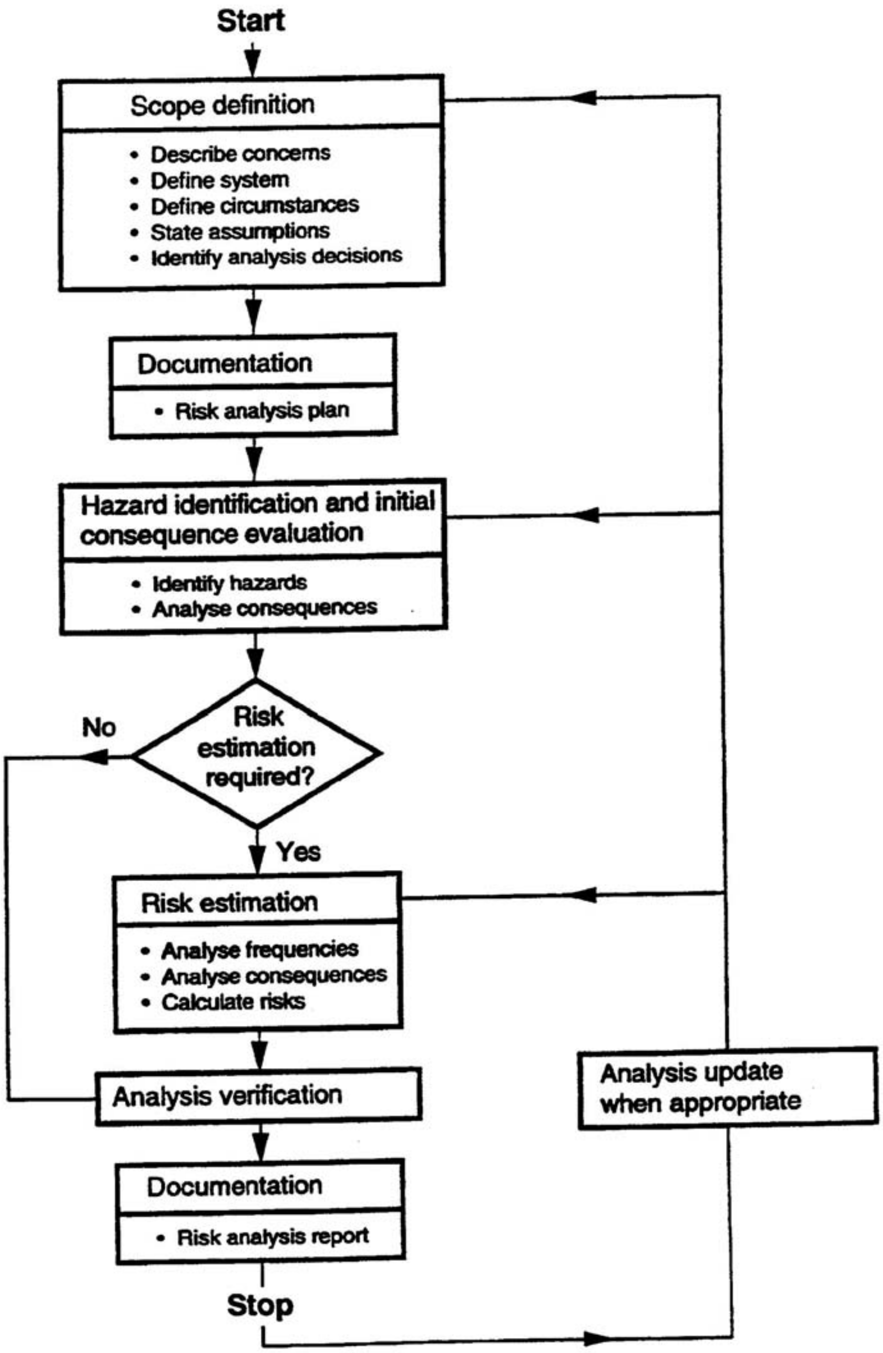


Figure 10.1: Risk Analysis procedure
(AS/NZS 3931:1998 p.18)

- **Frequency Analysis**

  The frequency of each accident scenario identified at the hazard identification stage should be determined.

  Three approaches are used to estimate event frequencies. They are:

  (i) To use relevant historical data,
  (ii) To derive event frequencies using analytical and simulation techniques, and
  (iii) To use expert judgement.

- **Consequence Analysis**

  The impact of the accident is estimated.

  Consequence analysis should describe resulting consequences and consider protection measures.

- **Risk Calculations**

  The duration of the accident and the probability of casualties should be included in the calculation of risk levels.

10.3 RISK ASSESSMENT FORM

Students need to fill in the risk assessment form before commencing on laboratory experiments.

A sample of the risk assessment form is included in Appendix C.

11

How to Obtain More Information on Safety?

11.1 MATERIAL SAFETY DATA SHEETS (MSDS)

Material safety data sheets are supplied for all chemical substances used in the laboratory. They provide chemical composition, safety information and describe hazards associated with each chemical substance.

11.2 REFERENCE BOOK

John Cadick :

Electrical Safety Handbook

McGraw-Hill, Inc., U.S.A., 1994

11.3 WORKCOVER GUIDE

A Guide to the Draft Occupational Health and Safety Regulation 2001

WorkCover New South Wales

OHS Hotline: 1800 451 462

http://www.workcover.nsw.gov.au

11.4 UNSW RISK MANAGEMENT UNIT

UNSW Risk Management Unit provides information on Occupational Health and Safety and risk management.

http://www.riskman.unsw.edu.au

11.5 FIRST AID TRAINING

First aid courses are available from St. John Ambulance Association and Red Cross Association.

Appendix A
Treatment of Electric Shock

GENERAL PROCEDURES FOLLOWING AN ELECTRICAL ACCIDENT

Each laboratory in the School of EE & T has a wall poster giving instructions of procedures in the event of an electric shock accident.

The following procedures are taken from ELEC3017 Electrical Engineering Design lecture material on Electrical Safety pages 15-16, and AS 2243.7:1991.

1. Switch off the power source and separate the person from the energy source immediately without causing further damage.

2. If the power source is not able to be isolated and the person is still in contact with electrical source, insulate yourself from the person before making contact, e.g. use rope or any other suitable article. You should only do this after you have evaluated the risk and have taken all precautions to prevent a further electric shock occurring

3. Check on breathing. If present, keep the person warm and comfortable, and call for medical attention: in the first instance call on the School first aid officers (ext. 54005) and then the UNSW security office on ext 56666.

4. If breathing is not present, urgent resuscitation is required:
   - Clear airways by pulling tongue from throat,
   - Lay person on back, tilt head backwards so that mouth opens,
   - Attempt mouth-to-mouth resuscitation.

5. If breathing is restored, arrange for medical attention.

6. If breathing is not restored:
   - Feel for pulse in the neck.
   - Attempt to diagnose cardiac arrest (the combination of unconsciousness and loss of arterial pulse). Cardiac arrest (or ventricular fibrillation) results in:
     - Loss of consciousness,
     - Cessation of respiration,
     - Dilatation of pupils.
   - Call an intensive care (cardiac) ambulance.

7. Attempt to restart the heartbeat by applying external cardiac massage in combination with artificial ventilation:
    - Place person on firm surface.
    - Place heel of one hand on the lower part of the sternum and the heel of the other hand immediately above it.
    - Depress the sternum firmly (3-5 cm) once every second.
    - Do not apply force to any other area except the sternum – pressure on the ribcage can fracture ribs leading to lung, liver or spleen damage.
    - If the cardiac compression procedure is effective in circulating the blood, the pupils should become smaller.
    - Artificial ventilation must be maintained by the mouth-to-mouth resuscitation procedure throughout the cardiac massage. Refer to the following figure for the mouth-to-mouth resuscitation procedure.
    - The whole procedure may continue for about 30 minutes.

8. If the casualty has suffered burns, wash and cool the burned area under gently running cold water. Apply a clean, dry, non-adherent dressing to the burned area.

9. In a hospital or ambulance situation, use a defibrillator.

10. Notes:
    - Breathing may stop without cardiac arrest; respiratory arrest of central origin makes the resumption of breathing more difficult.
    - Cardiac arrest causes rapid acidosis (lowered blood pH), which requires injection of sodium bicarbonate.

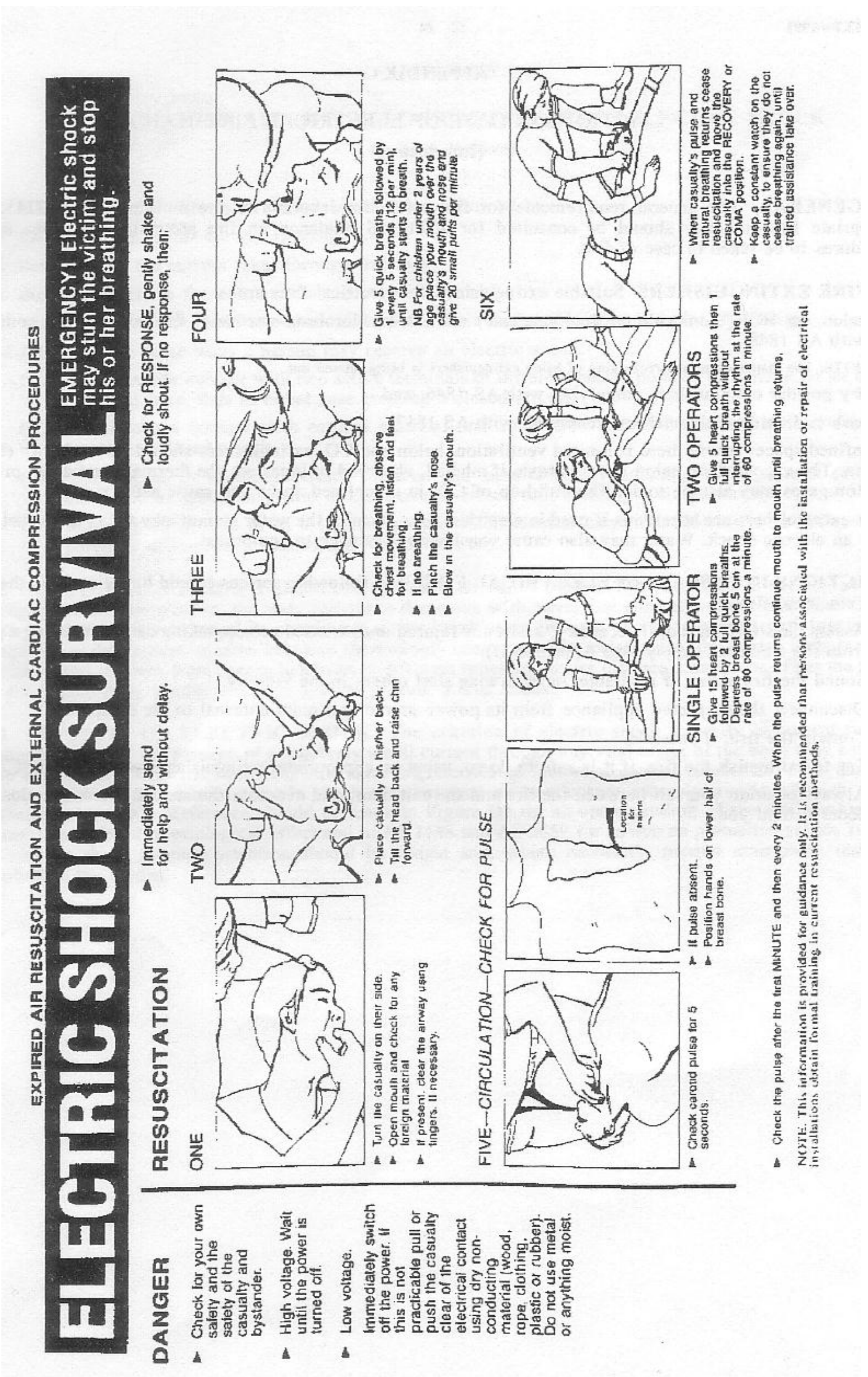


Figure A.1: Expired air resuscitation and external cardiac compression procedures
(AS 2243.7:1991, p.23)

Appendix B
Tagging System

The tagging system is a warning mechanism used by laboratory staff to indicate that a certain equipment item is faulty, dangerous or out of service. Authorized staff can only remove it after the equipment is serviced and has been tested and determined to be safe for operation.

Tagged equipment is not to be used. Please do not remove tags, ask laboratory staff for assistance.

Appendix C
Risk Assessment Form

INSTRUCTIONS

Students need to fill in the risk assessment form before commencing on laboratory experiments.

Teaching Laboratories

This is not necessary for scheduled teaching laboratories, although it is a good idea to use the methodology in all laboratory experiments that you do.

Any risks associated with the scheduled classes will be outlined by laboratory staff and demonstrators prior to the class starting.

Thesis/project Laboratories

In all laboratory activity that is not a scheduled class, for example experimental work associated with a thesis, students MUST fill the risk assessment form before starting the experimental work. The for should be given to your supervisor or to the laboratory supervisor for approval prior to commencing the activity assessed

THE UNIVERSITY OF
NEW SOUTH WALES

Risk Assessment Form

Laboratory: ____

Please complete this form for all research/experiments conducted in the School of Electrical Engineering and Telecommunications at the University of New South Wales.

Student Name: _______________ Student ID: ________ Demonstrator: ____________

Experiment Title: _________________________________ Date/Time: ______________

Description of Experiment: ____
____
____

Q1. Have you read the notes on Laboratory Regulations and Safety?

❑ Yes ❑ No

Q2. Briefly describe any electrical hazard(s) and list ways in which risk from these hazards may be eliminated or minimised.

____
____
____
____
____
____

Q3. Does the work require any of the following?

- ❑ Use of mains referenced potentials (3-phase mains or Variac outputs)?
- ❑ Equipment with hazardous potentials (> 32V AC or > 115V DC)?
- ❑ Use of non earthed and/or isolated outlets?

Q4. Are there any mechanical hazards associated with your experiment?

❑ Yes ❑ No

Q5. Briefly describe any mechanical hazard(s) and list ways in which risk from these hazards may be eliminated or minimised.

____

Q6. Are there any other specific hazards not covered in the above? Please list.

Q7. Unsupervised work is not permitted. Have you arranged for appropriate supervision? (answer where applicable)

❑ Yes ❑ No

I declare that the information submitted in this form is correct and complete.

Signature of Student: Date:

Signature of supervisor or Laboratory staff

Date

Appendix D

Safety Incident Report Form

INSTRUCTIONS

The Safety Incident Report Form must be completed when:

- there is an accident causing injury to the person(s) involved,
- there is a near accident, but fortunately no one was injured,
- there is a dangerous situation, which may result in personal injury if it remains unattended to.

THE UNIVERSITY OF
NEW SOUTH WALES

Safety Incident Report Form

Laboratory: ______________________________

Please complete this form for all accidents that occurred during research/experiments conducted in the School of Electrical Engineering and Telecommunications at the University of New South Wales.

Student Name: _______________Student ID: _______ Demonstrator: ___________

Experiment Title: _______________________________ Date/Time: _____________

Description of Experiment: ____
____
____

I wish to report

- ❑ an accident
- ❑ a near-accident
- ❑ a dangerous situation

Q1. List the hazards/risks involved in this experiment.

____
____
____
____

Q2. Describe the circumstances leading to the accident.

____
____
____
____

Q3. What are the precautions taken?

____
____
____
____

I declare that the information submitted in this form is correct and complete.

Signature of Student: Date:

Appendix E
Safety Declaration

INSTRUCTIONS

You are required to sign the safety declaration form before commencing any laboratory activities within the School of EE&T.

Please complete the safety declaration form and return it to the School Office.

THE UNIVERSITY OF
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Occupational Health and Safety Declaration

School of Electrical Engineering & Telecommunications

Student Name: _______________ Student ID: ________

Course/Stage ______________

Session/Year: _____________

I have read and understood the safety regulations and emergency information for the School of Electrical Engineering and Telecommunications given in the Laboratory Safety Manual for Undergraduate Students.

Signature of Student: Date:

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