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LABORATORY PROCEDURES AND  
SAFETY MANUAL



LABORATORY FOR INTEGRATION OF  
POWER ELECTRONICS (LIPE)

Washington State University

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January 20, 2015

Ali Mehrizi-Sani: *Laboratory Procedures and Safety Manual*, Laboratory for Integration of Power Electronics (LIPE), © January 20, 2015.

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## ABSTRACT

This safety manual is developed for LIPE, Laboratory for Integration of Power Electronics, School of Electrical Engineering and Computer Science, Washington State University. Students working in this lab are *required* to study this manual and sign the signature page (p. 11).

## ACKNOWLEDGEMENTS

I thank my graduate students for their help in maintaining and developing LIPE. In particular, I thank *Saleh Ziaeinejad* for proofreading the text and adding the description of electrical equipment, *Younes Sangsefidi* for drawing the dreaded diagram of the lab floor plan, and *Hooman Ghaffarzadeh* for maintaining the LIPE website.

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# 1 | INTRODUCTION

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### 1.1 PURPOSE

The manual provides general guidelines on the safety of both personnel and equipment. In all cases, you are required to exercise caution (and you are advised to exercise common sense).

### 1.2 AVAILABILITY

A PDF of this manual can be found at [http://eecs.wsu.edu/~mehrizi/LIPE\\_LabManual.pdf](http://eecs.wsu.edu/~mehrizi/LIPE_LabManual.pdf). A hard copy is available in LIPE.

### 1.3 VALIDITY

These laboratory rules apply to the use of the following laboratory of the Energy Systems Innovation (ESI) Center Washington State University (WSU).

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Laboratory for Integration of Power Electronics (LIPE) EME B58

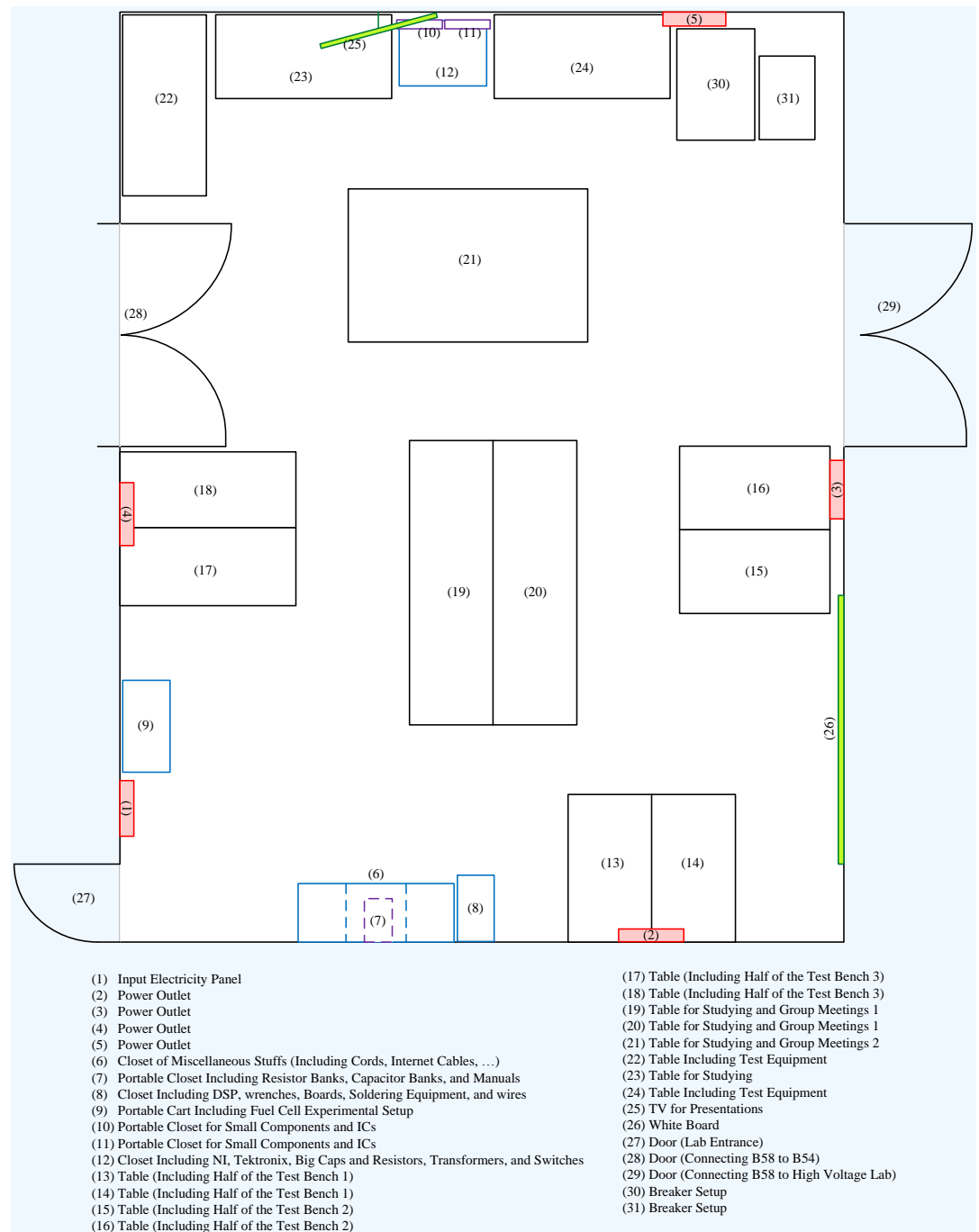
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*EME B58 is on the south wing of the EME building.*

### 1.4 LIPE'S OTHER DOCUMENTS

- Ground Rules: [http://eecs.wsu.edu/~mehrizi/LIPE\\_GroundRules.pdf](http://eecs.wsu.edu/~mehrizi/LIPE_GroundRules.pdf)
- Writing in Academia: [http://eecs.wsu.edu/~mehrizi/LIPE\\_WritingInAcademia.pdf](http://eecs.wsu.edu/~mehrizi/LIPE_WritingInAcademia.pdf)
- Laboratory Procedures and Safety Manual (this document): [http://eecs.wsu.edu/~mehrizi/LIPE\\_LabManual.pdf](http://eecs.wsu.edu/~mehrizi/LIPE_LabManual.pdf)
- PowerPoint Template: [http://eecs.wsu.edu/~mehrizi/LIPE\\_PowerPointTemplate.pptx](http://eecs.wsu.edu/~mehrizi/LIPE_PowerPointTemplate.pptx)
- Common Mistakes Presentation: [http://eecs.wsu.edu/~mehrizi/LIPE\\_CommonMistakesPresentation.pdf](http://eecs.wsu.edu/~mehrizi/LIPE_CommonMistakesPresentation.pdf)

## 1.5 LIPE FLOOR PLAN



## 1.6 DISCLAIMER

In case of discrepancy between any part of this manual and the internal University regulations, the latter prevails. If a part of this manual is not valid, it shall not affect the validity of the remaining parts.

# 2 | GENERAL RULES

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For your own safety, and to abide by the university safety regulations, you are required to observe the following rules.

### 2.1 GETTING A KEY

If your project involves working in LIPE (B58), you need to have a key for yourself. To get a key

1. Email/tell Prof. Mehrizi-Sani that you need a key.
2. Sign acknowledgement (p. 11) that you have read this manual.
3. Get your key from Ms. Ning Hsu. If she does not have a spare one, she will order one, which may take a few days.

### 2.2 WORKING WITH EQUIPMENT

- If you are working with high-voltage equipment, it is required that at least two people be present in the lab.
- Know the location of safety equipment. Know the location of the closest first-aid kit and who to talk to when something happens.
- There are lead-acid batteries in LIPE. Please familiarize yourself with the risks involved with operating such batteries, e.g., explosion and leak. Know the location of the spill kit.
- Know the location of the turn-off switches.
- No material, including computing equipment, can be removed from LIPE without express approval of Prof. Mehrizi-Sani.
- Do not attempt to repair an electrical device unless you are authorized to do so.
- When working on systems with rotating shafts, be mindful of your accessories, e.g., tie, necklace, and loose sleeves. Do not try to rotate the shaft by hand whether the machine is on or off.

*Anything higher than 40 V is considered high voltage.*

## 2.3 LIPE ETIQUETTE

- Lock the doors (your key opens two doors of LIPE) and switch off the lights before you leave. Disconnect the experimental setup from the mains.
- Drinks and food are not allowed in LIPE.
- Keep LIPE neat and tidy. Put the equipment back in their original place after you are done.

## 2.4 CONTACT NUMBERS

*Do NOT save the 9-1-1 number in your cell phone.*

Contact the following in case of emergency or specific events.

<b>Name</b>	<b>Number</b>	<b>Nature of Event</b>
Emergency Number	911	Emergency situations
Ali Mehrizi-Sani	(509) 335-6249	During office hours; LIPE director
Jody Opheim	(509) 335-6456	During office hours; ESI Center manager
John Yates	(509) 335- 8060	During office hours; VCEA IT manager
John Yates	(509) 338-5530	After hours; VCEA IT manager
WSU EH&S	(509) 335-3041	WSU Environmental Health & Safety



# 3

## ELECTRICAL EQUIPMENT IN LIPE

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### 3.1 COMPUTERS, TELEVISION, AND PRINTER

There are three personal computers and one printer in LIPE, as listed below:

Model	Description
HP Pavilion	Personal computer, Core i7
Dell T5400	Personal computer, Quad core
Dell T3400	Personal computer, Core 2 Duo
Samsung UN58H5005	58" Television
Brother DCP-7065DN	Printer

### 3.2 POWER SUPPLIES

There are four different power supplies, ranging from 360 W to 15 kW.

Model	Description
GW instek SPD-3606	30V/12A, 60V/6A, 120V/3A switching power supply (2 units)
B&K precision XLN15010-GL	150V/10.4A switching power supply
Magna Power 200/15	200V/75A switching power supply

### 3.3 SIGNAL GENERATORS

There is one GW Instek SFG-1013 Function Generator in LIPE.

### 3.4 ELECTRONIC LOAD

There are several electronic loads in LIPE. These include the following:

Model	Type (DC/AC)	Rating
B&K 8514	DC	1200 W
Chroma 63201	DC	2600 W
Chroma 63802	AC/DC	1800 VA
Chroma 63804	AC/DC	4500 VA

### 3.5 OSCILLOSCOPES

There are three oscilloscope in LIPE. Each oscilloscope is equipped with several probes.

Model	Number of channels
Yokogawa DL850 scopecorder	8
Tektronix TDS3014C	4
Tektronix TDS 2024C	4

### 3.6 METERS

There is a multitude of meters available in LIPE:

Model	Description
GW-Instek LCR-821	LCR meter
Fluke 287	Multimeter
Fluke 179	Multimeter
Fluke 332	Clamp Meter
Fluke 566	Thermometer

### 3.7 VOLTAGE AND CURRENT PROBES

There is one low voltage differential voltage probe and two current probes equipped with probe amplifiers.

Model	Description
Tektronix P6246	400 MHz, Low voltage differential probe
Tektronix TCP312A	100 MHz, 30 A current probe
Tektronix TCPA300	100 MHz, current probe amplifier

### 3.8 VOLTAGE AND CURRENT TRANSDUCERS

There are several current transducers (LEM LA55/P, LEM LA100/P) and several voltage transducers (LEM LV 25-P).

### 3.9 VOLTAGE-SOURCED CONVERTERS

There are three voltage-sourced converter modules.

Model	Description
Semikron SKiip 613GD123-3DUL	1200 V, 450 A VSC module
Semikron 08753450	600 V, 30 A VSC module (2 units)

### 3.10 CONTROLLERS

LIPE has the following controllers:

Model	Quantity	Description
National Instruments cRIO-9024	2	Real-time controller
NI 9215	1	Analog input module for cRIO
NI 9211	1	Thermocouple input module for cRIO
eZdsp-F28335	3	DSP board
C2000 Series XDS510LC JTAG Emulators	2	DSP emulator

### 3.11 FUEL CELL SETUP

There are two fuel cell setups. Both available fuel cells are of proton exchange membrane (PEM) type.

Model	Description
Horizon H-300	36 V, 300 W PEM fuel cell
Horizon H-1000XP	55 V, 1000 W PEM fuel cell

### 3.12 SIMULATORS

Educational version of PSCAD/EMTDC (including Intel FORTRAN Compiler) is available for the members. In addition, MATLAB/Simulink is also available for the members.

### 3.13 LEAD-ACID BATTERIES

There are 12 Lead-acid batteries, each one is 55 Ah, with nominal voltage of 12V.

### 3.14 RESISTORS, CAPACITORS, SWITCHES

There are several resistor and capacitor assorted kits, as listed below:

Type	Description
Fixed resistor (SMD)	1206 package SMD resistor assorted folder 170 value x 50pcs
Fixed resistor (1/4 W)	86 Value 860 Piece Resistor Kit
Fixed resistor (1 W)	86 Value 860 Piece Resistor Kit
Variable potentiometer	12values, 5 pieces each
Electrolytic Capacitors	125pcs 25 Values 1uF to 2200uF
Ceramic Capacitors	36 Value/Type 3600 pcs Assortment Box Kit

There are also several high-voltage capacitors and high-power resistors, as listed in the following table:

Type	Description
Capacitor	400V, 12000 $\mu$ F (2 pieces)
Capacitor	500V, 12000 $\mu$ F
Capacitor	200V, 47000 $\mu$ F (2 pieces)
Resistor	0.20 $\Omega$ , 300 W

### 3.15 INTEGRATED CIRCUITS (ICS)

There are several ICs for implementation of driver and signal conditioning boards.

Index	Description
1	Linear voltage regulators (3.3 V ~ 15 V)
2	Motor driver (L293 D)
3	AVR ATMEGA 32 microcontroller
4	Logic gates and D-latch
5	MOSFETs with different voltage and current ratings
6	MOSFET driver (IR2113)
7	Diodes with different voltage and current ratings
8	Zener diodes with different voltages
9	LEDs with different colors
10	Optocouplers
11	Thyristors with different voltage and current ratings
12	Timer (LM555)
13	Op-amps and comparators
14	Digital to analog converters
15	IC sockets

### 3.16 OTHER ELECTRICAL EQUIPMENT

Other electrical equipment that are available in LIPE are listed below:

Index	Description
1	Several fuses (0.5A ~ 25 A) and fuse holders
2	Tact switches
3	Wires (10, 14, and 18 AWG)
4	Inductor cores
5	Breadboards and bread-board wires
6	Pin-headers and connectors
7	Wire wrap tools
8	Low voltage transformers (110 V in, 3 ~ 24 V out)
9	115 V/115 V, 175 VA isolating transformer
10	60 A, 2P breakers (15 units)
11	63 A, three-phase breakers (3 units)
12	100 A, three-phase breakers (4 units)
13	220 V autotransformers (3 units)
14	Universal programmer

### 3.17 GENERAL-PURPOSE TOOLS

General-purpose tools available in LIPE are listed below:

Index	Description
1	"X-TRONIC" model 4010-XTS - 4000 series (soldering station)
2	Drill set
3	Screw driver set
4	Wrench set
5	Glue gun and glues



# 4 | SIGNATURE

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### 4.1 PROCEDURE

In order to receive a key to LIPE and beginning to work, you need to confirm that you have read and understood the rules mentioned here and other WSU safety regulations and you agree to follow them.

### 4.2 CONFIRMATION

I, the undersigned, have read and understood this lab manual and will comply with it. I have received the key to LIPE and will return it once I am done with my experiments or leave WSU.

---

**FULL NAME**

---

**SIGNATURE**

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**DATE**