Electrical Safety Plan

This plan establishes rules for both the design and operation of the LPRDS-ETS. These rules are intended to enhance the safety of the participants in the initial project and future users or developers.

1 General Responsibility

1.1 Participants

1.1.1 All participants in the LPRDS-ETS project and all spectators will abide by the guidelines of this safety plan, the Lafayette College Department of Electrical and Computer Engineering Laboratory Safety Policy, and the Lafayette College Public Safety Electrical Safety Program.

1.1.2 Any **immediate safety hazard** must be reported to the Lafayette Department of Public Safety, **dial 4444 from any campus phone or call 610-330-4444.**

1.2 Documentation

1.2.1 This safety plan and all approved safety procedures will be archived on the course website; a hardcopy of each approved safety procedure will also be stored in a Safety Procedure binder in AEC Room 401.

1.3 Lockout/Tagout

1.3.1 All High Voltage systems and sub-systems (see 2.1.1 below) are subject to the Lockout/Tagout requirements of the Lafayette College Public Safety Electrical Safety Program. For definition of High Voltage see section 2.1.1.

1.3.2 Only qualified individuals are permitted to lockout or tagout a High Voltage electrical circuit.

1.3.3 Lafayette students are not qualified individuals for the lockout/tagout of High Voltage systems or sub-systems.

1.3.4 Before energy is restored to a locked out system, a visual inspection of the entire LPDRS-ETS-2009 system will be performed and all people in the general area will be advised that energy is to be restored to the system. After a lock is removed, the individual restoring the energy source will announce “all clear” before engaging the energy source. This process is repeated until all sources of energy are restored. After all sources of energy are restored, another visual inspection will be performed on the entire

LPDRS-ETS-2009 system to ensure that no unsatisfactory conditions exist. A minimum of two people are required to be present when a lock is removed and an energy source is restored. One person must be outside of AEC Room 401 and have a clear line of sight to the person restoring the power; this person is designated as the "safety watch". The safety watch must have a working cell phone in their possession when energy source is restored.

1.4 Safety Interface

1.4.1 After successful testing of the Safety Interface, it may not be modified or defeated in any way for any period of time without written permission of the ECE Director of Laboratories.

2 Design Requirements for Safety

2.1 High Voltage (HV) Isolation

2.1.1 High Voltage is defined as any system (individually or in series) containing or producing a voltage greater than 30V.

2.1.2 There must be no connection between enclosures (or any other conductive surface that might be inadvertently touched by a team member or spectator), and any part of any HV circuits.

2.1.3 HV and low voltage (LV) circuits must be physically segregated: never run through the same conduit.

2.1.4 Where both HV and LV are present within an enclosure, the circuits must be separated by insulating barriers such as Nomex, Formex, or other moisture resistant, UL recognized insulating materials.

2.1.5 If both HV and LV are on the same circuit board, they must be on separate, clearly defined areas of the board.

2.2 Low Voltage (LV) Circuits

2.2.1 Low Voltage is defined as any system (individually or in series) containing or producing a voltage less than or equal to 30V.

2.2.2 Low Voltage circuits must be grounded to the frame of the enclosure and to building safety ground. (This ensures that, in the event of a fault in the isolation of the HV circuit, no HV will be present between controls or anything else that personnel might touch and the frame.)

2.2.3 If a battery or other source that is not inherently current limited powers the low-voltage circuits, proper fusing must be used.

2.2.4 Low-voltage and HV circuits must be segregated and isolated as described in section 2.1.3 through 2.1.5.

2.3 Maximum Voltage

2.3.1 Voltage potentials between any two points in the design may not exceed 600V.

2.4 HV Insulation, Wiring and Conduit

2.4.1 All insulation materials used in HV systems must be rated for the maximum temperatures expected. Insulated wires must be commercially marked with a wire gauge, temperature rating and insulation voltage rating. Other insulation materials must be documented.

2.4.2 All HV wiring must be done to professional standards with appropriately sized conductors and terminals and with adequate strain relief and protection from loosening due to vibration etc.

2.4.3 All HV wiring that runs outside of electrical enclosures must be enclosed in orange nonconductive conduit, such as Electri-flex LNMP or equivalent. The conduit must be securely anchored at least at each end, and must be located out of the way of possible snagging or damage.

2.5 Fusing

2.5.1 All electrical systems (both low and high voltage) must have appropriate overcurrent protection. Any wiring protected by a fuse or circuit breaker must be adequately sized and rated for current equal or exceeding the protection.

2.6 External Heat Sinks

2.6.1 All external heat sinks must be securely grounded.

2.7 Ground Fault Detector

2.7.1 The system requires a Ground Fault detector. This can be a Bender IR486, IR475LY, or equivalent, and must be explicitly approved by Senior Management.

2.7.2 The output relay of this device must be wired in series with the shutdown buttons such that a ground fault will cause an immediate shutdown of all HV electrical systems.

2.7.3 The ground fault detector will be accessible, or have a remote LED indicator to show when it is tripped.

2.7.4 Senior Management will test the ground fault detector before the RPI or ESS can be energized. This shall be done by connecting, a 40,000 Ω resistor between multiple points on the HV circuit and the grounded chassis, building safety ground, or enclosure with the HV systems at full charge. This must cause the Ground Fault detector to trip, and all electrical systems to shut down safely in a fault condition. The fault must be logged by the SCADA. Also see section 3.1 High Voltage System Seals.

2.8 No Exposed Connections

2.8.1 No HV connections may be exposed. Non-conductive covers must prevent inadvertent human contact. This would include team members working on or inside the system.

2.8.2 All HV connections must be in plain sight. There will be no HV connections behind any demonstration display, maintenance interface switch, or control panels.

2.9 Controls and Isolation

2.9.1 All controls, indicators, and data acquisition connections must be isolated using optical isolation, transformers or the equivalent.

3 Safety Procedures for Hands-On Work

3.1 High Voltage System Seals

3.1.1 Seals will be placed on HV enclosures by Senior Management after Senior Management observes satisfactory completion of the ground fault detector test.

3.1.2 HV seals must be present and unbroken before operation can be permitted.

3.1.3 The number and location of the HV seals will be recorded as an addendum to this document.

3.1.4 HV seals may not be broken except when permitted by Senior Management.

3.1.5 If the seals are broken, the system will be locked out and may not be re-energized until the ground fault test has been satisfactorily re-done. (If a repair is simple, and done in the presence of Senior Management, Senior Management may choose to waive the retesting requirement.)

3.2 Charging Equipment

3.2.1 All charging equipment must be maintained in safe working condition.

3.2.2 High Voltage chargers and/or power supplies must be marked with appropriate High Voltage stickers.

3.2.3 All purchased chargers must be UL (Underwriters Laboratories) listed.

3.2.4 The system must be de-energized while charging from external sources (as much as possible while still allowing charging), and no other activities (including any mechanical or electrical work) shall be allowed.

3.3 Batteries

3.3.1 All batteries will be handled and disposed of in accordance to the MSDS sheets provided for by the battery manufacturer.

3.3.2 Any group or team member that develops a system or sub-system that includes batteries must develop a safety plan to include fire extinguishers that are sized and rated to handle a potential battery fire.

3.3.3 When the type and quantity of batteries is specified, a letter of awareness will be sent to the Lafayette Department of Public Safety to inform them of the nature and location of the batteries.

3.4 Sub-Systems and Additional Safety Procedures

3.4.1 Any group or team member that develops AC RMS or DC potential differences of greater than 30 Volts between any two points within the design must develop a safety procedure that will ensure the safety of all participants.

3.4.2 Any use and design that includes lasers >= 5mW will require safety procedure that will ensure the safety of all participants.

3.4.3 Any group or team member that involves RF power of any level must submit an RF analysis document that ensures all participants are not exposed to RF in excess of the recommended exposure limits adopted by

the FCC. If project requirements necessitate radiated RF power in excess of 100 mW, a safety procedure must be developed.

3.4.4 Any safety procedure required by section 3.3 must be approved by the ECE Director of Laboratories *before* the circuit is energized. All approved safety procedures will be archived on the course website; a hardcopy of each approved safety procedure will be stored in the Safety Procedure binder in AEC Room 401.

4 Reporting and Consequences

4.1 Reporting of Safety Violations

4.1.1 Any individual observing the violation of a safety plan directive is required to report the act to Prof. C. Nadovich and Dr. W. Jemison as soon as possible. If the safety violation presents an immediate hazardous condition, report the condition to Lafayette Public Safety immediately: dial 4444 from any campus phone or call 610-330-4444.

4.1.2 Consequences for violation may include a reduction in the course grade or failure for the course. Consequences for egregious violations to this safety plan may be subject to Lafayette College disciplinary procedures and applicable local, state, and federal laws.

5 Acknowledgement of Understanding of the Electrical Safety Plan for the LPRDS_ETS

In case of emergency dial 4444 from any campus phone or call 610-330-4444.
I have read and understand the Electrical Safety Plan for the LPRDS-ETS and agree to abide by the rules set forth in that document.

_____
signature

_____
printed name

_____
date

Emergency Contact Information:
In the event of an emergency, contact the person listed below:

_____ _____
name phone