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LSST Summit Electrical and Control Systems Standards

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Summary This document describes the standards to be followed when designing electrical, electronic, safety interlocks and control systems for use in the LSST summit facility.

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OMW	8/23/2011	Added standardization of units using SI.

Contents

1 Overview

This document describes the Large Synoptic Survey Telescope (LSST) standards used for the design and fabrication of electrical, electronic and control system modules for use at the summit location for both: internal projects and external contracts.

The objective is to convene in one document the essential information regarding electrical, electronic and control system standards adopted by LSST. This is for system designers to have an overall view of the provisions to be taken in account for their system design to operate in harmonious coexistence with other systems. This document also takes in consideration national and local standards for compliance with existing laws and regulations, and to ensure the corresponding requirements are implemented accordingly.

These standards apply to the design, fabrication, commissioning and operations of all electrical and electronic equipment and their integral control systems, in particular control panel design, safety mechanisms and wiring. Troubleshooting, maintenance and upgradeability shall be kept in mind at all times while complying with the above.

2 List of References

Document No.	Title	Author
LTS-52	Summit Support Facility Electrical Requirements	O. Wiecha
LTS-54	LSST Summit Environmental Conditions	J. Sebag
LTS-98	LSST Summit Control Panel Manufacturing Guidelines	O. Wiecha
LTS-99	LSST Summit Safety Interlock System	O. Wiecha

3 Control System

The LSST control system follows a very modern and straightforward distributed architecture where the Observatory Control System (OCS), the Telescope Control System (TCS) and all Node Controllers exchange information through a Data Distribution Service (DDS) over Ethernet - see Figure 1.

Adding a new subsystem implies in the corresponding Node Controller being able to communicate with the DDS to send and receive control parameters and other pertinent information. The link between Node Controllers and their respective sensors and actuators is left open to the subsystem designer to specify based on performance and component availability.

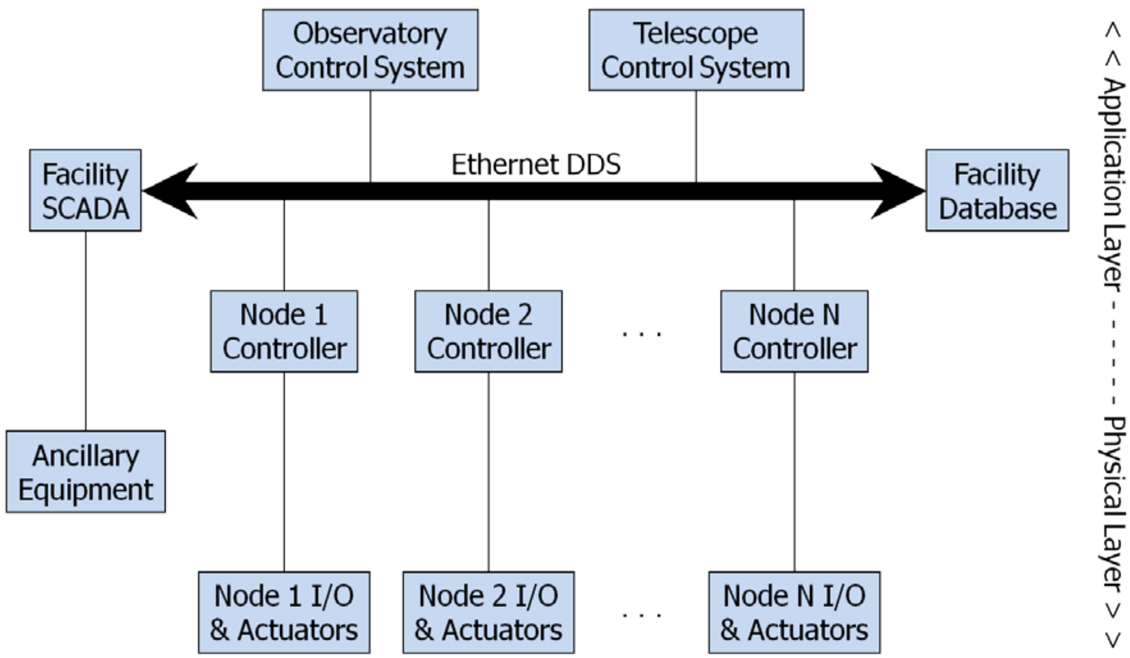

Figure 1: Basic Block Diagram of LSST Control System

3.1 Communications Standards

As a state of the art distributed control system, LSST is deploying a facility-wide gigabit Ethernet network for interconnecting computers, process controllers, sensors and any other devices requiring digital communications. Ethernet is based on the IEEE 802 series of standards and it is generously distributed throughout the facility as the primary communications protocol. When the use of Ethernet is not possible for reasons of availability, practicality or performance, other communications buses can be used instead and shall be converted into Ethernet before they reach the upper layers of the control system.

For systems requiring deterministic communications using real time Ethernet, there is no preferred standard as there are many competing solutions and their availability is rather application oriented. Predicting the future of any communications standard is not an exact science, nevertheless this may be the weakest point of a subsystem if the chosen real time Ethernet flavor is phased out and replacement parts quickly become unavailable or software drivers stop being developed.

3.2 Middleware

For a node controller to interact with the TCS over the Ethernet it shall be able to interpret and assemble the command and data packets (messages) that constitute the protocol used by the communications layer software called middleware.

3.3 Safety System

For application of safety system standards refer to document LTS-99 “LSST Summit Safety Interlock System” stating the standards and procedures to be followed for hazard analysis and physical implementation of active safety measures and global safety interlocks.

4 Power and Grounding

Document LTS-52 “Summit Support Facility Electrical Requirements” describes the LSST electrical system in detail as well as interface issues. Commercial power delivered to the site is backed up by a fossil fuel power generator - see Figure 2. Large loads tolerant to voltage oscillations are fed directly from the automatic transfer switch. For feeding critical loads and loads sensitive to power quality issues there is a large uninterruptible power supply (UPS) for power conditioning and also to guarantee continuous supply of electricity to mission critical systems. The primary substation voltage is 400Y/230 V, TN, 50 Hz Chilean standard. Frequency conversion is unnecessary and every piece of equipment should be capable of operating at the local power grid frequency.

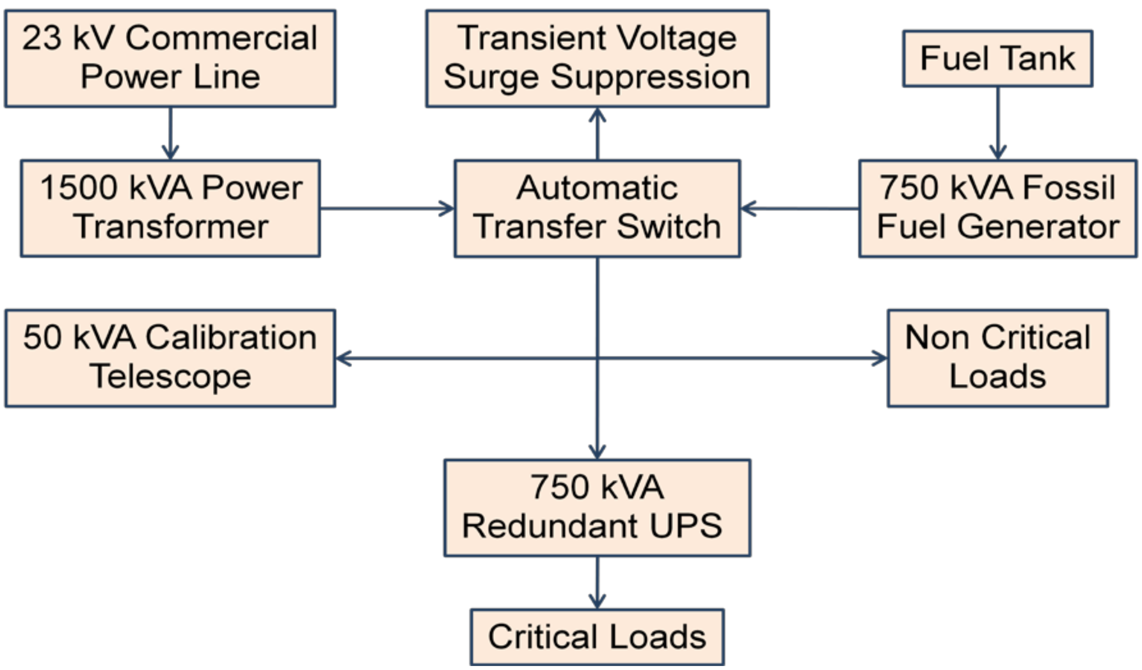

Figure 2: LSST Power Distribution Diagram

Chilean standard electric power will be available throughout the facility, telescope mount and dome. Systems requiring large amounts of power will have dedicated power feeds installed at a nearby location. Dedicated ground pigtails will be available for all major subsystems. Instrument grounding is available at each power distribution panel for use as required.

By the nature of the commercial power delivery system, located at the end of a long, medium voltage power line, power quality is a major concern for all users at Cerro Tololo and Cerro Pachón. The large facility UPS at LSST with low harmonics and active power factor correction will very much contribute to presenting LSST as an "ideal load" to the power grid. Other large power consumers within the LSST facility not fed by the facility UPS are also required to be equipped with means to avoid large inrush currents and harmonic content. This can be achieved by the use of modern variable frequency drives (VFDs), which also bring a huge benefit in keeping the power consumption of large motors at a minimum, reducing motor heating and heat dissipation to the environment.

5 Panel Manufacturing

This very important subject, which involves most of the topics here discussed, is described in LSST document LTS-98 "LSST Summit Control Panel Manufacturing Guidelines". It was developed to cover all pertinent issues in more detail, listing requirements particular to LSST.

5.1 Environmental Conditions

Environmental conditions found at LSST summit location are described in document LTS-54 "LSST Summit Environmental Conditions".

5.2 Power Supplies

Power supplies deserve special consideration because they easily may become the Achilles heel of any system if attention is not paid to a few basic factors. First of all power supplies shall be able to operate not only at the nominal input voltage and power grid frequency, but also at a range of voltages and frequencies determined by the oscillations of the power grid. Except for large power consumers like chillers, compressors and alike, most systems at the LSST summit facility will be served by a large, dual on line UPS with output voltage stability typically in the order of ±1%. In those cases where loads are fed directly from the commercial power grid, power supplies will see voltage variations in excess of ±5%. Another factor to be accounted for is altitude, which significantly changes the thermal characteristics of the surrounding air and altitude derating must be considered. Last but not least, power supplies may be installed in close proximity to electrically noisy loads, which may in turn cause additional stress to the input stage of the power supplies, and surge protection may have to be added. It is highly recommended to use good quality industrial grade power supplies made to withstand input voltage variations as high as +10%, -15% and frequency oscillations of ±5%, conditions usually found when operating under emergency generator power. All power supplies below 42.4 V peak shall be SELV and/or PELV certified, and additionally all power supplies used in control panels shall be UL 508 listed. Computer power supplies shall be 80+ certified.

5.3 Wiring and Connectors

Equipment wiring is discussed in LSST document LTS-98 "LSST Summit Control Panel Manufacturing Guidelines". NFPA 79 Electrical Standard for Industrial Machinery and UL 508A

Industrial Control Panels Standard – parts related to facility wiring can be found in NFPA 70 (NEC). UL 758 Standard for Safety of Appliance Wiring Materials governs the different aspects of wire construction and suitability for different applications. Equivalent international standards specifying metric wire sizes are acceptable as well. Whenever possible, wires and cables should be terminated with connectors, terminals or ferrules for long life, ease of maintenance and improved reliability. Most standards used for industrial connectors and particularly their related tooling are issued by the *Deutsches Institut für Normung*, most commonly known as DIN, establishing parameters for application of crimped connectors and their quality control.

6 Electromagnetic Compatibility (EMC)

The LSST facility carries a large amount of electronic instrumentation for control and scientific purposes. There are also a number of very likely sources of EMI namely variable frequency drives (VFDs) and large loads using power converters. All electromagnetic emissions caused by electronic equipment shall be kept within the limits established by FCC Rules and Regulations, Title 47, Part 15, Subpart B, Class B or IEC standard CISPR 22 Class B. Although this is usually known as "home environment", it is more stringent than class A: "industrial or business environment". This requires all electromagnetic radiation emitting equipment, notably VFDs, to be installed inside metal cabinets. Wiring to loads being controlled by power conversion devices shall be shielded.

As for immunity to EMI, all electronic equipment shall withstand electromagnetic radiation within the limits established by FCC Rules and Regulations, Title 47, Part 15, Subpart B, Class A or IEC standard CISPR 22 Class A, which describes "industrial or business environment". The reason for this apparent disparity between classes for emission and immunity to electromagnetic interference is because electromagnetic radiation from different sources can add up in much unexpected ways, in particular given the amount and diversity of electrical and electronic equipment in a facility of this nature. Fortunately in most cases the solution is restricted to the use of metal enclosures and shielded wiring.

7 Controllers

The large amount of equipment with distinct functionality required to operate the LSST facility is expected to be sourced from a variety of vendors. As such it is not practically feasible to demand the use of specific control hardware, except that any device requiring communicating with the TCS shall do it directly. The use of protocol and/or media converters is acceptable, but adding a duplicate of an entire control system built with different hardware just for the purpose of making it compatible with the LSST middleware is not acceptable. In such cases it is recommended to simply incorporate a PC compatible miniature industrial computer to perform the function of communications interface, and for all purposes act as protocol converter. In any case controls equipment should be chosen also taking in account compatibility with IT equipment and technologies used by other LSST systems.

8 Testing and Certification

For the most part, electrical equipment built with certified components used as intended only need to demonstrate their functionality and get evaluated for EMC. Testing shall be performed before shipping the equipment to site except when agreed otherwise. In general, testing procedures must be conducted under maximum load and in similar site conditions. Certification shall be sought for any personnel safety system built with non safety-rated components. Instrumentation used to demonstrate critical qualities of the equipment shall have current calibration certificate.

9 Environmental Responsibility

LSST is an environmentally conscious project, looking to cause minimum interference with the natural environment. This also relates to materials used in the construction of all kinds of equipment including serviceable parts and consumables. Equipment vendors shall provide material safety data sheets (MSDS) of any hazardous substances encountered in their equipment and instructions of how to dispose of them in a safe way. Directives similar to the Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) are slowly but surely being introduced in different countries at different pace, and Chile is no exception. RoHS rated components shall be the preferred choice whenever available.

10 Documentation

Documentation shall be made available illustrating the essential steps for proper installation and maintenance of the equipment and related software if any. Parts list and calibration procedures must be included for specialized maintenance personnel to perform necessary adjustments or replacement of components.

ANSI standards are the primary standards to be followed when producing any kind of documentation. However, because part of the documentation may be already preexisting, and most documentation is created by means of CAD programs with predefined libraries, other standards are also acceptable as long as a list of symbols and their description is provided.

Electrical and control system drawings, including their screen version, shall be produced on clear background so they are indistinguishable from the printed version (WYSIWYG) – old style CAD drawings with black background screens are not acceptable.

The documentation shall contain all the necessary information for installation, commissioning, troubleshooting and operations. When adjustments or calibration are necessary, a procedure for doing so shall be included. Replacement of parts requiring partial or total disassembly of a device shall be described in detail.

All documentation shall be delivered at least in electronic form in PDF format; nevertheless the original editable files are always preferred.

11 Units

For standardization purposes the LSST Project has elected to adhere to the metric system and use the international system of units (SI) to express all magnitudes used in all aspects of the design and construction of the telescope like support facility, mount, instruments, control and utility systems. This doesn't preclude from using materials and components made in imperial units as long as dimensions, weight, gage, etc. are expressed in metric units.

The US National Electrical Code (NFPA70) is already metric and provides information about how to reference electrical materials in metric units. For further information about the SI see NIST special publications 330, 811 and 1038.

12 Applicable Standards

12.1 Chilean Standards in Alphabetical Order

- NCh Elec 4/2003, Instalaciones de Consumo en Baja Tensión

12.2 International Standards in Alphabetical Order

- IEC 60617 – Graphical Symbols for Diagrams
- IEC 60204-1:2009, Safety of machinery — Electrical equipment of machines – Part: 1 General requirements
- IEC 61000-6-2, Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
- IEC 61000-6-4, Electromagnetic compatibility (EMC) – Part 6: Generic standards – Section 4: Emission standard for industrial environments
- ISO 10218-1, Robots for industrial environments – Safety requirements – Part 1: Robot (includes Technical Corrigendum 1)
- ISO 9283:1998, Manipulating industrial robots – Performance criteria and related test methods
- ISO 13849-1:2006, Safety of machinery — Safety-related parts of control systems – Part 1: General principles for design (includes Technical Corrigendum 1)
- ISO 13849-100:2000, Technical Report – Safety of machinery – Safety-related parts of control systems – Part 100: Guidelines for the use and application of ISO 13849-1
- ISO 13849-2:2003, Safety of machinery — Safety-related parts of control systems – Part 2: Validation
- ISO 13850:2006, Safety of machinery – Emergency stop – Principles for design
- ISO 13855:2002, Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body
- ISO 14121-1:2007 Safety of machinery — Risk assessment – Part 1: Principles
- ISO 14121-2:2007 Safety of machinery — Risk assessment – Part 2: Practical guidance and examples of methods

12.3 U.S. Standards in Alphabetical Order

- ANSI 315-1975 & 315a-1986 Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)
- ANSI/ASSE Z244.1, Control of Hazardous Energy – Lockout/Tagout and Alternative Methods
- ANSI/ISO 12100-1:2007, Safety of machinery — Basic concepts, general principles for design – Part 1: Basic terminology, methodology
- ANSI/ISO 12100-2:2007, Safety of machinery — Basic concepts, general principles for design – Part 2: Technical principles
- ANSI/RIA R15.06-1999, Industrial Robots and Robot Systems – Safety Requirements
- ANSI/RIA/ISO 10218-1-2007, Robots for Industrial Environment – Safety Requirements – Part 1 – Robot
- NFPA 70: National Electrical Code 2011
- NFPA 70B: Recommended Practice for Electrical Equipment Maintenance
- NFPA 70E: Electrical Safety in the Workplace
- NFPA 72: National Fire Alarm Code
- NFPA 75: Standard for the Protection of Electronic Computer/Data Processing Equipment
- NFPA 77: Recommended practice on Static Electricity
- NFPA 79: Electrical Standard for Industrial Machinery
- NFPA 780: Standard for the Installation of Lightning Protection Systems
- OSHA Part 1920 of Title 29 of the Code of Federal Regulation: Safety Standards for Machinery
- RIA TR R15.206-2008, Technical Report for Industrial Robots and Robot Systems – Safety Requirements – Guidelines for Implementing ANSI/RIA/ISO 10218-1-2007
- UL 508: Standard for Industrial Control Equipment
- UL 508A: Standard for Industrial Control Panels
- UL 508C: Standard for Power Conversion Equipment
- UL 924: Standard for Emergency Lighting and Power Equipment