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SECTION E.3.1 LOW VOLTAGE SERVICES – SCHEDULE OF CHANGES

As a guide only, attention is drawn to changes that have been made in the following clauses since the last revision:

Revision	Clause	Date
	General Revision	
4	E.1.1.7	August 2004
4.1	E.3.1.2 MCC section reinstated	November 2005
5	General Revision	February 2014
5.1	E.3.1.2 Metering	May 2014
6	General Revision	April 2018

E.3.1. LOW VOLTAGE

E.3.1.1. Electricity Supply

General
The UNSW Kensington Campus power supply is provided from the 11 KV distribution system which is owned and operated by the UNSW.

The 11kV power is distributed around the campus via four rings, to over 25 substations where the voltage is stepped down to 415 V AC and distributed to the main buildings and points of consumption.

The LV power supply on UNSW Kensington campus is as follows:

Nominal supply voltage	415/240 V AC
Number of phases	3
Frequency	50 Hz
Number of wires – system	4
Neutral connection	MEN

E.3.1.2. Metering

The university has an extensive campus-wide Energy Management and Control System (EMACS) comprising of several digital meters located on both HV and LV circuits.

The HV electricity meters are installed within the 11kV main intake substations and are used to measure the consumption and demand of electricity from the Ausgrid 11kV network as well as to monitor the power flow through the UNSW 11kV rings.

The LV electricity meters are generally installed on the LV consumers mains within the LV section of the substations and on selected submains within LV main switchboards and are used to monitor the consumption and demand of electricity within the UNSW LV network. These are remotely monitored via a purpose-built communications network.

All new metering arrangements shall comply with the requirements of the UNSW Design and Construction Specifications, Appendix 7- UNSW Energy Management Metering Requirements.

Appendix 7 of the UNSW Design and Construction Specifications covers the following topics:
• Documentation, Approvals and Checklists for new installations and changes to existing meters or the metering network architecture.
• Meter Data Communications Network
• Electricity Meters
• Water Meters
• Gas Meters

Design planning and coordination discussions with UNSW EM Energy Management representatives shall take place at an early stage.

E.3.1.3. Photovoltaic Installation

All new PV installations shall comply with the requirements of the UNSW Design and Construction Specifications, Section E3.5 – Photovoltaic Systems.

E.3.1.4. Main Switch room

General

Switch rooms shall be designed to allow adequate clearances for maintenance and egress around equipment and switchgear as per the AS/NZS 3000 requirements

Smoke detectors and appropriate fire extinguishers shall be installed in all switch rooms. The smoke and thermal detectors shall be connected to an alarm system that contains voltage free contacts for connection of alarms to the BMS system via the local PLC.

A local bell alarm shall be installed to indicate the operation of a detector.

The switch rooms shall as a minimum cover the following items:

a) Entry door(s) suitably labelled.
b) Emergency and exit lighting.
c) Clearance around switchboards.
d) Switchboards are clearly identified.
e) MEN point(s) and main earth labelled.
f) Technical earthing system for research building
g) Consumer mains/busway correctly supported.
h) Cable support system adequate.
i) Location indicated at main entrance(s)

UNSW EM Engineering has learned from experience that the risk of fire because of the Power Factor Correction (PFC) capacitor failure and ignition is very high. Therefore UNSW EM Engineering prefers that the PFC equipment is not installed in the same room as the Main Switchboard.

The PFC equipment shall be installed outside the Main Switch room, in a separate fire rated room, well ventilated to ensure internal cabinet temperature rise does not exceed the manufacturer's recommendations.

E.3.1.5. Switchboards & Switchgear

E.3.1.5.1. Main Switchboard

General
The main switchboard shall be the product of a well-established switchboard manufacturer and shall be specified as a custom-built switchboard and designed to either AS/NZS 3439 series or AS/NZS 61439.2016 which will supersede the AS/NZS 3439 series five years from the date of publication.

The switchboard shall be segregated (as a minimum) into the following sections and circuits:

a) Essential Services
b) Non-Essential Services
c) General Lighting and Power
d) Life Safety
e) Plant, Equipment and Process Heating

Each circuit shall have a minimum of 30% minimum spare capacity for space and maximum demand.

The switchboard shall be of the dead front, totally enclosed type and shall have a degree of protection of IP 56 for external use.

The switchboard is to be floor mounted on a galvanised steel plinth.

The switchboard shall incorporate an earth bar and a neutral link.

Protective devices shall be interconnected by a three-phase busbar assembly that is independently supported off the switchboard enclosure.

Pay attention to cabling space around the circuit breaker assembly, and Current Transformers.

Space around Current Transformers for any maintenance or replacement shall be included.

The switchboards shall be of a modular layout having sections of standard current rated functional units related to the main busbar and busbar dropper systems in a regular fashion. The design shall be the same as a type of switchboard that has been verified as complying with the type tests specified in AS/NZS 3439 the switchboard be a TTA.

Type test certificates shall be submitted with details of the equipment tested by an approved Testing Authority. The manufacturer of the type-tested equipment shall be the manufacturer of the proposed equipment.

Should the type test documents not be available, or be inappropriate to the actual design, submit the switchboards for type testing by a NATA approved Testing Authority at no cost to the Principal and within the construction program for the contract.

The Project Officer shall be notified in writing of the name of the proposed manufacturer of switchboards before any work or drawings are commenced.

The manufacturer shall provide the UNSW the Temperature rise requirement stated in AS/NZS 3439 prior to any work being started.

Operating Conditions
The switchboard shall comply with the requirements of AS/NZS 3439 with the following specific Conditions of Operation to appendix BB:

a) Supply is 415/240V, 3-phase, 4-wire, 50 Hz, MEN solidly earthed.
b) Control circuit voltage is 240V.
c) Minimum fault level of the assembly shall be:
    - 63 kA r.m.s. symmetrical
    - 95 kA peak minimum
d) Space available: 30%.
e) Segregation required is form 3b.

Preferred method of connection of equipment is Front connected (unless otherwise approved by UNSW EM Engineering).

Automatic power factor correction brand shall be supplied, (Note: protection against capacitor damage by harmonics is required).

Front connected provisions (unless otherwise approved by UNSW EM Engineering).

a) Provision for connection of stand-by generator.
b) Provision for connection of a mobile generator set.
c) Type tested design to AS/NZS 3439.
d) Preferred arrangement is in line.

e) Rated short time withstand current of bus-bars required is 63 kA r.m.s. for one second.

f) Diversity factor for load circuits is as per Table 1, AS/NZS 3439.

g) Degree of protection is IP43 for interior or IP56 for external usage.

h) Form of segregation required is Form 3b.

f) Possible future extensions are from one end.

g) Service and Installation Conditions Not exceeding the limits of clause 6.1, AS/NZS 3439.

h) Switchboard safety measures shall be by mechanical means *(AS/NZS 3439 clause 7.4.2.2 Protection by barriers or enclosures)* including mechanical interlocking of doors and access by tool rather than key.

i) Graded protection (upstream & downstream).

j) Full sized neutral.

k) The switchboard shall be insect and vermin proof.

l) The switchboard shall be finished Orange external; White internal.

m) The switchboard shall be mounted on or incorporate a 100 mm high galvanised steel plinth.

Submit detailed drawings, including single line diagram, of the main switchboard to the Supply Authority for approval prior to manufacture and co-ordinate the Supply Authority during the inspection of the completed switchboard to ensure compliance with their requirements.

Switchboard Configuration
The items described herein shall be included in the design, manufacture and installation of all switchboards.

UNSW EM Engineering must be given notice in writing of the name of the proposed manufacturer of the switchboard(s) before any works and/or drawings are commenced.

Conduits and ducts shall be securely attached to the switchboard/s utilising pre-punched conduit knockouts or removable gland plates.

Where space is provided for future breakers, fuses, etc., the switchboard/s shall be fitted with the necessary bus-bars and connections to facilitate the future fitting of additional equipment without disturbance to the existing installation. Where this involves provision of unused lengths of bus-bar, this bus-bar shall be adequately supported. The escutcheon (if any) shall be cut for the future equipment and suitable filler pieces provided.

Equipment shall be firmly supported, symmetrically and neatly mounted and all wiring shall be neatly run and supported.

Connections between various pieces of equipment shall be copper bus-bar.

Terminate all incoming and outgoing cables using crimp type cable lugs or tunnel type terminals.

Doors shall be dust sealed by neoprene gaskets and ventilation openings shall be gauze screened to prevent dust and insect entry.

Doors and escutcheon panels shall cover all front adjustable settings of circuit breakers, relays and contactors.

Escutcheon panels should be hinged where possible and shall be fixed in place with a fixing which can be undone without the use of tools.

Where multiple conduits and/or ducts, which would otherwise be visible, enter a wall-mounted switchboard they shall be covered by a removable sheet metal panel folded and finished to match the switchboard. Alternatively, approved timber panels may be installed.

Cables and conduits run from the top and bottom of the switchboards to the floor slab below and ceiling space above shall be enclosed in neat metal duct. Ductwork shall be not less than 1 mm thick in any case.

Metal ducts shall be zinc anneal of suitable thickness and painted. Pop rivets shall be used for all joints.

Where conduits or ducts required to be concealed enter a wall-mounted switchboard they shall enter the switchboard through a metal box recessed into the wall and located behind the board.

Wall mounted switchboards shall be mounted approximately 2m from top of board to floor.

E.3.1.5.2. Mechanical Control Centre Board (M.C.C)

General

The switchboard shall be the product of a well-established switchboard manufacturer and shall be of the dead front, totally enclosed type. (See also clause "Main Switchboard General").

Modular switchboard configuration will not be accepted.

The switchboard shall have a degree of protection of IP43, for interior use and IP 56 for external use.

Protective devices shall be interconnected by a three-phase busbar assembly that is independently supported off the switchboard enclosure.

Pay attention to cabling space around the circuit breaker assembly, and Current Transformers.

Space around Current Transformers for any maintenance or replacement shall be included.

The switchboards shall be of a modular layout having sections of standard current rated functional units related to the main busbar and busbar dropper systems in a regular fashion.

The design shall be the same as a type of switchboard that has been verified as complying with the type tests specified in Section 8 of AS/NZS 3439.

UNSW EM Engineering must be given notice in writing of the name of the proposed manufacturer of the switchboard/s before any works and/or drawings are commenced.

The Manufacturer shall provide the Temperature Rise requirement stated in AS/NZS 3439 to UNSW EM Engineering prior any work start.

The switchboard shall comply with the requirements of AS/NZS 3439 with the following specific Conditions of Operation *to* appendix BB:
All MCCB should have true RMS monitoring and will be unaffected by harmonics in the system, up to including the 19^{th} harmonic.

Construction

Supply is 415/240V, 3-phase, 4-wire, 50 Hz, MEN solidly earthed.
Control circuit voltage is 240V.
Maximum fault level of the assembly shall be a minimum:
20kA r.m.s. symmetrical.
Space available: 30%.

Segregation required is form 2

The contractor/ shall provide to UNSW EM Engineering all calculations in relation to fault level prior any design, or construction.
Any design/construction of MCC board which has not been accepted in writing by UNSW EM Engineering will be rejected.

Preferred method of connection of equipment is Front connected (unless otherwise approved by UNSW EM Engineering Section).

Preferred arrangement is in line.
Rated short time withstand current of bus-bars required is 20kA r.m.s. for one second minimum.
Diversity factor for load circuits is as per Table 1, AS/NZS 3439.
Degree of protection is IP43for interior or IP56 for external usage.
Form of segregation required is Form 2.
Possible future extensions shall be considered when MCC board is designed.

M.C.C board shall have physical barrier between the isolating unit (circuit protection device) and the main busbar arrangement. Segregation shall, by means of approved sheet metal physical barrier, be installed between all isolating unit/circuit protection/busbar arrangement with control units/stop/start switches and indicating lights.
All equipment mounting cubicles shall be by means of hinged lockable doors.

Full sized neutral.
The switchboard shall be insect and vermin proof.
The switchboard shall be finished Orange external; White internal.
The switchboard shall be mounted on or incorporate a 100 mm high galvanised steel plinth.

Submit detailed drawings, including single line diagram of the switchboard to the UNSW EM Engineering for approval prior to manufacture.

E.3.1.5.3. Switchboard Components

Material

All sheet steel used in the manufacture of the switchboards shall be cold rolled, commercial, bright mild steel, free from rust and blemishes.

All structural sections used for frameworks or supports shall be first grade mild steel, truly straight and shall be thoroughly descaled and degreased. All welds shall be full fillet welds ground smooth and free of weld spatter and wire brushed clean.

Minimum thickness of steel sheets shall be as follows:
For back and sides of cabinets, cubicles, etc. - 1.6 mm.
For front and top -

Diagonal not longer than 600 mm - 1.6 mm.
Diagonal not longer than 900 mm - 2.5 mm.

Steel thickness less than 2.0 mm and 2.5 mm may be used provided the panels are stiffened by dishing, folding or bracing, but only after approval is obtained from the Superintendent.

Interchange ability of parts and equipment shall be maintained wherever practicable. Metal parts shall be machined where necessary for accurate fit and good appearance.

All bolts, screws, etc., whether used in assembling equipment or fixing it in place, shall be galvanised or made from corrosion resistant metal. Where visible on front of panels, they will be chromium plated, not cadmium plating.

Door hinges shall be of a lift-off type and for outdoor applications shall be zinc coated and fitted with hinge pins of bronze or other corrosion resistant material.

Door handles shall be chromium plated and shall incorporate a barrel type lock mechanism

Treatment of Metal Surfaces

The surfaces of switchboard enclosures shall be painted. The colour of finishes shall be as follows:

White enamel internally for both indoor and outdoor application.
Orange enamel externally, colour number X15 to AS/NZS 2700 for indoor application.
Depending on the location, the finish colour of outdoor switchboards to be advised by the UNSW EM Engineering.

Doors shall be dust sealed by neoprene gaskets and ventilation openings shall be gauze screened to prevent dust and insect entry.

Doors and escutcheon panels shall cover all front adjustable settings of circuit breakers, relays and contactors.

Termination and Connection
Switchboards shall be complete with cable terminating boxes/glands mounted to provide ample space for making off the cable terminations; install insulated tails from these terminations to the associated switchgear and fix the tails securely to prevent any displacement.

Switchboards shall be complete with cable lugs mounted on the switchgear studs, bus-bars, extension flags etc. for all connections rated at 200 A and above.

Equipment shall be firmly supported, symmetrically and neatly mounted and all wiring shall be neatly run and supported.

Connections between various pieces of equipment shall be copper bus- bar.

Terminate all incoming and outgoing cables using crimp type cable lugs or tunnel type terminals.

Any incoming existing or new cables running from the top of the switchboards to the floor slab above shall be enclosed within a ductwork. Type of ductwork shall be not less than 1 mm thick in any case and shall be zinc anneal type.

Busbars
Requirement: Busbar circuits within the switchboard, extend from the termination of the incoming unit to the line side of protective equipment for outgoing circuits. The whole busbars installation horizontal, vertical and dropper shall be fully insulated.

Where dual incoming feeds are provided, the main busbar system shall be in two sections with each incoming feed supplying a corresponding bus section. The outgoing circuits distributed evenly between the two sections. A bus section circuit breaker or switch shall be provided so that it is possible to energise both bus sections through one feed only.

***Segregation*:** Where a switchboard requires “essential” and “non-essential” circuits divide the busbar system into separate ‘essential’ and ‘non-essential’ circuits, each segregated from the other by fixed and continuous barriers. Clearly label each segregated section of the busbar system.

***Standards*:** AS/NZS 3768, AS/NZS 3865 and AS/NZS 4388.

Definitions: Busbars connecting incoming terminals to line side terminals of main. Busbars connecting incoming functional unit terminals, or incoming busbars where no main switches are included, to outgoing functional unit terminals or outgoing functional unit tee-offs.

Tee-off busbars: Busbars connecting main busbars to incoming terminals of outgoing functional units.

Material**:** Hard-drawn high-conductivity electrolytic tough pitched copper alloy bars.

Busbar Insulation and Protection: The whole Busbar configuration layout shall be insulated and be in accordance with AS/NZS 3439. Full size neutral shall be installed. The whole busbars installation vertical and dropper shall be fully insulated.

a) ***Type of Insulation***: shall be polythene at least 0.4 mm thick with dielectric strength of 2.5kV rms for I min, applied by fluid bed process in which the material is phase coloured and directly cured on to the bars. Close fitting moulding insulation mouldings at least 1mm thick. Use heat shrink material only around edges of the busbar.

b) ***Taped joints*****:** Apply non-adhesive stop-off type tape, coloured to match adjacent insulation and half lapped to achieve a thickness at least that of the solid insulation.

Neutral busbars and joints: Select from the following:

Polyethylene: At least 0.4 mm thick with dielectric strength of 2.5 kV r.m.s. for 1 min, applied by a fluidised bed process in which the material is phase coloured and directly cured onto the bars.

Close fitting busbar insulation mouldings at least 1 mm thick.

Heat shrink material: Use only on rounded edge busbars.

Taped joints: Apply non-adhesive stop-off type tape, coloured to match adjacent insulation and half lapped to achieve a thickness at least that of the solid insulation.

Temperature Rise Limit
The manufacturer shall provide all Temperature Rise test as designed.
The Manufacture shall provide the Temperature Rise requirement stated in AS/NZS 3439

Main Switches and Isolating Switches
Main switches on main switchboards and isolating switches on distribution switchboards and in other locations shall comply with AS/NZS 1775 and shall be suitable for fault making and load breaking duties. Switchgear and Control Gear Assembly incoming isolators shall have the same fault capacity as the assembly busbar system unless otherwise specified.

Unless otherwise specified, the following requirements shall apply:

- Type of switching shall be independent manual operation.
- Rated duty shall be uninterrupted duty for non-ventilated enclosure.
- Indicated fault capacity refers to the rated short time withstand current.
- Utilisation category shall be AC-23.
- Incorporate a primary indication of the ON and OFF positions.
- Incorporate a secondary indication of the ON and OFF positions on the switch body where the operating handle is not a fixed part of the switch.

Air Circuit Breakers
Air circuit breakers shall be in accordance with AS/NZS 1930; they shall be suitable for operation on 415 V, 50 Hz systems and shall be rated for continuous operation as indicated on the drawings.

Drawings are to be enclosed in the switchboard.

The main incoming ACB shall be capable of withdrawal and interlocked so that withdrawal or reconnection can be done only with the circuit breaker in the open position.

Air circuit breakers shall have the following monitoring system:

a) Single-phase indication selectable for each phase
b) Earth fault current
c) Reverse power indication
d) Line voltage
e) Trip current and operating time
f) Availability of transmitting data to a PC

Molded Case Circuit Breakers
Specify current ratings for all moulded case circuit breakers.

All moulded case circuit breakers within one installation shall be of the same manufacture

The manufacturer shall state the maximum value of current that a circuit-breaker, fitted with a specified overcurrent tripping relay, can carry indefinitely at an ambient temperature without exceeding the specified temperature limits of the current carrying parts.

The size and mounting arrangements shall be such as to permit interchange of single pole and three pole breakers of the same frame size.

Circuit breakers with current breaking capacities of 10 kA and above shall comply with AS/NZS 2184.

Circuit breaker trip ratings shall be labelled or inscribed on the circuit breaker body and shall be clearly visible with the switchboard escutcheon cover in place.

Load-break and switch fuses, motor isolators, fuses.
All load-break & combination switch fuses should be of robust quality design and construction and be tested according to IEC947-3.

They should be designed to perform as switch disconnectors, motor circuit switches with AC ratings up to 1000 volts, main switches, local safety isolators and bus ties.

They should be pad-lockable in the off position and when in this position, both sides of the fuse link (in the case of switch fuse units) shall be isolated. Switch fuse 32 A and greater, and load-break switches 45 A and greater shall have positive drive contact position indication and quick-make/quick-break mechanisms, independent of the operator's speed.

All switches must provide a high standard of shrouding preferably as standard. Fuse shrouds on switch fuses shall be integral and hinged to avoid misplacing when fuses are changed.

All line and load terminals shall be able to be shrouded to avoid accidental touch to a protection rating of IP 20. Unshrouded conductors on the front of the switch are unacceptable.

They shall be Stromberg OT, OETL or OS, OESA Series or approved equal.

Operational Durability
Mechanical endurance shall conform to the following figures as a minimum.

Switch fuses

up to 160 A	20,000 operations
200 A to 400 A	16,000 operations
630 A to 800 A	10,000 operations

Load break

up to 160 A	20,000 operations
200 A to 400 A	16,000 operations
400 A to 800 A	10,000 operations
1000 A to 1600 A	6,000 operations
2500 A to 3150 A	1,200 operations

Enclosed Motor Isolators

All enclosed motor isolators shall have published AC23 kW ratings and shall conform to the following standards; IEC 947-3, AS/NZS 3947-3.

They should be IP 65 protection rating and be supplied with a safety red and yellow rotary pad-lockable handle. The units should be available in polycarbonate, cast aluminium or sheet steel boxes with interchangeable internal switch components for product compatibility. The switches should be able to accept 2 auxiliary contacts minimum.

The handle and cover positive contact indication of the true position of the contacts. All switches from smallest to “teasing” of the contacts in either direction is not possible. They shall be Stromberg OT/OETL Series, NHP “Isoswitch”, Sprecher + Schuh LY3 Series or approved equal.

Motor Starters and Contactors
Motor starters shall be of the magnetic contactor type, fitted with triple pole double break contacts and thermal overload protection on each pole. Overload protection shall be of the differential single-phase protection type.

Overload protection shall be sized suitable for adjusting the set point sufficiently low enough to test operation.

Under no circumstances will relays be accepted as motor starters or power duty of any kind.

Motor starters and other contactors shall comply with AS/NZS 1029 and AS/NZS 1202 or the equivalent local standard.

Selection of motor starters and contactors shall be according to the duty required. All contactors shall be noise-free when energised.

Relays
All relays shall be plug-in type.
Fit relays with clear plastic dustproof covers that enclose the complete relay.

Use contactors for switching current in excess of 6A. Contactors used as relays shall have clear plastic dustproof covers that enclose the complete assembly. Provide twin contact spring sets for relays used for light duty switching (under 1 A).
Use the constant resistance contact type, e.g. gold contact or reed relays for where relay contacts are to be used for mixed voltages, contacts shall be adequately isolated from each other.
Clearly mark voltage type on each contactor, e.g. 24 V.D.C, 240 V.A.C.

Switches
For Mechanical Services and Hydraulic Services control systems, all manual switches except main switches shall be the rotary type suitable for the voltage and current controlled.

Contactors & Overloads
General
Contactors and overloads used in this installation shall be of the same brand and be of consistent high quality. They shall be rated to a minimum 690 Volts and conform to the relevant standards, namely IEC 947 and AS/NZS 3947

Contactors
Where nominated, Type 1 or Type 2 co-ordination shall be demonstrated. Contactors shall be rated to AC 3 switching category at an ambient temperature of 60°C. For contactors above 250 kW, AC 3 ratings at 55°C will be allowed providing operation at 60°C is acceptable with a de-rating of no more than 15% applied.

Contactor Coils
For contactors up to 55 kW standard AC coils are preferred. For contactors above 55kW AC controlled, contactors with DC coil mechanisms shall be used. The DC coils shall be controlled via an electronic circuit to precisely control the pick-up and dropout voltages of the contactor coil. It must not be possible for the contactors to “chatter”.

Maximum pick up power for these contactors shall not exceed 700 VA to minimise burden on the supply. Contactor coils above 250 kW shall have facilities for adjusting the drop out times on loss of supply. The pick-up power shall not exceed 2500 VA. All contactor coils must be accessible from the front of the contactor.
Contactors shall be Sprecher + Schuh type or an approved equal.

Thermal Overloads
Thermal and electronic overloads must be of the same brand as the contactors. For currents up to 90 A, directly heated thermals or electronics can be used. Above 90 A the thermal overloads must be current transformer operated. Electronic overloads can be used providing they comply with clause 5.4.

Thermal overloads must be of the ambient temperature compensated type and for motors above 7.5 kW, must have a differential mechanism for phase loss protection. They shall be provided with a test facility and a N/C and N/O auxiliary contact.
They shall be Sprecher + Schuh type CT 3, CT 3 K, CT 7 or approved equal.

Electronic Overloads
Electronic overloads must be used above 110 kW but can be additionally be used on all drives, where nominated, in place of standard thermal overloads.

Electronic overloads must also be the same brand and manufacture as the contactors for mechanical compatibility. Whenever possible, electronic overloads must be fitted directly to the contactors.

Electronic overloads for drives above 11 kW shall include the following functions and be constructed with integral current transformers:

- 15 selectable trip curves
- Test button
- Current adjustment in 1 A steps
- Optional thermistor relay function
- Tripping cause indication retained on power loss less than 30 minutes
- Remote electrical reset facility
- Phase asymmetry detection

Critical Motor Drives
High level electronic relays shall be used on critical motors and shall be standard on all drives above 350 kW. Such drives must comply with a separate specification written for that purpose and forming part of this set of specifications.

Electronic Motor Protection Unit.
The motor protection units will be required to comply with the following standards and tests:

- Impulse Voltage Withstand to IEC 255.4 Appendix E
- High Frequency Disturbance to IEC 225.4 Appendix E
- Noise Emission to EMC Standard EN 50082-1/2
- Noiseproof to EMC Standard EN 50082-1/2
- Electrical Test
- Motor Circuit to IEC 947-1 Uimp 6 kV
- Control Circuit to IEC 947-1 Uimp 4 kV
- Dielectric to IEC 255.5
- Insulation Resistance to IEC 255.5
- Operating Temperature Range –5 ºC to +60 ºC
- Degree of Protection IP 65

All programmable set points shall be adjusted via a sealed keypad on the front of the unit. Adjustment of the set points via potentiometers or dip switches will not be accepted.

The motor protection set points shall be user selectable and shall have the facility to prevent the operator from changing any set point data.

Motor protection for the following shall be incorporated as standard and shall be user adjustable:

- I^2t thermal protection
- Overcurrent/stall
- Undercurrent (to start over-ride timer)
- Current Unbalance (asymmetry)
- Earth Fault
- Run-up time protection
- Number of starts per hour protection
- Adjustable cooling constant ratio

The motor protection shall be fitted with trip and alarm relays where nominated. Each alarm relay shall be independent of the other and each relay must have programmable set points for the modes of protection. A digital display shall be incorporated as standard for trip indication, alarm indication, read out of set point values, read out of measured values and pre-trip conditions. The alpha /numeric display shall be of English text read-out. Short form code will not be acceptable. Indication of the following functions shall be provided via the digital display;

(i) I^2t thermal capacity
(ii) Motor current in % of full load setting
(iii) Phase current in % for each phase
(iv) Current asymmetry
(v) Earth fault current
(vi) Temperature (PT100) for each sensor input where fitted
(vii) Time to trip and reset after a thermal trip

When a trip occurs, the conditions which caused the trip should be displayed. Other conditions that occurred just prior to the trip should be stored in a non-volatile memory for recall to allow fault analysis, including the last 5 starts and the last 5 trips and their causes.

The set point data, stored and running data and trip indication shall be retained in the event of a loss of power to the motor protection unit, including loss of power elapsed time recorder.

Indication available following a trip shall include:

- Motor current prior to the most recent trip

- Current imbalance prior to the last trip (asymmetry)
- RTD temperature prior to the last trip
- RTD temperature during the most recent emergency thermal reset
- Earth leakage prior to the most recent trip

Communications
Serial communications shall be available via optional plug-in cards for one of the following protocols:
• Modbus

Thermal Magnetic Over-Current Relay
Thermal Magnetic types of MCCB shall be available up to 800 A rating.
All thermal-magnetic MCCBs will have an adjustable rating (I_r) between 63% and 100% of the MCCB nominal rated current (I_n).
Adjustable magnetic (Instantaneous) will be standard on all 400 A MCCBs and above, with a setting range of 5 – 10 x I_n

Electronic/Microprocessor Over-Current Relay
Electronic/Microprocessor type MCCBs will be available in ratings from 250 A to 2500 A. The adjustable ranges should be as follows:

	Current (x I_0)	Time (secs)
Long Time Delay (LTD)	0.8 – 1.0	5 - 30
Short Time Delay (STD) *	2 – 10	0.1 – 0.3
Instantaneous (INST)	3 – 10	-
Ground Fault Trip (GFT)	0.1 – 0.4 In	0.1 – 0.8

* An I^2t Ramp function will be standard, for the purposes of grading with other devices.

Led Indication
LED indicators are to give the type of fault interrupted by the MCCB, namely an overload (LTD), short-circuit (STD/INST) or ground fault (GFT).

Control Wiring
Control wiring shall be stranded conductor of minimum size 7/0.50. TPI. Flexible connections to door mounted equipment shall be 30/.025 TPI flexible cord.
(Wiring systems other than the above may be accepted -particularly for connection of solid-state components - however such departures will be by approval of the Superintendent only).

Differentiate between AC and DC conductors by continuous colour coding of the insulation.

Identify each end of every conductor by slip on ferrules (not clips) numbered to correspond with the circuit drawings.

Install multiple runs of control cable in slotted plastic ducting that shall be complete with clip on covers.

Terminate all incoming and outgoing control circuit cables using crimp lugs on numbered rail mounted clip-on terminal blocks.

Miscellaneous Switchboard Components
Indicating Instruments
The main switchboard and main distribution board shall be fitted with an multi-function meter to comply with the requirements of the UNSW Design and Construction Specifications, Appendix 7- UNSW Energy Management Metering Requirements.

Indicating lights shall be coloured in accordance with AS/NZS 1431 and shall have a "Lamp Test" button facility.

Push buttons shall be coloured in accordance with AS/NZS 1431.

Terminals shall be clip-in rail mounting and mounted not less than 400 mm from bottom of board.

Surge protection devices shall protect all phases and neutral. Surge protection devices Erico Critec TDSMT-277 shall be connected between active conductors and earth and between neutral and earth.

Power factor correction equipment is to be provided and capable of maintaining the power factor to 0.97 min.

E.3.1.5.4. Distribution Boards

General
All distribution boards shall be:

- designed to fully comply with AS/NZS 3000 and AS/NZS 3439
- 3-phase and rated to 415 V, 50 Hz,
- IP 42 rated if installed within a cupboard or IP 43 if installed within a room provided with sprinklers.
- Form 2 (or Form 1 with the UNSW approval) except where supporting emergency equipment (e.g. lift, etc) in which case the board will have an increased form of separation.
- designed to have 30% spare capacity

- designed to withstand the fault levels specified

Residual Current Protection shall be provided to all circuits protecting:

- "Blue" cleaning GPO's
- "White" GPO's in laboratories and workshop areas
- any outlets which are located in wet areas

All circuit breakers connecting sensitive equipment shall be equipped with surge diverter protection. The designer shall coordinate with UNSW to asses if any surge diverter protection is required.

Dedicated circuits shall be used for each different type of GPOs. Connection of dissimilar types of GPO to the same circuit is not allowed.

Where possible, circuit breakers protecting "Red GPO" circuits shall be positioned at the bottom end of the Distribution board.

Where a new Distribution Board is installed for connection of new power outlet circuits, a space of 150 mm shall be provided between "White GPO" circuits and "Red GPO" circuits.

Active Harmonic Filter provisions
In areas where solid-state power supply units are used for computers or instrumentation (for example, in laboratories, server/IT rooms, data centres, etc.), the riser distribution board design shall be based on the effect of harmonics. In such cases, the design of the riser DB shall include provision for Active Harmonic Filter installation including space for CTs installation and AHF power supply. The rating of the AHF power supply should be equal to approx. 1/3 (one third) of the DB incoming supply rating.

Where possible, the Active Harmonic Filters will be installed within the distribution board cupboard or in a separate room.
To ensure the proper operation and to enhance the operating life span of the AHF, the designer shall coordinate with the architect that the AHF is installed in a dust free environment where temperature and humidity are maintained at the values specified by the AHR manufacturer.

BCA compliant power meters provisions
To comply with the requirements of the BCA Part J, all new distribution boards without exception shall have a split bus bar chassis arrangement (one for lighting circuits and the other for power circuits). This may be incorporated into one distribution board or may be via separate distribution boards. Each section shall be fitted with provision for future installation of BCA-compliant power meters, should this become desirable for the UNSW.
The above provision shall be such that the installation of meters would only require the installation of current transformers. A space between the two chassis

sections should be provided to accommodate current transformers to the UNSW EMACs standard.

Miniature Circuit Breakers
The miniature circuit breakers (MCB), as shown on the drawings, shall comply with AS/NZS 60898.1and AS/NZS 60947-2. The miniature circuit breakers shall be DIN rail mounted type and available in 1, 2, 3, or 4 pole versions. They shall be of the fault current limiting design. MCBs shall be available in the range of 5 A to 63 A in a DIN format and be available with breaking capacities up to 15 kA.

The breaking capacities of the MCB's shall be equal to the prospective fault level at the point of the distribution system where they are installed or 10 kA whichever is greater. When cascading with an upstream circuit breaker the characteristics of the two devices must be coordinated in such a way that the energy let through by the upstream device is not more than that which can be withstood by the downstream device and the cables protected by these devices without damage. Full details shall be available regarding co-ordination (cascading and discrimination) with upstream devices. Detail shall be either published tables or software based.

The MCB's shall be able to be reverse-fed without reduction in performance and be capable of being chassis mounted in either position.

The MCBs shall have the following features:

- Positive contact indication to IEC/EN 60947-2
- Fault tripping indication by a red mechanical indicator in circuit breaker front face
- Safe operation indication by a green mechanical indicator on the toggle to indicate that the contacts have opened
- Fast closing independent of the speed of actuation of the toggle
- Thermal reference temperature 50^{o} C
- Class 2 front – improved personnel protection
- Large circuit labelling area
- Double clip for dismounting with comb busbar in place

It shall be possible to padlock the operating handle in the "ON" or "OFF" position. An easy clip on side mounted locking device shall be available with the following features:

- Locks MCB in the off position.
- Permanently attaches to the circuit breaker, so it cannot be lost.
- Have the same profile as the MCB, therefore no need to modify the enclosure or escutcheon.
- Suitable for installing in moulded plastic enclosures and standard chassis without modification.
- Available in left and right-hand configurations.

- be 9 mm wide.

Each pole shall be provided with a bi-metallic thermal element for overload protection and a magnetic element for short circuit protection.
It shall be possible to fit on-site, auxiliaries of the following type: shunt trip coil, under voltage release, auxiliary switch, alarm switch or residual current device (add-on RCD) rated at 30mA. Field fixable add-on RCD's shall comply with AS/NZS 61009.1.

Where applicable the MCBs should be distinguished with one of the following instantaneous magnetic trip type characteristics.

Type C	-	General applications such as: - Lighting - GPO's - Small motors
Type D	-	Control and protection of circuit having important transient inrush currents (large motors)

Residual Current Devices
RCCB – Residual Current Operated Circuit Breaker Without Integral Overcurrent Protection

All RCCBs shall comply with IEC 1008 (AS/NZS 3190) Standard and carry an appropriate state regulatory prescribed approval No.
The RCCB shall have a current rating capable of interrupting the connected load between 40 – 100 A, 2 or 4 Pole. All RCCBs will have an integral test button to test the functioning of the earth leakage detection circuit. RCCB shall accept DIN T side mounted auxiliary / alarm contacts.

RCBOs - Residual current operated Circuit Breaker with integral Over current protection.

All RCBO's shall comply with IEC 1009 (AS/NZS 3898 AS/NZS 3190) Standard and carry on an appropriate state regulatory prescribed approval No.
RCBO's shall be of the fixed thermal magnetic type with fixed earth leakage sensitivity ($I\Delta n$) and trip time characteristics.
RCBOs should be capable of field installation of clip on accessories such as shunt trip and auxiliary and alarm switches.
They shall meet the back-up and selectivity criteria when used downstream with moulded case circuit breakers (MCCB) in accordance with published tables from manufacturer technical literature.

E.3.1.6. Emergency Standby Power Generator

General

An emergency stand-by power generator will be provided for a project, based on the extent of critical facilities in the project.
Facilities can include animal holding rooms, server rooms, data centres, laboratories, communications facilities, and critical processes.
Where emergency standby power generators are installed, a packaged type acoustically-attenuated containerised type system is preferred.
The following items are to be considered in every emergency stand by power generator installation:

- Fuel storage tank/s with sufficient capacity to provide generator running time of minimum 12 hours at generator 100% load or as advised by the UNSW EM Engineering
- All fuel piping and transfer facilities to the engine together with float type signalling to the filling pumps.
- The fuel fill point needs to be in a readily accessible location at ground level.
- The fuel line pipes are to be installed into a dedicated riser.
- A permanent artificial load bank for automatic supplementary loading and for regular load testing may be required to be provided when the generator is installed in locations not readily accessible such as roof tops.
- Where the generator is readily accessible, such as at road level, a temporary load bank will suffice, subject to the UNSW EM Engineering approval and the project requirements. Provision for connection of temporary load bank is required to be integrated into the Mobile Generator Link Box.
- Noise levels are to be considered in the design.
- The discharge of the engine exhaust is to be considered in relationship to any air intakes or building openings.

For generators over 400 kVA, the consultant shall put forward proposals for utilising the generator set for load management purposes (peak load looping) and shall provide proposals to UNSW EM Engineering for consideration.

E.3.1.6.1. Artificial Load Bank

The load bank shall:

- Have a capacity of approximately 40% of the generator prime rating in kVA for the generator to operate efficiently and reduce bore glazing.
- Be automatically switched on when the external loads fall below 40% of the generator prime rating in kVA.
- Be fan cooled, free standing units incorporating a fan failure or air flow restriction protection system.
- Incorporate switchgear and circuit breaker protection.
- Have a weatherproof construction, incorporating full stainless-steel resistors and corrosion proof housing.

Installation of load banks on the discharge side of the radiator is subject to the generator rating capacity and space requirements therefore, this arrangement requires UNSW EM Engineering approval.

E.3.1.7. Mobile Emergency Power Generator Connection

In order to ensure continuity of power supply during times of extended power outages, UNSW EM Engineering requires the Main Switchboards to be provided with a Mobile Generator Link Box in addition to the permanent connection of a standby emergency power generator.

The mobile generator may be required to supply only specific sections of the MSB or the entire load supplied by the MSB however, the standby emergency power generator and the mobile generator must never be connected in parallel. The exact configuration of the two generators will be determined and advised by the UNSW EM Engineering on a project by project basis.
Mechanical interlocking is to be provided to ensure supplies are not paralleled when a generator is connected.

A Mobile Generator Link Box (MGLB) shall be provided to enable the safe and convenient connection of the mobile generator.

The MGLB shall be rated to meet the power requirement of all the equipment that needs to be maintained in operation and shall incorporate a phase rotation relay (with LED indicator) to provide visible indication when generator wiring matches building wiring.

The MGLB can be either wall mounted or free standing and shall be positioned and secured at a suitable location determined by the UNSW EM engineering.
The MGLB shall be provided with a hinged flap with internal latching devise for the generator cables access.
The final location of the generator connection box and the mobile generator parking bay shall ensure that:

- cable length is minimized.
- the generator connection box and the mobile generator will not obstruct public circulation spaces and access or egress to the facility.
- noise or vibration from the generator will not have an adverse impact on the facility.

E.3.1.8. Wiring and Cables

General
All wiring and cables shall:

- comply with the latest requirements of AS/NZS 3008
- have copper conductors. Aluminium conductors shall not be installed in any new installation unless specific permission is granted, for specific applications, by the UNSW.
- be insulated with 0.6/1 kV grade PVC compound type V75 or higher
- have an insulation temperature rating of 90^{o} C
- be installed with a suitably sized earthing conductor. Metallic conduit systems shall not be used as the earthing conductor

All circular main and submain cables installed on cable ladders/trays shall be installed in trefoil arrangement. All submains to distribution boards are to be installed within electrical risers as much as possible or in common areas. Submains shall never be installed through CATS, offices or other occupied rooms.

Cables shall be installed within the floor that it is to service, unless specific permission is granted by the UNSW.

E.3.1.8.1. Cable selection

Provide cable calculations using proprietary software equivalent to POWERCAD. Provide output documents showing:

- Protective device type and setting
- Cable installation method (trefoil, spaced, etc)
- Cable current rating for the method of installation
- Maximum cable length
- Voltage drop at rated maximum demand load
- Earth fault return impedance
- Fault current at the load end

E.3.1.8.2. Voltage Drop

The maximum acceptable voltage drop values, calculated at the rated maximum demand including any future spare capacity on all mains, submains and final circuits shall be 5% or 6% where a substation is located on the premises:

- Mains 0.5% or 1.5% where a substation is located on the premises
- Submains 2.5%
- Final sub-circuits 2.0%

E.3.1.8.3. Cable support systems

General
The cable support system shall comprise:

- Cable tray and/or
- Cable Ladder and/or
- Cable Mesh tray and/or
- Cable Ducts

Cable trays, ladders and ducts shall be fully galvanised and fitted with the manufacturer's standard bends, risers, curves, reducers and fishplates.
All cable trays, ladders or ducts leaving switchboards or load centres shall have 100% spare capacity up to the ceiling space.
All cable trays, ladders and ducts shall have 50% spare carrying capacity.

E.3.1.9. Locking and Labelling

E.3.1.9.1. Locking

In this clause the word “Switchboard” shall also mean “Distribution Board”

All new switchboards shall be equipped with a lockable door. When locked the door shall prevent access to circuit breakers and/or fuses and shall prevent the removal of any cover which would otherwise expose the live conductors within the switchboard.

The lockable door shall accepting a Bilock lock, which will be fitted by the UNSW Locksmith. Initially, however, the switchboard shall be delivered with the supplier’s lock and the UNSW Locksmith will subsequently change this lock to the Bilock lock.

The following locking mechanisms are suitable for conversion to the Bilock system:

i. Standard Lockwood 100 Nightlatch with 60 mm Backset and 32 mm hole in door
Standard “Double D” hole for a L&F cam lock 19.5 mm diameter (Various backsets are available, approx. 40 mm cam preferred.
Standard cut out for L&F padlockable L-handle to accept padlock.
ii. Abus hasp & staple part no 110/155 to accept a padlock.

Where a contractor is required to work on an existing switchboard which has been fitted with a Bilock lock, the contractor will be required to apply to the Zone Manager for a key. In these circumstances the contractor may be required to sign an undertaking to return the key by a specified date or to meet the cost of re-keying should the key be lost or stolen. Other conditions may be imposed in the undertaking depending on the circumstances.

E.3.1.9.2. Labelling

In this clause the word “Switchboard” shall also mean “Distribution Board”

A labelling system has been adopted for the campus to meet the following objectives:

To have a uniform switchboards Labelling System across the campus.
To uniquely identify each switchboard.
To identify the location of the switchboard.
To be adaptable to change of location name (i.e. room number).

E.3.1.9.3. Locations of the Labels

The Switchboard label wording will appear in the following places:

- On the door of the cupboard, or the door of the switchboard if not mounted in a cupboard.
- On the switchboard circuit schedule.
- In all other references to the switchboard.
- On the door of the room containing the switchboard. This will be determined by UNSW on a case by case basis.
- On the door of the room leading to the room containing the switchboard. This will be determined by UNSW on a case by case basis.
- On the Electrical Fixtures circuit labels (but without the building reference number, see later) which are affixed either to each fixture or in the vicinity thereof. The exception to this is where the switchboard and fixture are in different buildings, in which case the building reference number shall be included.

E.3.1.9.4. Label Elements

The switchboard labels shall be of the following format and by way of example the label shall contain the following elements:

"**D26 DB-G.01 (G21)"**

The elements of this label are as follows:

D26 – Building reference number
DB – Distribution board. Other possibilities are
DBR – Riser board
MSB – Main Switchboard
MCC – Mechanical Services Board
G – Location of the board is on Ground level. Other possibilities are:
B – Basement
LG – Lower ground
M – Mezzanine
01 - Level 1
02 – Level 2 etc.
01 – A sequential number for that type of board starting with 01
(G21) – Room number of the room in which the board is located

All numbers less than 10 shall have a leading zero.

E.3.1.9.5. Electrical Fixtures Circuit Labelling

The fixtures circuit labelling shall follow the main number with an end qualifier denoting the circuit breaker number. The building grid reference is not included unless the switchboard and fixture are in different buildings, in which case the building reference number shall be included.

Therefore, the circuits connected to circuit breakers 1,2,3, and 4 etc. in the distribution board “D26 DB-G.01 (G21)” will carry the following labels:

DB-G.01 CB01, DB-G.01 CB02, DB-G.01 CB03, DB-G.01 CB04, Etc.

In the case of light fittings controlled by a wall switch, it shall be sufficient to label the wall switch rather than each light fitting.

E.3.1.9.6. Circuit schedule

The fuses or circuit breakers shall be numbered sequentially on each distribution board as shown on the *as installed* drawings.

The UNSW will supply a circuit schedule form in Microsoft Excel format for the Contractor to fill in and return to the UNSW.

A hard copy of each circuit schedule shall be mounted in the circuit schedule holder in the cubicle door for each board. Enclose the circuit schedule with a clear Perspex cover.

The board shall be clearly zoned by scribing or neat painting or other approved means. Adhesive tapes are NOT acceptable. Each zone shall be clearly labelled using white lettering minimum 10 mm high on black labels of same material.

E.3.1.10. General Purpose Outlets

E.3.1.10.1. Types of Outlet

Generally power outlets will fall within the following four categories:

10 A single-phase Outlets for connection of general electrical equipment to which any interruption or any interference of the supply will not create a loss of data information or damage to the equipment such as photocopy machines, desk-lamps, general laboratory equipment.

10 A single-phase Outlets for the connection of electrical equipment to which any interruption or any interference of the supply will create a gloss of data information and/or damage to equipment. Examples include computer equipment, server high tech monitoring, and laboratory equipment.

10/15 A single-phase Outlets for the connection of electrical equipment powered by electric motors. Examples include vacuum cleaners and other cleaning equipment.

15/20 A Three Phase Outlets For the connection of industrial electrical equipment. For example, workshop machinery.

Power outlet circuits in any design for new buildings or upgrading of existing facilities are to reflect the above requirements.

E.3.1.10.2. General Purpose Outlets

Power Outlets are to be flush combination type, 10A,
Single pole switch 3 flat pin receptacle unless specified otherwise.

The General-Purpose Outlets shall comply with the following standard:
AS/NZS 1428 Design for Access and Mobility

The layout drawings shall indicate clearly the purpose and colour of the outlets

Outlets shall be impact resistant plastic mouldings unless otherwise specified.

GPO body and cover plates shall be coloured as follows:

- WHITE or Black, to architect selection, for outlets where electrical equipment for general purposes any interruption or any interference of the supply will not create a loss of information or damage to the equipment. (e.g. photocopy machines, desk-lamps and general laboratory equipment)

- RED for outlets where the connection of electrical equipment to which any interruption or any interference of the supply will create a loss of information and some damage to the equipment. (e.g. UPS circuits). (See note below)

- BLUE for cleaning equipment

  NOTE: The power outlets backed up by the emergency generator should not have a dedicated colour however, labelling of those power outlets shall clearly state that their source of supply is the essential power section of the MSB that is backed up by the emergency generator.

Colour for any 3-phase outlets is not critical.

Note: Painted plates are not acceptable.

Mounting height of general-purpose outlets shall be determined on site in relation to the type, application and usage.

Any weatherproof type outlets shall be heavy duty, high impact resistant polycarbonate or metal-clad construction with degree of protection IP 56.

Different types of GPO's shall not be ganged under a common flush plate.

No cleaning equipment or other purpose GPOs shall be installed directly below toilet hand dryers.

Hand dryers shall be hard wired and provided with a local isolation switch.
The isolation switch should be installed at 1900 mm AFFL directly above the hand dryer on its centre line.
Currently the UNSW EM is installing the Dyson V-Blade dryer.

E.3.1.10.3. Accessories

Accessories shall conform to the following Standards:

Generally: to AS/NZS 3000.
Plugs and Socket outlets: to AS/NZS 3112.
Socket outlet: to AS/NZS 3133.

E.3.1.10.4. Mounting Arrangements

The outlet shall always be mounted with the earth pin at the 6 o'clock position.

E.3.1.10.5. Labels, Signs and Notices

Unless otherwise stated by the UNSW EM Engineering Project Officer, the construction and application of labels, signs and notices shall be as follows:

Multi-layered plastic laminates with the core a contrasting colour to the faces; lettering shall be engraved to reveal the contrasting coloured core; edges shall be bevelled. Use for interior or internal applications within office and teaching areas. Labelling on final sub-circuits may be of durable stick on type affixed to either the fixture or in the immediate vicinity of the fixture.

Fibreglass or rigid vinyl products with embedded legends or graphics and resistant to abrasion or impact, corners shall be rounded edges smoothed and with reinforced fixing holes. Use for safety signs for the laboratory.

Brass or bronze plates with engraved painted filled lettering. Use in exterior applications.

E.3.1.11. Testing and Commissioning

The electrical installation shall be fully tested