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This section of the Specification describes and specifies requirements for the supply, delivery, installation, testing, commissioning, handing over in approved working order and maintenance thereafter during the Defects Liability Period of the low voltage automatic power factor correction equipment in accordance with the Specification, Supplementary Notes, Bill of Quantities, Condition of Contracts and Drawings.

All items incorporated for the complete installation of the automatic power factor correction equipment not specifically covered by this Specification shall be deemed to comply with the relevant sections and requirements as prescribed in other Specifications included herewith this Specification.

Tenderer shall submit together with his tender catalogues and literatures describing the capacitors, series blocking reactors and power factor regulators offered in addition to filling in Appendix A (Schedule of Technical Data and Guarantee) to this Specification.

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## 2.1 TYPE

The power factor correction capacitor (hereinafter referred to as “capacitor”) shall be of dry type and self-healing. The dielectric medium shall be metallised polypropylene film or foil. The elements shall be insulated with fire-proof material. The capacitor shall be environmentally-friendly.

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## 2.2 STANDARD

The capacitor shall comply with IEC 60831 Part 1 and Part 2.

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### 2.3 LOSSES

The losses of the capacitor shall be not more than 0.5 watt per kvar at the specified ambient temperature measured at the connecting terminals.

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## 2.4 PROTECTION

The capacitor shall be provided with overload disconnecter which will interrupt the internal connection and disconnect the capacitor from the circuit in the event of pressure built-up within the capacitor.

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## 2.5 DISCHARGE DEVICE

Each capacitor shall be provided with suitable means to discharge the capacitor to 50 volts or less within 60 seconds from an initial peak voltage of  $\sqrt{2}$  times the rated voltage. No isolating device, fuse or otherwise shall be placed between the capacitor and the discharge device.

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## 2.6 AMBIENT TEMPERATURE

The capacitor shall be Category C rated and suitable for operation under tropical ambient conditions with the highest mean temperature of 40 0C over a 24 hour period of continuous operation.

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## 2.7 VOLTAGE RATING AND MAXIMUM PERMISSIBLE CURRENT

Capacitor shall be rated at 525 volts, 50 Hz. The capacitor shall be suitable for continuous operation at an r.m.s. line current of 1.3 times the rated current that occurs at the rated sinusoidal voltage and rated frequency of the supply source. The rated short time peak current of the capacitor shall be at least 140 times the rated current.

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## 2.8 HOUSING

The capacitor shall be housed in container fabricated from heavy metal sheet steel coated with non-corrosive polyurethane resin enamel or in extrusion-processed aluminium container.

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## 2.9 TEST RESULTS

Factory certified test results for routine test shall be provided for the capacitors supplied. The routine tests according to IEC 60831 shall include: -

- (a) Test voltage between terminals - 1.75 times capacitor rated voltage for 2 seconds
- (b) Measuring voltage - 525 V, 50 Hz
- (c) Voltage test between terminals and container - 3000 V, 50 Hz for 10 seconds; or 3600 V, 50 Hz for 2 seconds
- (d) Capacitance measurement
- (e) Loss measurement

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### 3.0 SERIES BLOCKING REACTORS

Where series blocking reactors (hereafter referred as “reactor”) are specified in the Drawings and/or Bill of Quantities, they shall be of dry type copper windings rated at 440 volts 50 Hz. class H insulation connected in series with the capacitors suitable to operate in ambient Temperature up to 40 0C. Unless otherwise specified in the Drawings and/or Bill of Quantities, the kvar rating (reactance) of the reactor shall be 6 % to the kvar rating (reactance) of the capacitor to where the reactor will be connected.

The reactors shall be securely fastened and installed in a separate compartment of the power factor correction board. If necessary, rubber pad shall be used to reduce noise.

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#### 4.1 TYPE

The power factor regulators (hereinafter referred to as “regulator”) shall be micro-processor based, solid state in construction, compact, easy to install and use. The regulator shall automatically and/or manually step-in or step-out various capacitors to correct the power factor to the required pre-set level.

The regulator shall be insensitive to harmonics and screened from stray electric and magnetic interference and shall be housed in case suitable for panel mounting. Operating ambient temperature shall be up to 60 0C. The regulator shall be 6 or 12 steps type as specified in the Drawing and/or Bill of Quantities. No-voltage trip and zero current trip shall be provided.

For a voltage loss of longer than 15 ms or current loss of longer than 3 s, all capacitor stages connected shall be switched off. until discharged. After voltage or current is restored the regulator switches the required steps on.

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## 4.2 SWITCHING SEQUENCE

The regulator shall incorporate minimum following automatic switching sequence modes, viz. cyclic switching sequence and multi-step switching sequence allowing minimum following combinations of switching programme of capacitor stages:

(a) 1:1:1:1:1:1 ... (b) 1:1:2:2:2:2 ...

(c) 1:1:2:2:4:4 ... (d) 1:2:2:2:2:2 ...

(e) 1:2:4:4:4:4 ... (f) 1:2:4:8:8:8 ...

The first three control output may be allowed to be set as fixed steps which are not included in the normal control cycle but are switched on immediately after the regulator is switched on and always remain switched on.

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### 4.3 SETTING AND DISPLAY

The following settings and displays shall be incorporated :-

- (a) Continuous digital actual power factor display (0.00 inductive - 1.00 - 0.00 capacitive);
- (b) Capacitor step indication;
- (c) C/k inductive setting and display;
- (d) C/k capacitive setting and display;
- (e) Target power factor setting and display (0.80 inductive - 1.00 - 0.80 capacitive);
- (f) Operation delay setting and display (5 s to 300 s);
- (g) Apparent current display or Active/Reactive current displays;
- (h) Flashing display when alarm is activated.

If specified in the Drawing and/or Bill of Quantities, the following setting and display shall be incorporated in addition to the above :-

- (a) Harmonics content display (5th, 7th and 11th harmonics on voltage);

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#### 4.4 ALARM

Provision of following alarm shall be incorporated :-

(a) Power factor alarm : If the threshold values set for ‘switch-on’ and ‘switch-off’ are exceeded and no further change can take place in the output steps, the alarm signal functions. If specified in the Drawing and/or Bill of Quantities, the following alarms shall be incorporated in addition to the above :-

(a) Harmonic Alarm : When the harmonics threshold values are exceeded, the alarm goes off; and

(b) Over-current alarm : If the capacitor current exceeded the rated current set, the alarm goes off.

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#### 4.5 MODE OF OPERATION

When the regulator is in manual operation mode, the capacitor steps can be switched in step by step and switched out in reverse step by step manually. The step that is being switched on shall be displayed. With the regulator in OFF mode, all equipment shall be switched off and deenergised.

In the automatic mode, the regulator shall switched in or switched out the required capacitors without undue switching on and switching off at any particular step to reach the nominal target power factor. In any event the zero voltage release function must take precedent at all modes of operation to prevent capacitive current surge.

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All switchgears shall have voltage and frequency rating suitable for the power system to which they are connected to. The current rating shall not be less than that specified in the Drawings and/or Bill of Quantities. They shall conform to the latest relevant IEC Standards.

### 5.1 MOULDED CASE CIRCUIT BREAKERS

Moulded case circuit breakers (mccb) shall have the number of poles as specified in the Drawings and/or Bill of Quantities. They shall comply with IEC 60947-1 and IEC 60947-2. They shall be fully tropicalised and suitable to be used up to an ambient temperature of 40 °C, enclosed in glass-reinforced polyester moulded case and suitable for use on 240/415 V, 50 Hz. a.c. supply system.

They shall be of the quick-make, quick-break type having manually operable toggle type handle. Permanent position indicators shall be provided to show status of the breaker. When tripping occurs, the handle shall be in the 'trip' position midway between the 'OFF' and 'ON' or 'O' and 'I' position so as to provide positive indication of automatic interruption. The operating mechanism shall be non-tamperable.

The mccb shall have trip-free feature to prevent the breaker from being closed against fault conditions. Multipole mccb shall have common-trip operating mechanism for simultaneous operation of all poles. The tripping units shall be of thermal-magnetic type with bimetallic elements for inverse time-delay overload protection and magnetic elements for short circuit protection. An arc extinguisher shall be incorporated to confine, divide and extinguish the arc drawn between the breaker contacts each time a breaker interrupts current.

The contacts shall be of non-welding type. Unless otherwise specified in the Drawings and/or Bill of Quantities, the minimum a.c. interrupting capacity of the mccb shall be 50 kA rms (symmetrical) for 1 second at 415 V. The rated service short-circuit breaking capacity (Ics) of the mccb shall be 100% of the rated ultimate short-circuit breaking capacity (Icu) at 415 volts. Unless otherwise specified in the Drawings and/or Bill of Quantities, the minimum continuous current ratings for the mccb shall be of 155 % of the rated capacitor currents.

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## 5.2 SWITCHING CONTACTORS

The switching contactors shall comply with IEC 60947-4-1 and shall be of utilization category AC-6B rated for switching low inductance capacitors. They shall be fully tropicalised, suitable for use on 240/415 V, 50 Hz. a.c. system.

The operating coil shall be 240 V 50 Hz. a.c. type and shall operate satisfactorily when the voltage at the coil terminals is between 85% and 110% of the nominal voltage. The electro-magnet shall be of laminated type.

Unless otherwise specified in the Drawing and/or Bill of Quantities, the minimum continuous current ratings for the switching contactors and the connection cables shall be of minimum 135 % of rated capacitor currents.

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## 6.1 ENCLOSURES

The power factor correction boards (hereinafter referred to as “board”) shall be suitable for operation on a 240/415 V, 3 phase, 4 wire, 50 Hz. system with solidly earthed neutral. Unless otherwise specified, the board shall be capable of withstanding the fault condition of not less than 50 kA at 415 V for 1 s as defined in IEC 60439-1.

The board shall not form part of but shall be independent and match the height and depth of the switchboard it is connected to. The board shall be self-contained, floor mounted, flush fronted, metalclad cubicle suitable for front and rear access, fabricated from rolled steel sections of thickness not less than 2.5 mm for framework and 2.0 mm for all panels, covers, and doors. They shall be of Form 2b separation with busbars separated from the switchgears and the incoming and outgoing terminals by metallic or non-metallic rigid barriers or partitions.

The board shall provide adequate dimensions for efficient natural heat dissipation of the capacitors and reactors at normal ambient temperature. The capacitors shall be separated at not less than 80 mm apart. All ventilation vent shall be provided with filter. In addition, ventilation fan with automatic shutter of capacity not less than 200 cubic metre per hour shall be installed. The fan complete with control switch and indicating lamp shall operate either automatically and/or manually with thermostat control at preset temperature.

The board shall undergo de-rusting treatment, anti-rust treatment and be finished with epoxy dry-powder and oven baked semi-gloss enamel grey.

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## 6.2 BUSBARS

Busbars shall conform to BS 159 and shall be tinned hard drawn high conductivity copper with an adequate uniform rectangular cross section to carry continuously their rated current without overheating. They shall be rigidly mounted on non-hygroscopic insulators so as to withstand any mechanical stresses to which they may be subjected under maximum fault condition.

Busbar sizes must not be less than that specified in the Drawings. However if the busbar sizes are not specified, then the busbar rating shall be based on a current density of not more than 1.5 A/sq. mm. In any case, the busbars rating shall not be less than the rating of the incoming switchgear.

Where multiple parallel bars are used, they shall be separated by tinned copper spacers at spacing equal to the busbar thickness. The main busbars shall be run for the full length of the board without reduction in size. Neutral busbar shall be of full size and full length as the phase busbars.

Connections shall be made up with bronze or other copper alloy bolts and nuts utilising tension washers on both outer faces. Tinned copper earthing bar of cross sectional area not less than 50 mm x 6 mm shall run along the board for its entire length.

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| <b>SECTION:<br/>6.0</b>                                                           | <b>POWER FACTOR CORRECTION<br/>BOARDS</b>                                                    | Revision: 0              |
|                                                                                   |                                                                                              | Date:                    |
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### 6.3 SHOP DRAWINGS

Two copies of shop drawings for the board showing the dimensional general arrangement and layout of the equipment and the schematic line diagram shall be submitted to the S.O.'s Representative for approval. No fabrication of the board shall proceed without the shop drawings being approved by the S.O.'s Representative.

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| <b>SECTION:<br/>6.0</b>                                                           | <b>POWER FACTOR CORRECTION BOARDS</b>                                            | <b>Revision: 0</b>              |
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After the installation work has been completed and before Certificate of Practical Completion is issued, the whole electrical installation covered under this part of the Contract shall be tested as prescribed in Electricity Regulations 1994 and IEC 60364 and any other tests deem necessary by the S.O.'s Representative. In the event the installation fails to pass any of these tests, the Electrical Contractor shall take such measures as are necessary to remedy the defects and the installation shall not be considered as completed until all such tests have been passed.

The tests to be carried out by the Electrical Contractor shall consist of the following tests as a minimum requirement:-

- (a) Continuity of protective conductors including main and supplementary equipotential bonding;
- (b) Insulation resistance;
- (c) Polarity;
- (d) Functional testing - operational tests for regulators and circuit breakers, on-off test for switches, etc.

All protection relays and device and power factor regulators shall be checked, tested and calibrated by an Electrical Services Engineer registered with Jabatan Bekalan Elektrik Malaysia. Stability and functionality test shall also be carried out to ensure the installation is in safe and good working order. The Electrical Contractor shall arrange with the Electrical Services Engineer to conduct and carry out the necessary check, test and calibration of the protection relays and device and regulators. Fee required for the check, test and calibration as described above is deemed to be included in the Contract.

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| <b>SECTION:<br/>7.0</b>                                                           | <b>TESTING AND TEST<br/>CERTIFICATES</b>                                                     | Revision: 0              |
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The S.O.'s Representative reserves the right to be present at all tests and the Electrical Contractor shall give at least one week notice in writing to the S.O.'s Representative for this purpose. In any case, no test shall be carried out without prior approval of the S.O.'s Representative.

Copies of all the tests certificates together with as-installed Drawings properly bound and titled shall be submitted to the S.O.'s Representative within one week after the completion of the testing.

Two sets of Supervision and Completion Certificate and Test Certificate including copies of all the test results and drawings as prescribed in Electricity Regulations 1994 shall be submitted to the S.O.'s Representative within two weeks after the completion of the testing. The aforesaid Certificates shall be properly bound in hard cover and titled

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| <b>SECTION:<br/>8.0</b>                                                           | <b>SERVICE AND MAINTENANCE</b>                                                   | <b>Revision: 0</b>              |
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During the Defects Liability Period, the Electrical Contractor shall be responsible for making good all defects for the complete installation. The Electrical contractor shall bear all cost incurred to rectify the defects.

The rectification work to be performed shall include but not limited to the following:-

- (a) Replacing or making good all regulators, control gears, capacitors, reactors, fuses, mccb, contactors, etc.
- (b) Replacing and making good all loose and burnt cables and termination, all mechanical support linkage, etc.
- (c) Making good any damage to roads, buildings, drains, cables, pipes, concrete areas, paved areas etc. which had not been properly made good arising out of his work.
- (d) All other works as deemed necessary by the S.O.'s Representative.

All works shall be carried out as soon as the Electrical Contractor is informed by the S.O.'s Representative or the occupant and shall be completed within a reasonable time except under emergency situation as stipulated in the Supplementary Conditions for Electrical Work. If the Electrical Contractor fails to comply with the above requirements, the S.O.'s Representative reserves the right to engage another party to carry out the work, in which case, the Electrical Contractor shall be responsible for all the expenses incurred.

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| <b>SECTION:<br/>9.0</b>                                                           | <b>AS INSTALLED DRAWINGS, MANUALS AND TOOLS</b>                                  | Revision: 0              |
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Within three calendar months after the practical completion of the project, one set of true to scale negative (155/115 gm/sq. ISO AO or A1 size) and four sets of prints for each of the following drawings shall be submitted:-

- (a) Site plan;
- (b) Schematic Wiring Diagram and Electrical Layout Plans;
- (c) Control Circuits drawings;
- (d) Layout plans of cable routes and earthing points with reference to easily recognisable buildings and structures.

These drawings shall be properly stenciled and shall have at the lower right hand corner the Electrical Contractor's name and address, date of commissioning, scale, drawing number (the drawing number to be obtained from the S.O.'s Representative), title and following particulars:-

JABATAN KERJA RAYA  
CAWANGAN ELEKTRIK  
CONTRACT NO.:  
TENDER NO.:

If the drawings submitted are not acceptable by the S.O.'s Representative, the Electrical Contractor shall amend and re-submit the drawings within two weeks from the date of return of the drawings. If required and specified elsewhere, in addition to the aforesaid negatives and prints, as installed drawings shall be stored in electronic media or any other media as specified.

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| <b>SECTION:<br/>9.0</b>                                                           | <b>AS INSTALLED DRAWINGS, MANUALS AND TOOLS</b>                                  | <b>Revision: 0</b>              |
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For electronic media they shall be either in floppy disks format or CD rewritable (CD-RW ) optical disks format as specified which can be easily retrieved by computer. The software programme shall be AutoCAD of latest release.

Two sets or copies in either format as specified, appropriately titled and stored in container or casing, shall be submitted. In addition, four sets of the following manuals and documents for regulators, capacitors, reactors, mccb and other important electrical switchgears shall be supplied:-

- (a) Installation manual;
- (b) Operation manual;
- (c) Service and Maintenance Manual;
- (d) Parts List;
- (e) Product Data and catalogue;
- (f) Product Test Certificates;

Each of the above sets of prints together with the manuals shall be in a stiff cover ring file. The cost of all these prints, manuals, tools etc. is deemed to be included in the Contract.

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| <b>APPENDIX A</b>                                                                 | <b>SCHEDULE OF TECHNICAL DATA AND GUARANTEE</b>                                  | Revision: 0              |
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*(Note: Unless otherwise specified elsewhere, the information indicated in italic are as stated in the Specification)*

### **(A) CAPACITORS**

- (1) Make :.....
- (2) Country of Manufacture :.....
- (3) Model No. :.....
- (4) Type (*Dry Type*) :.....
- (5) Losses (*Not more than 0.5 watts per kvar*) :.....
- (6) Rated Voltage (*525 V*) :.....
- (7) Ambient Operating Temperature (*40 0C*) :.....
- (8) Maximum Permissible Current  
(*1.3 times rated current*) :.....
- (9) Housing :.....

### **(B) SERIES BLOCKING REACTORS**

- (1) Make :.....
- (2) Country of Manufacture :.....
- (3) Model No. :.....
- (4) Type :.....

|                                                                                   |                                                                                  |                          |
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(5) Winding (*Copper*) :.....

(6) Rated Voltage (*440 V*) :.....

(7) Ambient Operating Temperature (*40 0C*) :.....

### **(C) POWER FACTOR REGULATORS**

(1) Make :.....

(2) Country of Manufacture :.....

(3) Model No. :.....

(4) Type (*Micro-processor Based*) :.....

(5) Number of Steps :.....

(6) Rated Voltage :.....

(7) Ambient Operating Temperature (*40 0C*) :.....

(8) Modes of Operation  
(*Manual/Cyclic/Multi Steps*) :.....

|                                                                                   |                                                                                  |                          |
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### 9) Settings and Displays

- (a) Power Factor Display :..... Yes / No
- (b) Capacitor Step Indication :..... Yes / No
- (c) C/k Inductive Setting and Display :..... Yes / No
- (d) C/k Capacitive Setting and Display :..... Yes / No
- (e) Target Power Factor Setting and Display :..... Yes / No
- (f) Operation Current Setting and Display :..... Yes / No
- (g) Apparent Current Display :..... Yes / No
- (h) Flashing Display When Alarm Activated :..... Yes / No
- (i) Harmonics Content Display :..... Yes / No

### (10) Alarm

- (a) Power Factor Alarm :..... Yes / No
- (b) Harmonic Alarm :..... Yes / No
- (c) Over-current Alarm :..... Yes / No

|                                                                                   |                                                                                  |                          |
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#### **(D) MOULDED CASE CIRCUIT BREAKERS**

- (1) Make :.....
- (2) Country of Manufacture :.....
- (3) Model No. :.....
- (4) Type :.....
- (5) Rated Voltage :.....
- (6) Rated Interrupting Current Capacity (50 kA, 1 s) :.....
- (7) Rated Service Short Circuit Breaking Capacity (100%) :.....

#### **(E) SWITCHING CONTACTORS**

- (1) Make :.....
- (2) Country of Manufacture :.....
- (3) Model No. :.....
- (4) Type :.....
- (5) Utilization Category (AC-6b) :.....
- (6) Rated Voltage :.....
- (7) Rated Voltage for Operating Coil (240 V) :.....

|                                                                                   |                                                                                  |                          |
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## (F) VENTILATION FANS

- (1) Make : .....
- (2) Country of Manufacture : .....
- (3) Model No. : .....
- (4) Type : .....
- (5) Diameter : .....mm
- (6) Air Exchange (200 cmh) : .....

.....  
(Cop dan Tandatangan Kontraktor Elektrik) (Tarikh)