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DOCUMENT COVER SHEET

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ENGINEERING SUMMARY

Project:

Durai Junction Substation EPC Subcontract

Subcontract No:

042246.73.1003

Submitted to:

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Date: 13 August 2013
Revision 1

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Introductory statement.

The project design summary document explains the procedure carried out throughout the developing stages of electrical and civil design process of substation engineering. It explains the use of technical specification and reference approved drawings for the different development stages of design techniques used and brief explanation provided along with attached details.

The document explains the reference documents used at the design stages provided by client, which includes technical specification and approved drawings. Design methodology of single line diagram, general layout, switchyard layout and additional design drawings has been added to this document. International standards used in the design phases have been mentioned with their requirements. Data input values taken from technical specifications and documents prepared for bill of quantity and procurement have been mentioned with their details.

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1. General Description

This project included the construction of a sectionalizing of an existing single circuit 110kV transmission line and its 110kV tap, installing a new 110kV substation and Durai Junction Substation.

1.1 Location

The project site is located east of the previous Durai junction tap. This tap was located adjacent to Highway A01, approximately 30km from Grishk. The previous Durai Junction tap was a three terminal pole, with one tap with one to Kajaki Dam substation, one to Kandahar substation and one tap to Lashkar Gah substation.

1.2 Scheme

The new Durai Junction Substation is 110kV breaker and a half configuration with double bus bar scheme.

- Design configuration
  - Breaker and half
  - DEFINITION:
    - Two main busses that are normally energized
    - Electrically connected between the busses are three breakers used as two independent circuits
    - Each circuit shares a common center breaker
    - Thus there are one and a-half breakers per circuit

- Breaker and a-half (cont)
  - Provide for circuit breaker maintenance
    - Any breaker can be easily removed from circuit with no circuit interruptions
  - Faults on either main bus causes no circuit interruptions
  - Center breaker failure – two circuits interrupted
  - Outside breaker failure – one circuit interrupted

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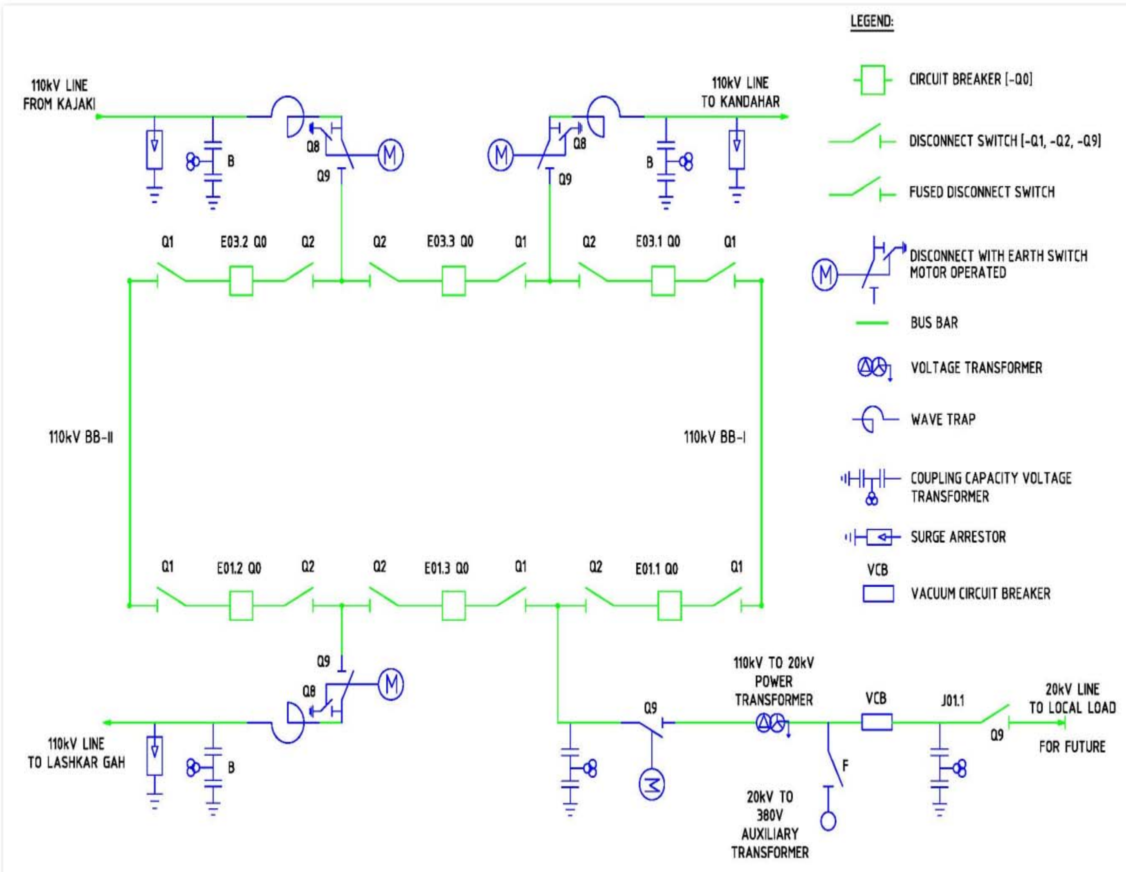


DJCN Breaker and a-Half Scheme

Typical Breaker and a-Half Scheme

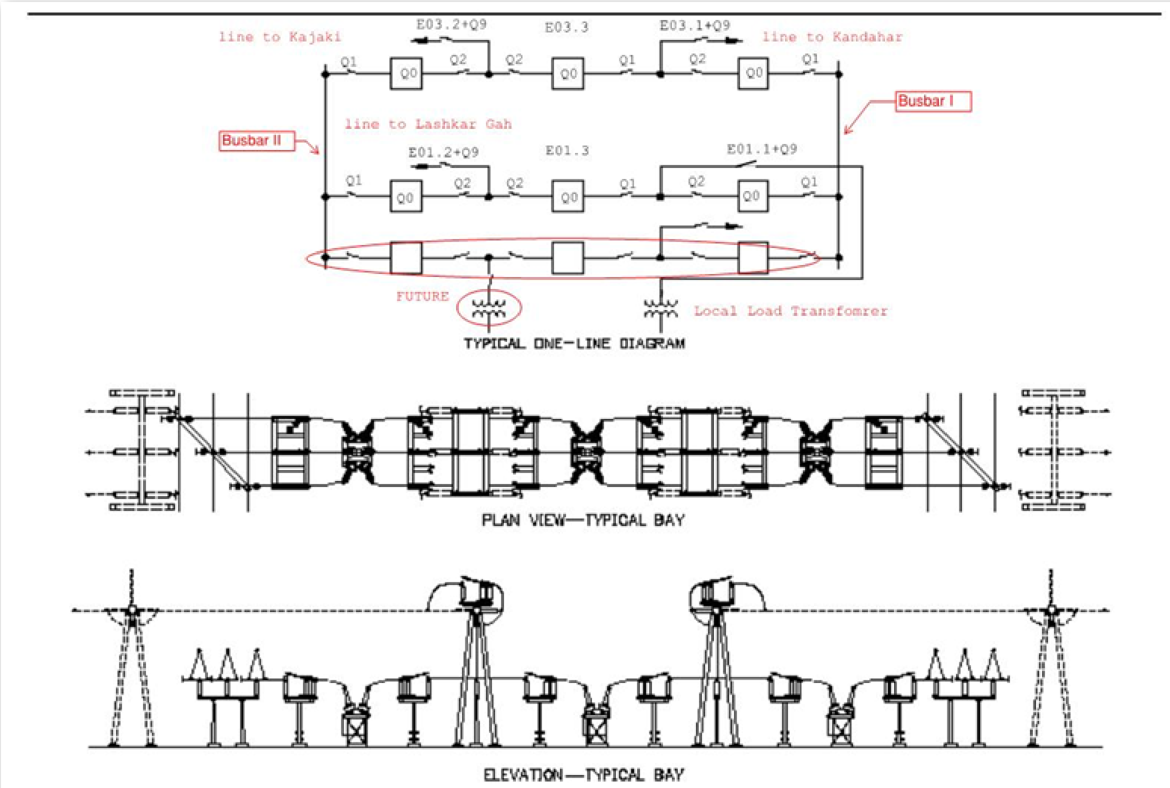


FIGURE 4.15: Breaker-and-a-Half

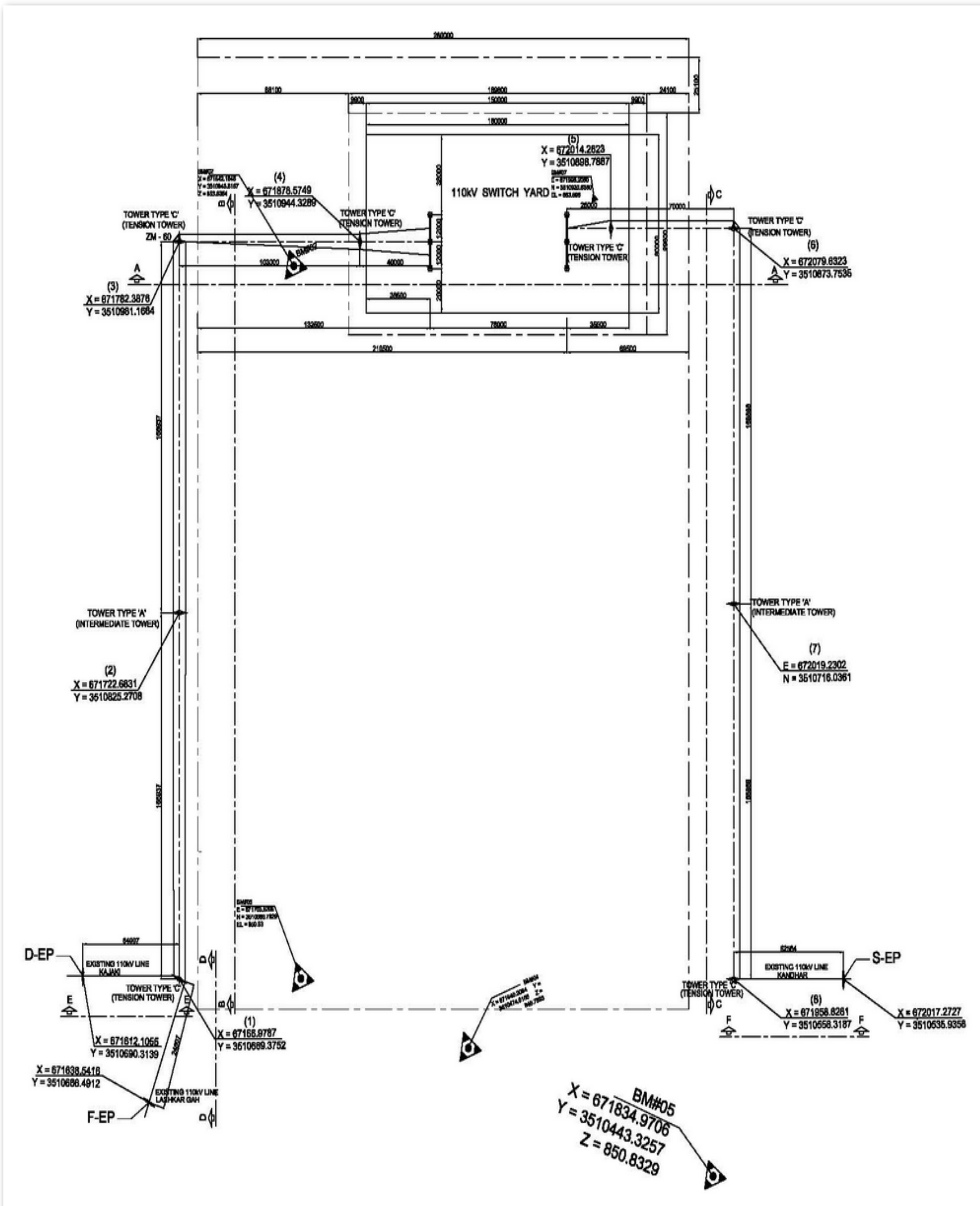
Reference from RUS Bulletin 1724E-300 page 138

1.3 Line Bays

The Durai Junction Substation has three line bays.

- Kajakai Dam Substation Line --Two spans north of the existing Durai Junction tap for Durai – Kajakai Transmission Line.
- Kandahar Substation Line -- Two spans west of the existing Durai Junction tap for the Durai- Lashkar Gah Transmission Line.

- Lashkar Gah Substation Line -- Two spans east of the existing Durai Junction tap for the Durai – Kandahar Transmission Line.



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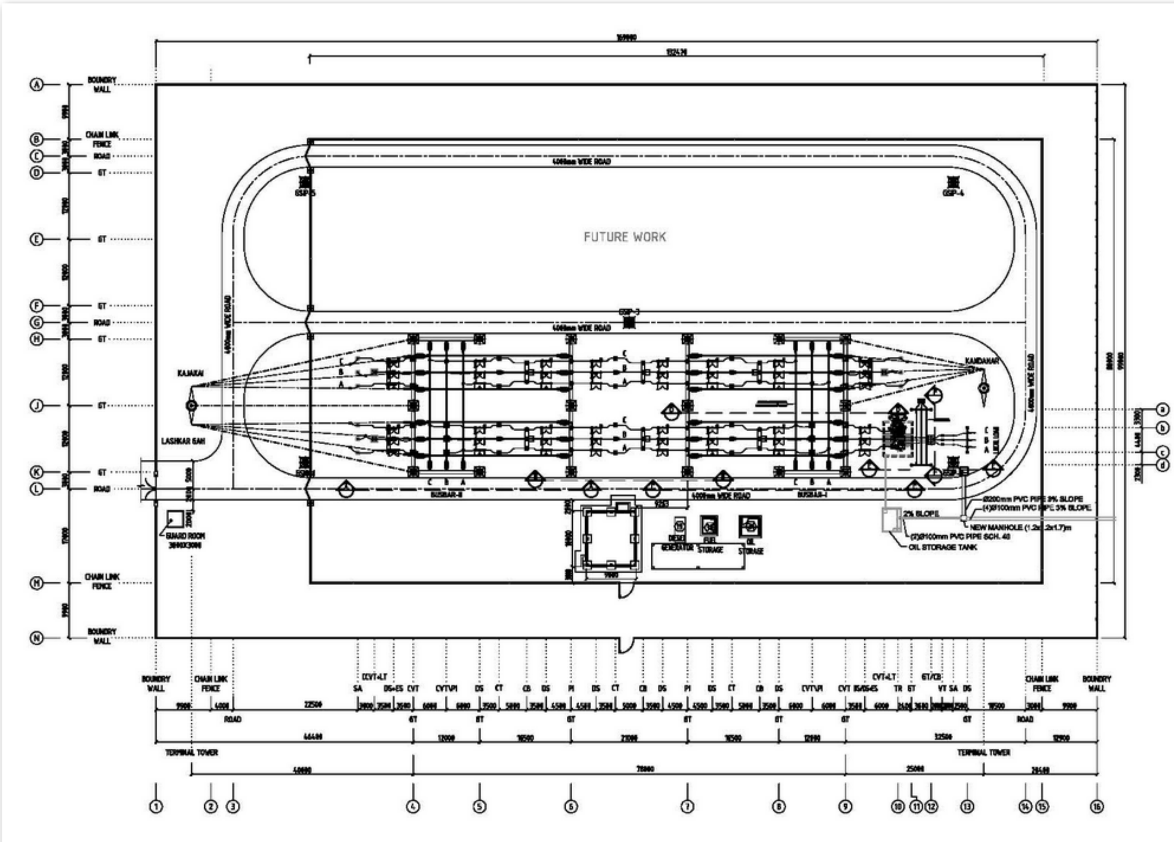
1.4 Transformer Bay

The Durai Junction Substation has one Transformer Bay.

- 110/20kV transformer, including a low side circuit breaker and disconnect switch.



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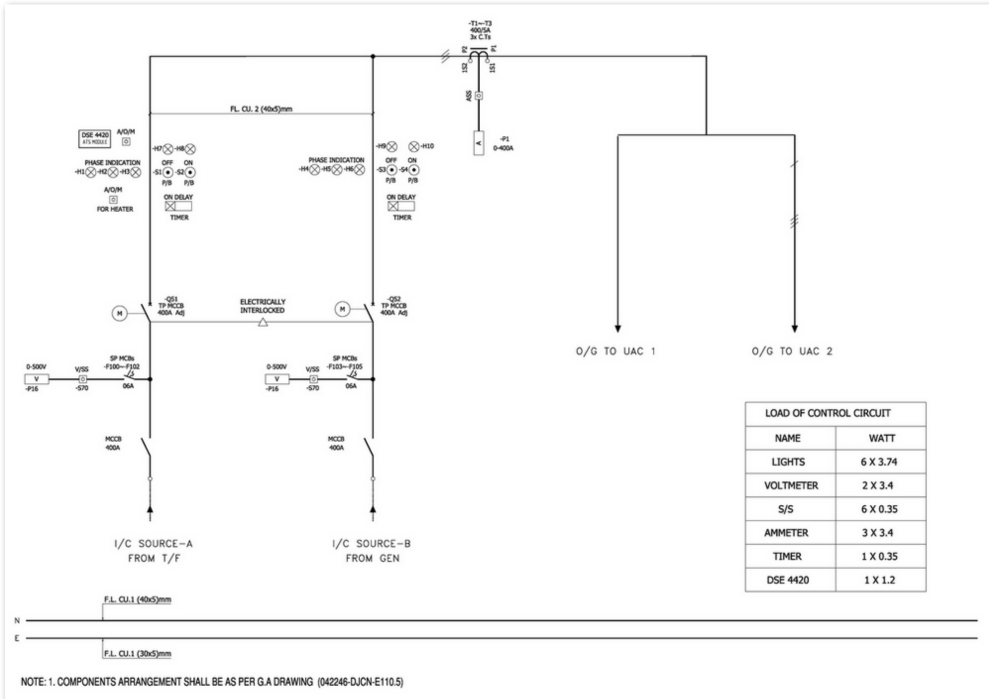
1.5 Substation Service System



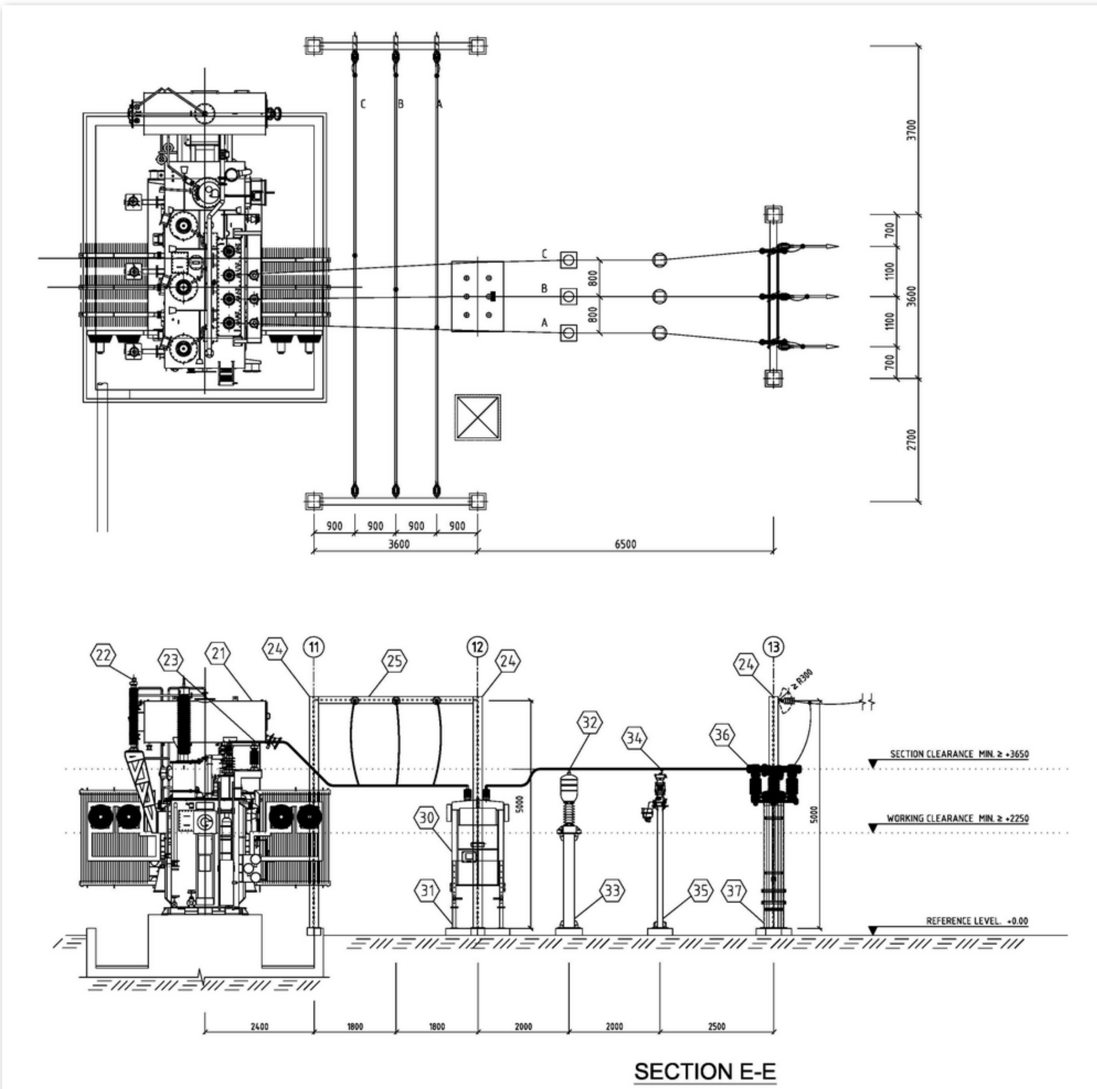
1. The AC and DC substation service systems, substation control system, building layout, sizing of raceway, interface between the control building and the yard etc. sized for the ultimate layout of the substation
2. The site is developed for the ultimate layout of the substation including grading, fencing perimeter wall, roads etc.
3. The substation is encircled by both a perimeter wall and safety fence, with a permanent guard house constructed to control access to the site.

1.6 Substation Buildings

1. The substation have a control building for metering, control, protection and communication equipment and a Separate containerized battery room.
2. The substation have a fluid storage building, oil containment system and a storm water management system.

1.7 20kV Distribution System

An additional 20kV Distribution transformer is installed to provide the primary AC station service source. A diesel generator and tank installed to provide an alternate AC station service source.



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1.8 Scope of Work

The work under the above specifications was included complete engineering and design services, procurement of the equipment and material, required construction at site, erection and installation of the equipment, testing and commissioning of the grid and energization.

Major components tasked to the contractor for the complete project are as follows.

- Complete Engineering and Design of the substation
- Procurement and supply of all equipment and material required for completion of job.
- Access road development from Highway A01 to substation site.
- Determine area of new substation
- Substation earthing, lightning surge protection and lighting design.
- Substation equipment design and procurement.
- Structure design, procurement, assembly and erection.
- Installation of structure grounding materials
- Substation cable, insulator material, assembly and erection.
- Substation control and protection equipment installation.
- Substation relay settings, equipment testing and commissioning.
- Equipment installation in the substation.
- AC and DC power system design and construction and expansion if necessary.
- Transmission line design and procurement, as required to realign the existing transmission lines in the new substation.
- Installation of site transmission line insulators, phase and shield conductors and grounding.
- Emergency generator set
- Storm water management.
- Dispose of removed equipment.
- Testing, checkout and any other activities required to make the substation ready for energization.
- Post energization testing.

2. Design Criteria / Outline

The design process completed in two phases. First half dealt with Base Design and in Second half, Detailed Design completed. Design was divided into following three major categories:

- Primary Design
- Secondary Design
- Civil Design

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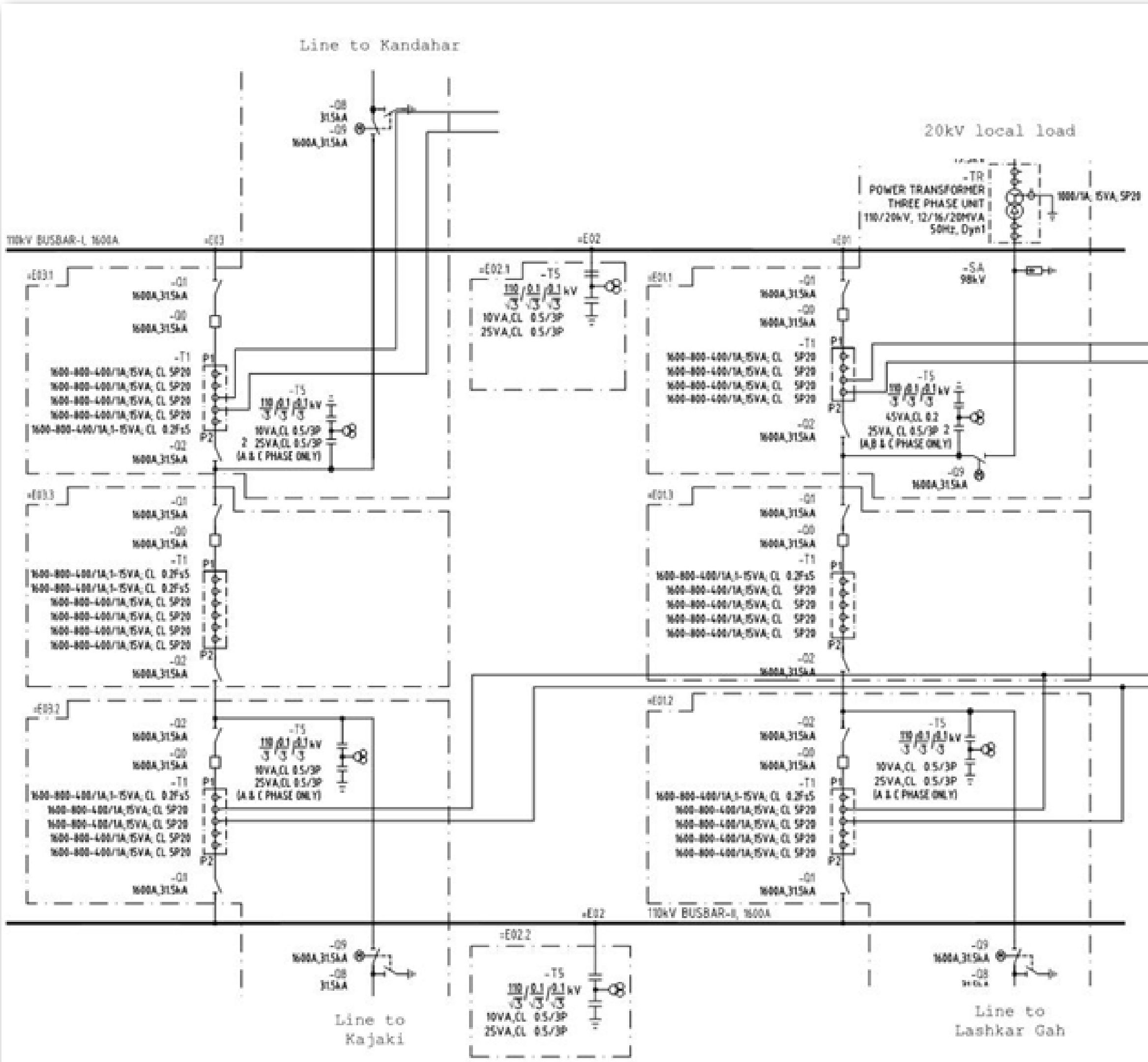
2.1 Primary Design Criteria

2.1.1 Single Line Diagram



2.1.1.1 Description

Durai Junction single line diagram is developed using multiple documents provided by client as reference. These documents were include technical specification, bid documents and pre-bid documents. Proposed single line diagram No. 041630-3PPS-E7000 along with revisions provided with these documents used as primary reference diagram. Busbar scheme for this design was breaker and a half scheme configuration as per required criteria from technical specification. Equipment description was taken from both client tender diagram and technical specification. DIN 40719 numbering system used for device and bay numbering used in the single line diagram.

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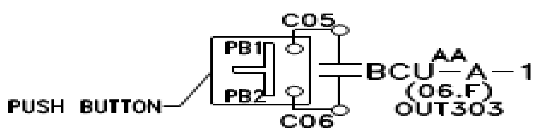
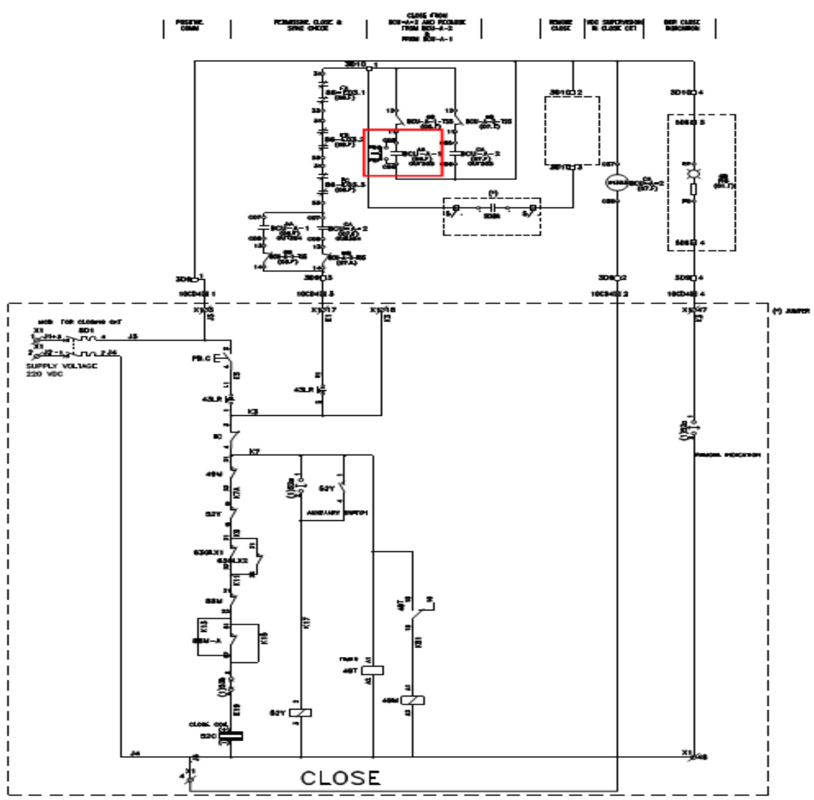
To ensure that the design meets local operation constraints, the following design criteria were included:

1. Disconnect switches are not designed to interrupt or close onto loads
2. In order to limit the stress on the Kajakai Generators, when the Kajakai line is reenergized, load may only be added in discrete steps. Operate the disconnect switches and CB's in the order of (a-e). This step by step process is also illustrated with the single line diagram in Appendix 4.5
   a) When there is a power outage of Kajakai incoming, the Circuit Breaker **E03.3 –Q0** will trip as it is programmed. This Circuit Breaker can close remotely <u>only</u> when the power is restored. A remote push switch added in Panel 3 for testing (circuit breaker closing) and reset if required. The added push button will not affect any protection functioning of the relay, but the button can be used to close the CB E03.3 Q0 for testing and or when Kajaki power is restored after an outage. Please note that this push button is the only change from the original design and it is provided for more convenient operation and testing of the breaker. The detail of Push Button connection is as below.



Push button connection enlarged view.



BREAKER E03.3—Q0

b) To operate remotely the Kajakai incoming Motorized disconnect switch **E03.1-Q9**, **CB E03.3 –Q0 and E03.1 –Q0** is required to be in the "open" position.
c) To operate remotely the Kandahar outgoing Motorized disconnect switch **E01.1-Q9**, **CB E01.3 –Q0 and E01.1 –Q0** is required to be in "open" the position.
d) To operate remotely the Lashkargah outgoing Motorized disconnect switch **E0 3.2-Q9**, **CB E01.2 –Q0 and E1.3 –Q0** is required to **be** in the "open" position.
e) To operate remotely the power Transformer 110/20 KV incoming Motorized disconnect switch **E0 1.2-Q9**, **CB E01.3 –Q0** and **E01.2 –Q0** are both required to be in the "open" position.
f) Standby power be operated for a minimum of four hours per day for battery charging to ensure that DC power system is fully charged and available for use.

2.1.1.2 Input Data for Design & Engineering

Tender single line diagram was used as primary reference for layout and equipment arrangement.

Ratings data took from technical specification and tender diagram with confirmation from both references.

Ratings were confirmed from equipment vendors to ensure equipment to be installed are according to design requirements. Equipment quantity took from tender drawing and technical specification.

Single line diagram was finalized based on time to time client revisions, related to equipment ratings, quantities and equipment location.

<u>Technical Specification Reference</u>

SF6 Circuit Breaker	-	Ref. # 00755.2
Surge Arrester	-	Ref. # 00755.7
Capacitor Voltage Transformer	-	Ref. # 00755.6
Current Transformer	-	Ref. # 00755.8
Disconnector	-	Ref. # 00755.3
Inductive Voltage Transformer	-	Ref. # 00755.25

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Vacuum Circuit Breaker	-	Ref. # 00755.24
Power Transformer	-	Ref. # 00755.14
Line Trap	-	Ref. # 00755.16

2.1.1.3 Calculations/Ratings

Equipment Ratings were as per project specifications. Vendor brochures for the equipment referred with the single line diagram.

Parameters added to the single line document details and all equipment precise details added to parameters.

2.1.1.4 Drawings

Drawing were developed using latest version of AutoCAD®. Single line were developed on A3 size paper with clear detail and equipment ratings. Legend column was provided with Symbols and equipment designations. Title block for drawing were provided by the client for use with all submittals and followed. Drawings were not scaled.

2.1.1.5 Matter

Submitted /approved single line diagram had 110 KV scope from

- Kajakai Dam 110kV line
- Kandahar Dam substation 110kV line
- Lashkar Gah substation 110kV line

For 20 kV Scope

- 20 kV line to Local Load

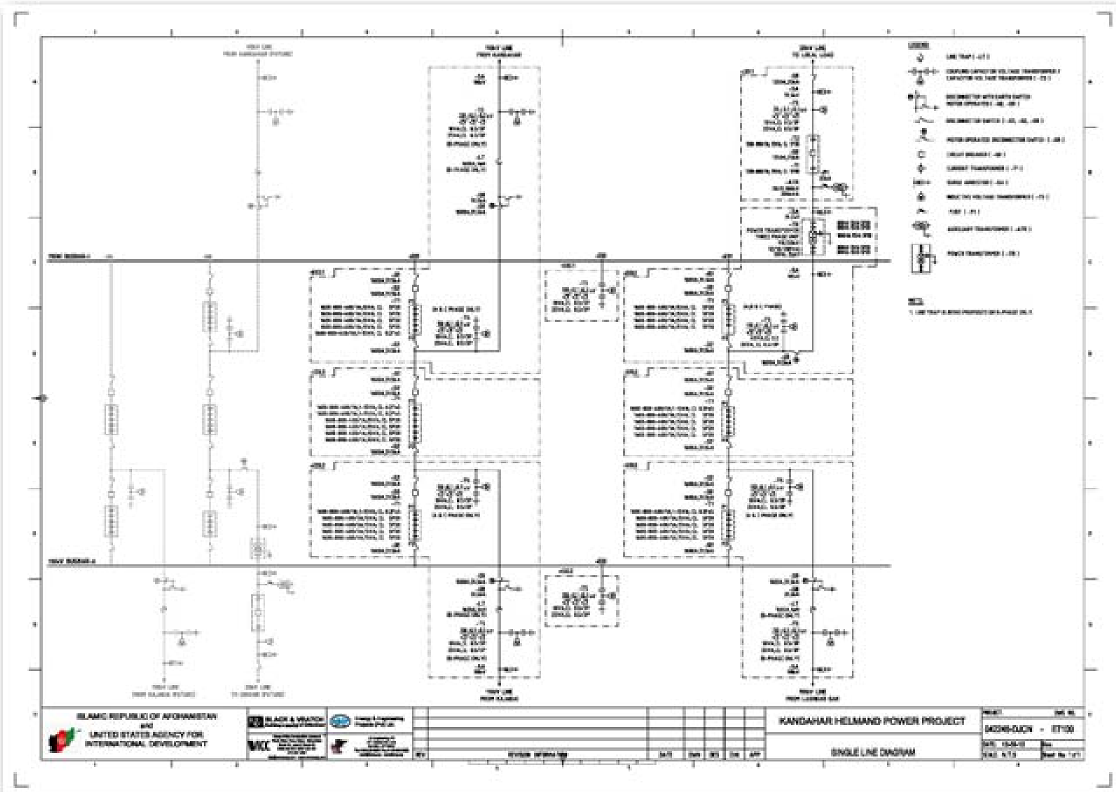
Single line depicted Line-Line Dia. and Line –Transformer Dia. in the diagram

2.1.1.6 Material Take-Off / B.O.Q

Main Equipment B.O.Q was prepared as part of Single line diagram submittal.

2.1.2 Switchyard Layout

2.1.2.1 Description



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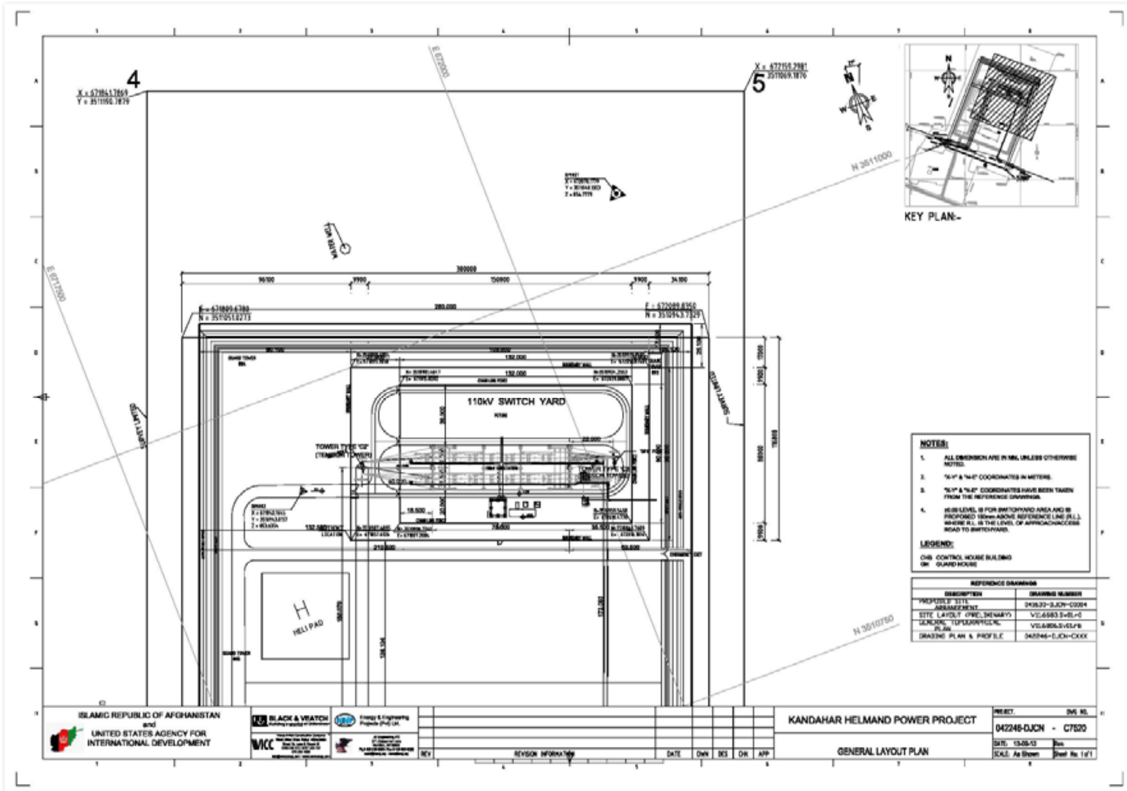

Durai Junction Switch yard layout & Switchyard Sections diagram developed using multiple documents provided by client as reference. These documents included technical specification, bid documents and pre-bid documents. Client proposed single line diagram No. 041630-3PPS-E7001 & proposed General Arrangement diagram No.041630-3PPS-E7100 provided with these documents was used as primary reference diagrams.

Bus bar scheme for this design was as proposed a breaker and a half scheme configuration as per suggested criteria from technical specification. Switchyard Layout was developed keeping in view the requirement of electrical and working clearances required for 110 kV and 20 kV systems. These clearances were maintained as per IEC standards.

General Arrangement for Equipment in the Switchyard along with Sections, bus bar height, clearances, steel support structures, all the Surrounding Area along with Control house building were fully dimensioned. Location of the Terminal tower was showed on the Switchyard Layout and their distances from the Substation gantries were marked in the submitted/approved drawings.

To Support the Switchyard Layout, Switchyard Sections were developed to give further insight about the Height of Steel Structures and Equipment. Switchyard Layout was divided in multiple sections as per requirement to show the equipment to equipment connections and Connections to Main Bus bars and Connections via Cross Busses. Switchyard Sections were given an estimate for all the Hardware required for Equipment to Equipment Connection and there Connection with the main Bus bars, Cross Busses and Transmission Lines.

2.1.2.2 Input Data

Approved Single line diagram was used as primary reference for Switchyard layout and Switchyard Sections. Equipment quantity & Location were taken from Approved Single Line Diagram and technical specification. Switchyard Layout and Switchyard Sections was finalized based on time to time client revisions, related to equipment ratings, quantities and equipment location.

2.1.2.3 Calculations

Calculations performed to maintain the required electrical equipment to equipment clearances keeping in view the External and Internal Insulations for the Equipment. Dielectric Strength for the Equipment selected in relation to the voltages which can appear on the system. Following basic calculations performed to prepare the Switchyard Layout and Switchyard Sections:

- Insulation Coordination Calculations
- Sag Tension Calculations
- Bus Bar Sizing Calculations

Equipment to Equipment minimum clearances was calculated via Insulation Coordination Calculations. For Insulation Coordination Calculations completed referred to IEC-60071-1 & IEC 60071-2. Ampacity Calculations for the Bus bar performed keeping in view the Heat Losses and Heat Gain by the Bus bar Conductor and from ampacity calculations, the conductor material is decided.

2.1.2.4 Specifications/Standards

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Specifications used for developing the Switchyard layout and Switchyard Sections keeping in view the minimum equipment to equipment electrical clearances are the Project Technical Specifications and the relevant IEC Standards. IEC Standards used are IEC 60071-1 and IEC 60072-2.

The later standards are used for Insulation Coordination procedure. Rated Dielectric Strength selected keeping in view the over voltages which can appear in the system. Using the Rated Dielectric Strengths, minimum clearances are decided.

2.1.2.5 Drawings

Drawings are developed using latest version of AutoCAD®. Switchyard Layout and Switchyard Sections are developed on A3 size paper with clear detail and equipment to equipment clearances and all the necessary dimensions. Legend column provided with Symbols and equipment designations. Reference Drawings used for developing the Switchyard Layout and Switchyard Sections. Title block for drawing provided by the client for use with all submittals are used.

2.1.2.6 Matter

Submitted Switchyard Layout and Switchyard Sections diagram showing 110 kV scope from

- Kajakai Dam 110kV line
- Kandahar Dam substation 110kV line
- Lashkar Gah substation 110kV line

For 20 kV Scope

- 20 kV line to Local Load

Switchyard Layout and Switchyard Sections depicted Line-Line Dia. and Line –Transformer Dia. in the diagram. Steel Support Structures, all the Surrounding Area along with Control house building fully dimensioned.

Location of the Terminal tower showed on the Switchyard Layout and there distances from the Substation gantries marked. Entrances, Gates, Paths, and Roads showed with their widths marked.

2.1.3 Foundation Layout

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2.1.3.1 Description

Durai Junction Foundation Layout diagram developed using multiple documents including Approved Single Line Diagram & Switchyard Layout and Switchyard Sections. Foundations for all the primary equipment including Steel Structures, Gantries, Post Insulators, Power and Auxiliary Transformers and Generator showed in the Foundation Layout Plan. Foundation Top level showed in the Foundation Layout Diagram for each primary equipment, Steel Structures, Control house building, Transformers. Level for each foundation marked by taking the zero level decided as reference. Numbering were provided to all the foundations, identical number were given to identical foundations and the dissimilar foundations marked with different numbers. Legend provided which were gave the detail for foundation against every number.

Detail for each foundation was provided separately in the Foundation layout. It also showed the phase separation for foundation of 3 phase equipment.

2.1.3.2 Input Data

Approved Switchyard layout and Switchyard Sections diagram used as primary reference for Foundation layout. Equipment quantity & Location was taken from Approved Switchyard layout and Switchyard Sections and foundations for all the Primary equipment and Steel Structures were located according to that. Foundation Layout was concluded based on time to time client revisions, related to equipment ratings, quantities and equipment location.

2.1.3.3 Calculations

Calculations were performed to finalize the Strength, level & dimensions for each foundation. Following Calculations were performed to prepare the Foundation Layout.

- Structure Loading Calculations
- Foundation Loading Calculations

Using Loading Calculations, total normal load on the Primary equipment, Steel Structures and an additional load due to wind, Short circuits & other factors were calculated and the foundations strength and dimensions decided according to that.

2.1.3.4 Drawings

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Drawing were developed using latest version of AutoCAD®. Foundation Layout was developed on A3 size paper with clear detail. Number was marked on each foundation. Similar number for identical foundations & different numbers for dissimilar foundations were marked. Legend column provided showing the detail of foundation against each number. Different levels for foundations taken with reference to zero level given in the Foundation Layout Plan. Reference Drawings used for developing the Foundation Layout were Switchyard Layout & Switch yard Sections. Number and title for each reference diagram was mentioned. Title block for drawing provided by the client for use with all submittal is used.

2.1.3.5 Matter

Submitted Foundation Layout showing the Scope of Foundations for 110kV:

- Primary Equipment
- Power and Auxiliary Transformers
- Control House Building

For 20 kV Scope

- 20kV Primary Equipment

Foundation Layout showing the levels for all the Primary equipment and location for their foundation which was taken from the Approved Switchyard Layout & Switchyard Sections.

2.1.4 Earthing System

2.1.4.1 Description

Prime Objective of Earthing is to provide a Zero potential surface in and around and under the area where the electrical equipment is installed or erected. To achieve this objective the non-current carrying parts of the electrical equipment is connected to the general mass of the earth which prevents the appearance of dangerous voltage on the enclosures and helps to provide safety to working staff and public. Durai Junction Earthing Layout Plan is developed using multiple documents provided by client as reference. These documents include technical specification, bid documents and pre bid documents.

A new earthing grid is installed. Earthing designed and installed in accordance with IEEE 80, Guide for Safety in AC Substation Grounding. Resistivity measurements obtained using the

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Wenner 4 pin method as described in IEEE 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a complete substation Grounding System.

The minimum thickness of the aggregate surfacing is considered 100 mm and the earth conductors installed at a minimum depth of 450 mm below rough grade. A galvanized steel grate earth mat provided at each disconnects and earthing switches operator location and positioned such that the operator's feet are on the mat when the handle is operated. The earth mat installed on the top of the aggregate surfacing and bonded to the earth grid and operating handle.

The aggregate surfacing complied with the requirements of the grounding calculations and extended 1.25 meter outside of the substation area. The nominal size of the aggregate considered was 25 mm.

Equipment grounds within the control enclosure are conformed to the following general guidelines:

All electrical equipment, such as switchgear, power centers, motor control centers, relay cubicles, panel boards, control cubicles, etc., have integral earth buses which is connected to the station earth grid by two separate distinct connections each having 100 percent capacity.

Electronic cubicles and equipment, where required, earthed utilizing insulated earth wire connected in accordance with the manufacturer's recommendations.

Each continuous laid length of cable tray is earthed minimum of two places to the earthing grid. The distance between the earthing points limited within 30 meters. It is ensured that no any raceway served as an earth conductor. All the earth pads are directly connected to the earth grid

All electrical equipment in buildings, disconnect switch stands, and shielding masts, wherever required, are provided with two paths to earth. Bus supports and similar structure is provided with one path to earth.

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An earthing conductor routed parallel to all power conductors operating above 250 volts.

All earth wires installed in conduit are insulated.

Above grade, connections are mechanical and below grade, connections are exothermal.

Earthing materials furnished are described in the following:

Earth grid and riser conductors are copper. Earth grid conductor cross-sectional area which installed are of 120 mm^2.

Riser conductors used are of 95mm^2

Earth wires installed in conduit were copper with Class 2 stranding, and green/yellow colored rated 1000 volt PVC insulation.

2.1.4.2 Input Data

Ratings data were taken from technical specification and engineering calculations with confirmation from both.

Ratings were confirmed with vendors for all material installed to ensure it is according to the design requirements.

Earthing Layout developed based on Foundation Layout Plan.

Earthing Layout diagram were finalized based on time to time client revisions and approvals.
Technical Specification Reference Section 00756.2.2 covers the furnishing and installation of earthing materials. Inputs considered are:-

• Rods	Ref. # 00756.2.2.2
• Cable	Ref. # 00756.2.2.2
• Soil resistivity report	Site survey report
• RMS value of fault current to ground.	Ref. # 00753.4.1.4
• X/R ratio of system.	Ref. # 00753.4.1.4
• Fault current division factor.	IEEE 80

- Fault current projection factor. IEEE 80
- Total fault duration (tf). Ref. # 00753.4.1.2
- Depth of Ground grid from ground level. IEEE 80
- Depth of Surface layer of grave IEEE 80

2.1.4.3 Calculations

Grounding Grid design and calculations were performed in line with IEEE Std. 80 with the help of power system software ETAP. ETAP allows the engineers to integrate with advanced 3D technology, enabling the engineers to optimize electrical grounding grid. Following 3 D graphs were submitted and approved prior to construction.

- Absolute Potential Profile.
- Touch Potential Profile.
- Step Potential Profile.

2.1.4.4 Drawings

Drawing were developed using latest version of AutoCAD®. Earthing Layout developed on A3 size paper with clear details. Legend column was provided with Symbols and equipment designations. Title block for drawing provided by the client for use with all submittals were used.

2.1.4.5 Matter

Submitted Earthing Layout was prepared on top of Equipment Foundation Layout clearly indicating the following.

- Location of Main Mesh
- Equipment riser interconnection
- Location of earthing rods
- Neutral Earthing connection

2.1.4.6 Material Take-Off / B.O.Q

Main Earthing B.O.Q was attached as part of earthing layout submittal and approved prior to procurement.

2.1.5 Shielding System

2.1.5.1 Description

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Durai Junction Shielding Layout & Shielding Sections diagram developed using Switchyard Layout. Other documents included were technical specification, bid documents and pre-bid documents. Proposed General Arrangement diagram No.041630-3PPS-E7100 provided with these documents was used as primary reference diagrams.

All the Substation equipment including Steel Structures, Primary equipment, Bus bars, protected against direct lightning strikes. Substation equipment protected against direct lightning strikes by means of spikes.

110/20kV Overhead line is protected by using shielding wire. Area protected by the spikes depicted in the Shielding Layout & Shielding Sections. Control House Building also protected via spikes. Rolling sphere method used for the Lightning protection and the IEEE 998 Standard for Substation.

Lightning protection was implemented to fulfill all these requirement.

2.1.5.2 Input Data

Approved Switchyard layout diagram used as primary reference for Shielding Layout & Shielding Sections. Equipment quantity & Location were taken from Switchyard Layout & Switchyard Sections Diagram. Shielding Layout & Shielding Sections was finalized based on time to time client revisions, related to equipment ratings, quantities and equipment location.

2.1.5.3 Calculations

Calculations performed using Rolling Sphere method according to the Standard IEEE 998 for Substation Lightning Protection to show the protected area used Spikes.

2.1.5.4 Specifications/Standards

Specifications used for developing the Shielding layout and Shielding Sections keeping in view the area protected by the Spikes and Shielding wires are the Project Technical Specifications and the relevant IEEE Standards. IEEE Standard used is IEEE 998.

The latter Standard used for Shielding Calculation Procedures. As according to the Project Technical Specifications, Rolling Sphere method was used for developing the Shielding Layout & Shielding Sections.

2.1.5.5 Drawings

Drawing developed using latest version of AutoCAD®. Shielding Layout and Shielding Sections developed on A3 size paper with clear detail of protection of Substation Switchyard & Control house building. Reference Drawings used for developing the Shielding Layout and Shielding Sections were given. Title block for drawing was provided by the client and same used with all submittals.

2.1.5.6 Matter:

Submitted Shielding Layout and Shielding Sections diagram were showing 110 kV scope of protection from Lightning Strikes for:

- Steel Structures
- Primary Equipment
- Transformers

For 20 kV Scope

- Primary Equipment

Control House building protection was also a scope of Shielding Layout. Spikes were used for the Protection of Substation Switchyard & Control house building.

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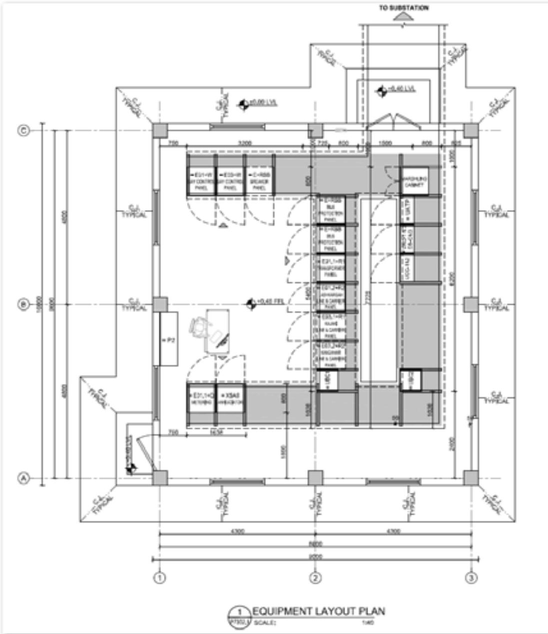

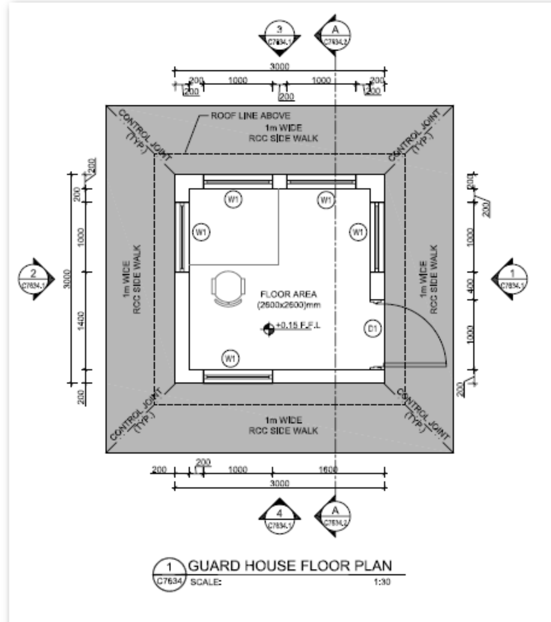

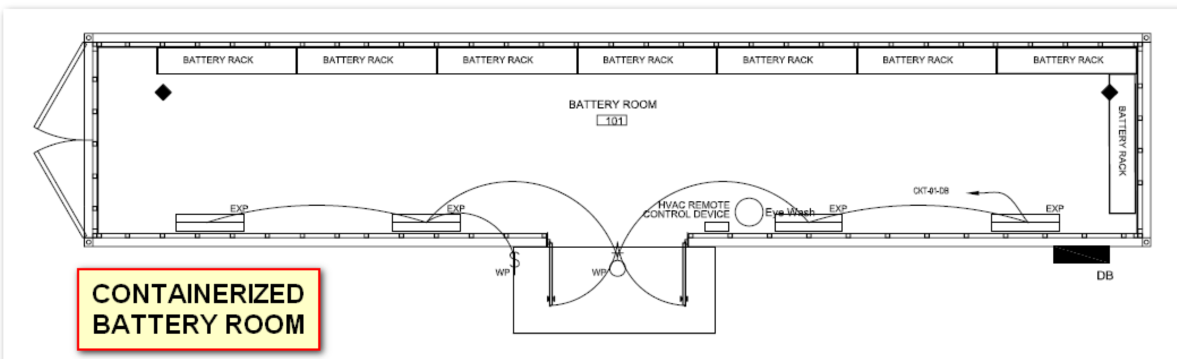

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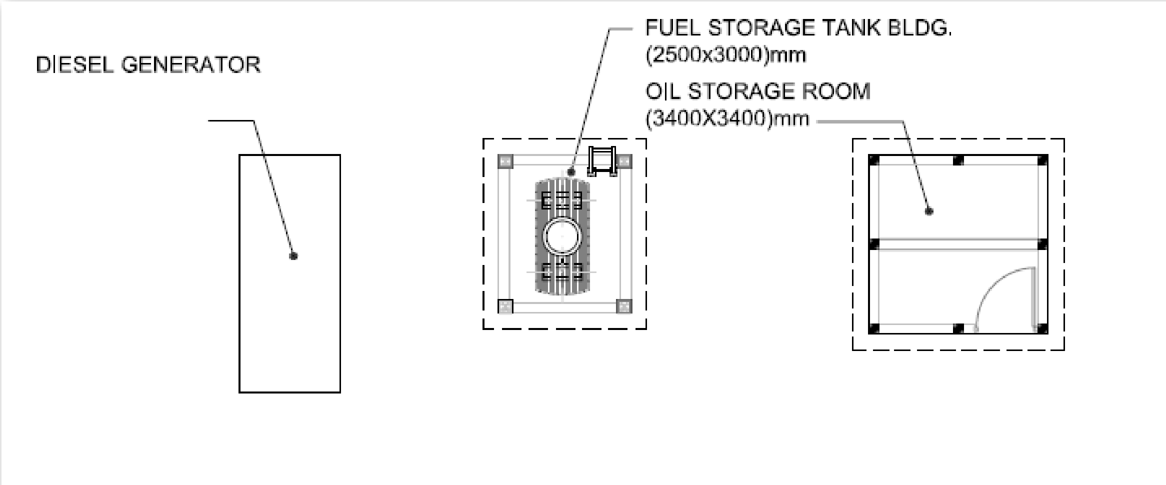

2.1.6 Control House Building Equipment Layout

2.1.6.1 Description

Control Building Equipment Layout Plan highlighted the arrangement of control, protection and automation panels, ac/dc service panels and equipment, Cable entrance and flow of cables inside the building shown in layout to trace the path of power and control cables. In addition, equipment support layout developed along with sectional views.

2.1.6.2 Input Data

Internal control building layout was finalized with the number and size of control and protection panels. Control building included coordinated grouping of electrical distribution, power conversion, and control and communication equipment contained within all-weather enclosure. Control building equipped with all equipment included in the specification; station service equipment is as per specification section 00755.23. All electrical equipment installed in the control building wired to appropriate panels and were ready for operation when the AC and DC station service was connected.

2.1.6.3 Drawings

Drawing developed using latest version of AutoCAD®. Control building layout provided on A3 size paper with actual dimensions of all the equipment included.

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2.2 Secondary System

2.2.1 Description

The substation protection philosophy is to provide accurate recognition of a fault condition and to ensure rapid isolation of faulty circuit from the system. The protection scheme have following features.

- High reliability and security
- Fast operating times
- Ability to maintain system stability

Control and Protection equipment are microprocessor type. Protection system of Durai Junction consisting of following Equipment

- Breaker Control and Bay control
- Line Protection (primary & backup)
- Transformer Protection (primary & backup)
- High Impedance Busbar Protection.

In addition to Protection, SEL 7000 provides fully integrated system for protection, automation and control and management of event reports, settings and sequential event recorder data. This significantly reduces the number of components present in the substation.

2.2.2 Input Data for Design & Engineering

Tender single line diagram and tender Protection and Metering single line diagram was used as primary reference for layout and equipment arrangement. Ratings data were taken from technical specification and tender diagram with confirmation from both references. Ratings confirmed from equipment vendors for all equipment to be installed according to design requirements.

Technical Specification Reference

- Control and Protection Equipment Ref. # 00753.4.9.3
- Circuit breaker Control and Bay Control Ref. # 00753.4.9.4
- Line Relaying Protection Ref. # 00753.9.4.5
- Transformer Protection Ref. # 00753.4.9.6
- Bus Protection Ref. # 00753.4.9.7
- Indication Metering Ref. # 00753.4.9.10
- SCADA System Ref. # 00755.12

2.2.3 Calculations

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Following basic calculation were performed as per International IEC/IEEE standards

- Current Transformer burden calculations
- Voltage Transformer burden calculations
- Battery Sizing
- Battery Charger Sizing

2.2.4 Drawings

Drawings were developed using latest version of AutoCAD®.

2.2.5 Material Take-Off / B.O.Q

Main Equipment B.OQ were attached as part of drawings submitted for approval.

2.3 Civil Design Criteria

2.3.1 Control House Facility

2.3.1.1 Design Methodology

- Architectural Design containing plans, elevations and section details. Locations and Type of doors, windows and ventilators etc are detailed.

- The building is designed for gravity loads based upon self-weight and superimposed loads over structure. The superimposed live load is based upon ASCE 7-05 [Minimum Design Loads for Buildings and Others Structures] & IBC-2009 [International Building Code]. The determination of seismic loads, wind loads and temperature load are based upon following.

2.3.1.2 Seismic Loads Determination

Occupancy category= III Importance factor = 1.25

Short period Mapped spectral acceleration = Ss = 0.16g

One second period Mapped spectral acceleration = S1 = 0.07g

Site class = determined through geotechnical investigation and Table 1613.5.2 IBC-2003

2.3.1.3 Wind Load Determination

The determination and application of wind forces over control house building is as per International building code [IBC-2009] and Euro code specifications. In addition following are accounted as per technical specifications 00752.1.5.

Wind Velocity = 41 m/s (148 km/hr.)

Wind and dust = sand and dust storms in summer

2.3.1.4 Temperature Loads

The stresses caused in structural members considered for the following variation of the temperature in accordance with the Technical specifications 00752.1.5 listed hereunder;

Average temperature = +24°C

Maximum temperature = +48°C

Minimum temperature = - 24°C

- Building foundation design is based upon the geotechnical investigation carried out and approved for the DJCN work. Bearing stresses under all conditions of loading remaining under the allowable bearing stresses. The factor of safety against overturning and sliding are as per building code requirements.

2.3.1.5 Materials

The materials for the structural steel elements, connection, anchor bolts, welding electrode and structure finish are as per specification listed hereunder in tables.

2.3.1.6 Steel Shapes and attachments

Structural Steel Member	Specifications
Wide flange members	ASTM A992. Minimum yield strength of 345 MPa (50 ksi).
Rolled steel shapes, placed and latticed	ASTM A36/A 36M. Minimum yield strength of 250 MPa (36 ksi).
Square and structural tubing members	ASTM A500 Grade B. Minimum yield strength of 320 MPa (46 ksi).

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Round structural pipe	ASTM A500 Grade B. Minimum yield strength of 290 MPa (42 ksi).
High strength steel shapes and plates.	ASTM A572/A 572M wieldable quality or ASTM A36/ A36M modified to 345 MPa (50 ksi) minimum yield strength.

2.3.1.7 Connection Materials

Structural Steel Member	Specifications
Connection bolts	ASTM A325/A325M, hexagonal bolts and nuts, flat or beveled washers. All bolting material are galvanized ASTM A394, Type O, with hexagonal head.

2.3.1.8 Anchor Bolt:

Structural Steel Member	Specifications
Connection bolts, nuts and washers for structures.	ASTM A36/A36M, threaded bars, heavy hexagonal nuts conforming to ASTM A563/A563M Grade A galvanized.

2.3.1.9 Welding Electrodes:

Welding Electrodes	Low hydration types
ASTM A36/A36M steel, ASTM A 500.	AWS D1.1. Tensile strength range of 485 MPa (70 ksi) minimum.

2.3.1.10 Galvanizing:

Shapes & Plates	ASTM A123, ASTM A384 and ASTM 385.
Bolts, nuts & washers.	Galvanized as specified in ASTM A325/A325M and ASTM A153.

2.3.1.11 Painting:

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Primer paint	ASTM A123, ASTM A384 and ASTM 385.
Finish paint	Silicon acrylic resin or acceptable equal. Color is as indicated on the specification data sheet.

- Supplier and fabricators are checked for the type of paint, type of insulation and assembly system of building components in view of site specific conditions and also in view of erection plan.
- Prepared lighting and other services for the facility as required.
- Prepared and submitted for approvals all construction drawings for building floor showing type of finishes required therein.

2.3.2 Guard House

The guard house is equipped with separate electric heating and air conditioning units, interior lights and an exterior 150 watt security light, 100 Amp panel board with a main breaker. Architectural drawings showing details for plans, sectional and elevation details prepared as per desired level. Windows are sliding type and complete details pertaining to size, layout and specifications are clearly marked on the drawings.

A complete structural design of the guard housing pertaining to substructure and superstructure design is prepared along with structural design calculations / criteria completed in all respects as per applicable building code laws and regulations.

2.3.3 Substation Roads

A complete road design along with pavement and geometric design prepared on the basis of topographic plan, drainage system layout and grade levels and approved prior to construction.

A set of drawings detailed to the required level and conforming to the specifications listed hereunder are approved for construction.

2.3.3.1 Base Course

Base course comprising of 10 cm natural ballast layer, a crushed stone layer and sand layer matching to the dimensions listed hereunder;

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Natural Ballast Layer	10 cm thickness, consisting of stones from ballast or from quarry having diameter varying from 0 to 7 mm.
Crushed stone layer	40mm to 63 mm thickness and 63 to 90 mm diameter.
Sand Layer	Consisting of stone from ballast of from quarry having 0 to 3mm diameter.

2.3.3.2 Surface Course

The surface course construction is conformed to the BcR4.50 road concrete specifications and requirements.

2.3.3.3 Precast Concrete Curbs

The precast curbs are 20cmx25cmx50cm, fabricated to C 6/7.5 type of concrete. The curbs mounted 10 cm above the top of roads.

2.3.4 External / Security Works

Engineering Design for external / security works pertaining to perimeter wall and chain link fence provided and approved prior to construction. Perimeter wall and chain link fence design / drawings conforming but was not limited to the following

2.3.4.1 Perimeter Wall

Wall is a solid wall, designed in accordance with the site topography and geotechnical investigation. Concrete masonry unit (CMU) wall material is used for construction. Wall height above ground line is maintained minimum 2500 mm.

2.3.4.2 Chain Link fence

Chain link fence surrounding entire substation placed inside of perimeter wall. Barbed wire consisting of three strands are installed on the top of fence.

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2.3.4.3 Gate

A manually operated counter weight upswing barrier type gate is designed as entrance gate to the substation.

2.3.5 Grading, Sewerage & Drainage Works

The substation gradation design is carried out keeping in view the proper drainage of the rain water. Standing of water after rain and entrance / drainage of water into cable trenches is avoided.

2.3.6 Power Transformer, Switchyard Equipment & Cable Trenches

Steel structures is designed and fabricated in accordance with the requirements of AISC specifications for structural steel building. All structures / structural foundation of outgoing and incoming lines are designed for ± 30 degree angle of deviation in horizontal plane and ± 20 degree deviation in vertical plane in conjunction with the consideration of height and type of structure provided on electrical requirements. The critical loading combination causing higher stress is considered for design of structural foundation / structures.

Following loading cases and shape factor used in wind loads is considered in design.

2.3.6.1 Structure loading cases

Equipment Supported Structures		
Extreme wind	41 m/s wind, 15°C	OLF :TBD
Short circuit force and extreme wind calculated bus short-circuit force plus extreme wind.	41 m/s wind, 15°C	OLF :TBD

Gantry Structures		
Extreme wind	41 m/s wind, 15°C	OLF :TBD
Precamber no wind	15°C	OLF :TBD

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2.3.6.2 Equipment and Structure Foundation

Foundation for all equipment and structures are spread footing.

2.3.6.3 Anchor Bolt Projection

The anchor bolt projections contained minimum three threads after installation of all nuts and washers.

2.3.6.4 Structure Member Stresses

Under each loading combination, calculated member stresses are considered below IEC design stresses limits. Deflections criteria and limitations are as per enlisted in technical specifications.

2.3.6.5 Foundation Design

The foundation design is conformed to ACI 318 and in accordance with the following design criterias;

Concrete strength	fc' = 27.6 Mpa (4000 psi) at 28 days.
Reinforcing steel	ASTM A 615, Gr 60. [fy= 413.7 Mpa (60,000 psi)]
Frost depth	80 to 90cm.

2.3.6.6 Safety Factor for shallow foundations

Overturning	1.50
Sliding	1.50
Bearing	3.0

3. Equipment Data

3.1 SF_6 Gas Circuit Breaker

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The power circuit breakers are SF6 gas insulated type. The standard ratings for circuit breakers are as shown below:

Ratings	**110 kV System**
Rated Voltage, U_r	123 kV
Rated Insulation Level	550 kV
Rated Frequency, f_r	50 Hz
Rated Normal Current, I_r	1600 A
Rated Short-Time Withstand Current, I_k	31.5 kA
Rated Peak Withstand Current, I_p	78.75 kA
Rated Duration of Short Circuit, t_k	1 second
Number of Poles	3
Class	Outdoor
Rated Operating Sequence	O - 0.3s - CO- 3 minutes -CO
Operating Time, cycles	3
Trip and Close Requirements	3 pole ganged trip and close
Mechanical Operations	M2
Tank Design	Live Tank

3.2 Motorized Disconnect Switch

Outdoor disconnect switches are furnished in accordance with the following requirements.

Ratings	**20 kV System**	**110 kV System**
Rated Voltage, U_r	24 kV	123 kV
Rated Insulation Level	125 kV	550 kV
Rated Frequency, f_r	50 Hz	50 Hz
Rated Normal Current, I_r	1250 A	1600 A
Rated Short-Time Withstand Current, I_k	25 kA	31.5 kA
Rated Peak Withstand Current, I_p	62.5 kA	78.75 kA
Rated Duration of Short Circuit, t_k	1 second	1 second
Earthing Switch Rated Short Circuit Making Current	25 kA	31.5 kA
Rated Mechanical Endurance	M2	M2
Rated Value for Electrical Endurance for Earthing Switches	E1	E1

3.3 Containment Leakage Alarm Sensor

Labkotec SET® alarm devices

Technical Data

Control units

	SET-100	SET-1000	SET-2000	LevelSET S
Dimensions	55 x 70 x 112 mm (L x H x D)	175 x 125 x 75 mm (L x H x D)		
Enclosure	Plastic housing IP 20, mounting on a 35 mm DIN rail	IP 65, material polycarbonate, wall-mounted		
Ambient temperature	-20 °C...+50 °C	-25 °C...+50 °C	-25 °C...+50 °C	-30 °C...+50 °C
Supply voltage	230 V AC ± 10 %, 50/60 Hz	230 V AC ± 10 %, 50/60 Hz, 110 V AC ± 10 %, 50/60 Hz, 12 VDC		
Power consumption	2 VA		4 VA	4,5 VA
Probes	SET/...2 probes	One Labkotec SET probe	Max two SET probe	Max. three SET probes
Relay outputs	One potential-free relay output, 250 V, 5 A, 100 VA	Two potential-free relay outputs, 250 V, 5 A, 100 VA	Two potential-free relay outputs, 250 V, 5 A, 100 VA	Three potential-free relay outputs, 250 V, 5 A, 100 VA
Electrical safety	EN 61010-1, CAT II, Class II	EN 61010-1, CAT II, Class II/III		
Certificates:				
ATEX	VTT 02 ATEX 018X	VTT 04 ATEX 031X	VTT 04 ATEX 031X	VTT 09 ATEX 027X
IECEx	N/A	IECEx VTT 10.0003X	IECEx VTT 10.0003X	IECEx VTT 10.0011X
Ex-classification	Ex II (1) G [Ex ia] IIC	Ex II (1) G [Ex ia] IIC	Ex II (1) G [Ex ia] IIC	Ex II (1) G [Ex ia] IIB

Probes

	SET/DM3AL	SET/DM3DL	SET/S2	SET/V	SET/OS2 SET/OSK2	SET/TSHS2
Principle of operation	Conductivity	Conductivity	Ultrasonic	Vibration	Capacitive	Capacitive
IP classification	IP 68					
Enclosure	PVC, AISI 316, NBR, PA	PVC, AISI 316, NBR, PA	PA, PVC, aluminium, NBR	PA, PVC, aluminium, NBR	PVC, AISI 316	PVC, AISI 316
Ambient temperature	-30 °C...+60 °C	-30 °C...+60 °C	-30 °C...+60 °C	-30 °C...+60 °C	-25 °C...+60 °C	-25 °C...+60 °C
Supply voltage	Approx. 12 VDC from SET control unit					
Cable	Fixed oil resistant PVC cable 3 x 0,5 mm, standard length 5 m					
Certificates:						
ATEX	VTT 09 ATEX 026X	VTT 09 ATEX 026X	VTT 09 ATEX 051X	VTT 09 ATEX 025X	VTT 03 ATEX 009X	VTT 03 ATEX 024X
IECEx	IECEx VTT 10.0001X	IECEx VTT 10.0001X	IECEx VTT 10.0002X	IECEx VTT 10.0006X	N/A	N/A
Ex-classification	Ex II 1 G Ex ia IIA T5 Ga	Ex II 1 G Ex ia IIA T5 Ga	Ex II 1 G Ex ia IIB T5 Ga		Ex II 1 G Ex ia IIA T5 Ga	Ex II 1 G Ex ia IIB T5 Ga

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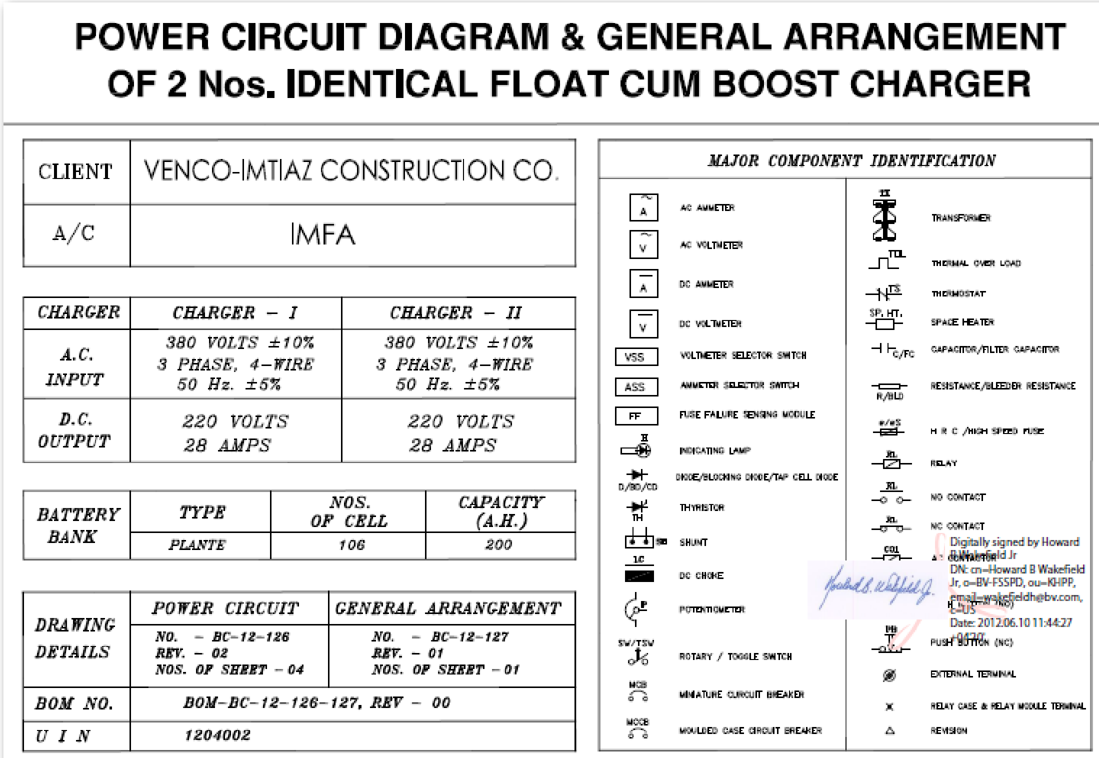
3.4 Battery Charger



3.5 Generator

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Output Ratings		
Generating Set Model	Prime*	Standby*
380-415V,50Hz	200.0 kVA 160.0 kW	220.0 kVA 176.0 kW
480V, 60 Hz	225.0 kVA 180.0 kW	250.0 kVA 200.0 kW

* Refer to ratings definitions on page 4.
Ratings at .8 power factor

Technical Data		
Engine Make & Model:	Perkins 1306C-E87TAG4	
Alternator Model:	LL5014F	
Base Frame Type:	Heavy Duty Fabricated Steel	
Circuit Breaker Type:	3 Pole MCCB	
Frequency:	50 Hz	60 Hz
Engine Speed: RPM	1500	1800
Fuel Tank Capacity: litres (US gal)	350 (92.5)	
Fuel Consumption, Prime: l/hr (US gal/hr)	49.4 (13.1)	56.6 (15.0)
Fuel Consumption, Standby: l/hr (US gal/hr)	54.3 (14.3)	61.1 (16.1)

3.6 Power Transformer 110/20 kV 20 MVA

Distribution power transformer is furnished in accordance with the following requirements:

110kV/20kV Power Transformers				
Capacity, MVA @ 65°C rise		20 MVA		
Winding Configuration		Two winding		
Vector group		Dyn1		
Frequency, Hz		50		
Cooling Class		ONAN/ONAF/ONAF		
Service		Outdoor, 3 - phase		
Winding/Bushing Data				
Winding or Bushing	Nominal (mid-tap) Voltage (kilovolts)	Winding BIL (kilovolts)	Bushing Voltage (kilovolts)	Bushing BIL (kilovolts)
High voltage, HV	110	450	123	550
Low voltage, LV	20	95	24	125
Neutral, XO	--	95	24	125
Minimum creepage distance, mm/kV_{LL}		31		
Winding Impedances				
Impedances (with manufacturer's standard tolerances) are as follows:				
HV to LV (%)	Per IEC Standard	at nominal voltage, on		20 MVA base
Tap Changer				

High voltage, HV	On Load Tap Changer (LTC) with remote tap changer controller (RTCC)
Low voltage, LV	--

3.7 CT

Free standing current transformers are multi-ratio furnished in accordance with the following requirements.

Ratings	110 kV System
Rated Voltage, U_m	123 kV
Rated Insulation Level	550 kV
Rated Frequency, f_r	50 Hz
Rated Normal Current, I_r	1600 A
Rated Short-Time Withstand Current, I_k	31.5 kA
Rated Peak Withstand Current, I_p	78.75 kA
Rated Duration of Short Circuit, t_k	1 second
Rated Secondary Current	1A
Rated Continuous Thermal Current I_{cth}	150%
Revenue Metering Accuracy Class	15VA 0.2FS5
Protective Relaying Accuracy Class	15VA 5P20

3.8 CVVT

Capacitor voltage transformers are furnished in accordance with the following requirements:

Ratings	110 kV System
Rated Insulation Level	550 kV
Rated Frequency, f_r	50 Hz
Rated Primary Voltage, U_{pr}, A-N	110 kV/√3
Rated Secondary Voltage, U_{sr}, a-n	100V/√3 / 100V/√3
Number of bushings for each CVT	1

3.8 Control and Protection System

Substation Control and Protection System equipment are provided in accordance with the following requirements:

Nominal Cubicle size	
Width, mm	800
Height, mm	2,300

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Depth, mm	800
Cubicle Wire	
Service	Minimum Wire Size, mm^2
Power supplies and packaged control systems	10
Current transformer circuits	6
Potential transformer circuits	4
Control wiring	2.5
Annunciator wiring	2.5
Analog circuits	2.5 (shielded cable)
IRIG distribution	Twisted shielded pair or coax cable
Earth Bus	
Vertical earth bus for cable shields to be provided	Yes
Power Supply	Station DC Battery
Time Synchronization	
Type	Match time synch equipment
Physical connection	Match time synch equipment
Status Inputs Wetting Voltage	
Station Battery/DC-DC Converter	Station Battery
RTU Supply	Station Battery
Distributed I/O Type	Manufacturer's Standard
Status Inputs Type	Sequence of Events
Pulse Accumulator or Counter Inputs Type	Form C
Counter Maximum Values	16-bit binary counter (65,535 counts)
Analog Inputs Type	± 1 mA, 0-1 mA, Digital with IED
Analog Outputs Type	Not required
Controls Type	Trip/Close (T/C), Raise/Lower (R/L)

Status Points	
The following points for each piece of equipment indicated is wired into the control /protection and Annunciation panels.	
Binary Status Points	
SF6 Circuit Breakers	
Normally open "a" contact[1]	Yes
Normally closed "b" contact[2]	Yes
Remote control enabled	Yes
Breaker Low Gas	Yes
Breaker trouble (common status point for any remaining alarms)	Yes
Disconnect Switches	
Normally open "a" contact[1]	Yes
Normally closed "b" contact[2]	Yes
Remote control enabled	Yes
Earthing Switches	
Normally open "a" contact[1]	Yes
Normally closed "b" contact[2]	Yes

Auto Transformers	Not Used
Distribution Power Transformers	
High oil temperature	Yes
High winding temperature	Yes
Sudden pressure alarm	Yes
LTC high oil temperature	Yes
XFMR trouble (common status point for any remaining alarms)	Yes
LTC in follower operation mode	Yes
Shunt Reactors	Not Used
Generator	
Generator running	Yes
Generator circuit breaker closed	Yes
Generator trouble (common status point for alarms)	Yes
Relay Communication	
Communication trouble (one alarm for each transmission line communication	Yes
Relays and GPS Equipment	
Relay failure alarm from each microprocessor based relay	Yes
Vacuum Circuit Breakers	
Normally open "a" contact	Yes
Normally closed "b" contact	Yes
Remote control enabled	Yes
Breaker trouble (common status point for any remaining alarms)	Yes
MV Metal-Clad Switchgear	
Main breaker normally open "a" contact	Yes
Main breaker normally closed "b" contact	Yes
Main breaker connected	Yes
Main breaker remote control enabled	Yes
Main breaker earthing switch closed	Yes
Main breaker trip coil failure	Yes
Feeder breaker normally open "a" contact	Yes
Feeder breaker normally closed "b" contact	Yes
Feeder breaker connected	Yes
Feeder breaker remote control enabled	Yes
Feeder breaker earthing switch closed	Yes
VT disconnect (withdrawable case only)	Yes
Miscellaneous Status Points	
Reclose enabled for each transmission line with reclosing capability	Yes
Fire alarm	Yes
Intruder Alarm	Yes
DC safety switch open	Yes
DC low battery voltage for each battery system	Yes
Loss of primary ac station service source	Yes
Loss of backup ac station service source	Yes
Oil spill alarm	Yes
High control building temperature	Yes
Low control building temperature	Yes

25 spare status inputs	Yes
Control Points	
Circuit Breakers	
Trip/close pair	Yes
Disconnect Switches	
Open/close pair	Yes
Earth Switches	
None	Yes
Power Transformers	
LTC raise/lower pair	Yes
Generator	
Start/stop pair	Yes
Emergency stop	Yes
Analog Input3	
Busbars	
3 - voltage for each busbar section	Yes
1 - frequency for each busbar section	Yes
Transmission Lines	
3 – Voltages	Yes
3 – Currents	Yes
MW	Yes
MVar	Yes
Auto Transformer	Not Used
Distribution Power Transformer	
3 – Voltages	Yes
3 – Currents	Yes
MW	Yes
MVar	Yes
LTC position	Yes
Reactors	Not Used
Capacitor Banks	Not Used
Station Service stand-by Generator	
Fuel level low	Yes
Digital Communication	
Microprocessor relays	Yes
Revenue meters	Yes

Notes:

1. Independent pole operated devices have three (one from each phase) normally open "a" contacts wired in series to provide positive indication the device is closed.
2. Independent pole operated devices have three (one from each phase) normally closed "b" contacts wired in series to provide positive indication the device is open.
3. Analog indications may be obtained via digital communications with IEDs.

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APPENDIX 4.1

Complete Drawings List

Drawing Number	Drawing Title
042246-DJCN-E7000	SWITCHYARD LAYOUT & SECTIONS
042246-DJCN-E7000.1	SWITCHYARD SECTIONS SECTION A-A (110kV)
042246-DJCN-E7000.2	SWITCHYARD SECTIONS SECTION B-B (110kV)
042246-DJCN-E7000.3	SWITCHYARD SECTIONS SECTION C-C (110kV)
042246-DJCN-E7000.4	SWITCHYARD SECTIONS SECTION D-D (110kV)
042246-DJCN-E7000.5	SWITCHYARD SECTIONS SECTION F-F (20kV)
042246-DJCN-E7000.6	SWITCHYARD SECTIONS SECTION E-E (20kV)
042246-DJCN-E7000.7	Primary Equipment List
041630-DJCN-E7005	AC STATION SERVICE
042246-DJCN - E7034	CONTROL HOUSE BUILDING FIRE PROTECTION SYSTEM
042246-DJCN-E7035	CONTROL HOUSE BUILDING ELECTRIFICATION LAYOUT (AS-BUILT FOR APPROVAL)
042246-DJCN-E7100	SINGLE LINE DIAGRAM
042246-DJCN-E7103.1	SINGLE LINE DIAGRAM (CONTROL & METERING) 110kV LINE & TRANSFORMER(=E01)
042246-DJCN-E7103.2	SINGLE LINE DIAGRAM (CONTROL & METERING) 110kV LINE DIA (=E03)
042246-DJCN-E7104.1	SINGLE LINE DIAGRAM (PROTECTION) 110/20kV TRANSFORMER & 20kV LINE
042246-DJCN-E7104.2	SINGLE LINE DIAGRAM (PROTECTION) 110kV LINE FROM LASHKAR GAH
042246-DJCN-E7104.3	SINGLE LINE DIAGRAM (PROTECTION) 110kV LINE FROM KAJAKAI
042246-DJCN-E7104.4	SINGLE LINE DIAGRAM (PROTECTION) 110kV LINE FROM KANDHAR
042246-DJCN-E7104.5	SINGLE LINE DIAGRAM (PROTECTION) BUSBAR PROTECTION
042246-DJCN-E7110	ATS,UAC1,UAC2,220 / 380V DC SYSTEM,220V DC BATTERY CHARGER
042246-DJCN-E7110.1	DISTRIBUTION BOARD 220/ 380V 3-PHASE, 4-WIRE, 50HZ SYSTEM LIST OF CONTENTS
042246-DJCN-E7110.2	ATS NORMAL PGCS PANEL 220/ 380V 3-PHASE, 4-WIRE, 50HZ SINGLE LINE DIAGRAM
042246-DJCN-E7110.3	DISTRIBUTION BOARD (UAC-1) 220/ 380V 3-PHASE, 4-WIRE, 50HZ SYSTEM SINGLE LINE DIAGRAM
042246-DJCN-E7110.4	DISTRIBUTION BOARD (UAC-2) 220/ 380V 3-PHASE, 4-WIRE, 50HZ SYSTEM SINGLE LINE DIAGRAM
042246-DJCN-E7111	220V DC PANEL 220/380V DC, SYSTEM SCHEMATIC DIAGRAM OF UDC-1 & UDC-2
042246-DJCN-E7112	MARSHALLING KIOSK (20kV) (E03+S03) GENERAL ARRANGEMENT
042246-DJCN-E7112.1	MARSHALLING KIOSK (110KV) (E03+S02) GENERAL ARRANGEMENT
042246-DJCN-E7112.2	MARSHALLING KIOSK (110KV) (E01=S02) GENERAL ARRANGEMENT
042246-DJCN-E7112.3	MARSHALLING KIOSK (110KV) (E01+S01) GENERAL ARRANGEMENT
042246-DJCN-E7112.4	MARSHALLING KIOSK (110KV) (E01+S03) GENERAL ARRANGEMENT
042246-DJCN-E7112.5	MARSHALLING KIOSK (110KV) (E03+S03) GENERAL ARRANGEMENT
042246-DJCN-E7112.6	MARSHALLING KIOSK (110KV) (E03+S01) GENERAL ARRANGEMENT
042246-DJCN-E7300	SWITCHYARD LIGHTING LAYOUT PLAN AS-BUILT FOR APPROVAL
042246-DJCN-E7303	CONTROL HOUSE BUILDING LIGHTING LAYOUT
042246-DJCN - E7303.1	CONTROL HOUSE BUILDING LIGHTING LAYOUT PLAN
042246-DJCN - E7303.2	CONTROL HOUSE BUILDING SMALL POWER LAYOUT
042246-DJCN - E7636	GUARD HOUSE ELECTRICAL PLAN
042246-DJCN - E7636.1	GUARD HOUSE ELECTRICAL DETAILS
042246-DJCN-E7400	Earthing Layout
042246-DJCN-E7402	Shielding Layout
042246-DJCN-E7402.1	Shielding sections
042246-DJCN-C7634	Guard House Floor Plan & Roof Plan
042246-DJCN-C7634.1	Guard House Elevations
042246-DJCN-C7634.2	Guard House Section A-A
042246-DJCN-C7634.3	Guard House Door/Window Schedule & Detail
042246-DJCN-C7401	Trench Layout Plan
042246-DJCN-C7401.1	Trench Layout Plan
042246-DJCN-C7401.2	Trench Layout Plan
042246-DJCN-C7602	Site Grading and Drainage Plan and Sections
042246-DJCN-C7602.1	Grading Profile & Sections
042246-DJCN-C7602.2	Cross Sections
042246-DJCN-C7602.3	Cross Sections
042246-DJCN-C7602.4	Cross Sections
042246-DJCN-C7610	Foundation Layout Plan
042246-DJCN-C7606	Foundation layout coordinates schedule
042246-DJCN-C7606.1	Foundation layout plan
042246-DJCN-C7700	Power Transformer(Concrete Detail) Foundation with Oil Containment Basin
042246-DJCN-C7700.1	Power Transformer (Reinforcement Detail) foundation with oil containment basin
042246-DJCN-C7700.2	Oil Water Separator Tank Concrete outline
042246-DJCN-C7700.3	Oil water separator tank reinforcement detail
042246-DJCN-C7701.1	Foundation for 24kV Inductive Voltage Transformer
042246-DJCN-C7701.2	Foundation for 24kV Lightning Arrester
042246-DJCN-C7701.3	Foundation for 123kV CVT Capacitor Voltage TR + Line trap
042246-DJCN-C7701.4	Foundation for 123kV Lightning Arrester
042246-DJCN-C7701.5	Foundation for 123kV Circuit Breaker
042246-DJCN-C7701.6	Foundation for 123KV Current Transformer
042246-DJCN-C7701.7	Foundation for 123KV Disconnect Switch/ Disconnector With Earth Switch

Drawing Number	Drawing Title
042246-DJCN-C7701.8	Foundation for 123KV Post Insulator
042246-DJCN-C7701.9	Foundation for 24KV Circuit Breaker
042246-DJCN-C7701.10	Foundation for 24KV Disconnector Switch
042246-DJCN-C7701.11	Foundation for Auxiliary Transformer
042246-DJCN-C7701.12	Diesel Generator Pad plan & section
042246-DJCN-C7701.13	Foundation for 110KV Marshalling Kiosk
042246-DJCN-C7701.14	Foundation for 20KV Marshalling Kiosks
042246-DJCN-C7702.1	Gantry Column Foundations -Type A (Concrete Outline)
042246-DJCN-C7702.2	Gantry Column Foundation-Type A (Reinforcement Detail)
042246-DJCN-C7702.3	Gantry Column Foundation-Type B (Concrete Outline)
042246-DJCN-C7702.4	Gantry Column Foundation-Type B (Reinforcement Detail)
042246-DJCN-C7702.5	Gantry Column Foundations-Type C (Concrete Outline)
042246-DJCN-C7702.6	Gantry Column Foundation-Type C (Reinforcement Detail)
042246-DJCN-C7702.7	Gantry Column Foundation-Type D (Concrete Outline)
042246-DJCN-C7702.8	Gantry Column Foundation-Type D (Reinforcement Detail)
042246-DJCN-C7702.9	Gantry ColumnFoundation Type (E) (Concrete outline
042246-DJCN-C7702.10	Gantry Column Foundation Type (E) (Reinforcement detail)
042246-DJCN-C7702.11	Gantry Column Foundation Type (E) (CONNECTION DETAIL AT BASE)
042246-DJCN-C7729	Foundation For Transmission Tower Type (A)
042246-DJCN-C7729.1	Foundation For Transmission Tower Type (A) Stub Angle Details
042246-DJCN-C7730	Foundation For Transmission Tower Type (C)
042246-DJCN-C7730.1	Foundation For Transmission Tower Type (C) Stub Angle Details
042246-DJCN-C7802	Loading Diagram
042246-DJCN-C7603.1	SWITCHYARD FENCING LAYOUT, ELEVATION, SECTIONS & DETAIL
042246-DJCN-C7603.2	Switchyard Road Network Plan
042246-DJCN-C7603.2.1	Switchyard Road Network Road detailed enlarged plan and sections
042246-DJCN-C7603.2.2	Switchyard road network -Trench Sections
042246-DJCN-C7603.2.3	Switchyard road network -Trench Covers, Sections & details
042246-DJCN-C7603.2.4	Switchyard fencing gate (G2) plan, elevations sections & details
042246-DJCN-C7604	Perimeter Wall Plan Elevation & Details
042246-DJCN-C7604.1	Perimeter Wall Sections & Detail
042246-DJCN-C7604.2	Perimeter wall column footing Type (B) Plan & Sections
042246-DJCN-C7604.3	Perimeter wall longitudinal section
042246-DJCN-C7604.4	Perimeter wall detailed plan & elevation
042246-DJCN-C7811.1	Tower Grounding Additional Arrangement
042246-DJCN-C7811.2	Tower Grounding Arrangement
042246-DJCN-C7400	Earthing Layout (As Built for Approval)
042246-DJCN-C7400.1	Earthing Layout coordinates schedule
042246-DJCN-C7630	CHB Ground Floor Plan
042246-DJCN-C7630.1	CHB Roof Plan
042246-DJCN-C7630.2	CHB Roof Drainage Plan
042246-DJCN-C7630.3	CHB Attic Vent Plan
042246-DJCN-C7630.4	CHB Elevations
042246-DJCN-C7630.5	CHB Section
042246-DJCN-C7630.6	CHB Doors and Window Schedules
042246-DJCN-C7630.7	CHB Details
042246-DJCN-C7630.8	CHB Roof Ceiling Insulation Framing Details
042246-DJCN-C7631	Control Building Structural General Notes
042246-DJCN-C7631.1	Control Building Foundation Plan
042246-DJCN-C7631.2	Control Building Roof Beam plan
042246-DJCN-C7631.4	Control Building Sections & Detail
042246-DJCN-C7631.6	Control Building Schedules
042246-DJCN-C7632	Control Building Mechanical Plan
042246-DJCN-C7632.1	Control Building Standard Mechanical Details
042246-DJCN-C7632.2	Control Building Louver Details
042246-DJCN-C7500	GENERAL TOPOGRAPHY PLAN
042246-DJCN-C7501	TOPOGRAPHY PLAN LOT- 1
042246-DJCN-C7502	TOPOGRAPHY PLAN LOT- 2
042246-DJCN-C7503	TOPOGRAPHY PLAN LOT- 3
042246-DJCN-C7504	SITE GRADING & DRAINAGE PLAN
042246-DJCN - C7521.1	SENIORS SITE MOBILIZATION - PROPOSED SEWER LAYOUT
042246-DJCN - C7521.2	SENIORS SITE MOBILIZATION - PROPOSED WATER SUPPLY LAYOUT
042246-DJCN - C7521.2.1	SENIORS SITE MOBILIZATION - PROPOSED WATER SUPPLY LAYOUT
042246-DJCN - C7521.3	ELECTRICAL POWER LAYOUT PLAN
042246-DJCN - C7601	GENERAL TOPOGRAPHY PLAN
042246-DJCN - C7601.1	TOPOGRAPHY PLAN LOT- 1
042246-DJCN - C7601.2	TOPOGRAPHY PLAN LOT- 2

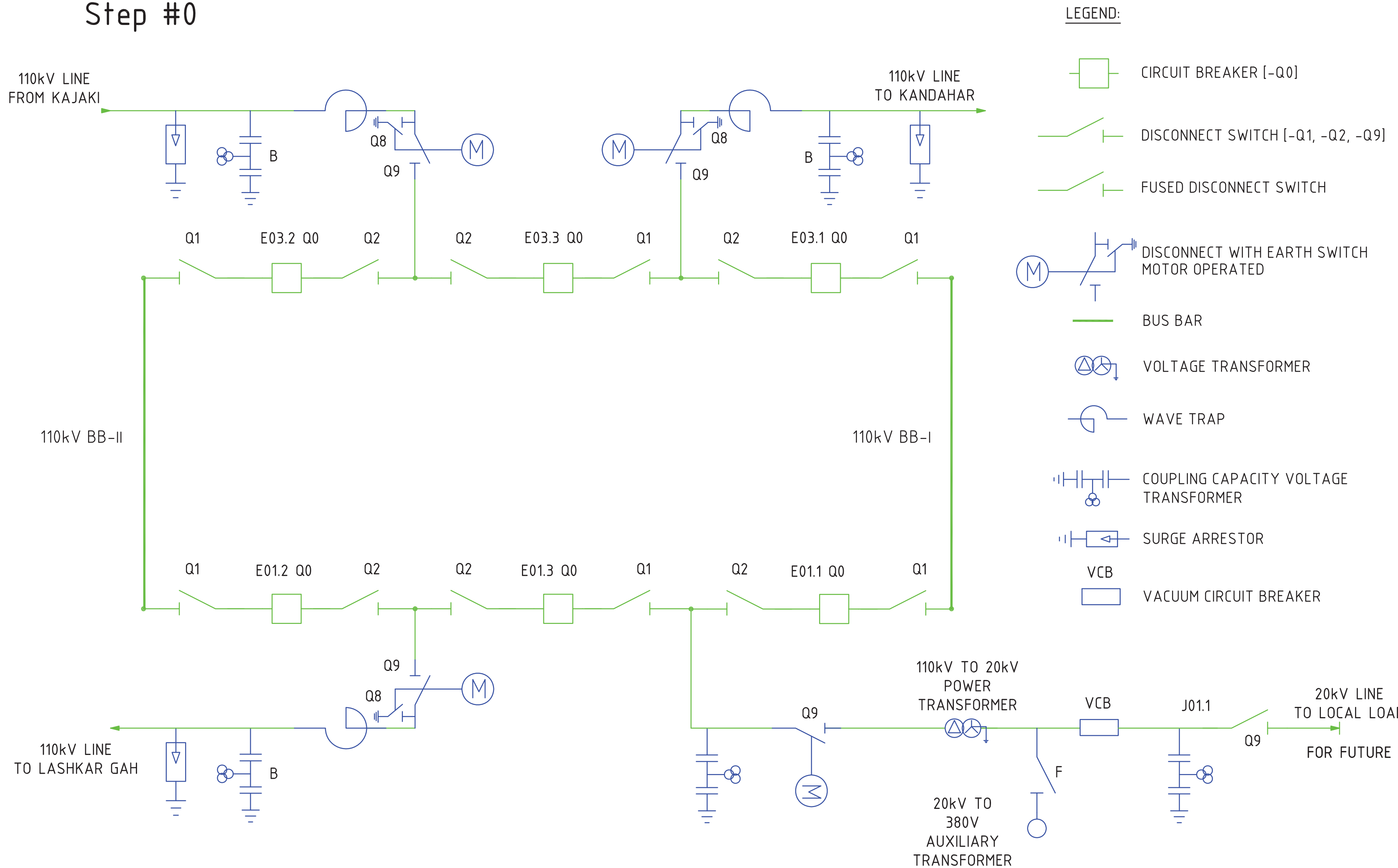
Drawing Number	Drawing Title
042246-DJCN - C7601.3	TOPOGRAPHY PLAN LOT- 3
042246-DJCN - C7525	GATE PLAN AND ELEVATION
042246-DJCN - C7525.1	GATE FOUNDATION PLAN, SECTIONS & DETAIL
042246-DJCN-C7010(Sheet 1/4)	Hardware Details- Material list 110kV Connectors
042246-DJCN-C7010(Sheet 2/4)	Hardware Details- Material list 110kV Connectors
042246-DJCN-C7010(Sheet 3/4)	Hardware Details- Material list 20kV Connectors
042246-DJCN-C7010(Sheet 4/4)	Hardware Details- Material list String assembly and insulators
042246-DJCN-C7010.1	Hardware Details Section A-A (110kV)
042246-DJCN-C7010.2	Hardware Details Section B-B (110kV)
042246-DJCN-C7010.3	Hardware Details Section C-C (110kV)
042246-DJCN-C7010.4	Hardware Details Section D-D (110kV)
042246-DJCN-C7010.5	Hardware Details Section E-E (20kV)
042246-DJCN-C7010.6	Hardware Details Section F-F (20kV)
042246-DJCN-C4110.1	Earthing detail 110 kV CT
042246-DJCN-C4110.2	Earthing detail 110 kV CVT
042246-DJCN-C4110.3	Earthing detail 110 kV Surge Arrester
042246-DJCN-C4110.4	Earthing detail 110 kV Circuit Breaker
042246-DJCN-C4110.5	Earthing detail 110 kV Current Transformer
042246-DJCN-C4110.6	Earthing detail 110 kV Disconnector Switch with earth switch
042246-DJCN-C4110.7	Earthing detail 110 kV Current Transformer
042246-DJCN-C4110.8	Earthing detail 20 kV Voltage Transformer
042246-DJCN-C4110.9	Earthing detail 20 kV Surge Arrester
042246-DJCN-C4110.10	Earthing detail 20 kV Disconnect Switch
042246-DJCN-C4110.13	Earthing detail 110kV Current Transformer
042246-DJCN-C4110.14	Earthing detail Gantry Tower & Shielding rod
042246-DJCN-C4110.15	Earthing detail 110kV Current Transformer
042246-DJCN-C4110.16	Earthing detail at Column Type E with shielding rod
042246-DJCN-C4110.17	Earthing detail at Column Type E without shielding rod
042246-DJCN-C4110.18	Earthing detail 20KV DISCONNECTOR SWITCH
042246-DJCN-C4110.19	Earthing detail 110kV Current Transformer
042246-DJCN-C4110.21	Earthing detail 110kV Current Transformer
042246-DJCN-C7520	General Layout Plan
042246-DJCN-C7520.01	Transmission line layout plan(Revised)
042246-DJCN-C7520.02	Transmission line sectional Views
042246-DJCN-C7520.03	110kV substation line profile
042246-DJCN-C7520.04	110kv Existing Tower Stay Wire Plan
042246-DJCN-C7520.05	Earthing Tension Set for 12.57mm shield wire
042246-DJCN-C7520.06	Tension clamp
042246-DJCN-C7520.07	Shackle
042246-DJCN-C7520.08	Earthing clamp 9mm
042246-DJCN-C7520.09	Stock bridge damper for Rail conductor
042246-DJCN-C7520.10	Single Tension set
042246-DJCN-C7520.13	single suspension set
042246-DJCN-C7520.14	Self locking ball hook
042246-DJCN-C7520.15	Disc Insulator
042246-DJCN-C7520.16	Socket Eye
042246-DJCN-C7520.17	Arcing Horn
042246-DJCN-C7520.18	Transmission Line Layout Plan
042246-DJCN-C7520.19	Earthing Suspension Clamp
042246-DJCN-C7520.20	Transmission Line Layout Plan
042246-DJCN-C7520.32	Towers detail
042246-DJCN-C7520.33	110kV D/C Tower TYPE A General Arrangement with Modified Cross Arms
042246-DJCN-C7520.34	110kV Double circuit Tower Type C
042246-DJCN-C7635	GH- Structural General Notes
042246-DJCN-C7635.1	FOUNDATION PLAN, SECTION & DETAIL
042246-DJCN-C7635.2	GH-Roof Framing Plan
042246-DJCN-C7635.3	GH-Roof Truss Sections & Details
042246-DJCN-C7635.4	GH- Schedules
042246-DJCN-C7637.1	Oil Storage Building Ground Floor Plan
042246-DJCN-C7637.2	Oil Storage Building Roof Plan
042246-DJCN-C7637.3	Oil Storage Building Elevations
042246-DJCN-C7637.4	Oil Storage Building Section
042246-DJCN-C7638.1	Oil Storage Building Foundation Plan, Section & Detail
042246-DJCN-C7638.2	Oil Storage Building Roof Framing Plan
042246-DJCN-C7639	Fuel Storage Tank Ground floor plan
042246-DJCN-C7639.1	Fuel Storage Tank floor plan
042246-DJCN-C7639.2	Fuel Storage Tank Elevations

Drawing Number	Drawing Title
042246-DJCN-C7639.3	Fuel Storage Tank Sections & Detail
042246-DJCN-C7640	Fuel Storage Tank Foundation & Roof Plans
042246-DJCN-C7640.1	Fuel Storage Tank Section
042246-DJCN-C7640.2	Fuel Storage Tank Sections & Details
042246-DJCN-C7801.1	110kV Gantry Tower Layout Plan
042246-DJCN-C7801.2	110kV Gantry Tower Column Type A& C Bridge Type:A
042246-DJCN-C7801.3	110kV Gantry Tower Column Type A& B Beam Type: A
042246-DJCN-C7801.4	110kV Gantry Tower Column Type C & D Beam Type: B
042246-DJCN-C7801.5	20kV Gantry Column (Type E) & Beam
042246-DJCN-C7801.6	Gantry Column Type (A,B,C) (Stub Angle Detail)
042246-DJCN-C7801.7	Gantry Column Type (D) (Stub Angle Detail)
042246-DJCN-C7801.8	20kV Gantry Beam Gantry Type (E) Section & Details
042246-DJCN-C7801.11	110kV Gantry Tower Beam
042246-DJCN-C7801.12	110kV Gantry Tower Column Type-A Detailed Drawing
042246-DJCN-C7801.13	110kV Gantry Tower Column Type-B Detailed Drawing
042246-DJCN-C7801.14	110kV Gantry Tower Column Type-C Detailed Drawing
042246-DJCN-C7801.15	110kV Gantry Gantry Tower Column Type-D
042246-DJCN-C7801.16	110kV Gantry Gantry Type-(E)
042246-DJCN-C7801.17	Beam Junction Box Detail
042246-DJCN-C7801.18	Template T1 (For Column Type A, B, & C)
042246-DJCN-C7801.19	Template T2 (For Column Type D)
042246-DJCN-C7702.1	GANTRY COLUMN FOUNDATION - TYPE A (CONCRETE OUTLINE)
042246-DJCN-C7702.2	GANTRY COLUMN FOUNDATION - TYPE A (REINFORCEMENT DETAIL)
042246-DJCN-C7702.3	GANTRY COLUMN FOUNDATION - TYPE B (CONCRETE OUTLINE)
042246-DJCN-C7702.4	GANTRY COLUMN FOUNDATION - TYPE B (REINFORCEMENT DETAIL)
042246-DJCN-C7702.5	GANTRY COLUMN FOUNDATION - TYPE C (CONCRETE OUTLINE)
042246-DJCN-C7702.6	GANTRY COLUMN FOUNDATION - TYPE C (REINFORCEMENT DETAIL)
042246-DJCN-C7702.7	GANTRY COLUMN FOUNDATION - TYPE D (CONCRETE OUTLINE)
042246-DJCN-C7702.8	GANTRY COLUMN FOUNDATION - TYPE D (REINFORCEMENT DETAIL)
042246-DJCN-C7702.9	GANTRY COLUMN FOUNDATION - TYPE E (CONCRETE OUTLINE)
042246-DJCN-C7702.10	GANTRY COLUMN FOUNDATION - TYPE E (REINFORCEMENT DETAIL)
042246-DJCN-C7702.11	GANTRY COLUMN - TYPE (E) (CONNECTION DETAIL AT BASE)
042246-DJCN-P7302.1	CHB Equipment Layout Plan
042246-DJCN-P7302.2	CHB- Trench layout Plan
042246-DJCN-P7302.3	CHB-Panel Support Layout
042246-DJCN-P7302.4	CHB-Sections
042246-DJCN - P7302.5	CHB Equepment layout plan
042246-DJCN-P7302.6	CHB Trench section & detail
042246-DJCN-P7303	54 CELL DRDT SEISMIC STAND FOR YCP17
042246-DJCN-P7110	AC Single line diagram
042246-DJCN-P7111	DC Single line diagram

APPENDIX 4.2

Energization Step/Plan

Step #0



REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

DRAWING STATUS: FOR APPROVAL

ISLAMIC REPUBLIC OF AFGHANISTAN
and
UNITED STATES AGENCY FOR
INTERNATIONAL DEVELOPMENT

BLACK & VEATCH Building a world of Difference

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REV	REVISION INFORMATION	DATE	DWN	DES	CHK	APP
0	FIRST SUBMITTAL	25Apr.13	Jorge.J	Jorge.J	Chacko	Chacko

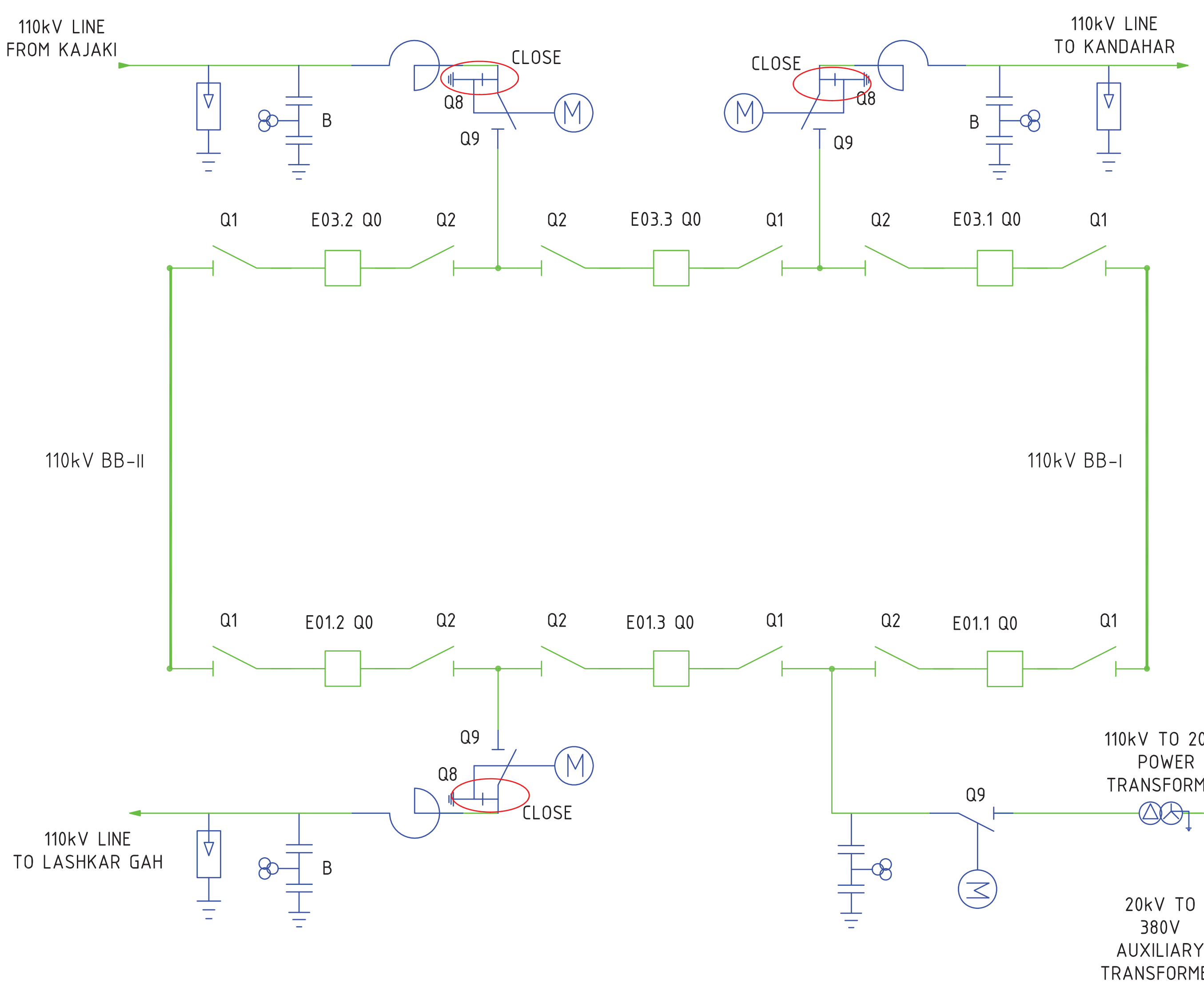
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN	DWG NO. SD - E104
DATE: 25 Apr. 2013	Rev: 0
SCALE: NTS	Sheet No: 1 of 25

Step #1

Note: Normally, While the T-Line construction is on going, all Disconnect with earth switch (Q8) must be closed till Energization proper of substation.



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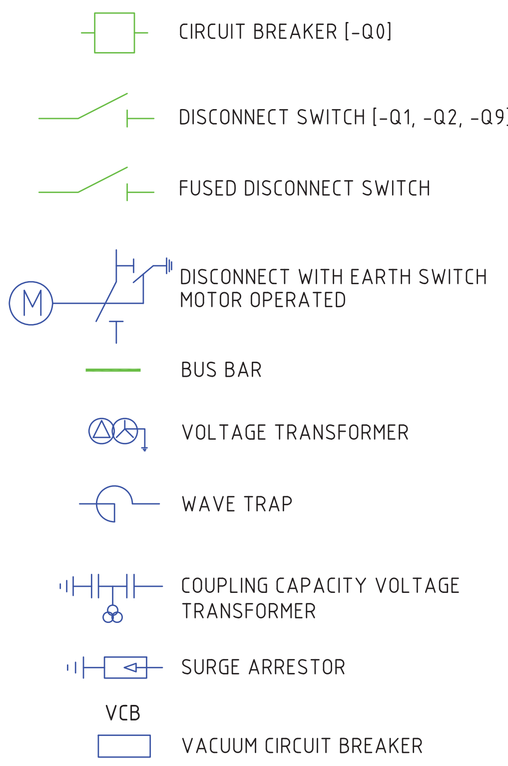

REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

DRAWING STATUS: FOR APPROVAL

ISLAMIC REPUBLIC OF AFGHANISTAN and UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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REV	REVISION INFORMATION	DATE	DWN	DES	CHK	APP
0	FIRST SUBMITTAL	25Apr.13	Jorge.J	Jorge.J	Chacko	Chacko

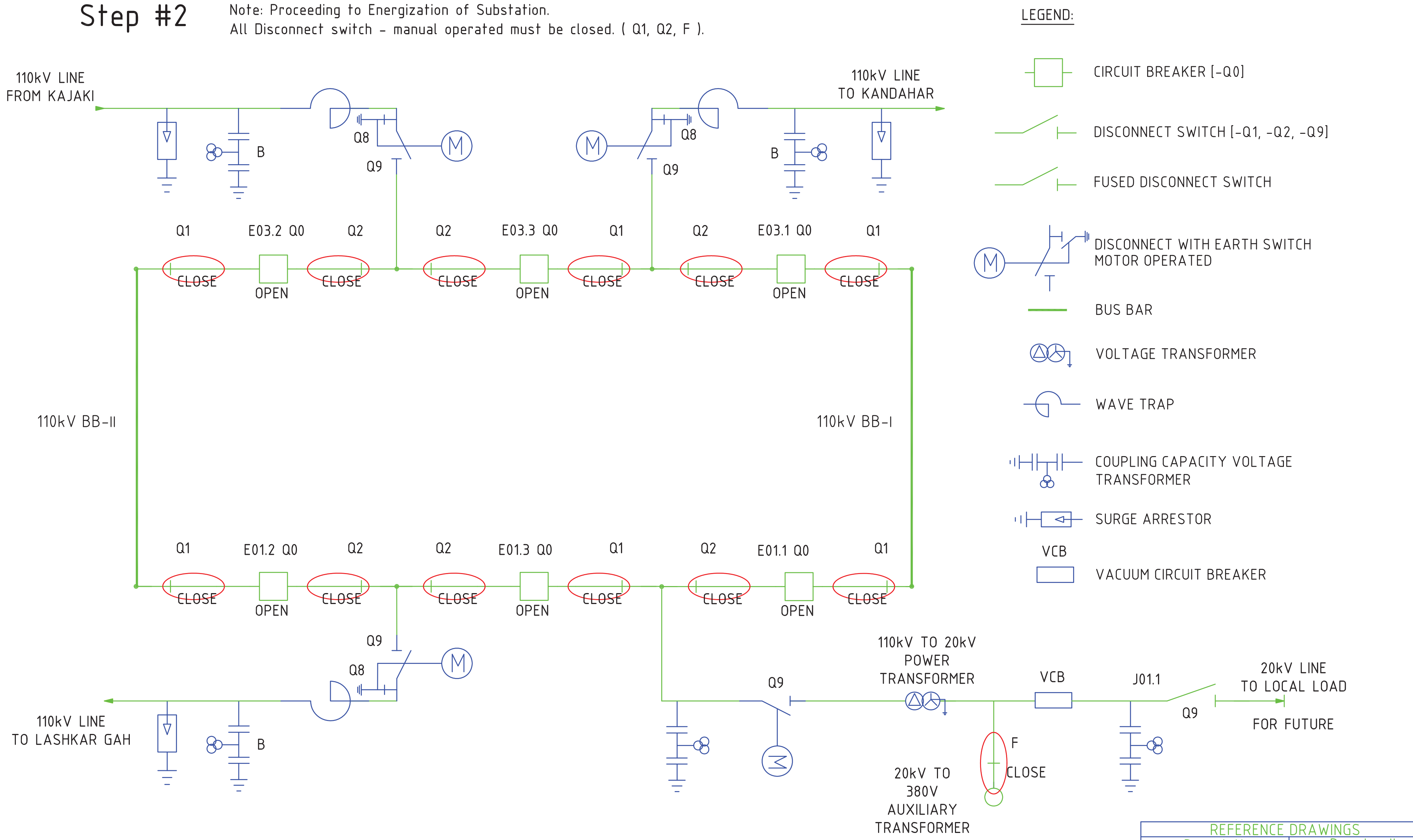
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN
DWG NO. SD - E104
DATE: 25 Apr. 2013
Rev: 0
SCALE: NTS
Sheet No: 1 of 25

Step #2

Note: Proceeding to Energization of Substation.
All Disconnect switch - manual operated must be closed. (Q1, Q2, F).



REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

DRAWING STATUS: FOR APPROVAL

ISLAMIC REPUBLIC OF AFGHANISTAN
and
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INTERNATIONAL DEVELOPMENT

BLACK & VEATCH Building a world of Difference
Pak Elektron Limited 14-KM, FEROZEPUR ROAD-LAHORE, PAKISTAN

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REV	REVISION INFORMATION	DATE	DWN	DES	CHK	APP
0	FIRST SUBMITTAL	25Apr.13	Jorge.J	Jorge.J	Chacko	Chacko

KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN
DWG NO.: SD - E104
DATE: 25 Apr. 2013
Rev: 0
SCALE: NTS
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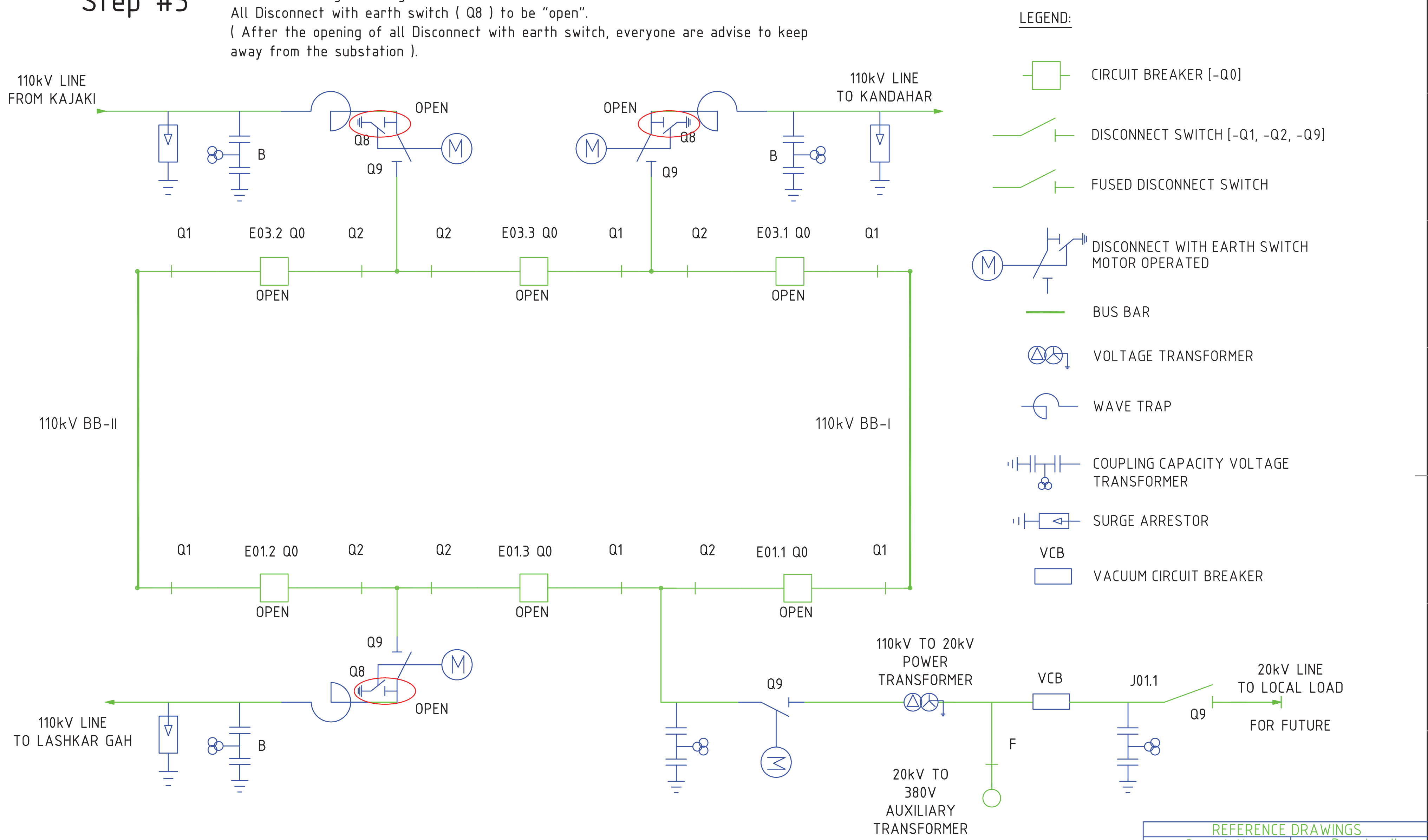
Step #3

Note: Proceeding to Energization of Substation.
All Disconnect with earth switch (Q8) to be "open".
(After the opening of all Disconnect with earth switch, everyone are advise to keep away from the substation).



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KANDAHAR HELMAND POWER PROJECT

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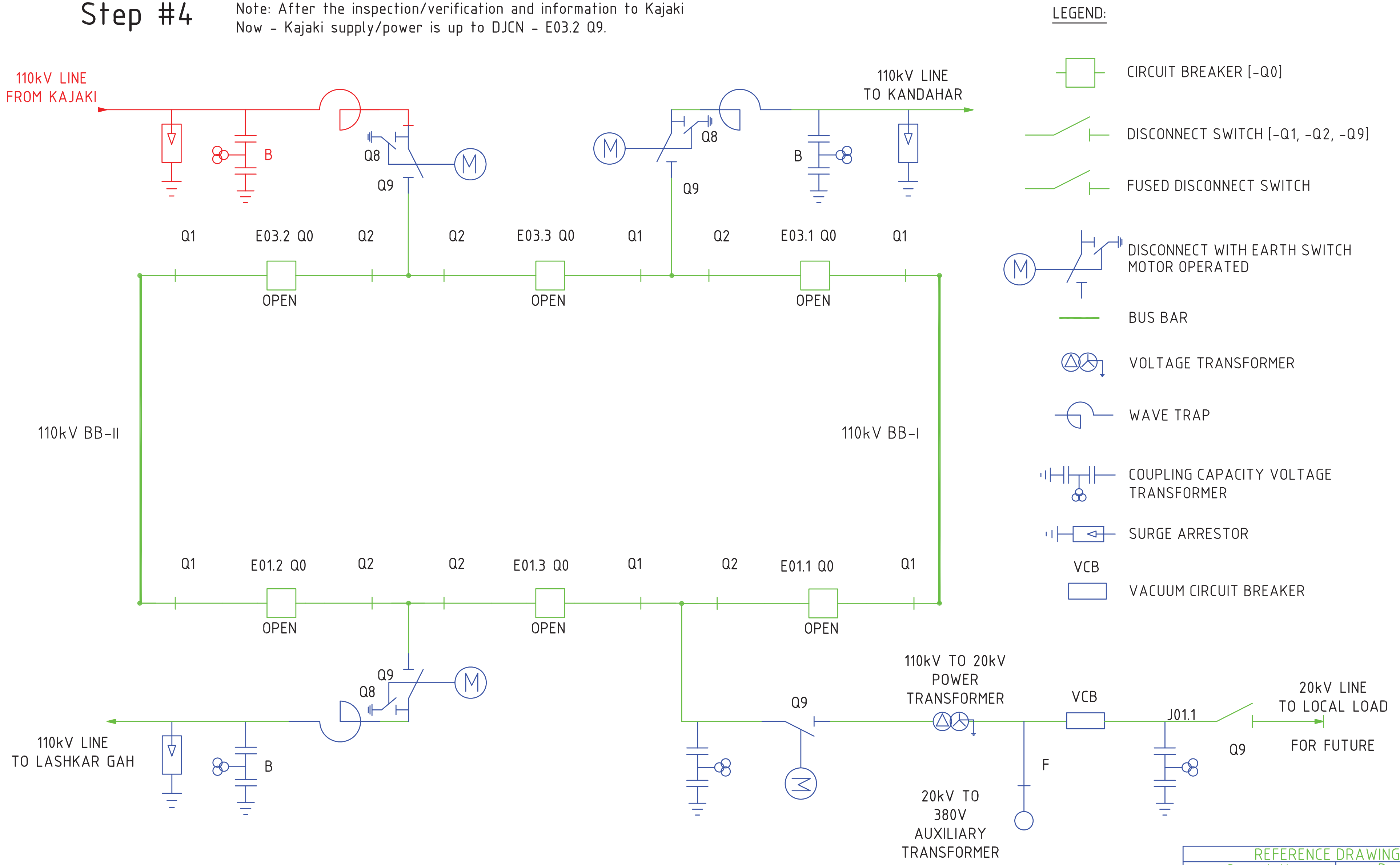
Step #4

Note: After the inspection/verification and information to Kajaki
Now - Kajaki supply/power is up to DJCN - E03.2 Q9.



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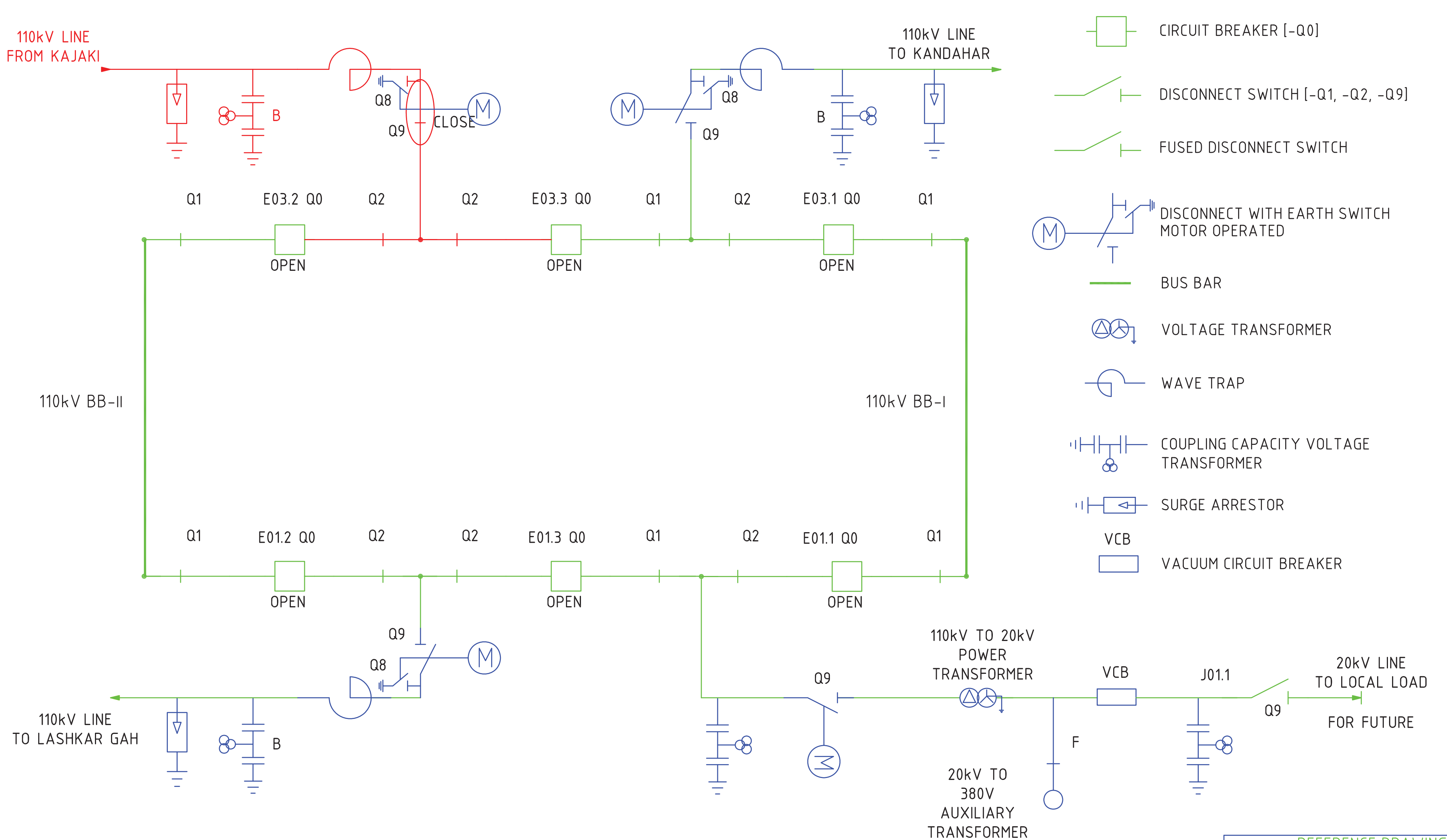
Step #5

Note: Proceeding to Energization of Substation.
Now - Disconnect switch motor operated (E03.2 Q9) "Close".



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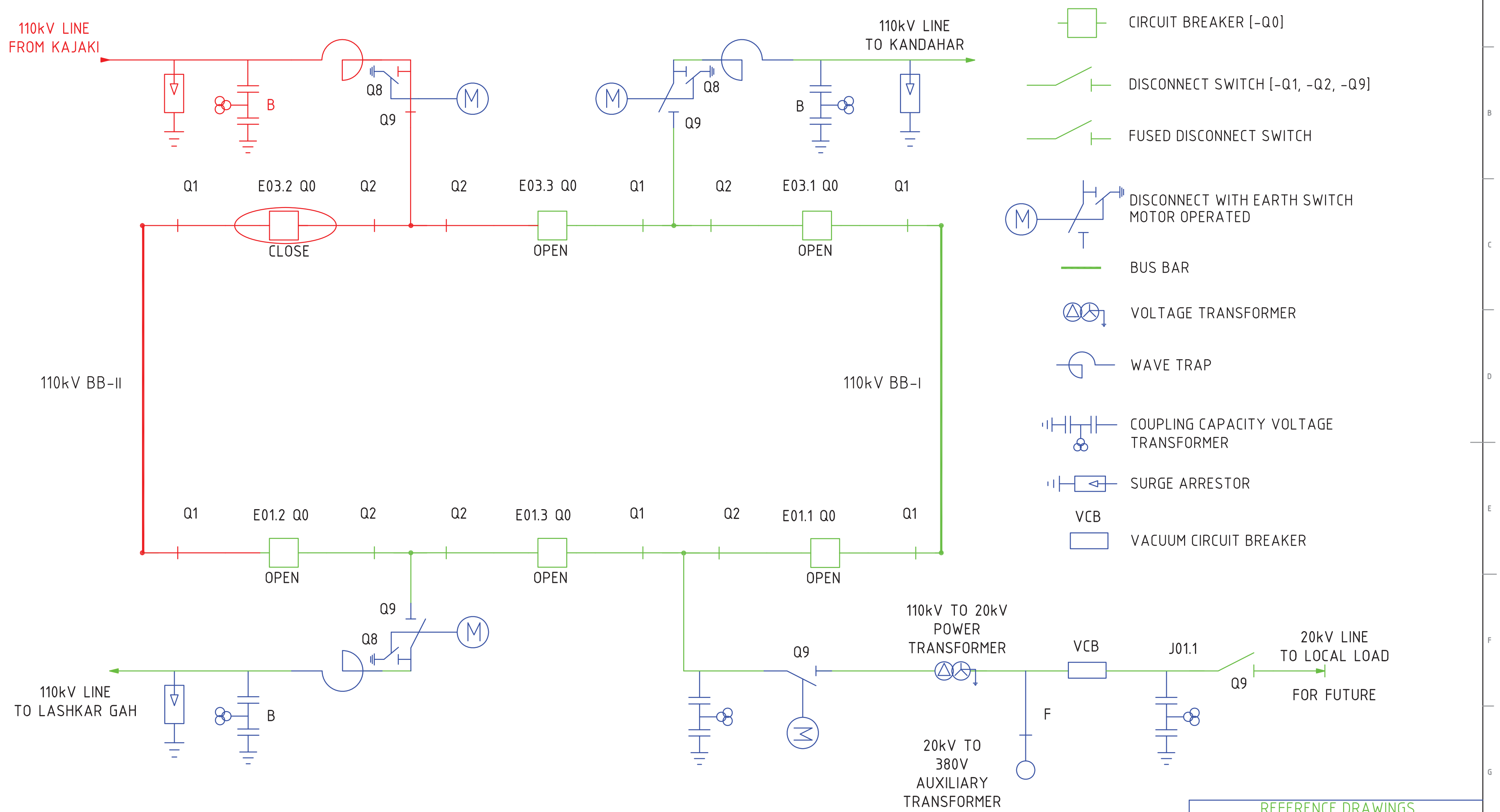
Step #6

Note: Proceeding to Energization of Substation.
Now – SF6 Circuit Breaker remote operated (E03.2 Q0) "Close".



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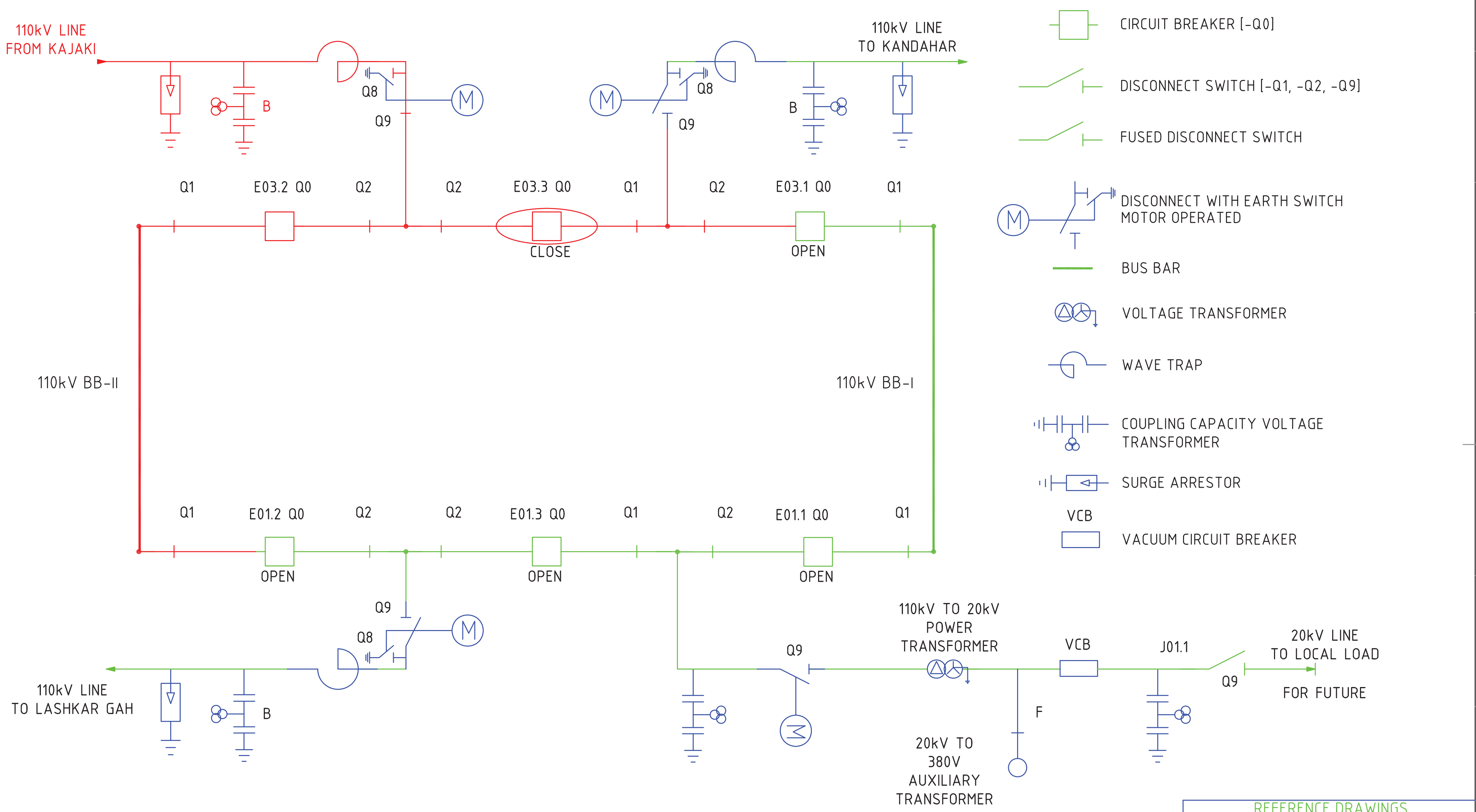
Step #7

Note: Proceeding to Energization of Substation.
Now – SF6 Circuit Breaker remote operated (E03.3 Q0) "Close".



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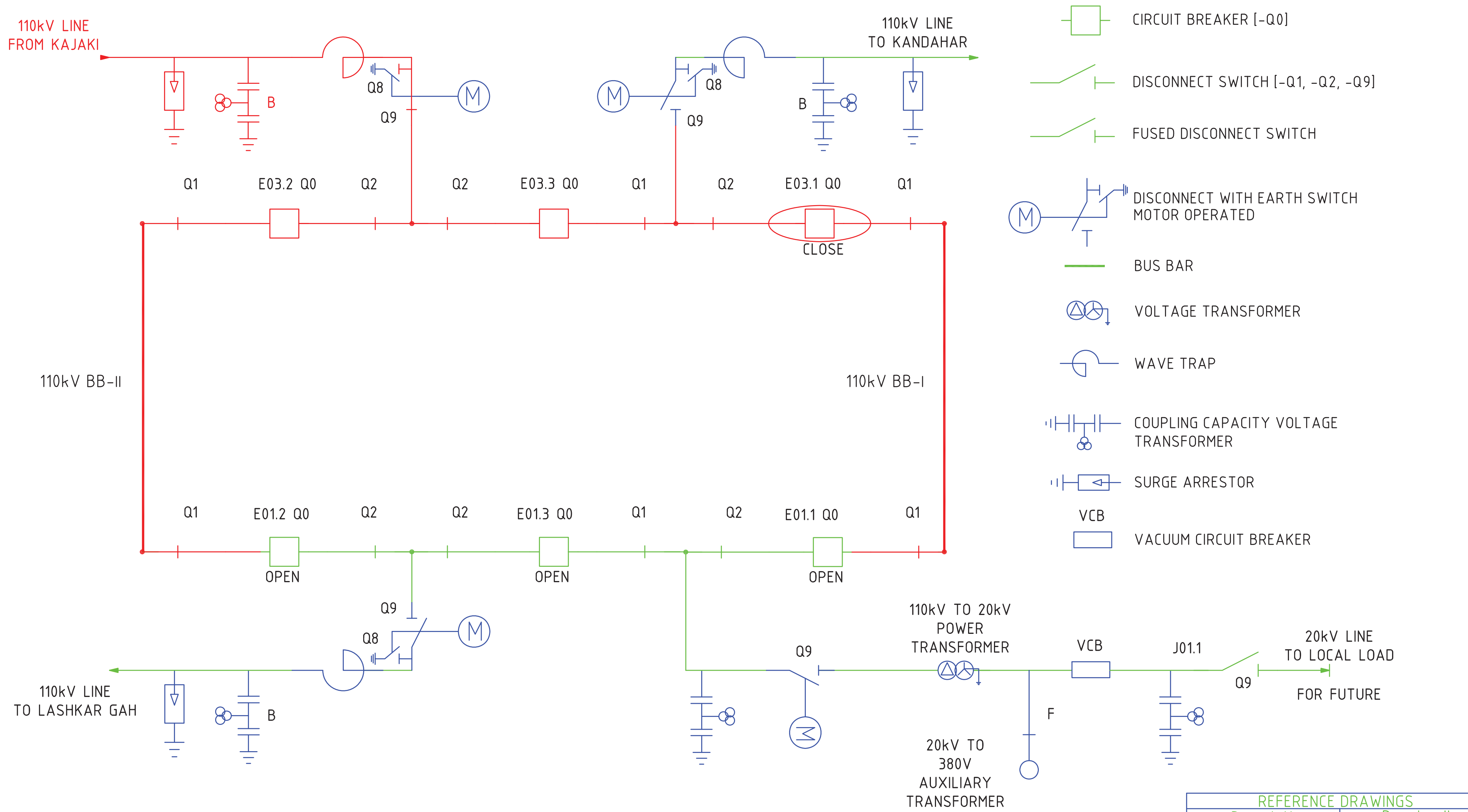
Step #8

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E03.1 Q0) "Close".



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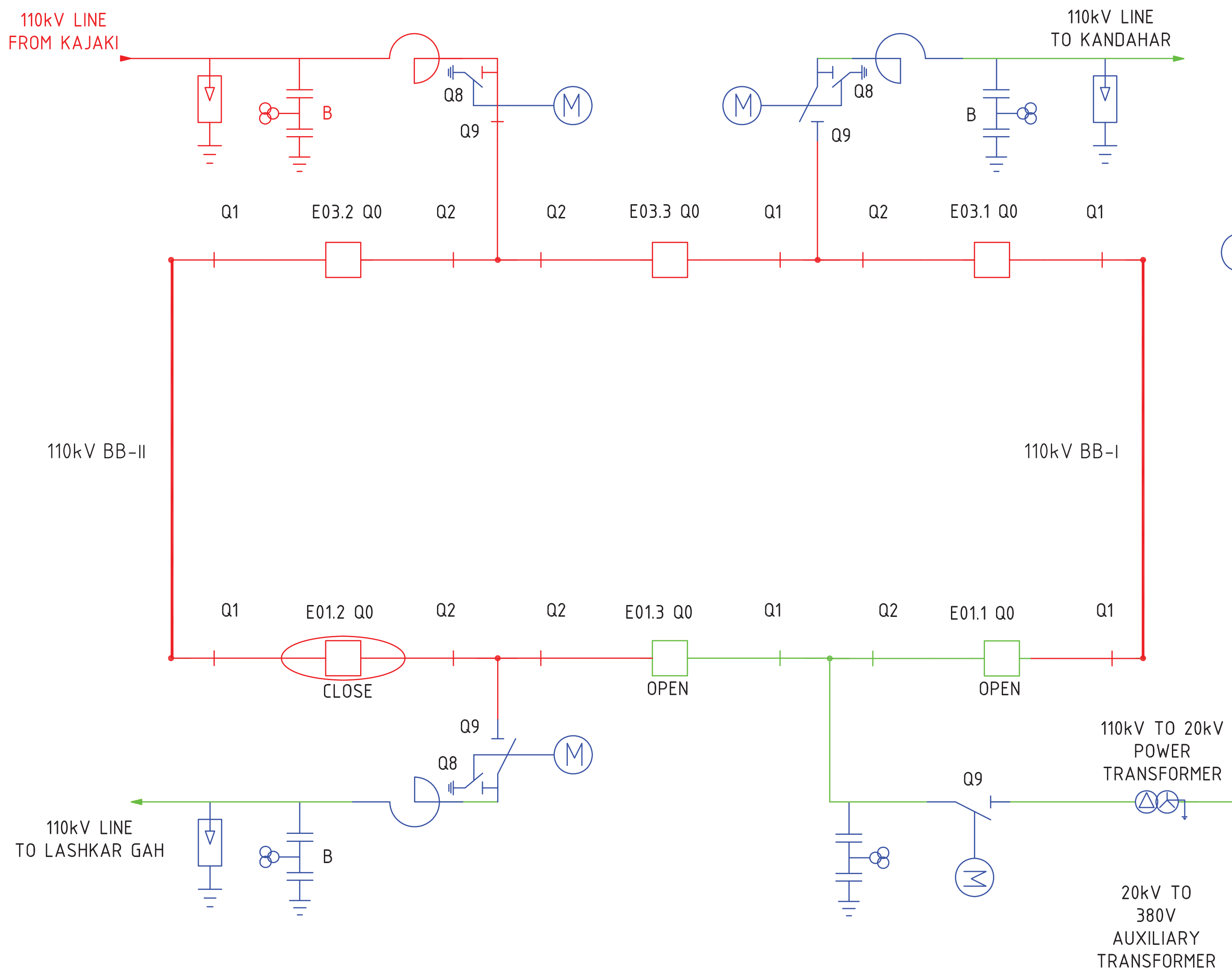
Step #9

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.2 Q0) "Close".



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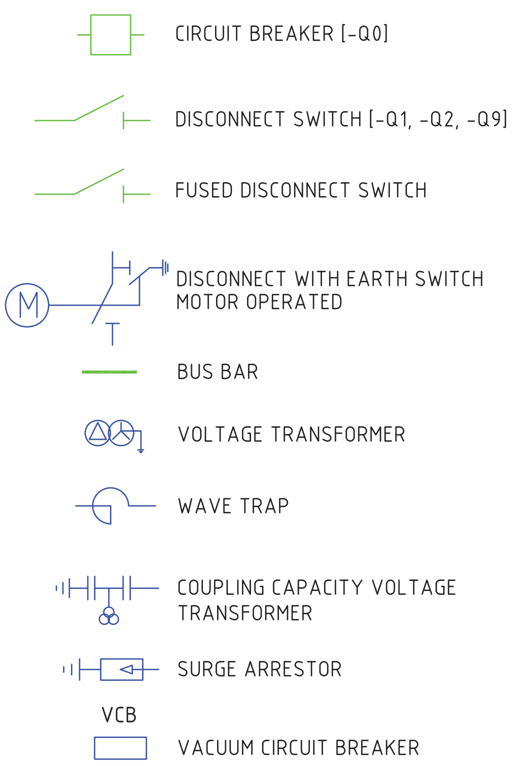

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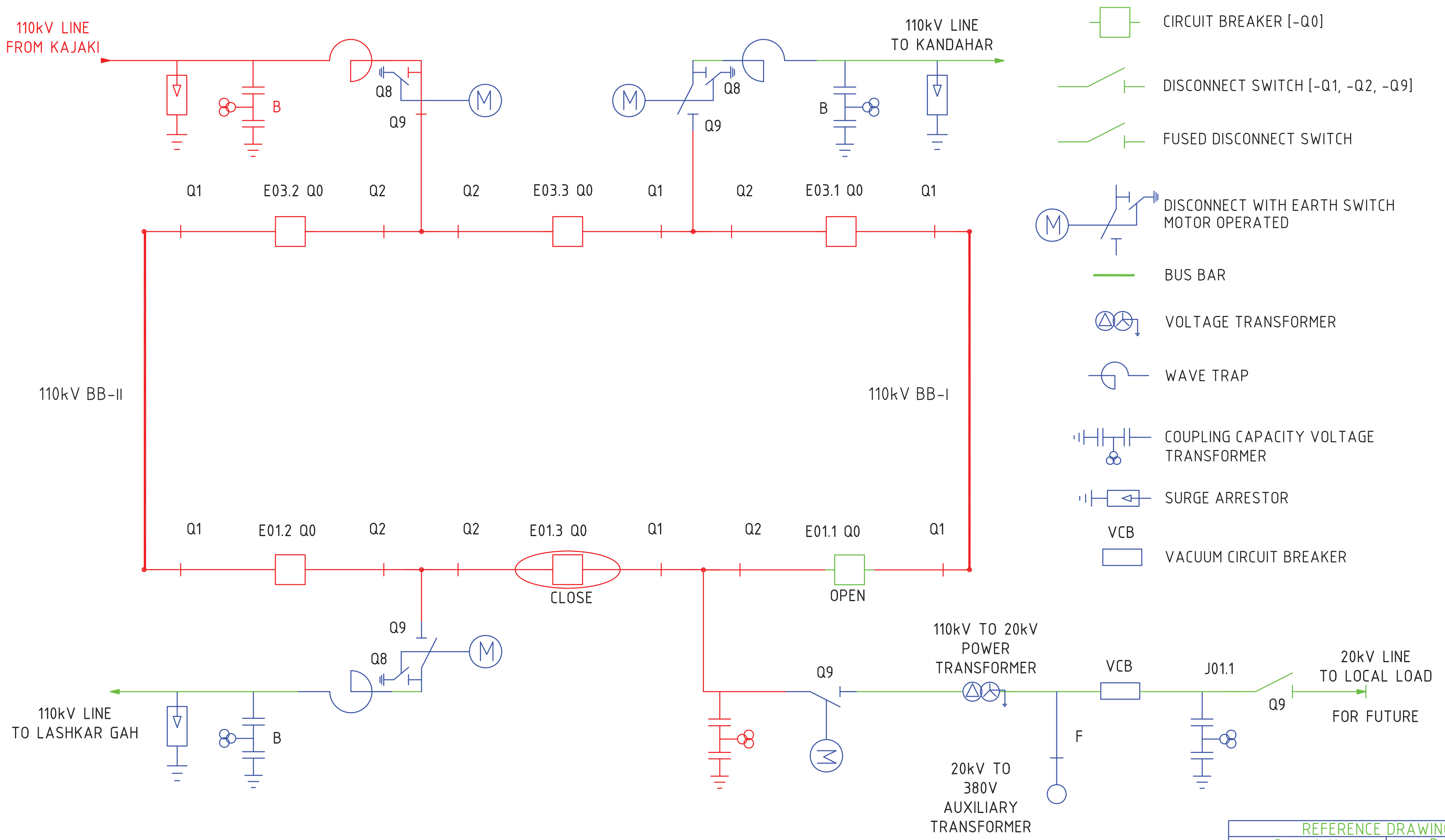
Step #10

Note: Proceeding to Energization of Substation.
Now – SF6 Circuit Breaker remote operated (E01.3 Q0) "Close".



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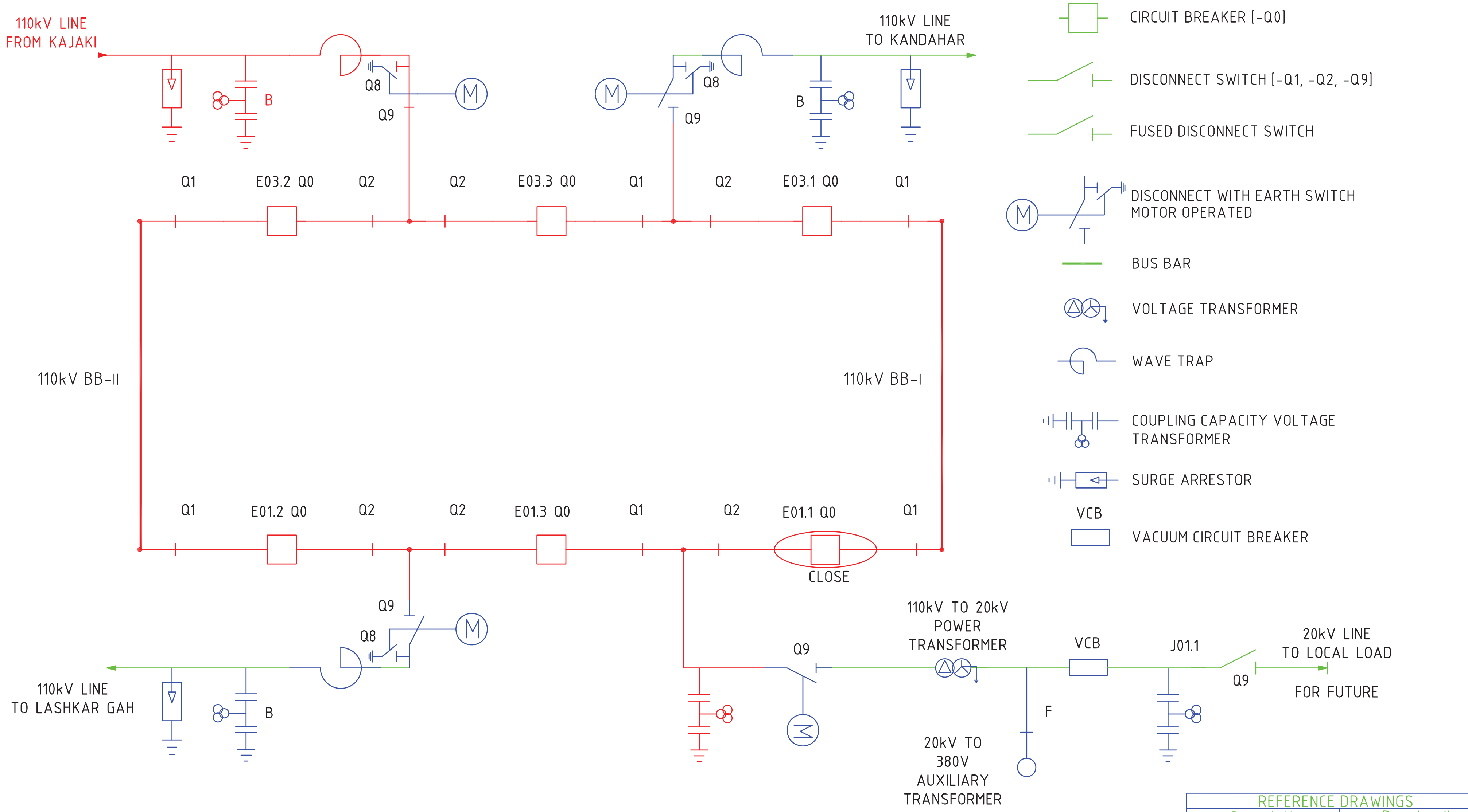
Step #11

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.1 Q0) "Close".
(Substation loop completed).



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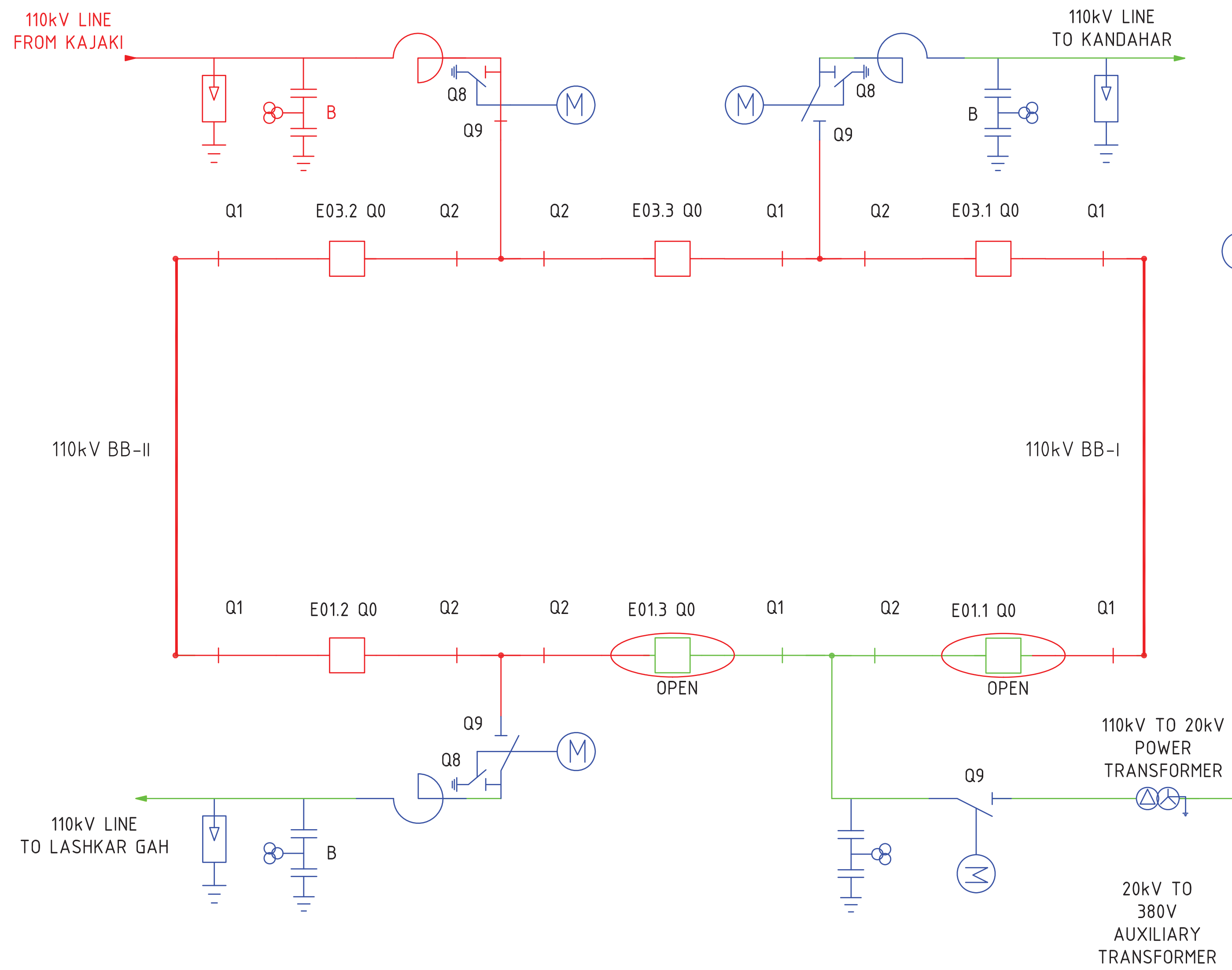
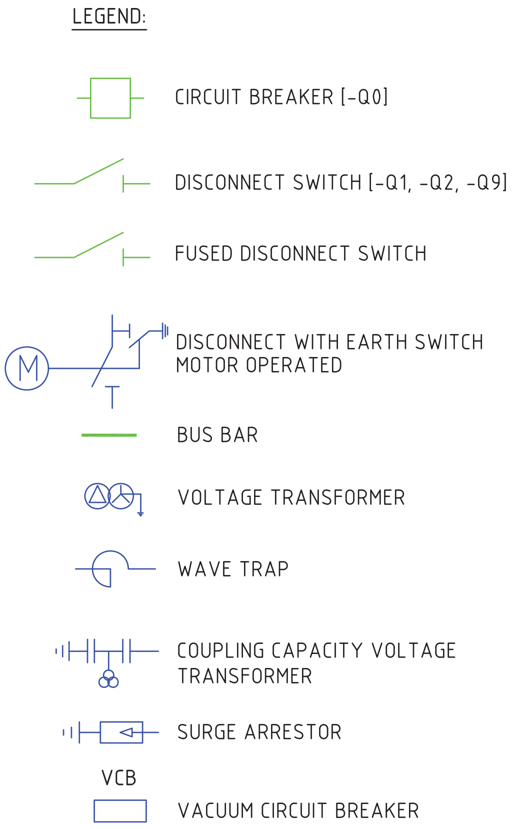
Step #12

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.1 Q0 & E01.3 Q0) "Open".





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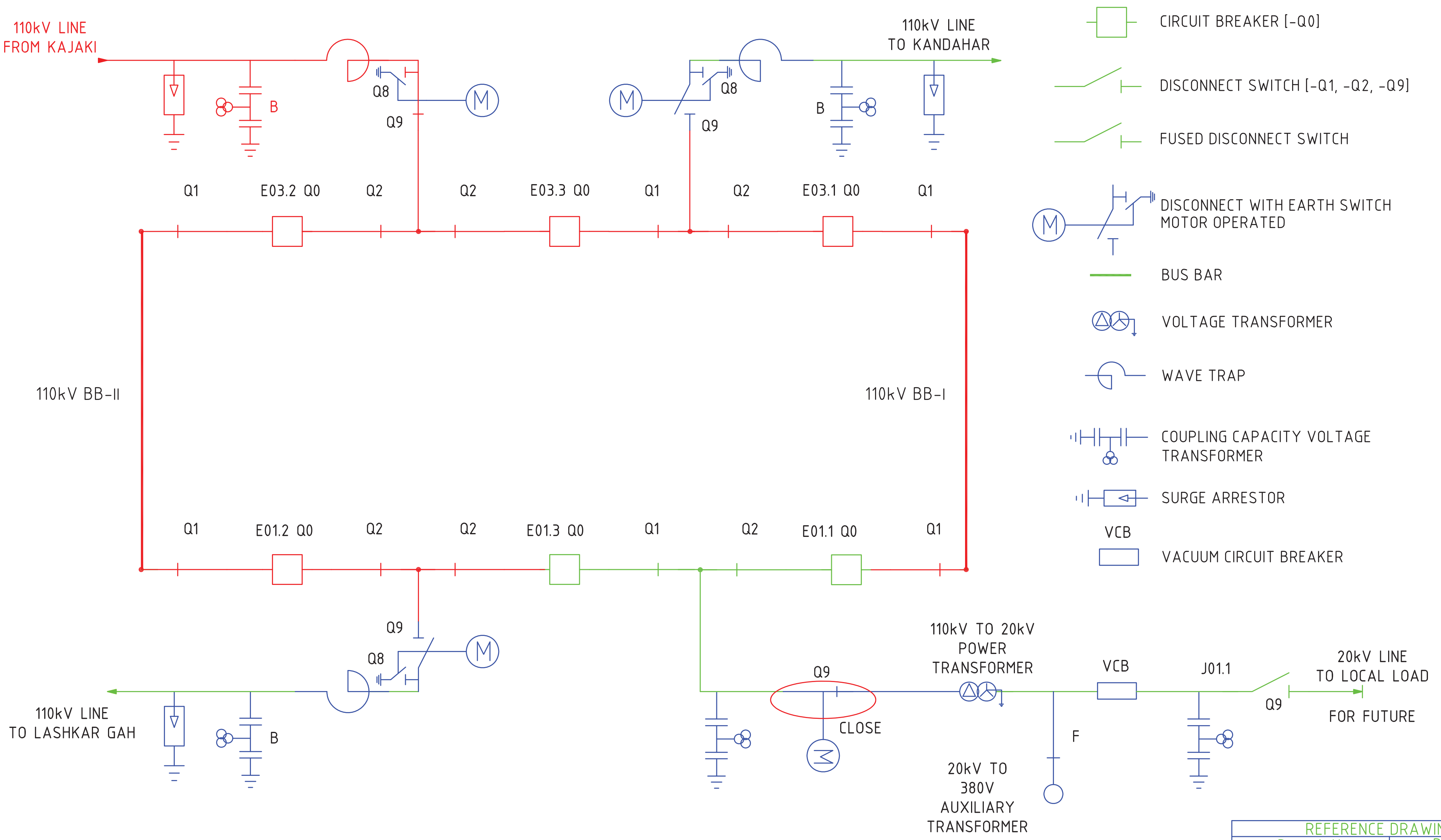
Step #13

Note: Proceeding to Energization of Substation.
Now – Disconnect switch remote operated (E01.1 Q9) "Close".



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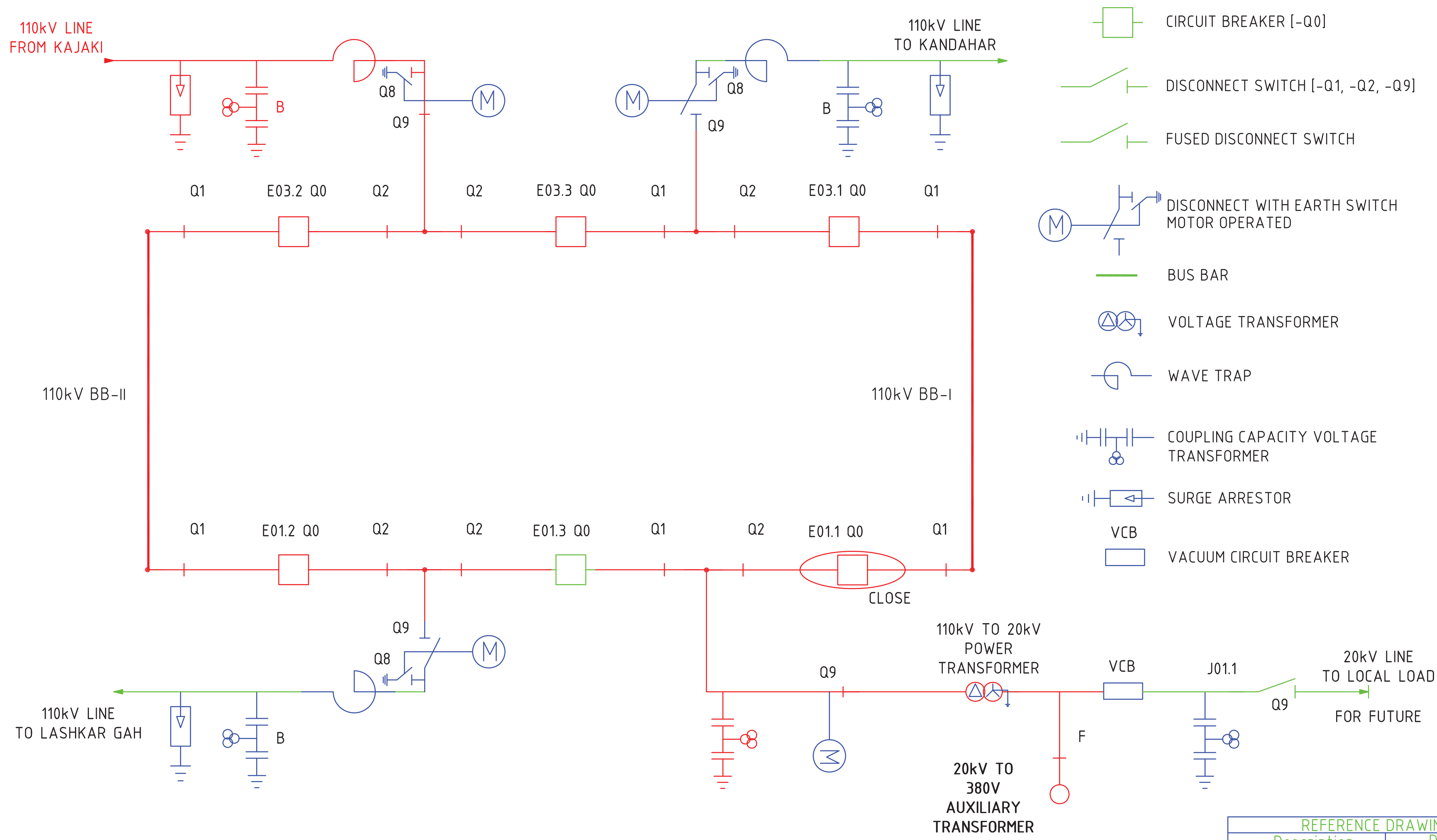
Step #14

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.1 Q0) "Close".
(DJCN - was completely energized and control building are getting power/supply from Auxiliary Transformer)

LEGEND:



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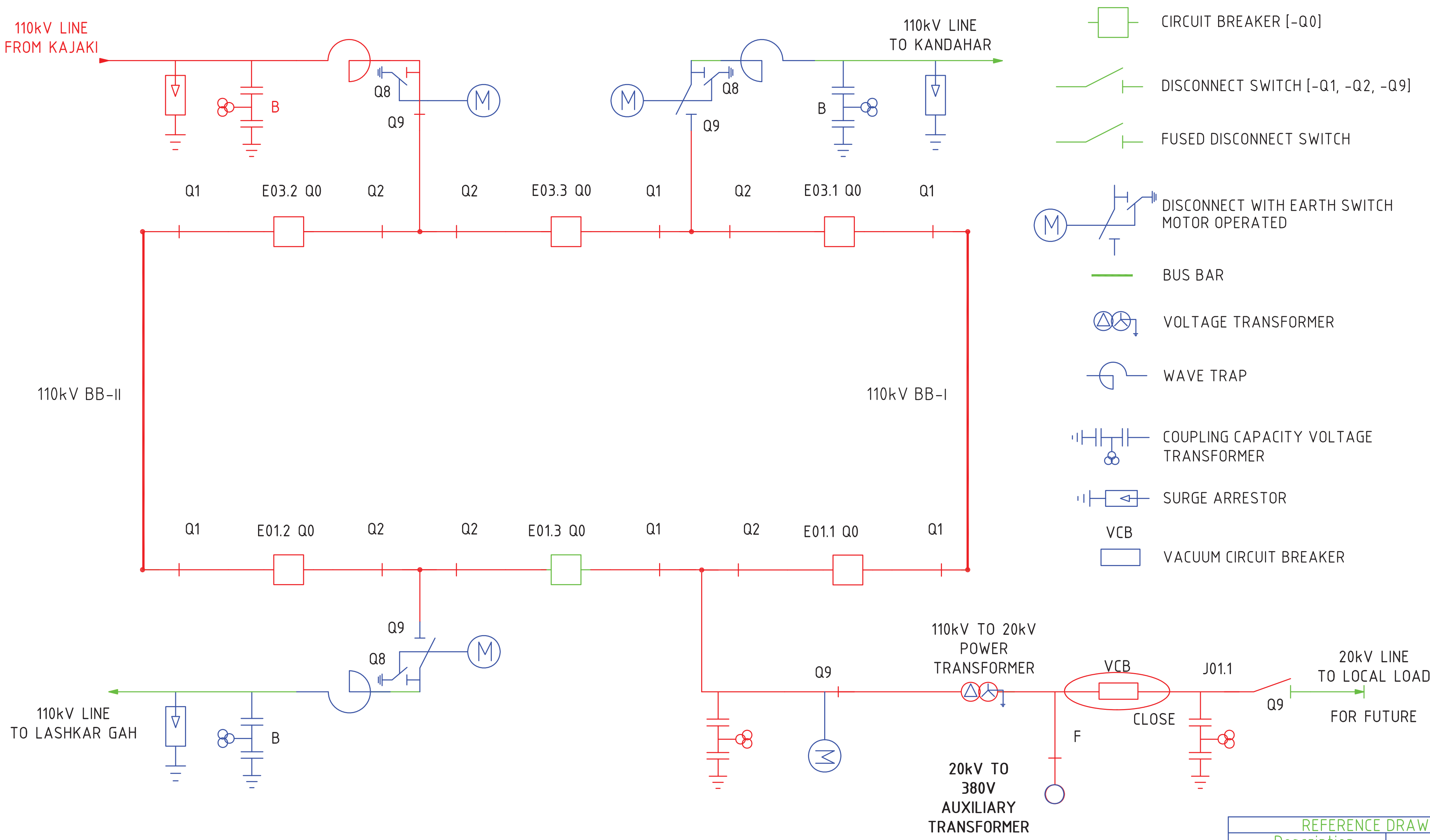
Step #15

Note: Proceeding to Energization of Substation.
Now – 20KV VCB Circuit Breaker remote operated – "Close".



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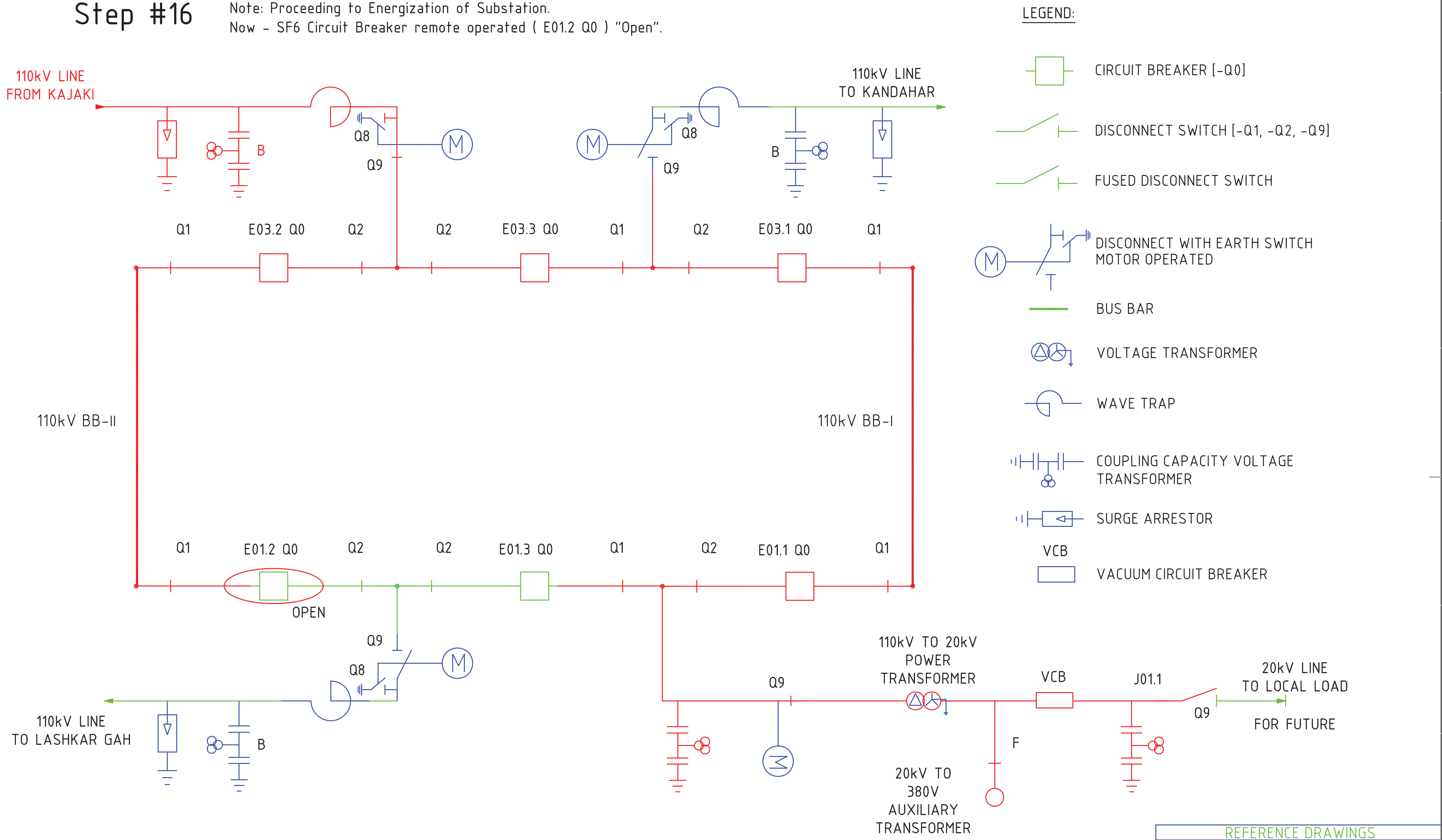
Step #16

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.2 Q0) "Open".



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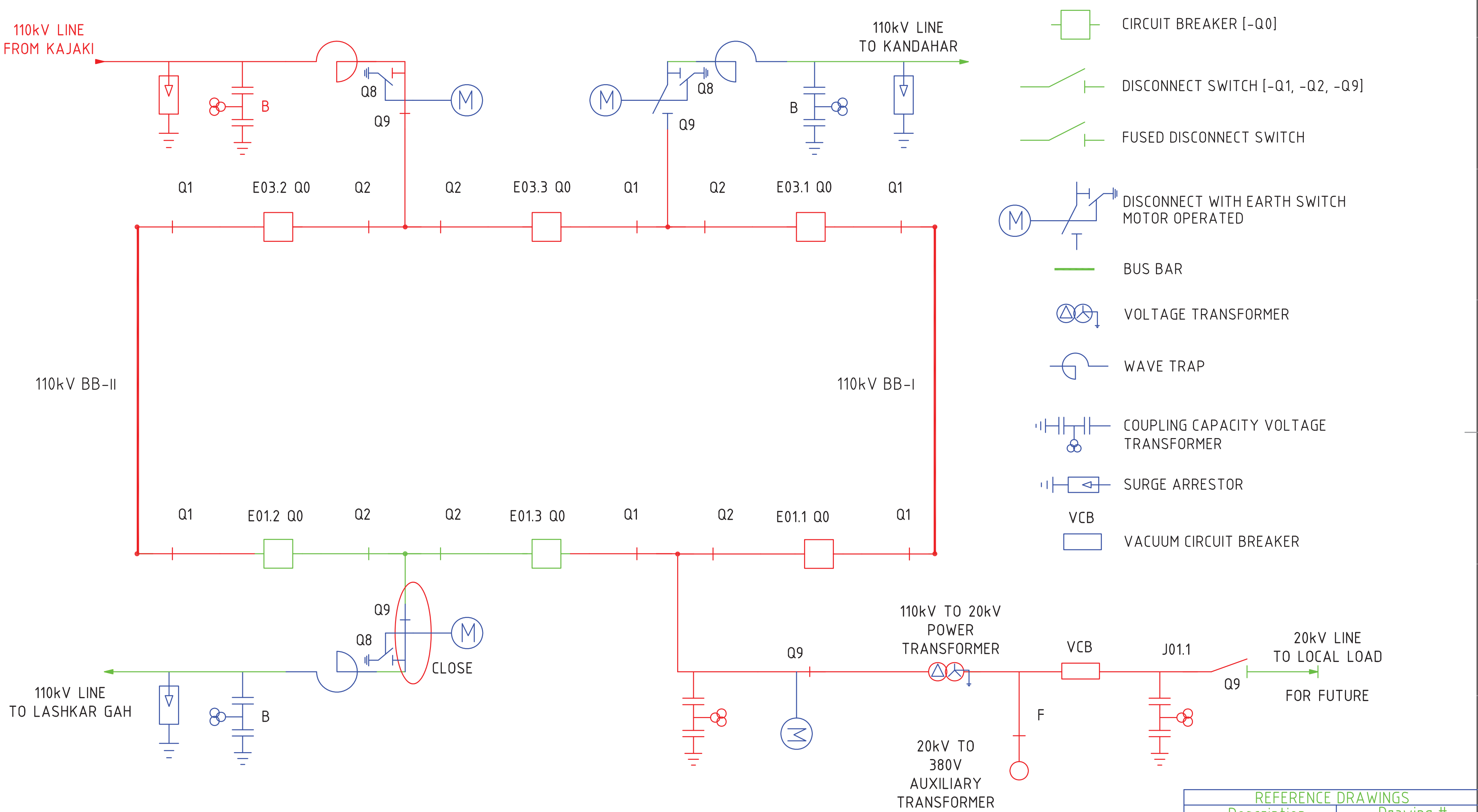
Step #17

Note: Proceeding to Energization of Substation.
Now - Disconnect switch remote operated (E01.2 Q9) "Close".



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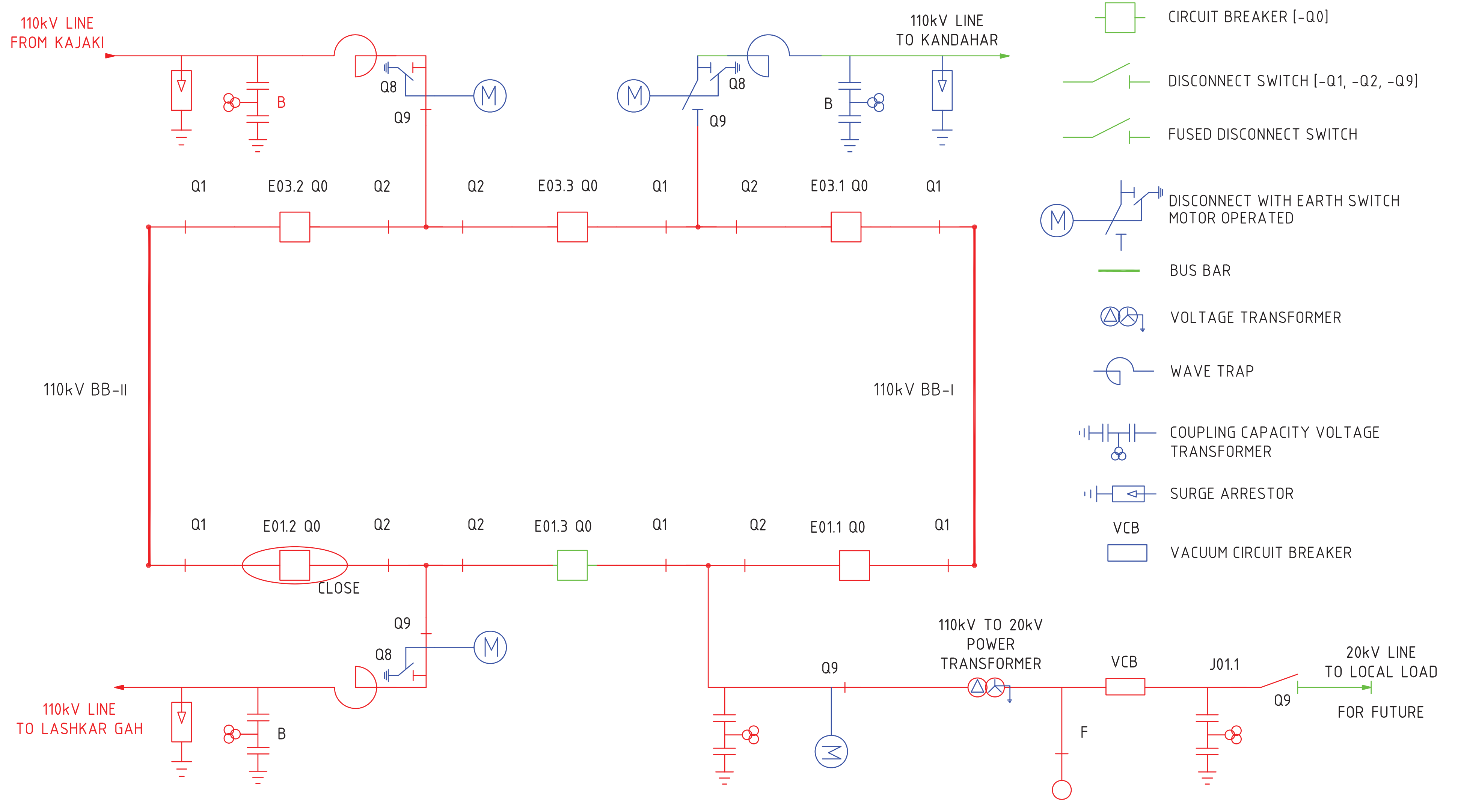
Step #18

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E01.2 Q0) "Close".
(the Power/ supply extended up to Lashkarga substation).



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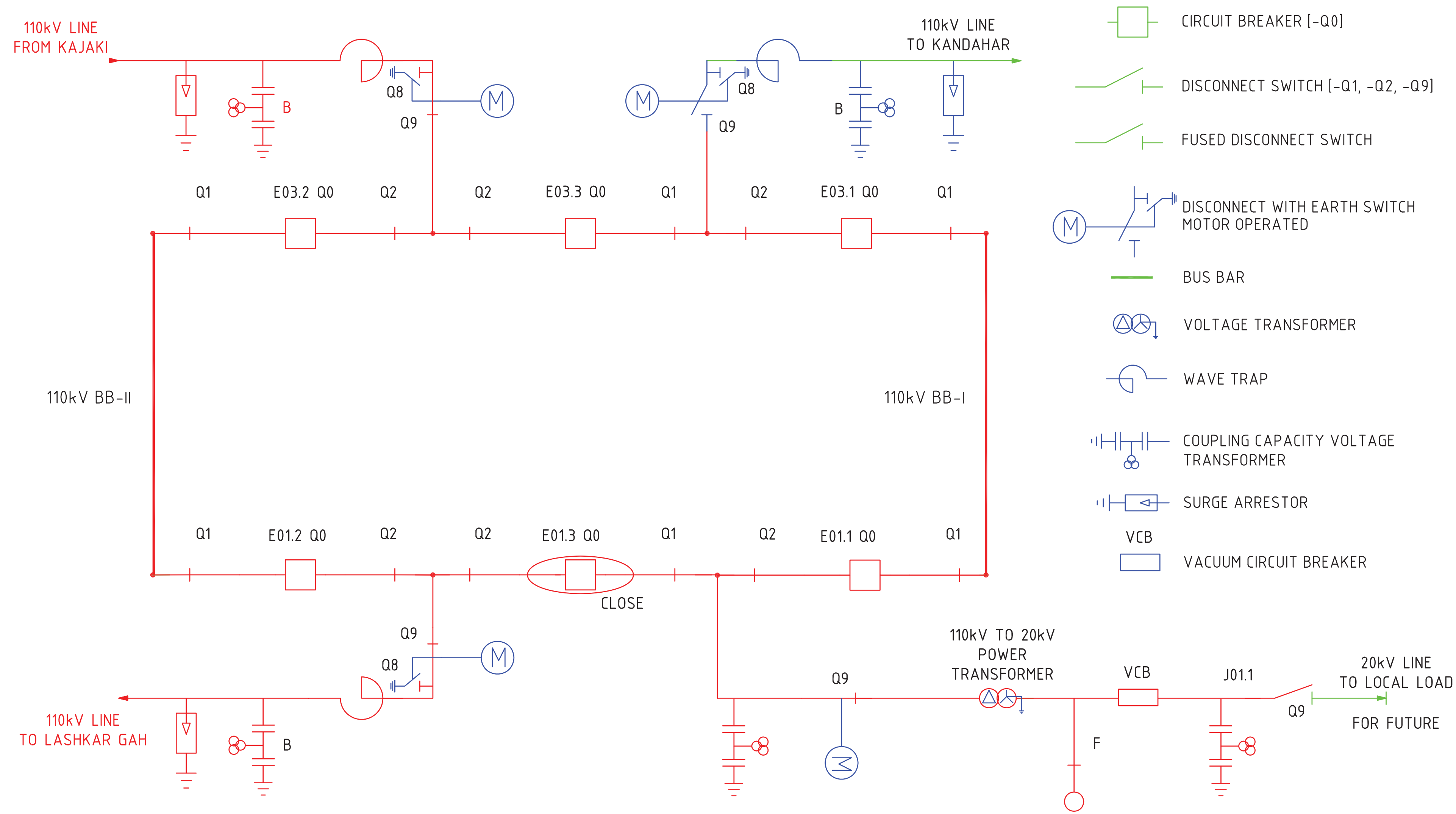
Step #19

Note: Proceeding to Energization of Substation.
Now – SF6 Circuit Breaker remote operated (E01.3 Q0) "Close".



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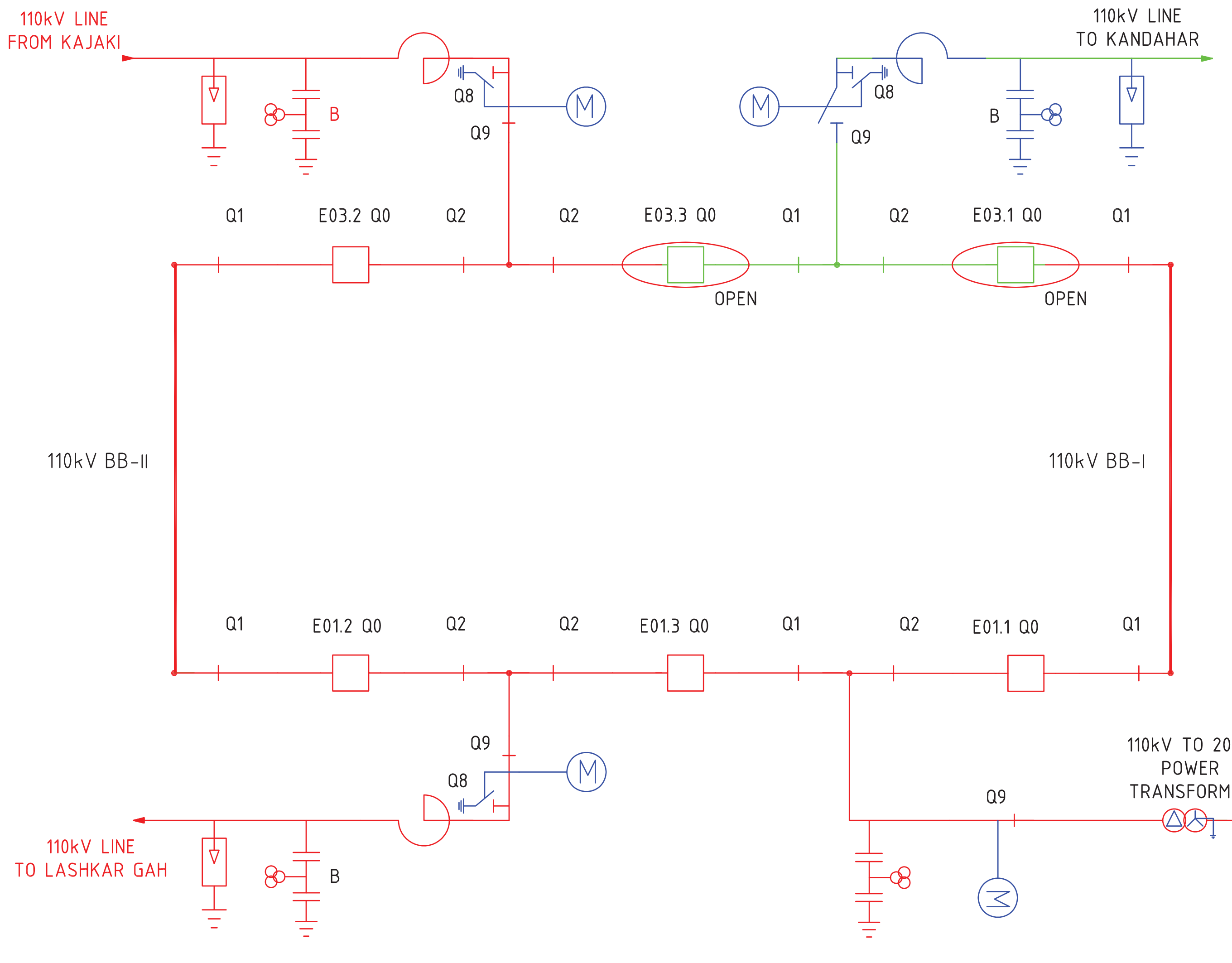
Step #20

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E03.3 Q0 & E03.1 Q0) "Open".



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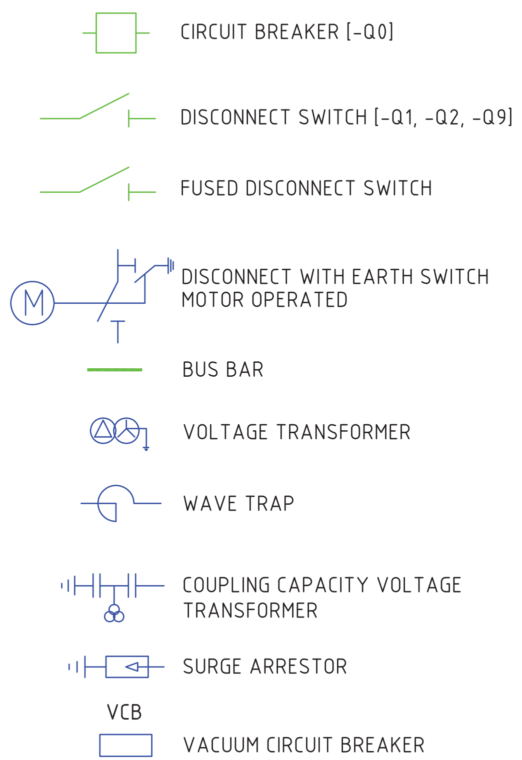

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REV	REVISION INFORMATION	DATE	DWN	DES	CHK	APP
0	FIRST SUBMITTAL	25Apr.13	Jorge.J	Jorge.J	Chacko	Chacko

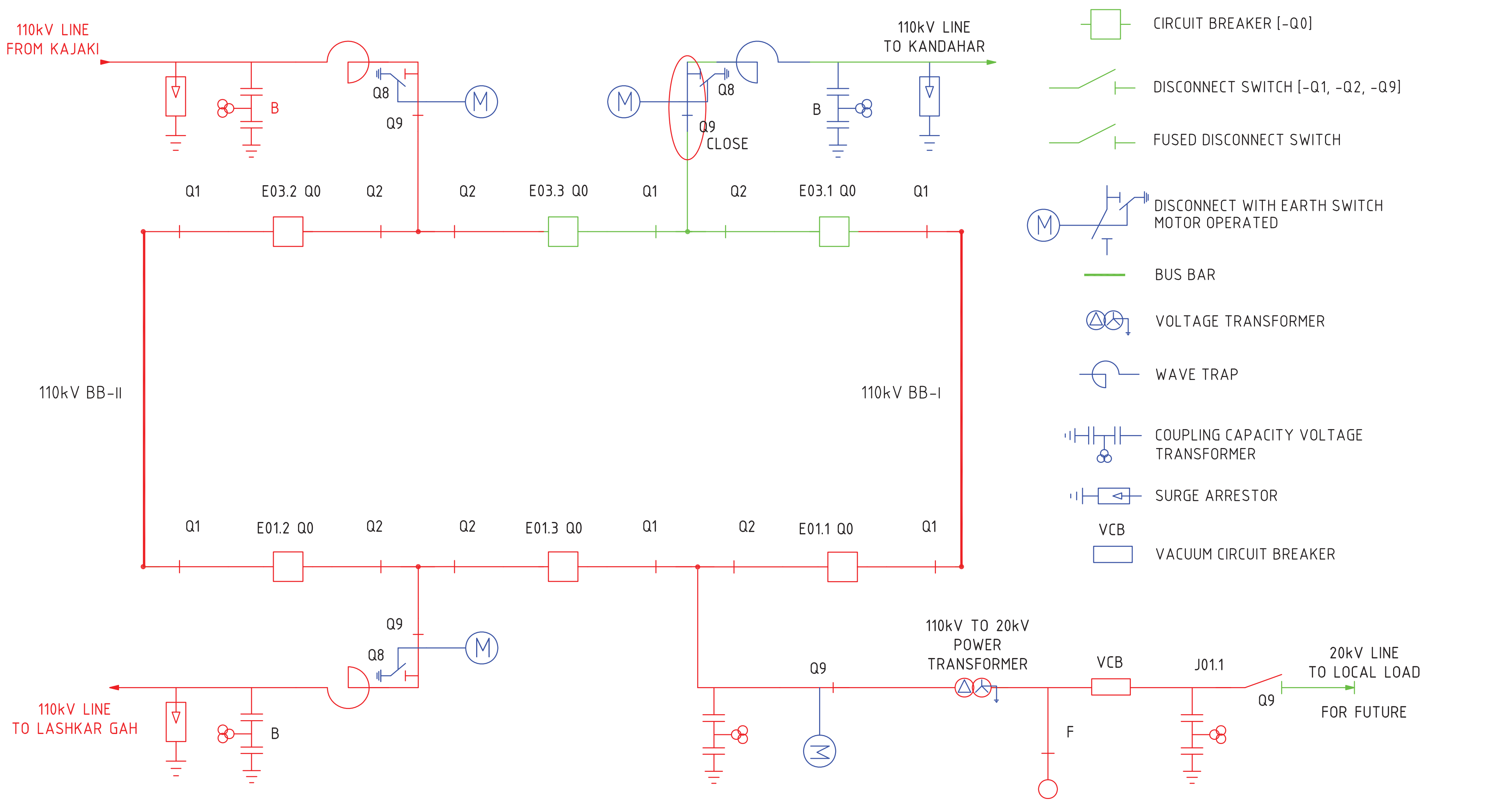
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN
DWG NO. SD - E104
DATE: 25 Apr. 2013
Rev: 0
SCALE: NTS
Sheet No: 1 of 25

Step #21

Note: Proceeding to Energization of Substation.
Now - Disconnect switch remote operated (E03.1 Q9) "Close".



REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

DRAWING STATUS:
FOR APPROVAL

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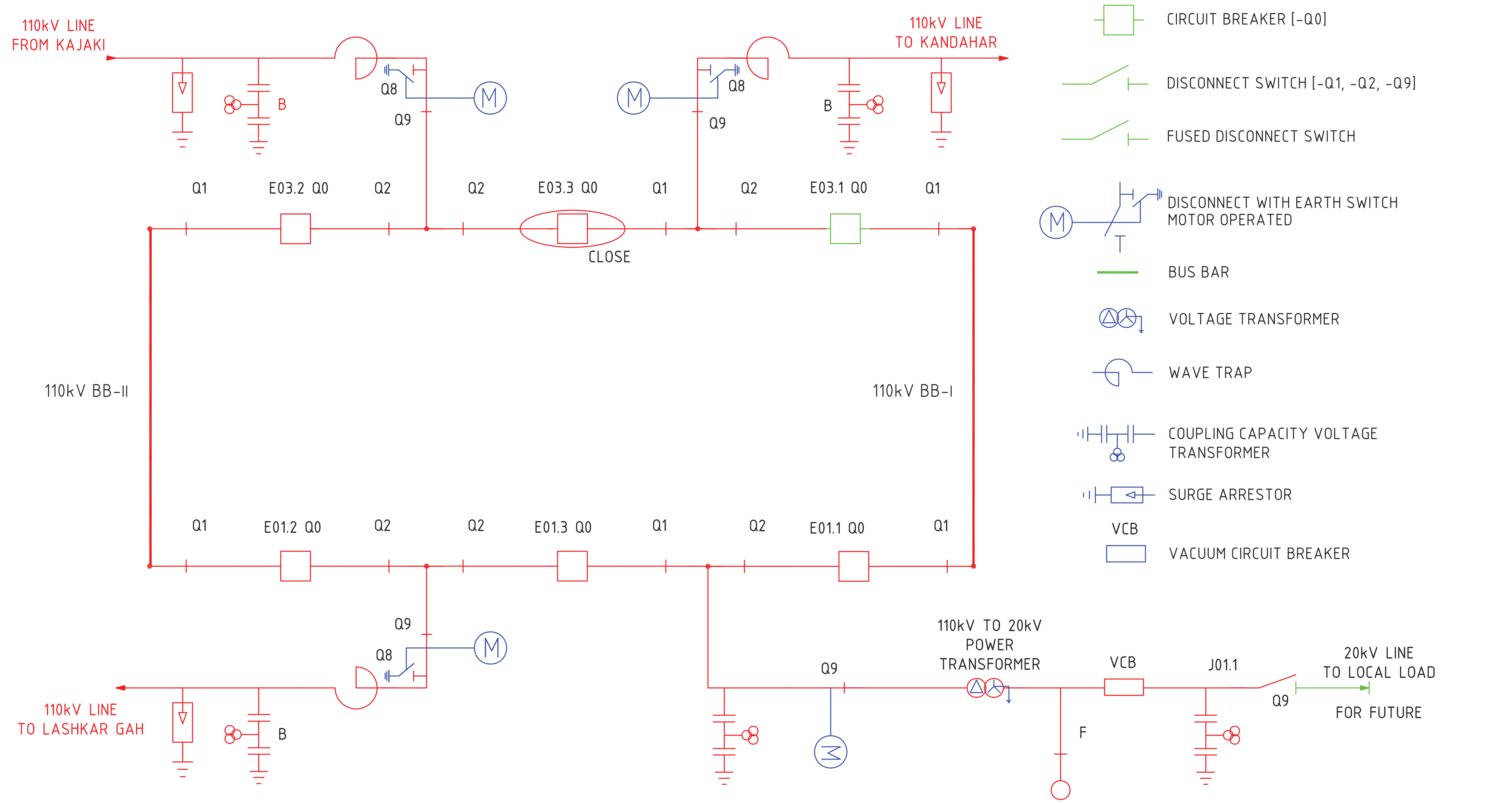
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN
DWG NO. SD - E104
DATE: 25 Apr. 2013
Rev: 0
SCALE: NTS
Sheet No: 1 of 25

Step #22

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E03.3 Q0) "Close".
(Power/supply extended up to Khandahar substation).



REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

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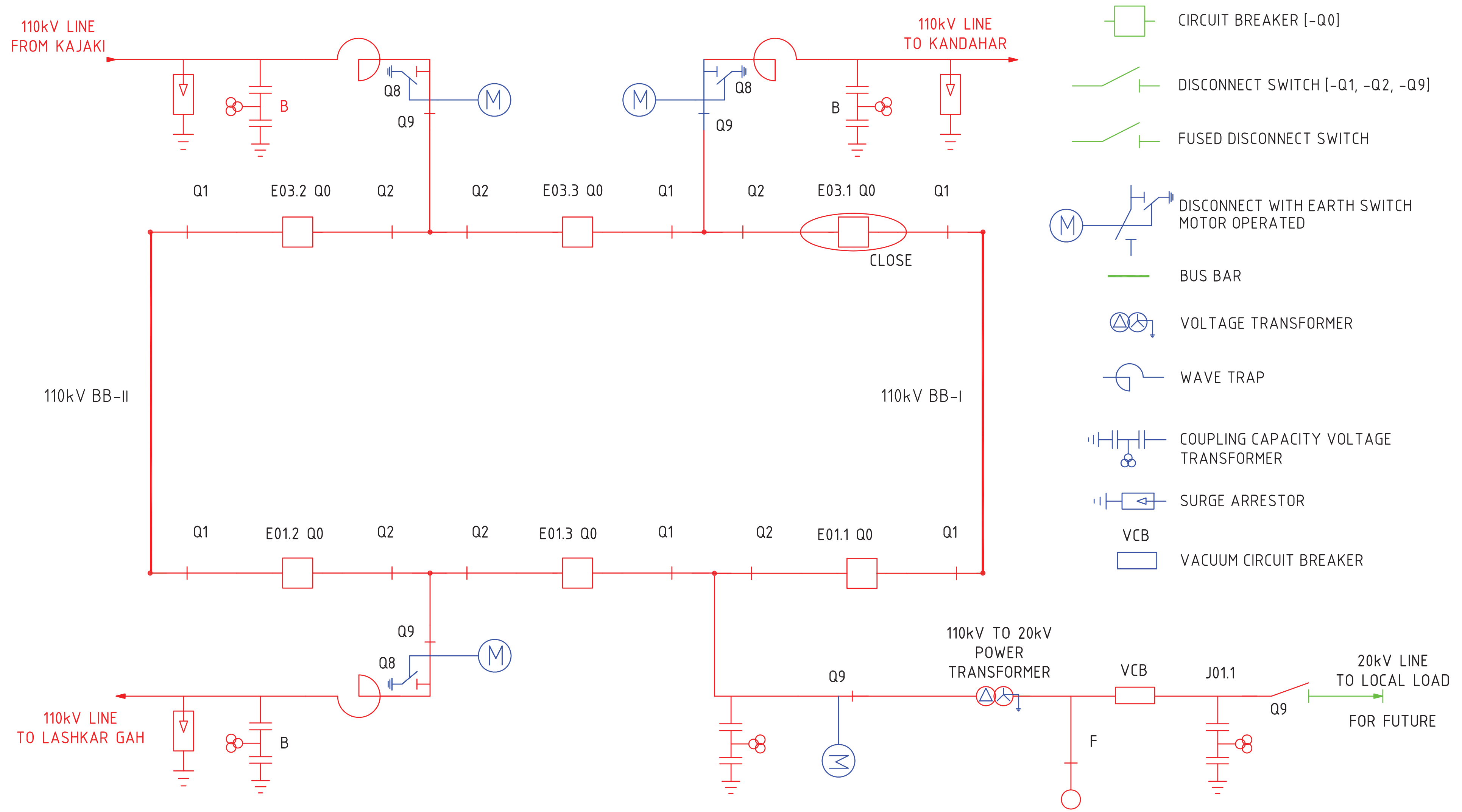
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT. 042246-DJCN
DWG NO. SD - E104
DATE: 25 Apr. 2013
Rev: 0
SCALE: NTS
Sheet No: 1 of 25

Step #23

Note: Proceeding to Energization of Substation.
Now - SF6 Circuit Breaker remote operated (E03.1 Q0) "Close".
(DJCN - completely energized).



REFERENCE DRAWINGS	
Description	Drawing #
SINGLE LINE DIAGRAM	042246-DJCN-E7100

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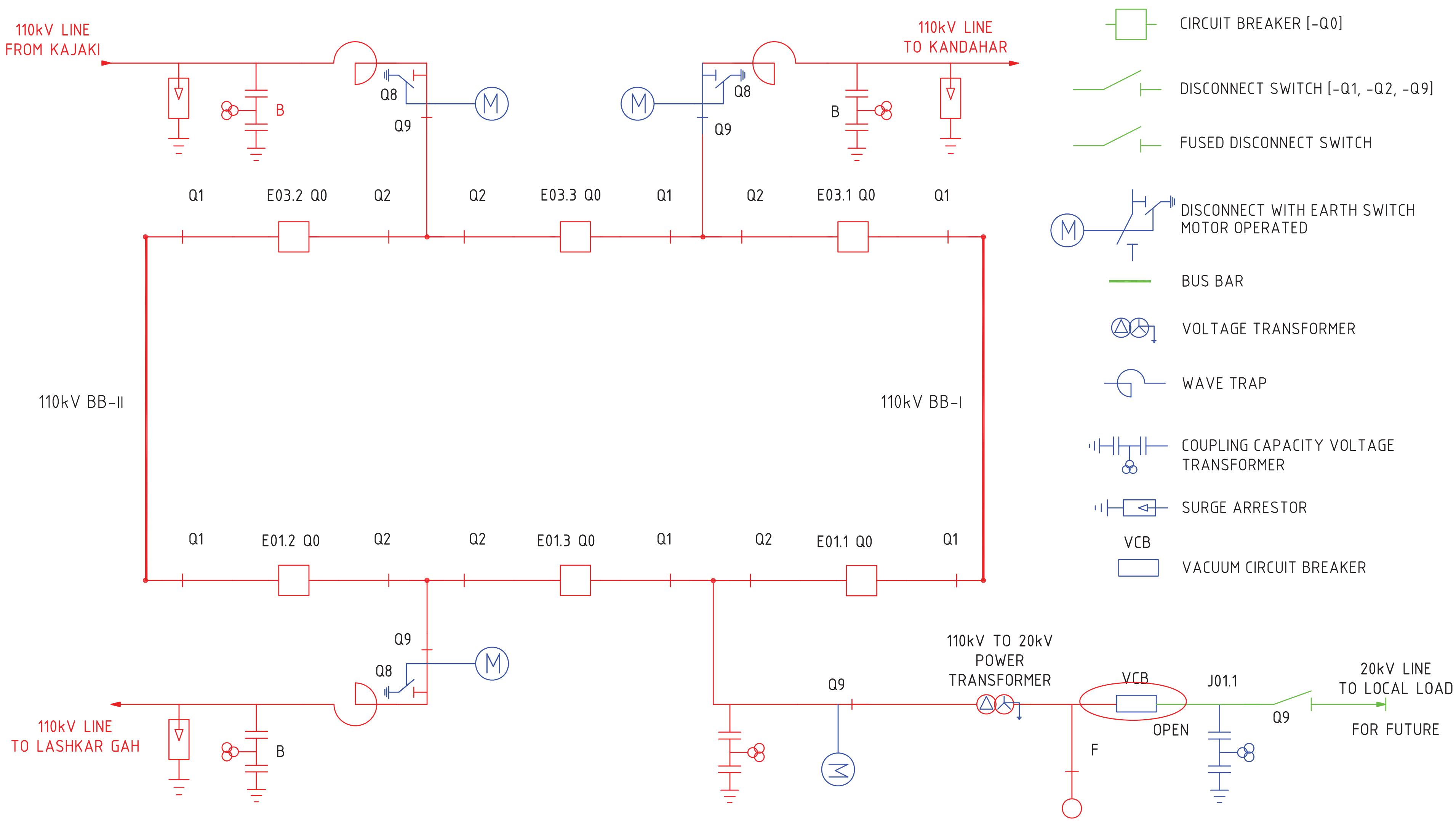
KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT:	DWG NO.
042246-DJCN	SD - E104
DATE: 25 Apr. 2013	Rev: 0
SCALE: NTS	Sheet No: 1 of 25

Step #24

Note: Proceeding to Energization of Substation.
Now – 20KV VCB – must be "Open" (for future used).



REFERENCE DRAWINGS	
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SINGLE LINE DIAGRAM	042246-DJCN-E7100

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KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
OPERATION SCHEME SUBSTATION

PROJECT: 042246-DJCN	DWG NO. SD - E104
DATE: 25 Apr. 2013	Rev: 0
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APPENDIX 4.3

Guide for High Voltage Systems Protective Relaying Design

Guide for High Voltage Systems Protective Relaying Design

Revision: 0
Date: June 28, 2010

Table of Contents

Introduction

High voltage ac transmission systems are designed and built to transfer ac power from one transmission facility to another. Major parts of transmission and substation systems are high voltage lines, buses, switches, circuit breakers, transformers, reactors and capacitors. Protective relaying systems are designed and implemented to protect these major parts. Other objectives of protective relaying systems are identified in the next individual sections. The purpose of this guide is to discuss protective relaying schemes and to establish general guidelines associated with the schemes for new 110 kV, 220 kV and 500 kV transmission and substation systems. In the event of retrofitting an existing substation, the existing protective systems should be evaluated and upgraded. If there are any reasons that it is impractical to upgrade the existing systems, it will become a judgment to adopt a workable solution.

Wording and Definitions

Should - designates a recommendation

A fault is an unintended connection that may occur between phases or from phase(s) to ground. Such connection may be solid (zero impedance) or may contain impedance.

Independent primary and backup schemes are a setup that includes primary and backup protective relays utilizing separate relays and associated fuses and test switches.

Pilot scheme is a communications-assisted protective relaying scheme to achieve high speed concurrent tripping of line terminals to clear a line fault.

Reliability is the measure of a protection scheme's ability to operate when required.

Security is the protection scheme's ability to refrain from operating when not required.

Objectives

Protective relaying systems are critical to transmission and substation systems and interconnected power systems as a whole. Protective relaying systems are designed to achieve the following objectives: (1) To operate with a high level of reliability and security (2) To protect transmission and substation system equipment and lines by interrupting fault(s) as fast as possible (3) To minimize outage time and area (4) To maintain system stability.

To support these objectives, required components for protection schemes such as protective relays, current transformers (CT's), potential transformers (PT's), circuit breaker trip circuits, direct current (dc) power supply, and types of communications for pilot schemes must be identified and the schemes must operate correctly. The protection schemes for different parts of transmission and substation systems will be discussed in the respective protection sections in this guide. The intent of these protection sections is to provide general guidelines for the design of protective relaying schemes.

Line Protection

The intent of this section is to cover the general guidelines for new 110 kV, 220 kV and 500 kV line protection. The protection for 110 kV lines should consist of a pilot scheme as primary protection and a non-pilot scheme as backup protection. The protection schemes for 220 kV and 500 kV lines should consist of two independent pilot schemes as primary and backup protection. The pilot schemes should be of two different types. In addition, a direct transfer trip scheme should be included for 220 kV and 500 kV line protection.

110 kV line primary and backup schemes:

Primary protection should be directional comparison blocking (DCB) which consists of protective relay(s) and a carrier set. Power line carrier communications should be used for the communication medium.

Backup protection should be a two-zone phase distance non-pilot scheme for phase fault protection and a directional overcurrent scheme for earth fault protection.

220 kV line independent primary and backup schemes and a direct transfer trip scheme:

Primary protection should be directional comparison blocking (DCB) which consists of protective relay(s) and a carrier set. Power line carrier communications should be used for the communication medium.

Backup protection should be phase comparison which consists of protective relay(s) and a carrier set. Power line carrier communications should be used for the communication medium.

To enhance the security level, direct transfer trip (DTT) scheme should be a dual frequency shift key (FSK) system using power line carrier (PLC) communications.

500 kV line two independent primary and backup schemes and a direct transfer trip scheme:

Primary protection should be directional comparison blocking (DCB) which consists of protective relay(s) and a carrier set. Power line carrier communication should be used for the communication medium. A second set of relay(s) should be used to provide non-pilot phase and ground fault protection.

Backup protection should be phase comparison which consists of protective relay(s) and a carrier set. Power line carrier communications should be used for the communication medium. A second set of relay(s) should be used to provide non-pilot phase and ground fault protection.

To enhance the security level, direct transfer trip (DTT) scheme should be a dual frequency shift key (FSK) system using power line carrier (PLC) communications.

110 kV/220 kV/500 kV line protection:

Line protection scheme should provide under/over voltage protection, ground fault protection, switch onto fault (SOF) protection, stub bus (STB) protection, and power swing blocking.

Line Protective Relay Criteria and Design Requirements

The line relays should be installed with test switches for testing and removal purposes. Output contacts of the line relays should be used to actuate auxiliary relays. Contacts of the auxiliary relays should be used to trip the associated high voltage circuit breaker(s). Output contacts from either the line relays or the auxiliary relays should be used to initiate stuck breaker failure and breaker reclosing.

Upon receipt of DTT signal from the remote end, the DTT scheme receivers' contacts in series should operate self-resetting relay(s) which trip and block close the associated line terminal circuit breaker(s).

The 220 kV and 500 kV primary and backup line relays should be fed from two separate dc battery systems. Independent circuit breaker trip coils should be used. The 110 kV primary and backup line relays may be fed from one battery system.

The 110 kV and 220 kV line relays should perform three-phase tripping. The single-phase tripping requirement of the 500 kV line relays will be determined on a case by case basis based on stability analysis.

CT/PT Connections

Primary and backup protective relays should be connected to independent sets of CT cores. CT connections should provide two independent protection zones. For the PT connections, the primary and backup protective relays should be connected to different windings of the same PT's.

Transformer Protection

The intent of this section is to cover the general guidelines for new 500-220 kV and 220-110 kV transformers protection. High voltage breakers are typically installed on the low and high sides of the transformers. New transformer protection should consist of independent primary and backup schemes.

Primary Scheme

The transformer primary protection should be current differential. The primary protection relay should also include time overcurrent and instantaneous overcurrent protection.

Backup Scheme

The transformer backup protection should be current differential. The backup protection should also include time overcurrent and instantaneous overcurrent.

In addition, a scheme should be implemented to trip transformer high and low side breakers when there is a rapid rise in transformer oil pressure.

Restricted Earth Fault protection should be included in the transformer protection. The transformer neutral CT should be used to connect to a protective relay for the restricted earth fault protection. The restricted earth fault protection should be an integral function of the transformer backup relay.

The tertiary winding of a three-winding transformer bank should be included in the transformer differential relay zone. The tertiary winding of an autotransformer that is brought out to supply load should also be included in the transformer differential relay zone.

Where there are no nearby distribution lines, a tertiary winding of the transformers is often used to provide an ac station service feed. Overcurrent and grounded phase protection should be provided for the tertiary station service feed utilizing a separate protective relay. This protective relay should be supplied by three CT's.

Power Transformers (40 MVA or Smaller) for Distribution Application

The primary scheme for this type of transformer should be identical to the primary scheme for the 500-220 kV and 220-110 kV transformers. The backup scheme should be the same as the backup scheme for the 500-220 kV and 220-110 kV transformers with the exclusion of the current differential.

Overexcitation Protection Scheme

An overexcitation protection scheme should be applied to transformer(s) where overexcitation conditions might exist during light load periods.

Transformer Protective Relay Criteria and Design Requirements

The transformer relays should be installed with test switches for testing and removal purposes. Output contacts of the primary and backup transformer protective relays should be used to actuate separate lockout relays respectively. Contacts of the lockout relays should be used to trip and block close the associated high voltage circuit breakers. Output contacts from either transformer relays or auxiliary relays should be used to initiate stuck breaker failure.

The primary and backup transformer relays should be fed from two separate dc battery systems for 220 kV and 500 kV substations. Independent circuit breaker trip coils should be used. The primary and backup transformer relays may be fed from one dc battery system for 110 kV substations.

The transformer relays should perform three-phase tripping.

CT/PT Connections

Current transformers from the transformer low and high side circuit breakers should be used to connect to separate restraint windings in the primary and backup transformer relays. Primary and backup protective relays should be connected to independent sets of CT cores. CT connections should provide two independent protection zones.

The primary and backup transformer differential protection zones should be extended to cover the high and low side circuit breakers. This will eliminate the need for separate protection for the bus sections between the breakers and the transformer.

For the overexcitation protection scheme, the transformer low side PT's should be used to connect to the protective relay.

Bus Protection

The intent of this section is to cover the general guidelines for new 110 kV, 220 kV, and 500 kV bus protection. The protection of 110 kV bus should consist of primary and backup schemes. The protection of 220 kV and 500 kV buses should be two independent primary and backup schemes.

Primary Scheme for 110kV, 220 kV and 500 kV bus

Primary bus protection should be current differential.

Backup Scheme for 220 kV and 500 kV bus

Backup bus protection should also be current differential.

Backup Scheme for 110 kV bus

The backup bus protection should include time overcurrent and instantaneous overcurrent.

Bus Protective Relay Criteria and Design Requirements

The bus relays should be installed with test switches for testing and removal purposes. Output contacts of the primary and backup protective relays should be used to actuate separate lockout relays respectively. Contacts of the lockout relays should be used to trip and block close the associated high voltage circuit breakers. Output contacts from either the bus relays or auxiliary relays should be used to initiate stuck breaker failure.

The primary and backup 220 kV and 500 kV bus relays should be fed from two separate dc battery systems. Independent circuit breaker trip coils should be used. The primary and backup 110 kV bus relays may be fed from one dc battery system.

The bus relays should perform three-phase tripping.

The bus differential relays should be provided with dead zone transfer trip capabilities to clear faults that occur between the breaker and the free standing current transformers.

CT Connections

Primary and backup protective relays should be connected to independent sets of CT cores. CT connections should provide two independent protection zones. To maximize performance of the differential schemes, CT's should have the same ratio and similar characteristics.

Shunt Reactor Protection

The intent of this section is to cover the general guidelines for new shunt reactor protection. The protection schemes in this section are for shunt reactors to be installed in a substation.

Primary Scheme

Primary protection should use current differential.

Backup Scheme

Backup protection should consist of instantaneous, time delay phase overcurrent and time delay neutral overcurrent for winding to earth faults.

Restricted Earth Fault protection should be included in the reactor protection where applicable.

A Buchholz relay (gas accumulator) should be provided as part of the reactor for turn-to-turn fault protection.

Different relays should be used for protection and backup protection.

Shunt Reactor Protective Relay Criteria and Design Requirements

The shunt reactor relays should be installed with test switches for testing and removal purposes. Output contacts of the primary and backup protective relays should be used to actuate separate lockout relays respectively. Contacts of the lockout relays should be used to trip and block close the associated high voltage circuit breaker(s). Output contacts from either shunt reactor relays or auxiliary relays should be used to initiate stuck breaker failure.

The primary and backup relays should be fed from two separate dc battery systems for 220 kV and 500 kV substations. Independent circuit breaker trip coils should be used. The primary and backup relays may be fed from one dc battery system for 110 kV substations

The shunt reactor relays should perform three-phase tripping.

CT Connections

Primary and backup protective relays should be connected to independent sets of CT cores. CT connections should provide two independent protection zones.

Shunt Capacitor Protection

The intent of this section is to cover the general guidelines for new shunt capacitor protection. The protection schemes in this section are for shunt capacitors to be installed and connected to a substation bus through high voltage circuit breaking device(s).

For very large capacitor banks at 220 kV and 500 kV, the following protection schemes should be applied:

Primary Scheme

Primary protection should include phase and ground overcurrent. A second set of protective relay(s) should provide an unbalance detection scheme.

Backup Scheme

Backup protection should be the same as the primary protection.

A case by case engineering analysis will be required to determine a most appropriate method of unbalance detection scheme for a shunt capacitor installation. The unbalance detection scheme should be used to prevent an overvoltage of more than 110 % of rated voltage imposing on the capacitor cans.

For capacitor banks at 110 kV, one phase and ground overcurrent scheme and one unbalance scheme might suffice. An analysis of the capacitor bank installation will be required to determine if additional protection is needed to obtain an optimal solution.

Shunt Capacitor Protective Relay Criteria and Design Requirements

The shunt capacitor relays should be installed with test switches for testing and removal purposes. Output contacts of the primary and backup protective relays should be used to actuate separate lockout relays respectively. Contacts of the lockout relays should be used to trip and block close the associated high voltage circuit breaker(s). Output contacts from either shunt reactor relays or auxiliary relays should be used to initiate stuck breaker failure.

The primary and backup relays should be fed from two separate dc battery systems for 220 kV and 500 kV substations. Independent circuit breaker trip coils should be used. The primary and backup relays may be fed from one dc battery system for 110 kV substations

The shunt capacitor relays should perform three-phase tripping.

CT/PT Connections

Primary and backup protective overcurrent relays should be connected to independent sets of CT cores. CT connections should provide two independent protection zones. CT/PT connections for unbalance detection schemes will vary depending on which method is chosen. Primary and backup unbalance detection relays should be connected to separate CT's cores or different windings of the same PT.

Breaker Failure

The intent of this section is to provide the breaker failure protection guidelines for 110 kV, 220 kV and 500 kV circuit breakers. The breaker failure protection should be a non-directional instantaneous overcurrent relay that starts a timing relay. Any protective trip of the breaker should enable the breaker failure relaying scheme.

The breaker failure scheme should make one attempt to retrip the failed breaker before actuating the breaker failure scheme lockout relay(s).

Pole disagreement relaying will be provided for circuit breakers that have single pole tripping/closing capability. The pole disagreement protection should trip all three poles if all three poles are not in the same position. The inherent time delay in pole position for single phase tripping and closing should be considered.

The breaker failure scheme may be a separate stand alone scheme, integral to a breaker or bay control relay or integral to a back-up protection scheme that trips that breaker.

Breaker Failure Protective Relay Criteria and Design Requirements

If not included as an integral function of another relay, breaker failure relays should be installed with test switches for testing and removal purposes. If the breaker failure relay is integral with another relay, the input and outputs of the breaker failure relay should be installed with test switches for testing and isolation purposes.

Output contacts of the breaker failure relays should be used to actuate a separate lockout relay. Contacts of the lockout relay should be used to trip **(both trip coils)** and block close the associated high voltage circuit breaker(s).

The breaker failure scheme should perform three-phase tripping.

Output contacts of the breaker failure relay should enable the breaker failure schemes of adjacent breakers and direct transfer trip schemes associated with the 220 kV and 500 kV lines or actuate an auxiliary relay which will perform the same function. Once the breaker failure condition has been removed, the signal to enable adjacent breaker failure and DTT schemes associated with the 220 kV and 500 kV lines should be disabled.

CT Connections

The breaker failure relay should be connected to the CT core used for the back-up protective relays.

Synchronism Check

The intent of this section is to cover the general guidelines for synchronism check relaying for 110 kV, 220 kV and 500 kV breakers. With the exception of high speed automatic reclosing, synchronism check will be performed and supervise the closing of the circuit breakers. The synchronism relay should monitor the single phase voltages on the line (or load) side and bus (or source) side of the circuit breaker. System operating requirements and good engineering practices should be used to determine hot line (HL), dead line (DL), hot bus (HB) or dead bus (DB) synchronism check requirements.

Where it is determined that HB/HL synchronism check is required, the relay should be set such that the maximum slip frequency between the two sides of the breaker is not exceeded. The following relay settings are suggested.

Locations without generation:
Phase angle: 40 degrees
Time delay: 2.5 seconds

Locations without generation, but where a phase angle greater than 40 degrees is required
Phase angle: 60 degrees
Time delay: 3.5 seconds

Locations with generation

Phase angle: 20 degrees (or as required by the generator manufacturer)

Time delay: 2.0 seconds (or as required by the generator manufacturer)

The above relay settings are suggestions only and should be verified with system study data and modified as required to meet system requirements or generator manufacturer's requirements.

Synchronism Check Relay Criteria and Design Requirements

The synchronism relays should be installed with test switches for testing and removal purposes.

Reclosing

The intent of this section is to cover reclosing guidelines for 110 kV, 220 kV and 500 kV transmission line circuit breakers. Reclosing for transformers, capacitors, reactors, generators, bus couplers, bus faults should not be provided.

Single shot (one attempt) high speed automatic reclosing should be provided for one end of 220 kV, and 500 kV transmission lines that are not electrically close to generation sources. Appropriate time delay should be provided to allow deionization of the fault arc. Two shot (two reclose attempts) should be provided for one end of 110 kV transmission lines.

The circuit breaker closest to the generation source (lead breaker) should be closed first. For configurations where there are two breakers, such as breaker and one-half or ring bus configurations, one breaker on the line should be designated as the lead breaker.

After the lead breaker is successfully closed, the remaining (follow) breakers should be closed starting with the second breaker, if any, at the same end of the line as the lead beaker. Reclosing of the follow breakers should use synchronism check.

High speed reclosing should only be initiated if at least one line relaying scheme is in service.

Reclosing should be blocked for direct transfer trip, breaker failure conditions and breaker trips caused by other system component trips such as bus faults, transformer faults, etc.

If the transmission line is electrically close to a generation source, high speed reclosing should not be provided and reclosing should be delayed. The time delay and synchronism check should be determined based on the generator manufacturer's requirements.

Reclosing for underground cables should not be provided. For combined underground and overhead (air insulated) transmission lines, the requirement for reclosing for the overhead portion of the line will be determined on a case by case basis

Reclosing Relay Criteria and Design Requirements

If not included as an integral function of another relay, reclosing relays should be installed with test switches for testing and removal purposes.

It is preferred that the line reclosing function be contained in a circuit breaker or bay control relay. If the reclosing is not an independent stand alone scheme or contained in the breaker or bay control relay, it should be part of the primary line protection relay.

Load Shedding

Power systems are interconnected to provide power transfer path(s) between interconnected power systems. Major faults can cause the interconnected power systems to be separated into smaller systems. When there is a large mismatch between the power being generated and the heavy connected loads in the system, the system frequency will decrease due to the heavy loads causing a drag on the system. Without any proper actions, the system frequency dipping below the unacceptable level will result in a major system shutdown. One method to mitigate the underfrequency problem is to shed some of the connected loads at the substation level using a load shedding scheme. Underfrequency relay(s) are used in the scheme to detect the system frequency. The intent of this section is to cover the general guidelines that should be observed in developing load shedding scheme.

1. The load shedding scheme should be designed to meet or exceed the frequency deviation norms as stated in GOST 13109-97.

2. The load shedding scheme should be designed to shed load in steps.

3. Loads being tripped by load shedding scheme should not have an auto-reclose function.

Underfrequency Relay Criteria and Design Requirements

The underfrequency relays should be installed with test switches for testing and removal purposes.

The load shedding detection scheme should be designed with a high level of security to ensure there are no misoperations.

Undervoltage and Overvoltage

Undervoltage conditions are a result of faults not completely isolated. Overvoltage conditions can occur when faults, switching and lightning happen in the power system. Without proper overvoltage protection, severe damages to transmission and substation equipment can result from the imposition of overvoltages over an unacceptable period of time. Transformers, reactors, and capacitors are highly susceptible to overvoltage conditions. There are different levels of overvoltage protection provided in the transmission and substation systems. The protection level in this section is associated with over/under voltage protective relaying system for substations.

The intent of this section is to cover the suggested relay settings associated with undervoltage and overvoltage protection.

1. The undervoltage and overvoltage protection settings should meet or exceed the voltage norms as stated in GOST 13109-97.

2. The undervoltage settings are typically 90%-95% of normal voltage.

3. The overvoltage settings are typically 106%-110% of normal voltage.

The above relay settings are suggestions only and should be verified with system study data and modified as required to meet system requirements or equipment manufacturer's requirements.

Under- and Overvoltage Protective Relay Criteria and Design Requirements

If not included as an integral function of another relay, the under- and overvoltage relays should be installed with test switches for testing and removal purposes. If the relays are integral with another relay, the input and outputs of the multi-function relays should be installed with test switches for testing and isolation purposes.

4.5 Important Notes (a) sequences of operation of DS and CB (b) Battery charger power requirement.

(a) sequences of operation of DS and CB

1) Disconnect switches are not designed to interrupt or close onto loads
2) In order to limit the stress on the Kajakai Generators, when the Kajakai line is re-energized, load may only be added in discrete steps.
3) When there is a power outage of Kajakai incoming, the Circuit Breaker **E03.3 –Q0** will trip as it is programmed. This Circuit Breaker can close remotely only when the power restored. A remote push switch added for testing (close) and reset if required.
4) To operate remotely the Kajakai incoming Motorized disconnect switch **E03.1-Q9**, it is required the **CB E03.3 –Q0 and E03.1 –Q0** in "open" position.
5) To operate remotely the Kandahar outgoing Motorized disconnect switch **E01.1-Q9**, it is required the **CB E01.3 –Q0 and E01.1 –Q0** in "open" position.
6) To operate remotely the Lashkargah outgoing Motorized disconnect switch **E0 3.2-Q9**, it is required the **CB E01.2 –Q0 and E1.3 –Q0** in "open" position.
7) To operate remotely the power Transformer 110/20 KV incoming Motorized disconnect switch **E0 1.2-Q9**, it is required the **CB E01.3 –Q0** and **E01.2 –Q0** in "open" position.
8) Operate the disconnect switches and CB's in above order of (4-7) step by step to avoid much stress to the Kajakai power generators.

(b) Battery charger power requirement.

1) It is to ensure Backup generator is available to provide power for the battery charger during main power outages
2) It is recommended minimum 4 Hrs standby power in a day for battery charging if the control room panels are provided battery power input during power outages.

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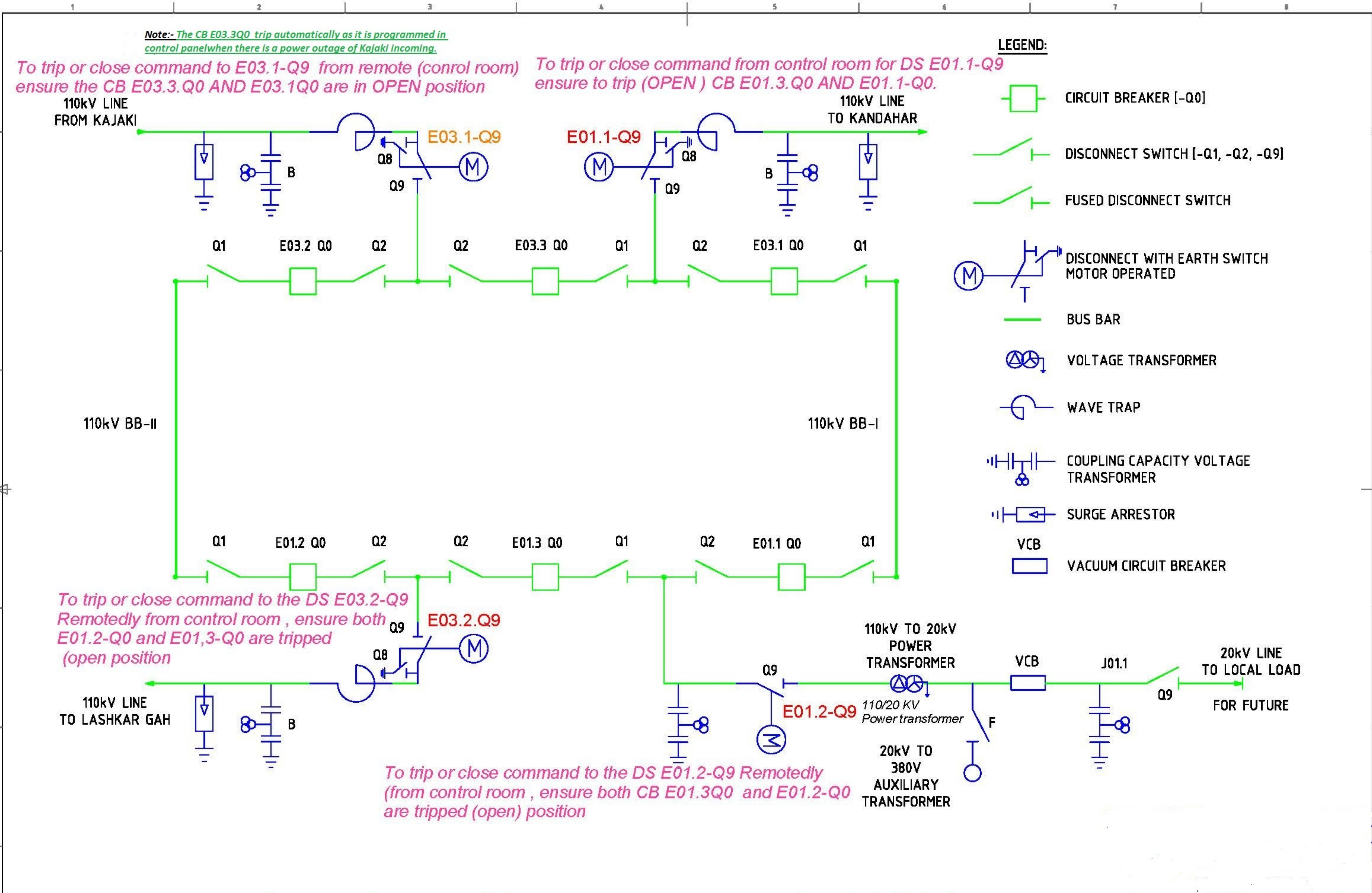

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REV	REVISION INFORMATION	DATE	DWN	DES	CHK	APP
0	FIRST SUBMITTAL	25Apr.13	Jorge.J	Jorge.J	Chacko	Chacko

KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM OPERATION SCHEME SUBSTATION

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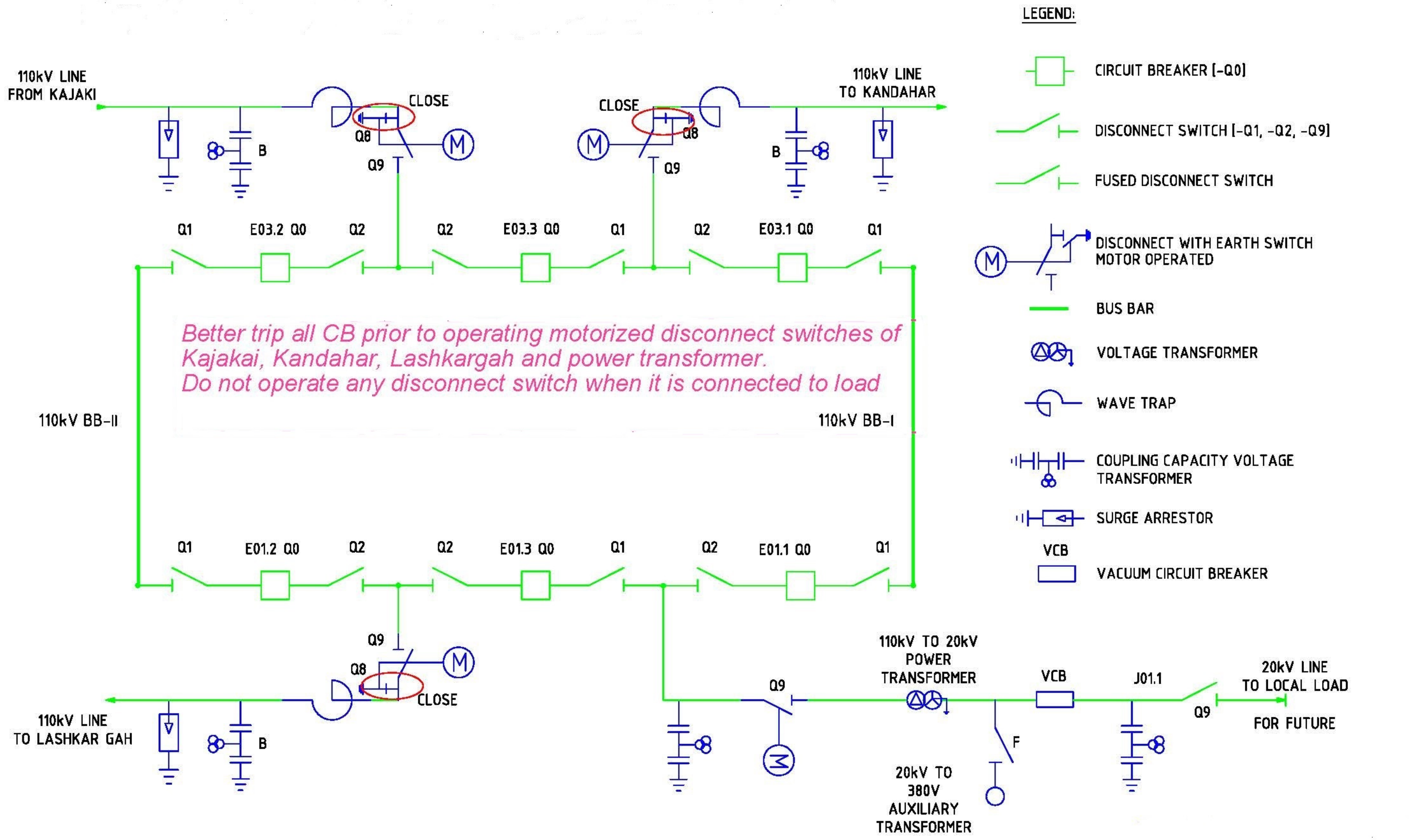

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KANDAHAR HELMAND POWER PROJECT

SINGLE LINE DIAGRAM
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