CHAPTER 9

HOW TO ENHANCE THE RELIABILITY & POWER QUALITY OF ELECTRICITY SUPPLY

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9.1 Introduction

1. HK Electric provides a very reliable power supply to our customers with a pledged reliability of over 99.999%. However, public electricity supply systems are liable to external influences. Despite the fact that we have made every endeavour to ensure high reliability of electricity supply and good power quality, power quality problems may still occasionally occur due to various causes.

   Loading conditions, defect or fault in the equipment/installation of one customer may affect other customers who share the same communal electrical installation and/or the same supply source. In other words, power quality problems may also originate from the customer side.

   Generally, the most common power quality problems a customer may encounter include supply interruption, voltage dip and harmonics.

2. This Chapter depicts the causes of the above problems and various enhancement/mitigation measures a customer may adopt to safeguard his power supplies for important services.

9.2 Supply Interruptions

1. Causes

   a. The most common cause of power interruption is underground cable damage or cable fault arising from disturbances by third parties' excavation work. Customers supplied by the damaged cable will experience supply interruption until backup supply is connected or the cable is repaired.

When a distribution high voltage (HV) supply cable is faulty or damaged, it may result in supply interruptions to customers. The supply interruption is usually very short and is in the order of a few minutes. However, in exceptional circumstances when there are simultaneous multiple cable faults or when there is a transformer or switchgear fault, a longer period of supply interruption may occur.

For low voltage (LV) network fault, supply can only be restored after the fault is repaired or after backup supply is connected by the emergency crew. Thus, the time for supply restoration would be longer.

b. Other than cable fault or damage, power interruptions may also be caused by equipment failures in the supplier's system as well as in the customer's installations.

c. Customer's electrical installations are usually connected in a radial network. Fault in any part of customer's electrical installations will trigger protective devices to isolate the faulty part. Supply interruptions will then occur to the downstream feeders. Common faults of customer's electrical installations that may cause supply interruptions include:

   i. Overload or under-rated equipment,

   ii. Improper connections,

   iii. Deteriorated insulation or faulty switchgear,

   iv. Defective electrical appliances,

   v. Improper setting of protection devices.

2. Possible Enhancement/Mitigation Measures

a. Interconnection Between Different Transformers/11-kV/22-kV Sources on Customer Side

When the customer's installations receive supply from two or more HK Electric transformers/11-kV/22-kV supplies, the customer is strongly recommended to install bus section switch(es) so that a backfeed source is available through the other transformer/ 11-kV/22-kV supply in the event of loss of supply from one of these sources. Typical examples are shown in Drg. Nos. GCS/9/01, GCS/9/02, GCS/9/03 and GCS/9/04.

If bus section switch(es) cannot be installed in the main switchboard due to site constraints, especially for the existing installations, transfer switch(es) should be considered on the load side for the important services downstream. A typical example is shown in Drg. No. GCS/9/05.

b. Uninterruptible Power Supply (UPS), Standby Generator and Other Automatic Backup Supply (ABS) for Important Services

i. Where an electricity supply for important services is required, the customer is recommended to install an UPS system, standby generator and/or other ABS system to prevent and minimize any damage, loss or inconvenience caused directly or indirectly by any expected or unexpected voltage fluctuation, voltage dip, interruption or failure of supply howsoever arising. A typical example is illustrated in Drg. No. GCS/9/06.

ii. For services that can tolerate a short time delay in power resumption after a power failure, a standby generator or alternative supply with automatic changeover device is a possible solution.

iii. For services where a continuous electricity supply is required, an UPS system (which may only maintain power supply for a limited period of time in case of normal supply failure) together with an ABS system is more advisable to prevent and minimize any damage, loss or inconvenience caused directly or indirectly by any expected or unexpected voltage fluctuation, voltage dip, interruption or failure of supply.

iv. As a general guideline, if the customer has any of the following equipment, he is strongly recommended to install an UPS system, standby generator and/or other ABS system in order to ensure that the equipment continues to operate properly when there is any voltage fluctuation, voltage dip, interruption or failure of supply:

- medical equipment which is supporting or treating patients;

- computer equipment, control equipment and any other equipment which requires continuous regulated supply;

- equipment used for ensuring and maintaining safe access to, exit from and environment for any activities inside a tunnel or confined space;

- equipment used in conditions of emergency such as rescue operations and combating with fire, flood, dangerous fumes/gas and other hazards;

- equipment used for security surveillance and other similar purpose;

- appliances/equipment which require critical supply of electricity to maintain proper operation and/or which would incur substantial loss and damage if there is any voltage fluctuation, voltage dip, interruption or failure of supply;

- appliances/equipment which the survival of live stock will rely on.

v. The customer shall consult an expert or a consultant on which type and capacity of UPS system, standby generator and/or ABS system he shall use. The customer is also advised to consult the supplier or manufacturer of his particular equipment/appliance on the requirements of the UPS system, standby generator and/or ABS system.

c. To Review Regularly the Capacity of UPS system, Standby Generator and Other ABS system for Important Services

As the demand may increase over time, the customer is advised to review the essential loading regularly and to ensure that the capacities of UPS system, standby generator and/or ABS system are adequate to meet the current demands of all essential services.

d. Inspection and Maintenance of Customer's Installations

Regular inspection and preventive maintenance of customer's installations should be carried out to improve the reliability of the electrical installations. The frequency of inspection and maintenance should be strengthened for installations supplying important services.

e. Selectivity of Protective Devices

Improper settings of protective devices will result in unnecessary interruption of supply and/or damage to electrical equipment. In the event of a fault, protective devices should operate to isolate the supply of the faulty part promptly. However, protective devices should be discriminated and so arranged that only the minimum necessary portion of the electrical installations would be isolated. The customer is recommended to regularly check and review the protection settings in his installations.

A typical example on grading arrangement of protective devices is shown in Drg No. GCS/9/07.

9.3 <u>Momentary Voltage Dips</u>

1. Causes

a. Momentary voltage dip is defined as a sudden voltage reduction to a value between 90% and 1% of the declared voltage. The actual magnitude and duration of the momentary voltage dip may vary according to the type of fault and/or other factors. The duration of the voltage dip caused by a HV fault is usually very short, typically less than 1 second. However, this momentary voltage dip can cause nuisance tripping of the customer's air-conditioning (A/C) system, electrical motor system or other services.

b. When a fault occurs on a supply cable or equipment, voltage dip may be experienced on all parts of the power supply system affected by the fault until the protective devices operate to clear the fault. Thus, apart from the supply interruption to those customers who are directly supplied by the faulty cable or equipment, other customers may also experience voltage dip. In the case of a distribution equipment/cable fault, the voltage dip is localized to the geographical area where the equipment/cable connected but for a transmission equipment/cable fault, the voltage dip will be geographically more extensive.

c. Since our supply network is interconnected with CLP Power, which in turn is interconnected with mainland China, customers supplied by HK Electric may experience momentary voltage dips as a result of faults in the transmission power systems other than HK Electric system.

d. Voltage dips can also be caused by customer’s installations, such as excessive starting current of large motors or fault current before the protective devices isolate the fault.

2. Possible Enhancement/Mitigation Measures

a. Motor Circuit Design Consideration

i. Starting of large motor usually draws an excessive current and may result in voltage dip. A customer should therefore specify his motors in such a way that starting of the motors shall not interfere with the sensitive equipment in the installation. In addition, the starting current shall comply with the requirements as stipulated in HK Electric Supply Rules.

ii. Voltage dip may cause an increase of motor current and tripping of the control circuit. To minimize inconvenience, plants and machines should be specified to be capable of continuously running and withstanding the momentary voltage dip without damaging effects. If there are two or more supply sources, the customer may also separate the supply sources to motors from those to the sensitive equipment.

iii. The equipment suppliers shall be consulted with regard to the capability of the machines to withstand the thermal and mechanical stress during and after the voltage dip. If it is confirmed that the machines have the design capability to run continuously and withstand the momentary voltage dip without damaging effects, a suitable short time delay may be introduced in the control circuits, and the voltage protection setting may be adjusted to prevent nuisance tripping.

b. Air-Conditioning Systems

Chiller plants and their associated equipment of the air-conditioning system are susceptible to voltage dips. A customer should therefore consider specifying his air-conditioning system to allow the chiller to ride-through voltage dips or to incorporate automatic re-start functions such that the impact to air-conditioning services will be minimized. These can be achieved by installing voltage dip ride-through devices for control devices and modifying the building management system software as appropriate.

c. Escalators and Lifts

i. Escalators will require manual reset when they are tripped during voltage dips. The ride-through capability of escalators can be improved by adding appropriate mitigation devices. For adding mitigation devices against voltage dips, please also refer to the latest Code of Practice on the Design and Construction of Lifts and Escalators.

ii. Lifts may be tripped during voltage dips. To minimize inconvenience, lifts should be designed with an automatic rescue device or a post-voltage-dip-operation means to send the car to a landing and open the car and landing doors to release the passenger, or resume the normal operation of the lift, when the normal power supply is stabilized. The automatic rescue device or a post-voltage-dip-operation means shall not cause the lift to be restarted, if further lift operation will lead to a dangerous situation.

d. High Pressure Discharge Lamp (HPDL)

HPDL is sensitive to voltage dips and cannot be re-ignited in a short time even when the supply has resumed to normal. This may cause interruption to important events. There are several suggestions to resolve this problem:

i. Use a constant Wattage Auto-Transformer with higher voltage dip ride-through capability.

ii. Employ lamps with double tube feature, whose side tube can be ignited when the main tube extinguishes.

iii. Employ a hot re-strike igniter to produce a higher re-strike voltage after voltage dips while the lamp is still hot.

iv. For critical lighting applications, install non-HPDL such as fluorescent or Lighting Emitting Diode lamps, or emergency HPDL lighting with UPS.

e. The Proper Use of Undervoltage Protective Devices

i. Undervoltage protective devices should not be installed at main switches or switches affecting supply to more than one customer and/or equipment.

ii. Whenever undervoltage protective devices are to be used, they should be installed on the load side in order to avoid unnecessary tripping to other equipment.

iii. As a preventive measure against nuisance tripping in the event of momentary voltage dip, a time delay device with suitable setting, such as 1 second should be incorporated provided that the equipment is capable of withstanding the thermal and mechanical stress during and after the voltage dip.

f. Power Conditioning Devices

i. UPS is an effective means to protect important services from momentary voltage dips. UPS contains energy storage components, which can also maintain voltage level instantly for a predetermined period of time in case of voltage dips/supply voltage fluctuations/interruptions. Please also refer to Clauses 9.2.2.b and 9.2.2.c for details.

ii. A typical voltage stabilizer will maintain the output voltage to within 2% of the normal value even when the mains supply voltage varies by up to 20%. The device will also prevent voltage spikes and other transient voltages from entering into the important services. However, voltage stabilizer does not compensate for complete interruption of main electricity supply and/or severe voltage dip.

iii. A line conditioner contains isolation and filter circuits, which will prevent voltage transients and voltage spikes from entering into the important services. Similar to voltage stabilizers, it cannot provide complete compensation.

iv. The customer shall consult an expert or a consultant on which type and rating of power conditioning devices he shall use. The customer is also advised to consult the supplier or manufacturer of his particular equipment/appliance on the requirements of the power conditioning devices.

9.4 Harmonics

1. Causes

Harmonic voltage is defined as a sinusoidal voltage having a frequency equal to an integer multiple of the fundamental frequency (i.e. 50 Hz) of the supply voltage. Harmonics are generated by any load that draws current not proportional to the voltage applied. In other words, harmonics are generated by non-linear loads that draw non-sinusoidal current. Harmonic currents flowing through the impedances of the electrical system give rise to harmonic voltages. Harmonic currents and thus the harmonic voltages vary over time. Such non-linear loads include but are not limited to fluorescent lamps, electronic machines (copiers and fax), power electronic devices in the control circuits of motors and battery chargers. The possible impacts caused by harmonics are listed below for information:

a. Overheating of motors/transformers,

b. Overheating of capacitors,

c. De-rating of electrical wiring and devices,

d. Decreased motor performance,

e. Improper operation of protection devices like breakers, relays or fuses,

f. Telecommunications interference,

g. Improper operation of sensitive electronic devices like motor control circuits.

2. Possible Enhancement/Mitigation Measures

a. Handling Non-linear Loads

i. It is always more economical to tackle the problems in design stage rather than to carry out remedial actions afterwards. It is advisable that a customer should specify to his equipment suppliers that the equipment of non-linear load must comply with relevant international standards for the harmonics performance. HK Electric Supply Rules have also specified the harmonic current and harmonic voltage distortion levels at HK Electric supply point, which must be complied with to prevent/minimize interferences with other customers. Although it may involve a higher initial cost, it is normally a more cost effective investment since the cost of any subsequent remedial work may be more expensive, not to mention the possible inconvenience to business that can arise from harmonic interferences.

ii. For existing equipment with extensive harmonics generation, such equipment should be electrically isolated from essential equipment. It can be done by connecting essential equipment to dedicated 'clean' circuit, electrically away from non-linear load.

b. Harmonic Filters

i. A customer may use passive or active harmonic filters to filter out the harmonics. A passive harmonic filter is capable of minimizing several fixed orders of harmonics on specified load conditions while an active harmonic filter is more sophisticated and can have a more complete bandwidth of dynamic harmonics minimization capability.

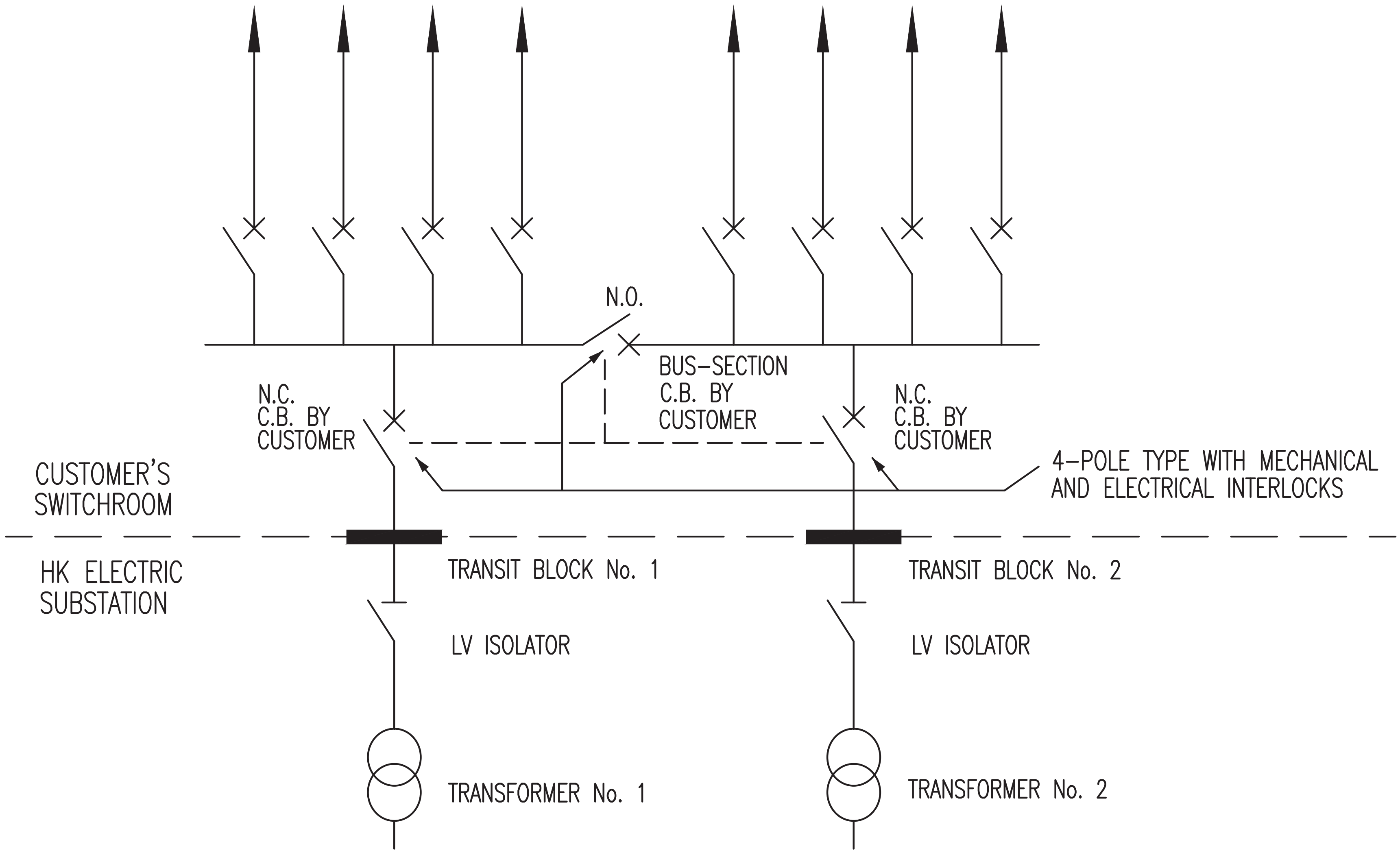
ii. Customers are recommended to consult the expert or consultant on which type and rating of harmonic filters they shall use. Customers are also suggested to seek advice from the supplier or manufacturer on the requirements of the harmonic filters for their particular equipment/appliances.

9.5 Power Quality Centre

A guided tour to our Power Quality Centre at Electric Centre, 28 City Garden Road, North Point can be arranged on request to introduce various enhancement/mitigation measures which customers may adopt to safeguard their power supplies for important services. Technical advisory services and relevant leaflets on power quality are also available. Customers are welcome to call our engineers at 2887 3455 for further information.

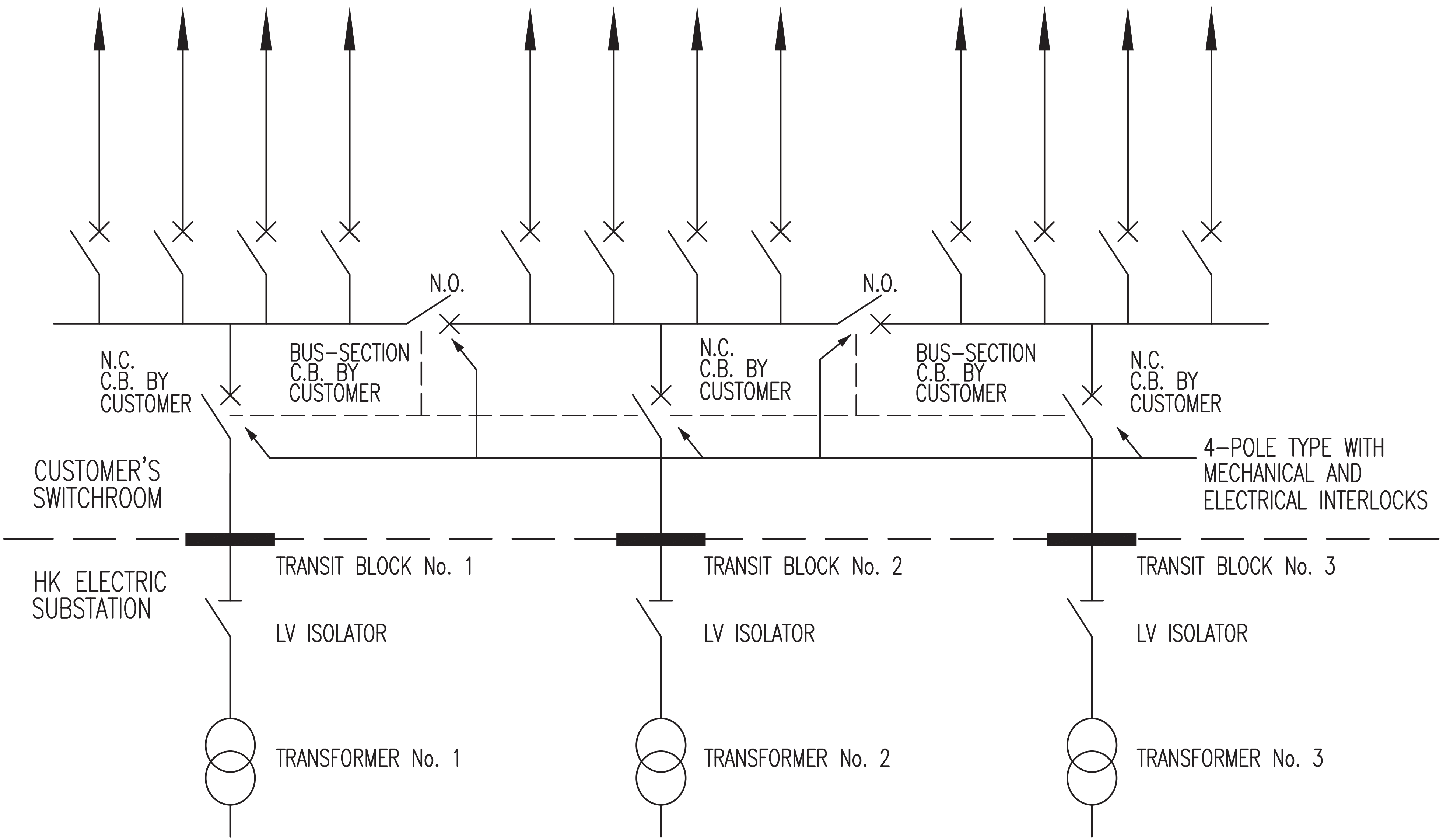
9.6 Schedule of Drawings – How to Enhance the Reliability & Power Quality of Electricity Supply

Drawing No.	Drawing Title
GCS/9/01	Typical Arrangement for Customer's LV Interconnection for a 2–Transformer Substation
GCS/9/02	Typical Arrangement for Customer's LV Interconnection for a 3–Transformer Substation
GCS/9/03	Typical Arrangement for Customer's LV Interconnection for a 4–Transformer Substation
GCS/9/04	Typical Arrangement for Customer's 11-kV/22-kV Interconnection
GCS/9/05	Typical Arrangement for Interconnection Between Transformers at Load Side
GCS/9/06	Typical Arrangement for UPS plus Standby Generator for Important Services
GCS/9/07	Typical Example on Grading Arrangement of Protective Devices at Customer's Installation



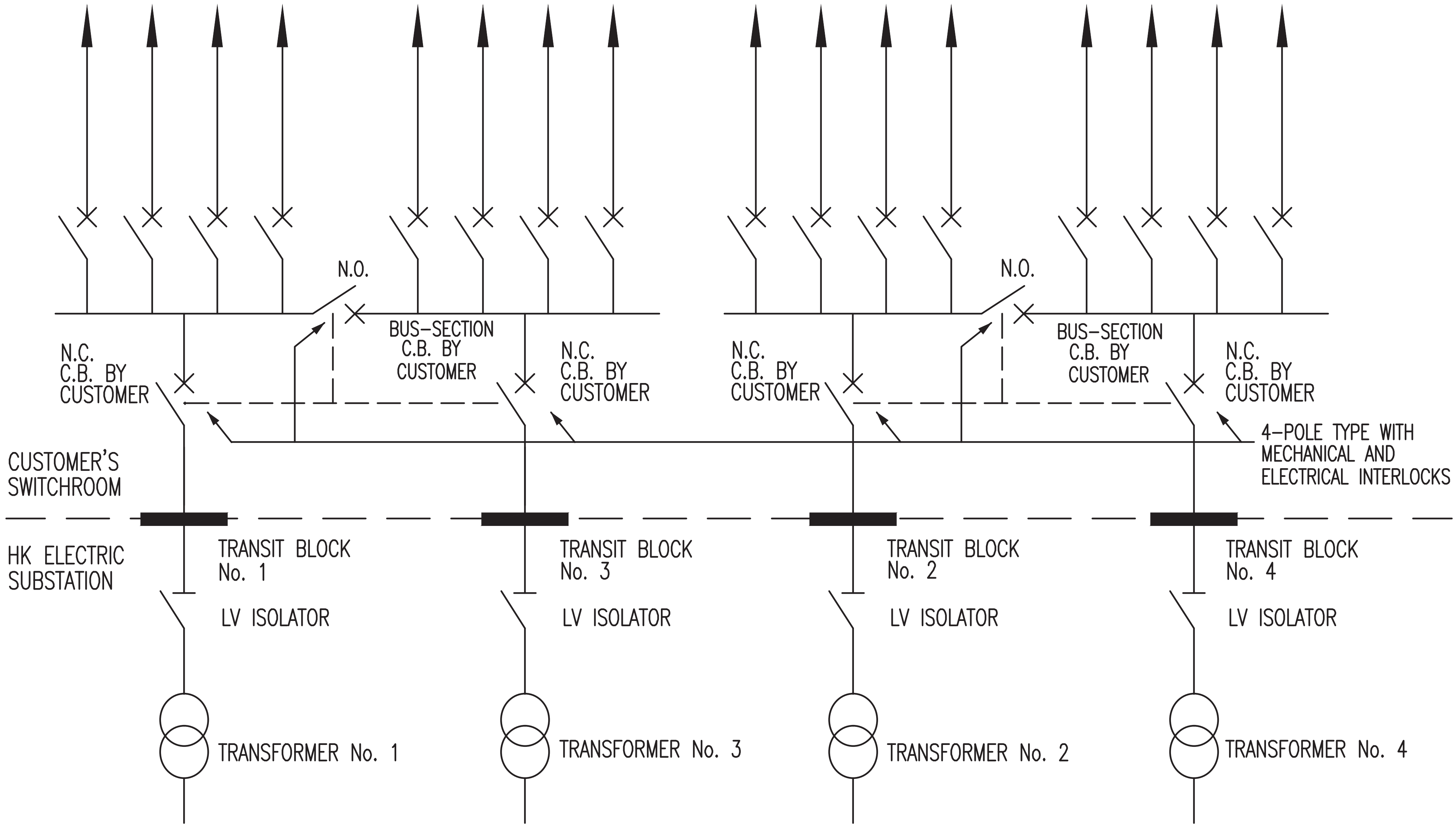
Drg. No. GCS/9/01

TYPICAL ARRANGEMENT FOR CUSTOMER'S LV INTERCONNECTION FOR A 2-TRANSFORMER SUBSTATION



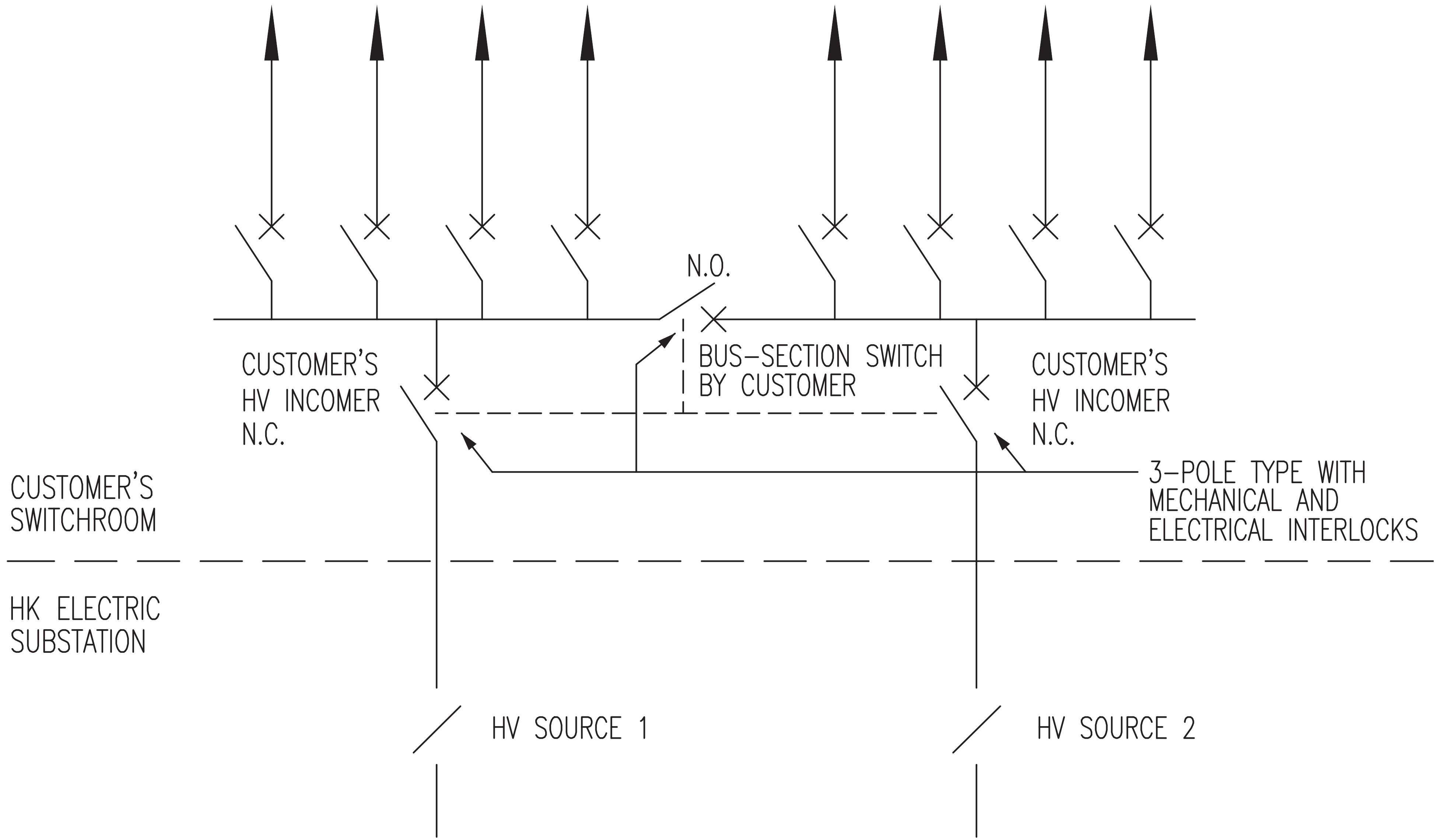
Drg. No. GCS/9/02

TYPICAL ARRANGEMENT FOR CUSTOMER'S LV INTERCONNECTION
FOR A 3-TRANSFORMER SUBSTATION



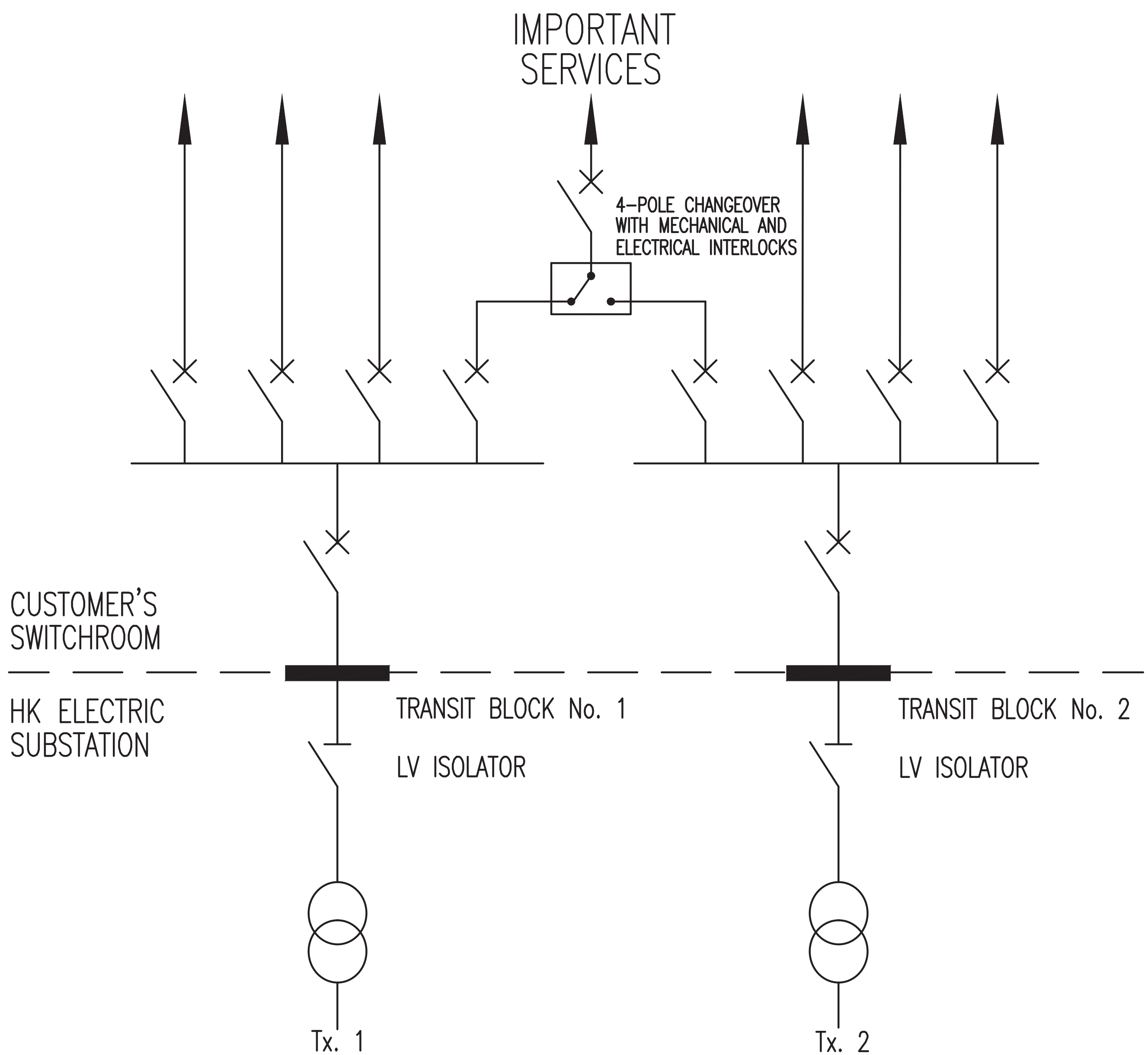
Drg. No. GCS/9/03

TYPICAL ARRANGEMENT FOR CUSTOMER'S LV INTERCONNECTION FOR A 4-TRANSFORMER SUBSTATION



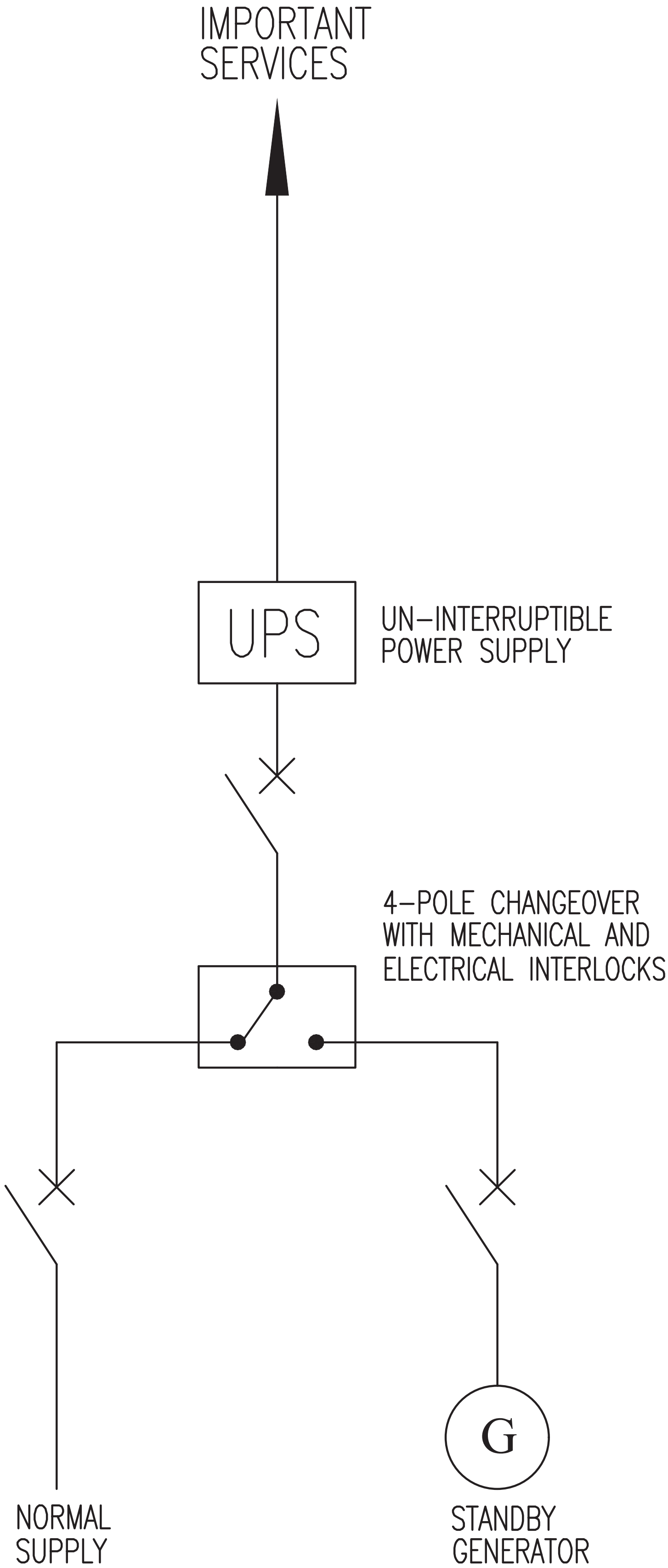
Drg. No. GCS/9/04

TYPICAL ARRANGEMENT FOR CUSTOMER'S 11-kV/22-kV INTERCONNECTION



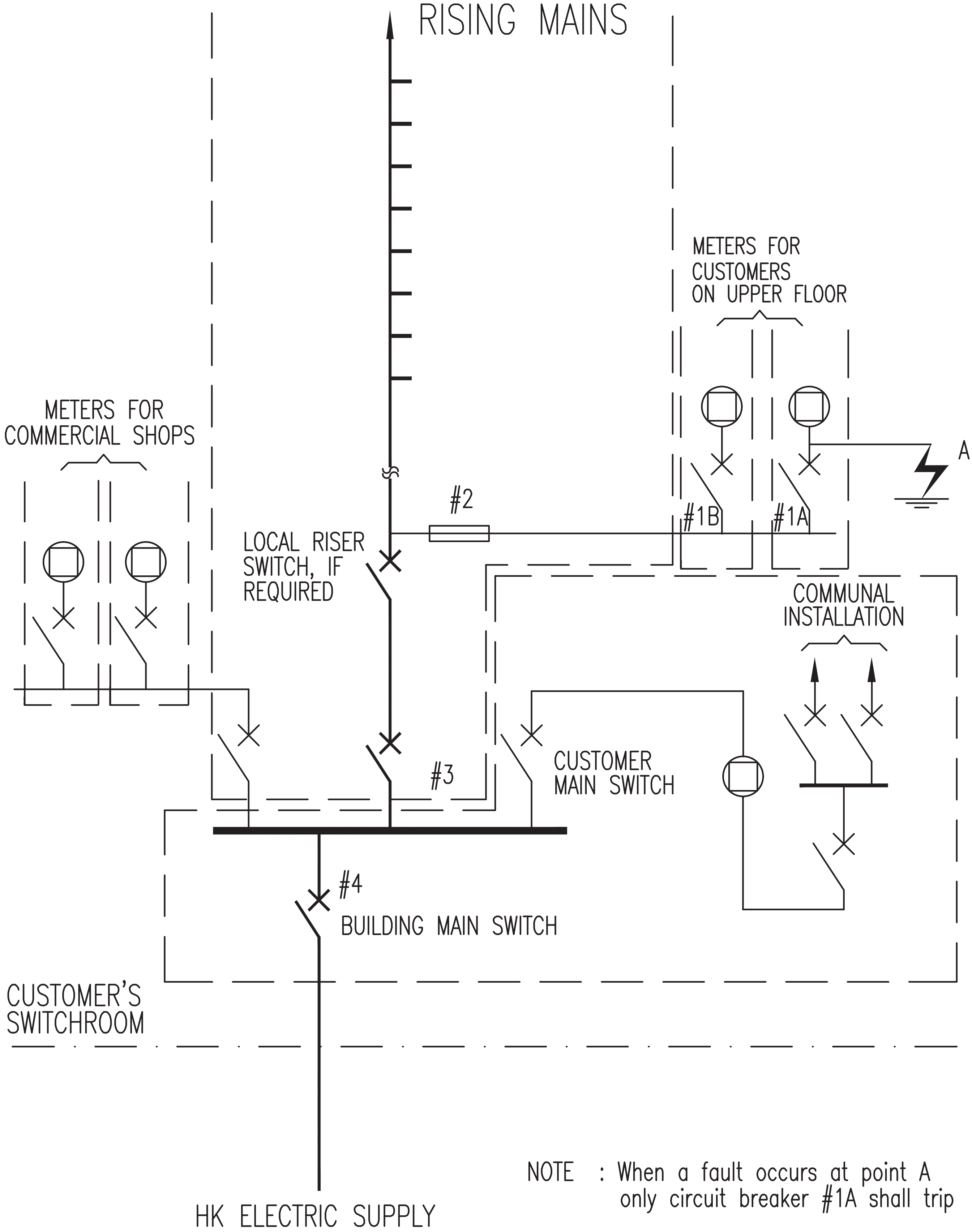
Drg. No. GCS/9/05

TYPICAL ARRANGEMENT FOR INTERCONNECTION BETWEEN TRANSFORMERS AT LOAD SIDE



Drg. No. GCS/9/06

TYPICAL ARRANGEMENT FOR UPS PLUS STANDBY GENERATOR FOR IMPORTANT SERVICES



Drg. No. GCS/9/07

TYPICAL EXAMPLE ON GRADING ARRANGEMENT OF PROTECTIVE DEVICES AT CUSTOMER'S INSTALLATION