

DISTRIBUTION SOLUTIONS

## **R-MAG®**

Magnetically actuated dead tank outdoor vacuum circuit breaker

### Instruction manual

15.5kV – 1200A...3700A

27kV – 1200A...2000A

38kV – 1200A...2000A





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## Instruction manual

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## Your safety first – always!

Keep these instructions available to those responsible for product's proper installation, maintenance, and operation.

Read these instructions carefully before attempting to install, operate or maintain this device. Failure to read these instructions could cause severe personal injury, death or property damage.

Equipment operation depends on proper handling, installation, and maintenance. Neglecting fundamental requirements may lead to injury of personnel, failure of the equipment and property damage.

When this apparatus is energized, bushings and insulating materials may be connected to high voltages. Coming too close to energized parts could result in severe personal injury or death

### Safety Notations

Safety notations alert personnel to possible death, injury or property damage situations. The safety notations appear before the step in which the condition applies. The one safety notice and two hazard levels notations are:



#### **WARNING**

Danger indicates a hazardous situation which, if not avoided, will result in death or serious injury, and substantial property damage



#### **CAUTION**

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



#### **NOTICE**

NOTICE, is used to address practices not related to personal injury.

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## Product safety foreword

Install the R-MAG circuit breaker within the design limitations as described on its nameplate and in these instructions and follow your company's safety procedures.

This breaker should not be used by itself as the sole means of isolating a high voltage circuit. For the safety of personnel performing maintenance operations on the breaker or connecting equipment, all components should be electrically disconnected by means of a visible break and should be securely grounded.

This product is intended to be operated and maintained by qualified persons, thoroughly trained and knowledgeable of the hazards involved. This publication is written only for such qualified persons and is not intended to be a substitute for adequate training and experience in the safety procedures for this device.

Detailed descriptions of standard repair procedures, safety principles and service operations are not included. It is important to note this document contains some warnings and cautions against some specific service methods that could cause personal injury to service personnel, damage equipment, or render it unsafe. These warnings do not cover all conceivable ways in which service, whether or not recommended by ABB, might be performed or the possible hazardous consequences of each conceivable way, nor could ABB investigate all such ways. Anyone using service procedures or tools, whether or not recommended by ABB, must satisfy himself thoroughly that neither personal safety nor equipment safety will be jeopardized by the service method or tools selected.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local ABB representative should be contacted

All information contained in this manual is based on the latest product information available at the time of printing. The right is reserved to make changes at any time without notice.

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# 1. Introduction

## 1.1. This manual

The maintenance and commissioning guide provides information about maintenance and commissioning activities on the R-MAG circuit breaker by providing details about its main components and proven testing methods.

These instructions do not attempt to provide the user of this equipment with every possible difficulty that may occur in the application, operation and maintenance of the product. Also, as improvement in parts and assemblies are made, some parts may differ in appearance as depicted in the illustrations; however, functionality will be equivalent.

The R-MAG vacuum breaker is a high-voltage, three-phase device incorporating three vacuum interrupters, gang operated by a magnetic actuator. Together with the optional relaying and current transformers, the breaker will sense an overload and automatically open.

Satisfactory performance of the breaker is contingent upon the correct installation, and adequate maintenance and service of the product. Careful study of these instructions will permit the user to obtain maximum benefit from this device.

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## 2. Receiving, handling and storage

Each breaker is assembled and tested at the factory prior to shipment.

This equipment was packed and shipped in factory new condition. If damage is noted, call the carrier at once for inspection and request an inspection report. File a formal claim with the carrier, supported with paid freight bill, inspection report and invoice. The local ABB Sales Office must be notified. This must be done within 10 days of receipt or receiver assumes all responsibility for damage.

### 2.1. Receiving Inspection

Upon receipt, it is important to inspect promptly to be certain that the correct material has been received. In case of shortage, immediately notify the local ABB Sales Office.

Check all parts against the shipping list as they are unpacked. Instructions and literature packed with the breaker should be kept with the unit. The cabinet provides a convenient place to keep this instruction book, a copy of the schematic diagram and the card with the service record of the unit. Additional copies may be obtained upon request from the local ABB Sales Office.

If the breaker is not to be placed in service immediately, it is essential that proper care be exercised in the handling and storage to ensure good operating conditions in the future. (See 2.3 Storage.)

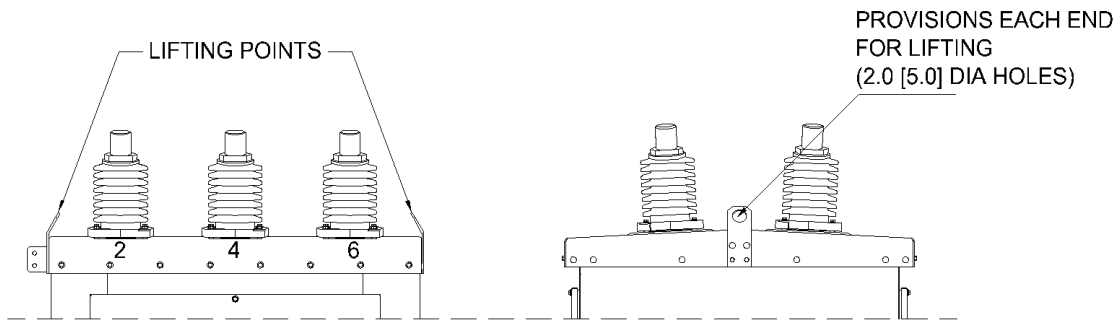
## 2.2. Handling



### WARNING

R-MAG breaker has a high center of gravity. If the breaker becomes unbalanced during lifting, there is a risk of death or serious bodily injury.

The R-MAG breaker comes with two brackets attached to the sides of the cabinet and provide provisions for lifting the breaker. A two-point lift is recommended using the loops in these brackets. (See Figure below)



**Figure 1.** Lifting Detail of 15kV, 27kV and 38kV R-MAG

## 2.3. Storage

For prolonged storage, indoor storage is recommended. If stored outdoors, the cabinet heaters must be energized to maintain the warranty. The mechanism and control compartment are equipped with heaters to reduce condensation. This recommendation is also shown in a nameplate located in the external side of low voltage compartment door.



### NOTICE

Indoor storing recommended.

When storing outdoors, the cabinet heaters must be energized for warranty to remain in effect. The mechanism and control compartment are equipped with heaters to reduce condensation



## 3. General Description

### 3.1. High-voltage assembly



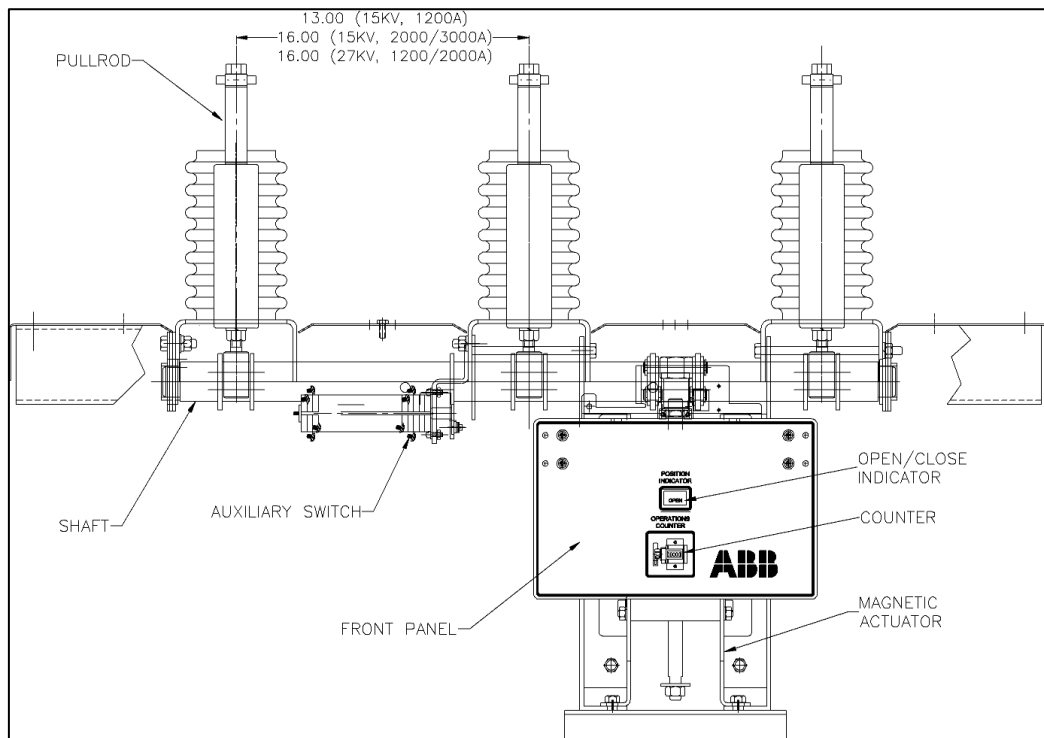
#### WARNING

Do not remove the HV covers unless the breaker is visibly disconnected and grounded, due to the risk of death or serious injury

The high-voltage section of the R-MAG consists of three individual phase assemblies mounted on insulating standoffs. Each phase of the R-MAG consists of a single vacuum interrupter, flexible shunt and operating rod.

### 3.2. High voltage compartment components

Following picture shows the standard components found in the high voltage compartment of a 15kV/27kV R-MAG



**Figure 2.** High voltage compartment components

### 3.3. Housing

The doors of the breaker housing are removable and retained by hinge pins. The position indicator is visible through the front door. The breaker nameplate showing rating information, serial number and shop order number is mounted on the right-hand side of the housing.

### 3.4. Magnetic Actuator

The magnetic actuator incorporates a very powerful permanent magnet assembly. When the armature is in contact with the upper plate, the magnet produces a holding force in excess of 1500 lbs in the case of 15kV and 27kV R-MAGs, the actuator used in the 38kV R-MAG produces around 2700lbs.

Two stainless steel guide rods are attached to the armature. The upper guide rod attaches to the lower end of the main operating rod, which connects directly to the moving contacts of the vacuum interrupters. The lower guide rod mounts to the manual trip assembly.

Disassembly of the magnetic actuator is not necessary, nor recommended. The magnetic actuator has no user serviceable parts and therefore no lubrication or maintenance is required. Should an actuator fail to operate, contact ABB for service.



#### CAUTION

Be careful when working around the magnetic actuator. The permanent magnet inside the actuator is extremely powerful, with the potential to trap fingers and metal tools.

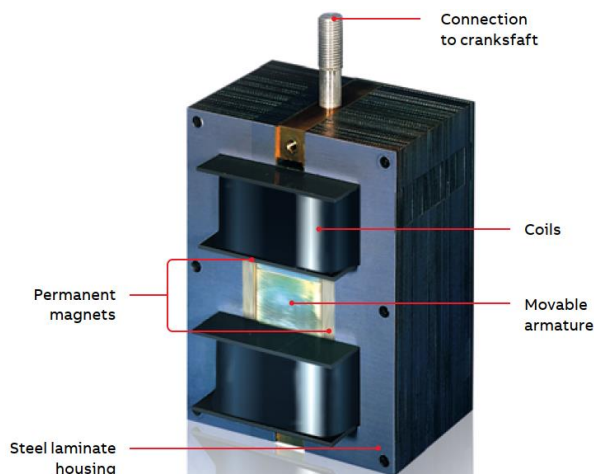
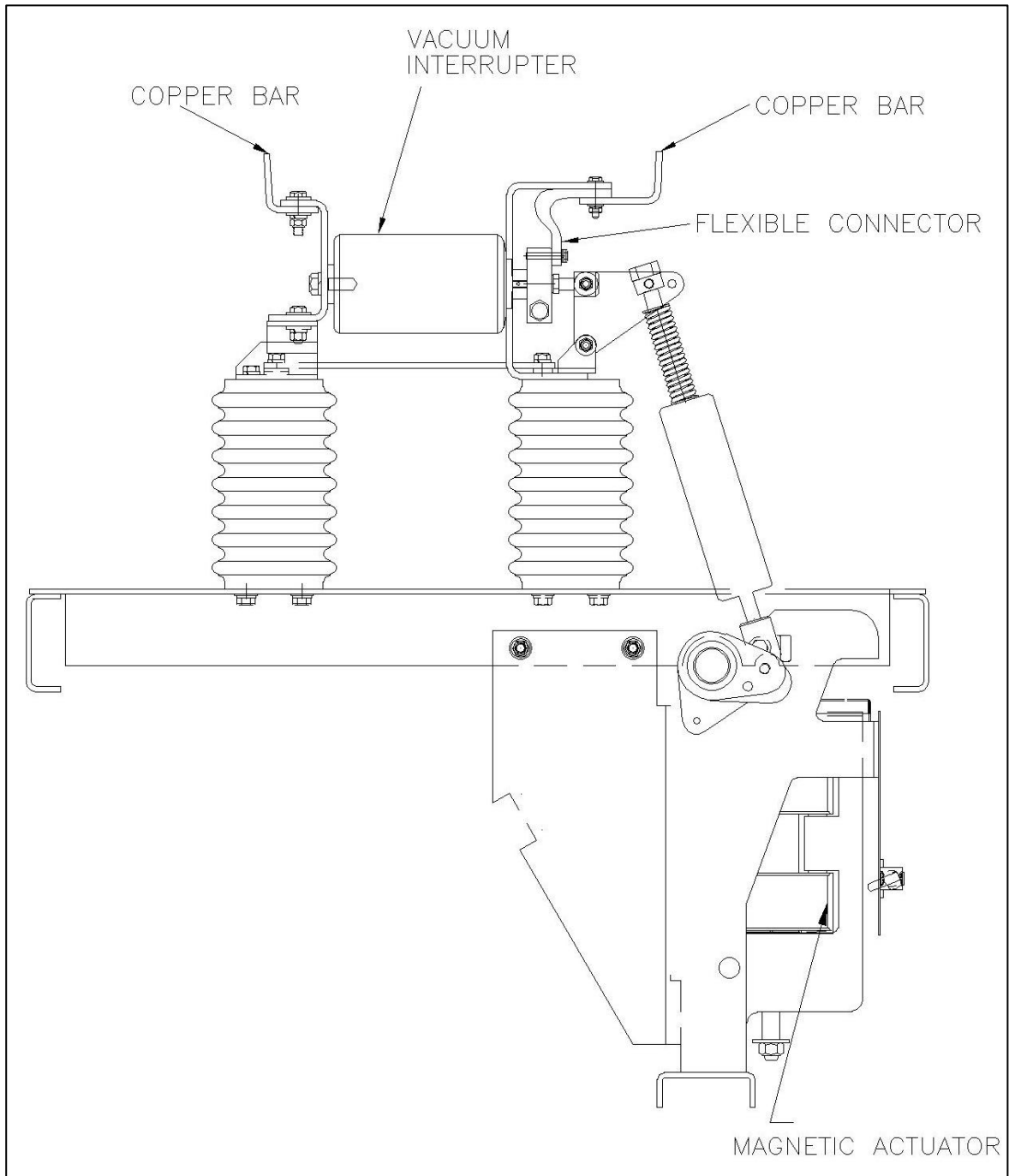


Figure 3. Magnetic actuator parts

### 3.5. Phase assembly – 15kV/27kV R-MAG

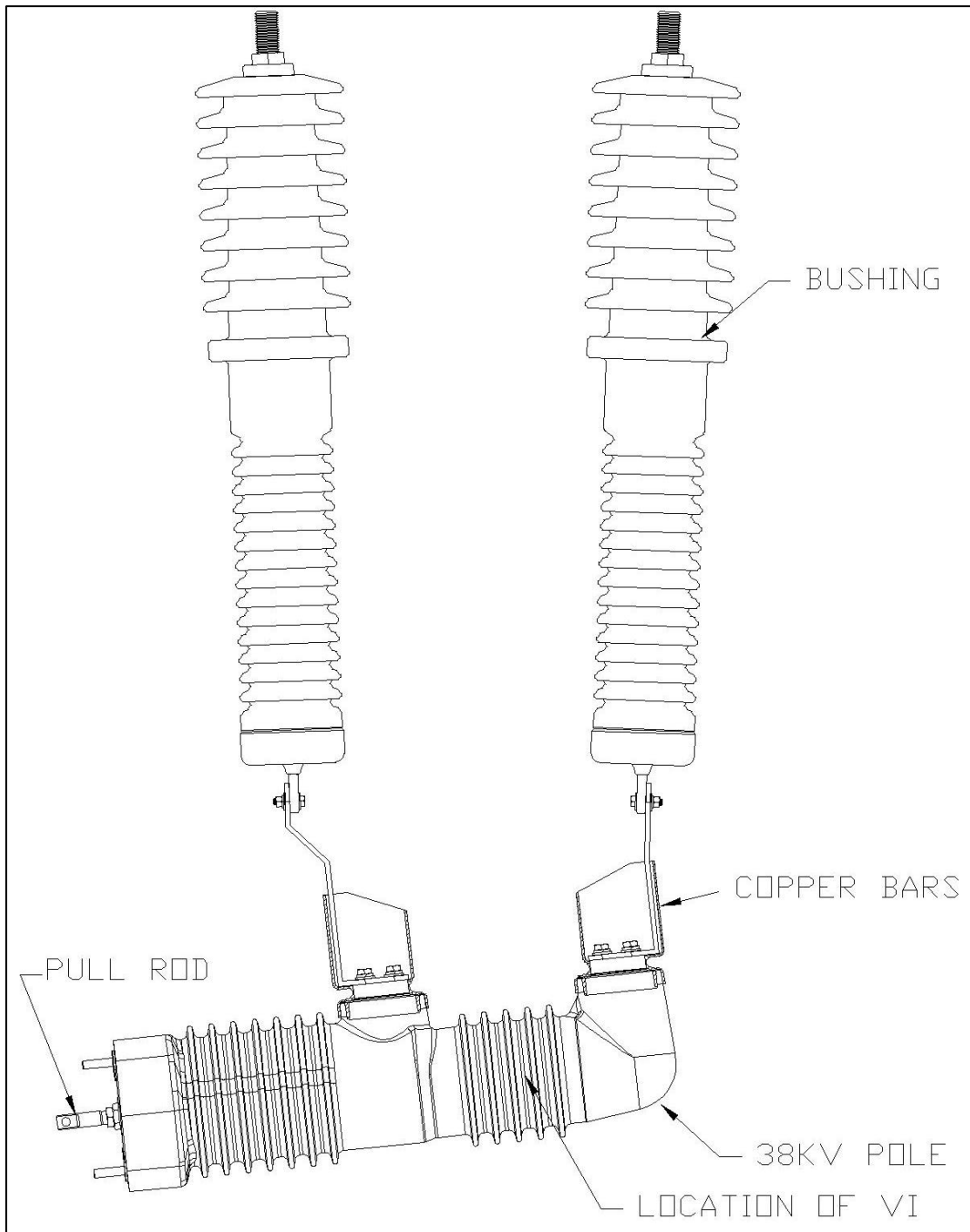
Figure below shows the details of the phase assembly in a 15kV/27kV R-MAG. The back bus is attached directly to the fixed contact stud on the back end of the vacuum interrupter. In the opposite side, a contact block with a flexible shunt transfers current from the moving contact of the vacuum interrupter directly through the bus to the bushing.



**Figure 4.** Phase assembly of 15kV and 27kV R-MAG

### 3.6. Pole assembly – 38kV R-MAG

Figure below shows the details of the pole assembly found on the 38kV R-MAG. The Poles contain the Vacuum Interrupter, fixed and flexible copper connectors and the pull-rod, encapsulated in epoxy resin to provide protection against mechanical and electrical stress.



**Figure 5.** Pole assembly of 38kV R-MAG

### 3.7. Auxiliary switches

Following specifications define the main auxiliary switches capabilities. The quantity of available contacts will depend on the specific control, refer to schematics to confirm.

Tested per UL Document 1054. AC tests specs with one set of contacts. DC tests specs with two sets of contacts in series

Contacts will carry 140A for 3 seconds

Overload test: 50 operations at 90A and 120VAC

Volts	Non inductive circuits make and break (A)	Inductive circuits make and break (A)	Continuous rating (A)
24/48 VDC	16	16	20
125 VDC	10	10	20
250 VDC	5	5	20
115 VAC	15	15	20
230 VAC	10	10	20
24/48 VDC	16	16	20

### 3.8. Current transformer connections

R-MAG circuit breaker can be featured with a maximum of 2 window type current transformers per bushing. These current transformers are usually manufactured by ABB following either IEEE or IEC standards, therefore secondary connections will follow standards regulations. Following table shows the secondary connections for most popular current transformers despite its application (relaying or metering). Refer to schematics to confirm ratio and secondary taps.

600:5 Multi-ratio		1200:5 Multi-ratio	
Terminal	Ratio	Terminal	Ratio
X2-X3	50-5	X2-X3	100-5
X1-X2	100-5	X1-X2	200-5
X1-X3	150-5	X1-X3	300-5
X4-X5	200-5	X4-X5	400-5
X3-X4	250-5	X3-X4	500-5
X2-X4	300-5	X2-X4	600-5
X1-X4	400-5	X1-X4	800-5
X3-X5	450-5	X3-X5	900-5
X2-X5	500-5	X2-X5	1000-5
X1-X5	600-5	X1-X5	1200-5

### 3.9. Electronic control board (ED2.0)



#### CAUTION

Be careful when doing any activity near the ED2.0, as it works with voltages that can result harmful. Make sure the capacitors are discharged before working in the ED2.0.

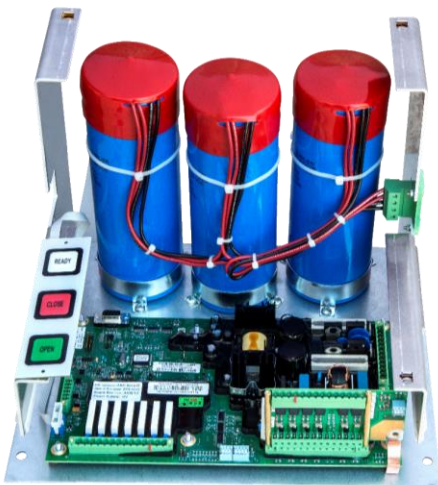
The R-MAG breaker mechanism (magnetic actuator) is controlled by an electronic board known as ED2.0. The ED2.0 consists of a power supply, position verification module and a capacitor charging/discharging system. Refer to ANNEX 1 for a complete overview of the ED2.0 board.

Additionally, the ED2.0 has a set of inputs to receive the close and trip breaker signals, the signals are processed by the ED2.0 microprocessor and issues the current needed from the capacitors to the magnetic actuator to make it shift to the required position. The ED2.0 is also equipped with several outputs to provide position indication and more importantly to provide information about the health of the board, capacitors and actuator: Ready and Not-Ready contacts.

Be sure of getting into the control and relaying strategy the Ready/Not-Ready to supervise the most important components of the R-MAG breaker.

There are two types of ED2.0 board regarding the input power level:

- **Low voltage ED2.0:** 17 - 75 VDC or 21 - 52 VAC
- **High voltage ED2.0:** 77 - 280 VDC or 85 - 264 VAC



**Figure 6.** Assembly of ED2.0 board including capacitors



### 3.12. General dimensions - 15kV 1200A

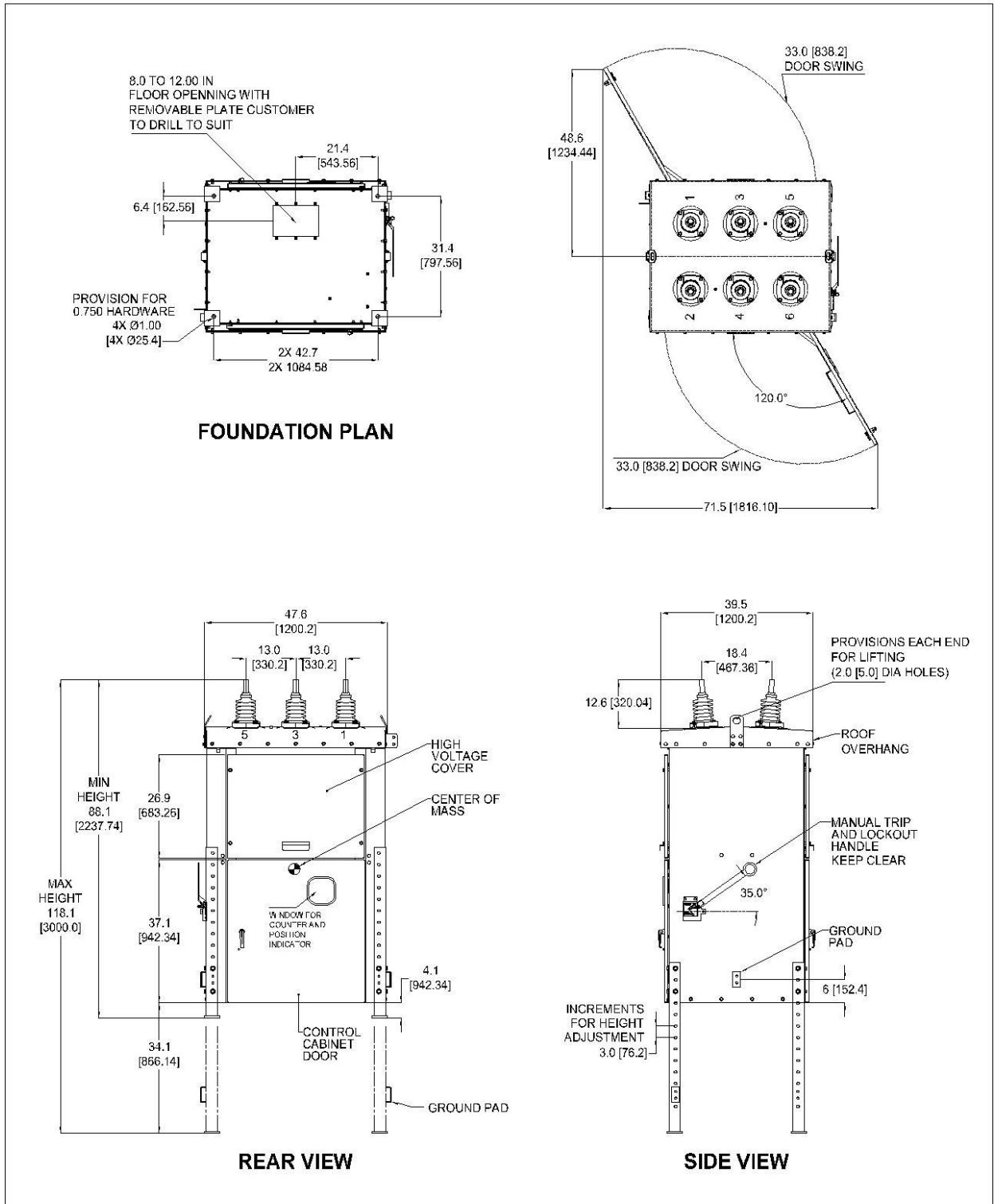


Figure 9. General dimensions R-MAG 15kV 1200A



### 3.13. General dimensions - 15kV 2000A

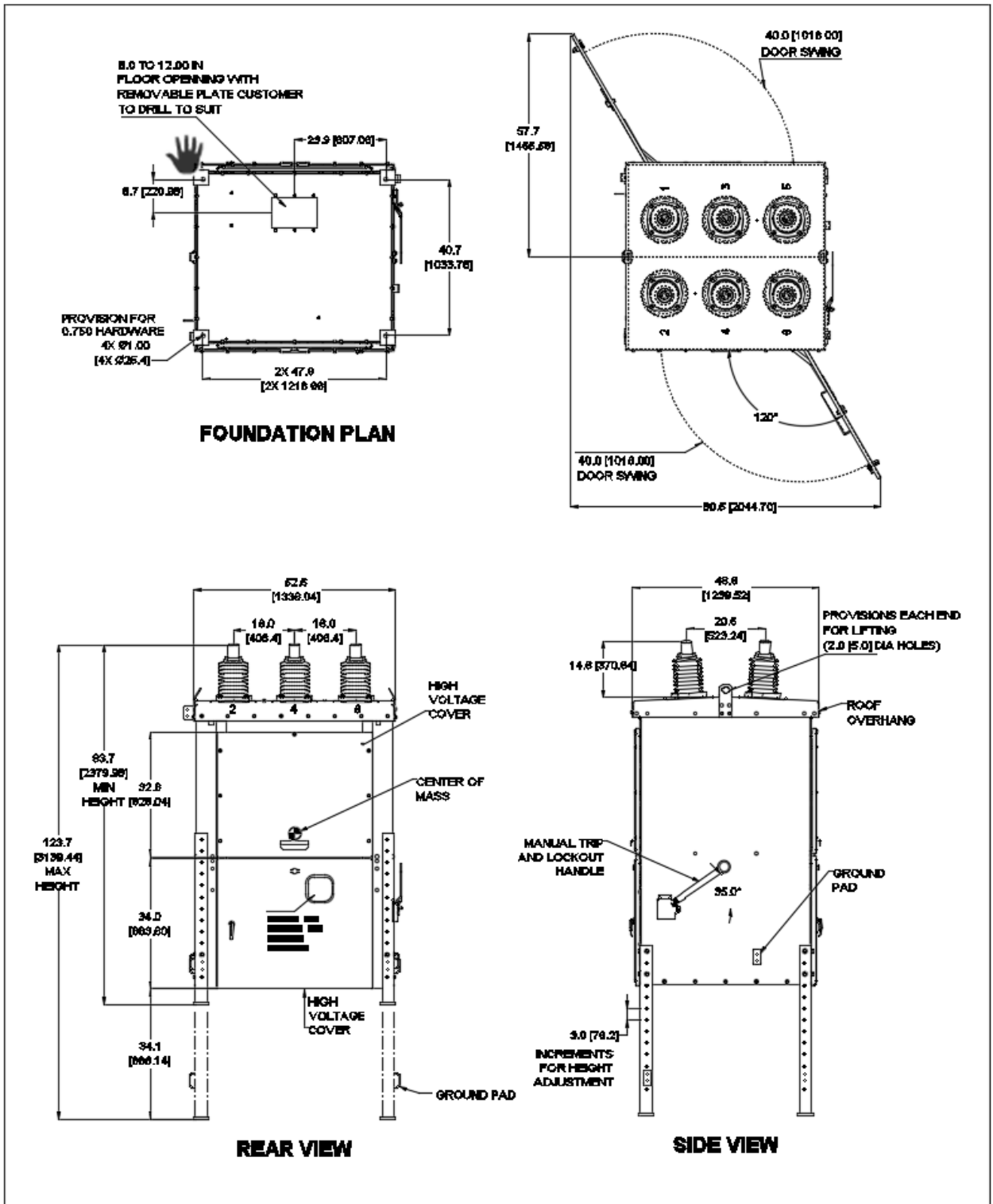


Figure 10. General dimensions R-MAG 15kV 2000A

### 3.14. General dimensions - 15kV 3000A/3700A

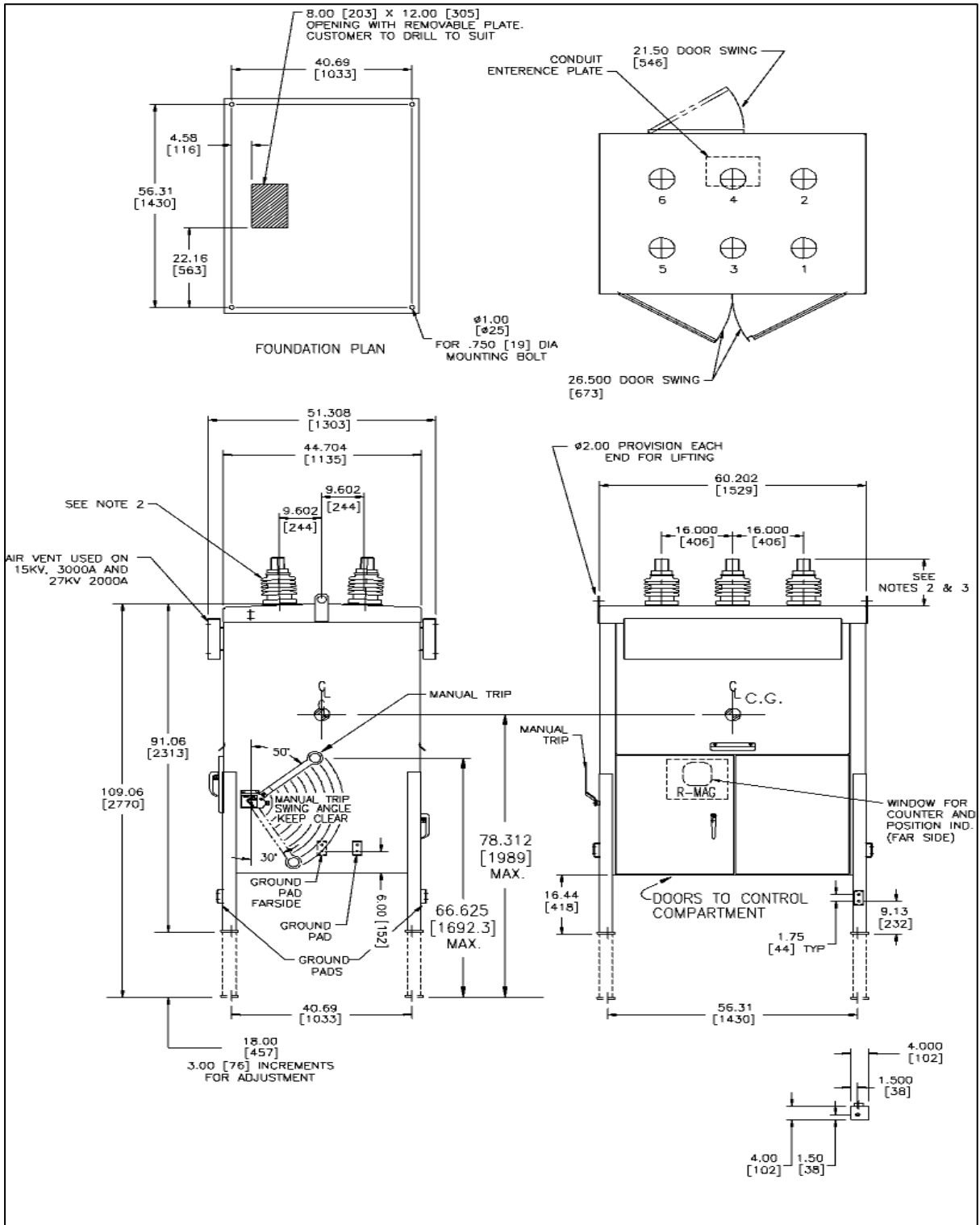


Figure 11. General dimensions R-MAG 15kV 3000A/3700A

### 3.15. General dimensions - 27kV 1200A/2000A

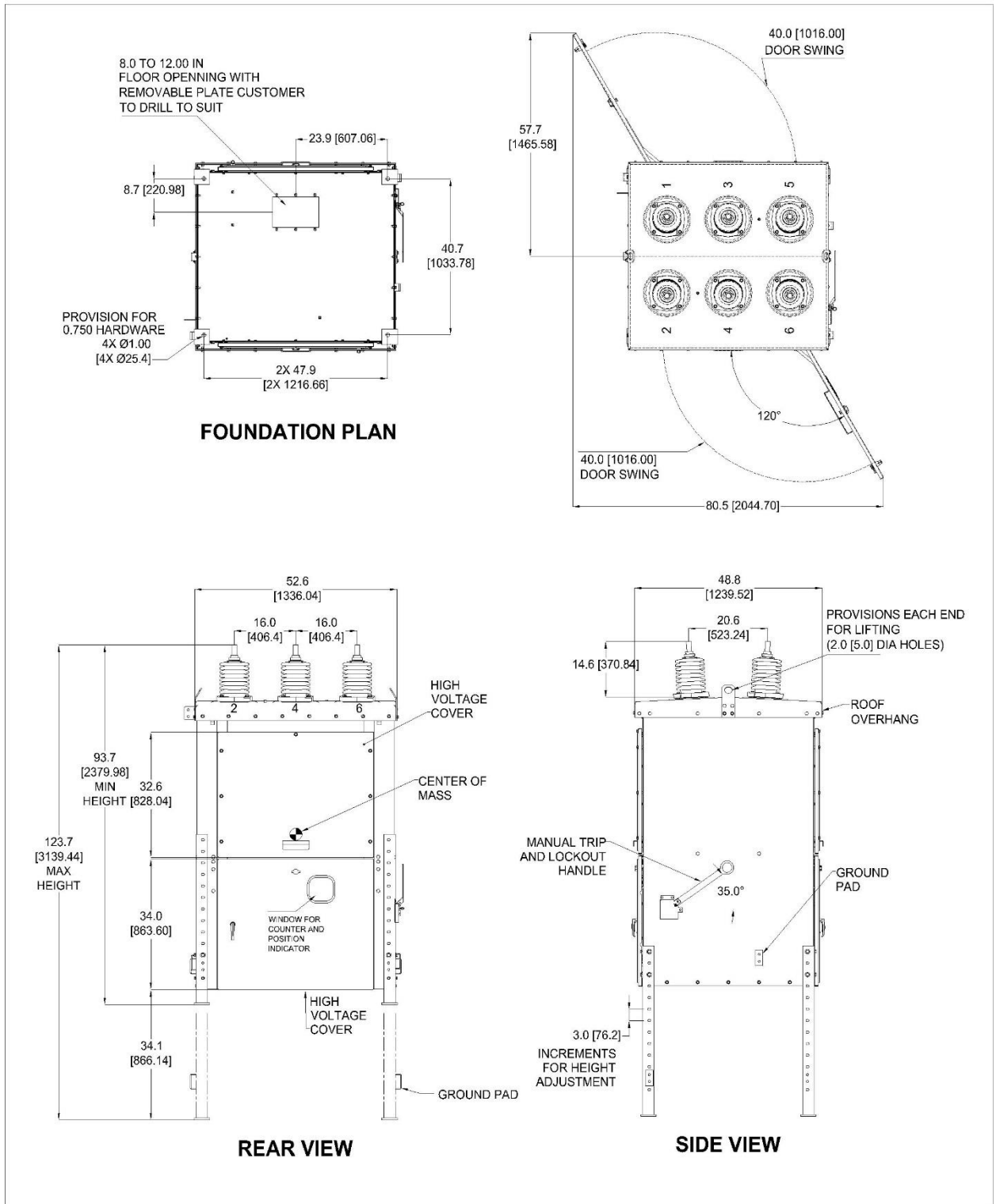


Figure 12. General dimensions R-MAG 27kV 1200A/2000A

### 3.16. General dimensions - 38kV 1200A/2000A

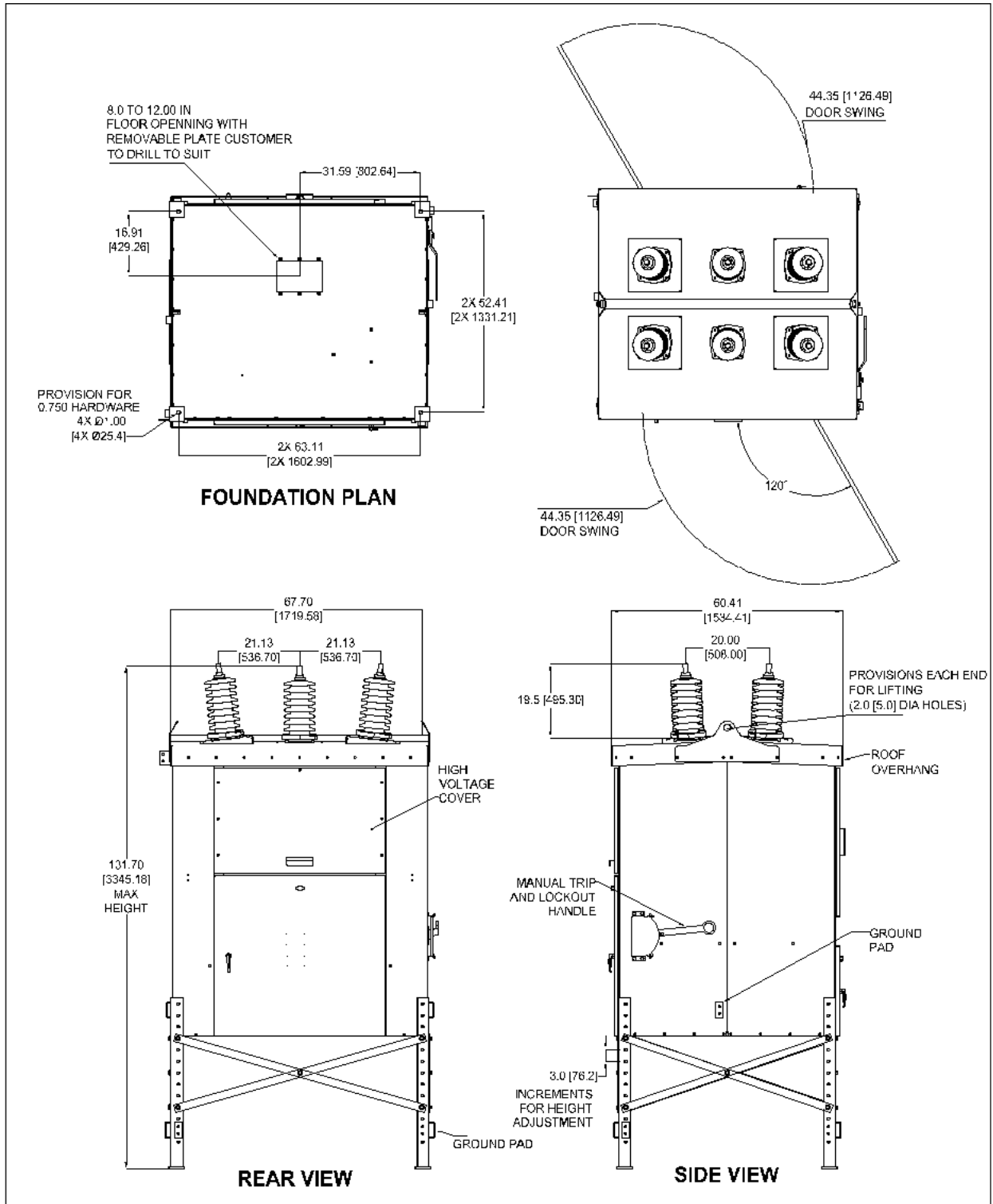


Figure 13. General dimensions R-MAG 38kV 1200A/2000A

### 3.17. Typical schematics

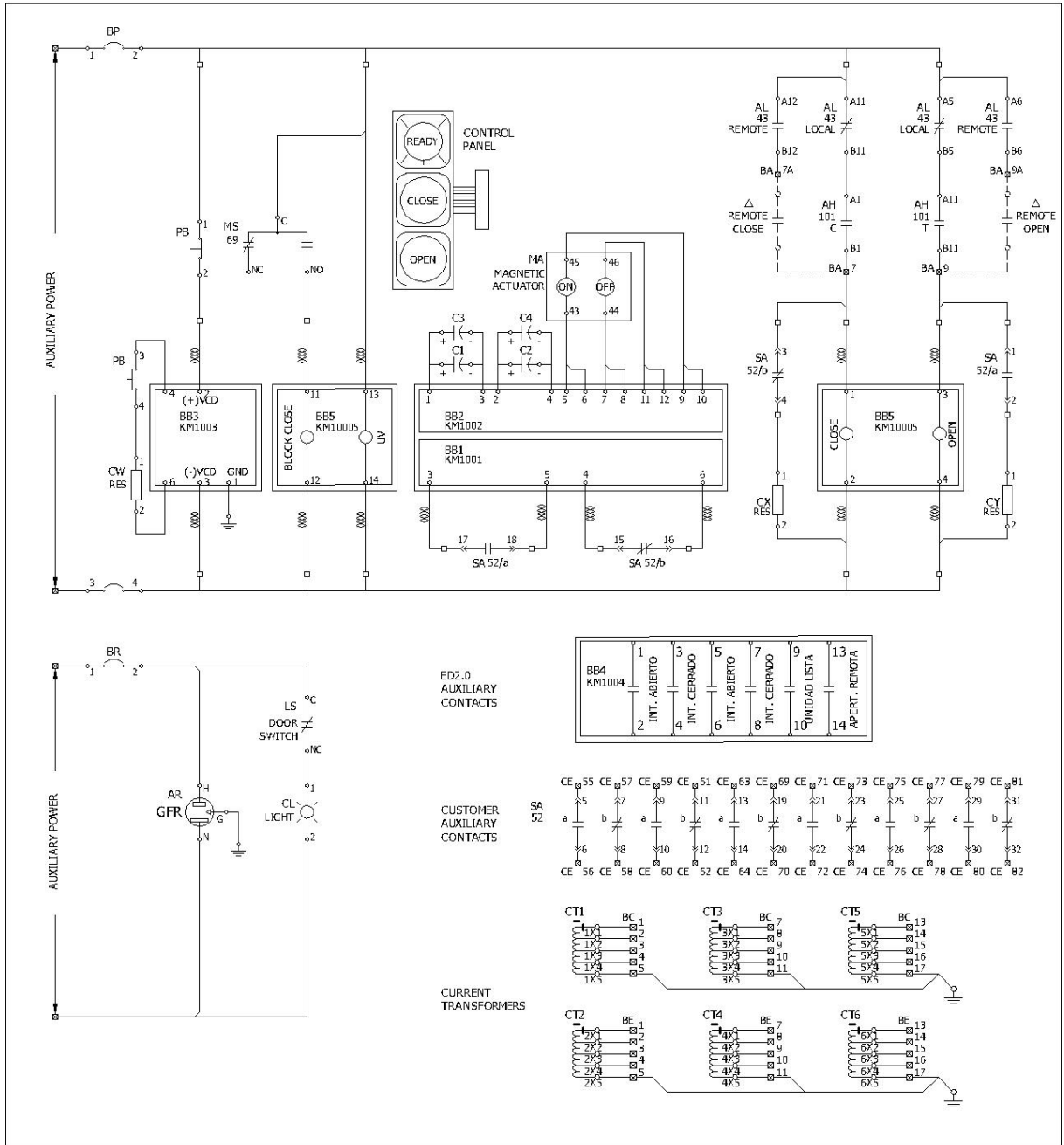


Figure 14. Example of a typical R-MAG schematic

### 3.18. ED2.0 functions

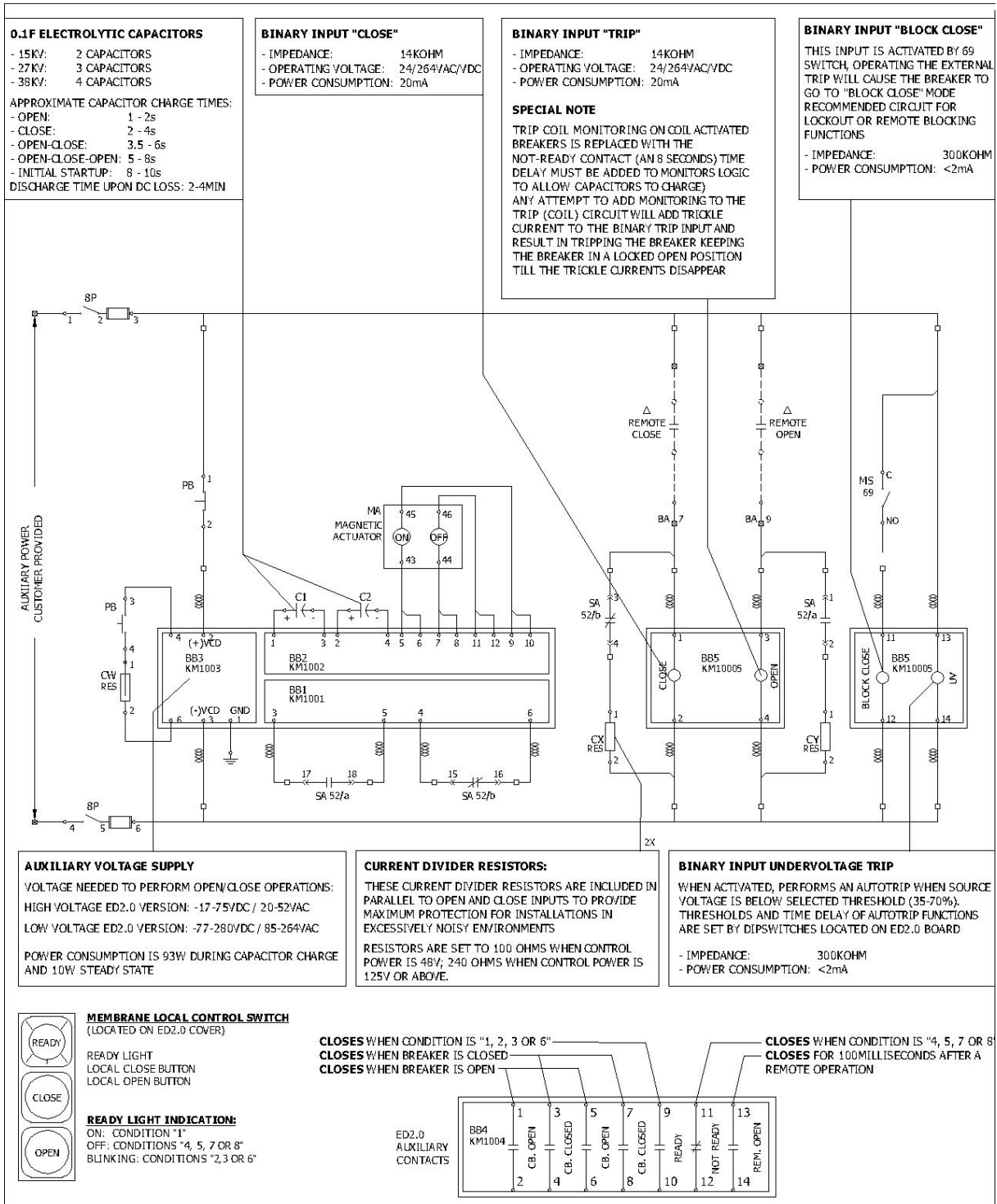


Figure 15. ED2.0 functions of inputs and outputs

## 4. Technical ratings

<b>Rated maximum voltage (rms):</b>	<b>15.5 kV</b>	<b>27kV</b>
<b>Voltage Range Factor, K</b>	1.0	1.0
<b>Rated lightning impulse withstand voltage (BIL)</b>	110 kV	125 kV / 150kV
<b>Rated power-frequency withstand voltage-Dry</b>	50 kV (1 min)	60 kV (1 min)
<b>Rated power-frequency withstand voltage-Wet</b>	40 kV (10sec)	50 kV (10sec)
<b>Rated frequency</b>	50/60 Hz	50/60 Hz
<b>Number of poles</b>	3 – simultaneously operated	3 – simultaneously operated
<b>Rated continuous current (rms) @ 50/60Hz</b>	1250A / 2000A 3000A / 3700A	1250A / 2000A
<b>Rated symmetrical interrupting rms current</b>	25 kA	25 kA
<b>Rated peak withstand</b>	65 kA	65 kA
<b>Rated short time current (duration)</b>	25 kA (3 sec)	25 kA (3 sec)
<b>Permissible Tripping Delay (Y)</b>	2 sec	2 sec
<b>Reclosing time</b>	0.3 sec	0.3 sec
<b>Rated Interrupting time</b>	3.0 cycles	3.0 cycles
<b>Operating duty sequence</b>	O-0.3sec-CO-3min-CO	O-0.3sec-CO-3min-CO
<b>TRV first pole to clear factor</b>	29.2 kV	51 kV
<b>Rated operating endurance</b>	10,000 Operations	10,000 Operations
<b>Out of phase making and breaking current</b>	6.25 kA	6.25 kA
<b>Line charging current</b>	100 A	100 A
<b>Cable charging current</b>	25 A	25 A
<b>Isolated capacitor bank switching current</b>	600 A	600 A
<b>Back to back capacitor bank switching current</b>	600 A	600 A
<b>Back to back capacitor bank inrush making current / Frequency</b>	20 kA-peak / 4240 Hz	20 kA-peak / 4240 Hz
<b>Operating temperature</b>	-50°C to +55°C (-58°F to 131°F)	-50°C to +55°C (-58°F to 131°F)

<b>Rated maximum voltage (rms):</b>	<b>38k</b>	
<b>Voltage Range Factor, K</b>	1.0	
<b>Rated lightning impulse withstand voltage (BIL)</b>	200kV	
<b>Rated power-frequency withstand voltage-Dry</b>	80 kV (1 min)	
<b>Rated power-frequency withstand voltage-Wet</b>	75 kV (10sec)	
<b>Rated frequency</b>	50/60 Hz	
<b>Number of poles</b>	3 – simultaneously operated	
<b>Rated continuous current (rms) @ 50/60Hz</b>	1250A / 2000A	
<b>Rated symmetrical interrupting rms current</b>	31.5 kA	40 kA
<b>Rated peak withstand</b>	81.9 kV	104 kA
<b>Rated short time current (duration)</b>	31.5 kA (2 sec)	40 kA (2 sec)
<b>Permissible Tripping Delay (Y)</b>	2 sec	2 sec
<b>Reclosing time</b>	0.3 sec	0.3 sec
<b>Rated Interrupting time</b>	3.0 cycles	3.5 cycles
<b>Operating duty sequence</b>	O-0.3sec-CO-3min-CO	O-0.3sec-CO-3min-CO
<b>TRV first pole to clear factor</b>	71.1kV	71.1kV
<b>Rated operating endurance</b>	10,000 Operations	10,000 Operations
<b>Out of phase making and breaking current</b>	8.14 kA	10.5 kA
<b>Line charging current</b>	100 A	100 A
<b>Cable charging current</b>	50 A	100 A
<b>Isolated capacitor bank switching current</b>	630A	
<b>Back to back capacitor bank switching current</b>	630A	
<b>Back to back capacitor bank inrush making current / Frequency</b>	20 kA-peak / 4240 Hz	
<b>Operating temperature</b>	-50°C to +55°C (-58°F to 131°F)	-50°C to +55°C (-58°F to 131°F)



## 5. Standard production tests



### NOTICE

Standard production tests are carried out before each R-MAG breaker is shipped out according to IEEE C37.09 requirements. All tests are being carried out following ABB safety regulations, when trying to reproduce any of these test must be done attending this manual safety foreword.

Some of the tests performed in factory before shipping are as following:

1. Visual inspection to R-MAG unit according to drawings
2. Verification of all wiring per connection diagrams
3. Electrical operation: close and trip. overcurrent response and automatic closing, with relaying control option
4. Check functioning of all manual controls: close/trip, local/remote, push-buttons, etc
5. Verification of correct mechanical functioning and correct operation of interlocks
6. Measurement and evaluation of each phase resistance, typical values do not exceed 100 micro ohms for 15kV/27kV and 150 micro-ohms for 38kV R-MAG.
7. Voltage Withstand: the complete breaker is tested between live parts and tank, across open contacts and between phases. An AC dielectric withstand test at values according to standards is performed. Test duration is one minute.
8. Wiring Insulation: The terminal block connections are given an over-potential test of 1800 volts AC to ground (for 1 sec).
9. Verification of CTs functionality: each current transformer is verified to confirm ratio and polarity as per order specifications
10. Manual trip validation: manual tripping functionality is verified; ANSI 69 function is tested (mechanical close blocking)
11. Vacuum interrupters travel and operation synchronization: after settling of vacuum interrupters, travel displacement, penetration, bounce and timing is confirmed
12. Develop of factory test report

Additionally, in order to support our customer expectations not-listed tests are also possible to perform on R-MAG units upon request and factory approval. Additional charges may apply.

Finally, FAT (Factory Acceptable Tests) are possible to perform upon request and factory approval to allow customers to witness the R-MAG factory tests. This FATs can be performed physically in the R-MAG factory or virtually. Additional charges may apply.

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## 6. Operation of R-MAG breaker

### 6.1. Closing

In the open position, the magnetic actuator's armature rests against the bottom plate in the actuator assembly. The armature is held there by the force developed by the magnet. When the top coil is energized, the magnetic flux generated is in the same direction as the magnet assembly. The armature is drawn into the coil and brought into contact with the upper plate. In this position, the coil is deenergized and the armature is held in position by the magnet alone. As the armature is drawn into the coil, the operating rod, which is attached to the top guide rod, moves the moving contact of the vacuum interrupter towards the closed position. The actuator has more stroke than the vacuum interrupter and the interrupter contacts make contact before the actuator has completed the stroke. The additional movement of the operating rod after the contact closing causes the contact pressure spring to compress at the top of the operating rod. This "over-travel" allows for contact wear in service.

### 6.2. Opening

When the bottom coil is energized, the magnetic flux opposes the force generated by the magnet assembly. This reduces the holding force, the armature is released and the coil attracts the armature to the bottom plate.

Once there, it is held open by the magnet; therefore, no current is being used to keep the breaker in open position.

### 6.3. External manual trip handle

A manual trip handle is provided on the outside of the cabinet (See following sections), to manually trip the breaker in case of loss of electrical supply to the ED2.0.

The external manual trip is not designed to perform mechanical closing operations in any rating.



#### **WARNING**

Do not attempt to manually close the R-MAG circuit breaker by using any kind of tool, as this will cause the breaker to not close properly and cause malfunctioning, destruction of components and serious injuries to personnel.

### 6.3.1. 15kV and 27kV R-MAG manual trip handle

The handle has three positions (**NORMAL**: Allows normal operation of R-MAG, close/trip local and remote, **TRIP**: lowest position, in this position the breaker opens mechanically, **CLOSE BLOCKED** position, in this position the handle is locked, any attempt to close the breaker locally or remotely is not performed).

- In the **NORMAL** position, the external trip handle is up, and the close block (69) switch is closed, providing a voltage path to the block close function on the ED2.0 board. This voltage path must be present in order for the breaker to close. The external trip handle can be locked into this position via a padlock.



- The **TRIP** position is a non-latching position of the external trip handle. Unlike spring-based circuit breaker, tripping via the external trip handle on an R-MAG requires sufficient force to separate the closing magnet from the holding plate inside the magnetic actuator. During a manual trip operation the handle will rotate easily against the internal spring in the trip shaft, until the point where the handle engages directly against the rotating main shaft. At this point a stronger force must be applied in order to separate the magnet from the holding plate. Tripping should occur via a downward thrust on the handle. When the external trip handle is placed in the TRIP position, the 69 switch is opened, removing voltage from the block close function of the ED2.0 board; the breaker is now electrically blocked from closing.



- In the **CLOSE BLOCKED** position, the handle is held in place by the pull-pin of the external trip handle cover. In the CLOSE BLOCKED position (69 switch open),

voltage is removed from the block close function on the ED 2.0 board; thus, the breaker will not close. Moving the handle from NORMAL to CLOSE BLOCKED without first rotating it to the TRIP position (on a closed breaker) will not trip the breaker AND WILL NOT ACTIVATE THE CLOSE BLOCK FUNCTION.



Picture below shows the different positions of the manual trip handle:

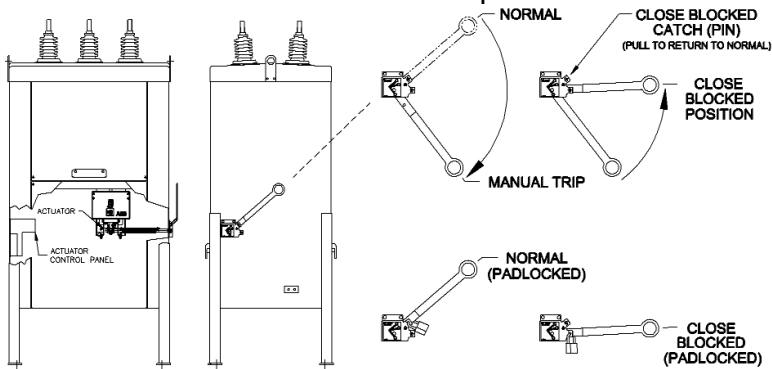


Figure 16. Functioning of external manual trip handle for 15kV and 27kV

### 6.3.2. 38kV R-MAG manual trip handle

The handle for 38kV R-MAG has two states: NORMAL and TRIP/CLOSE BLOCKED, which are described below in further detail.

**NORMAL** position: In the NORMAL position, the extern trip handle is up, and normal operation is possible.

**TRIP/CLOSE BLOCKED** position: When the trip handle is pulled down to this position, the breaker will be opened and will not close until handle is returned to the normal position

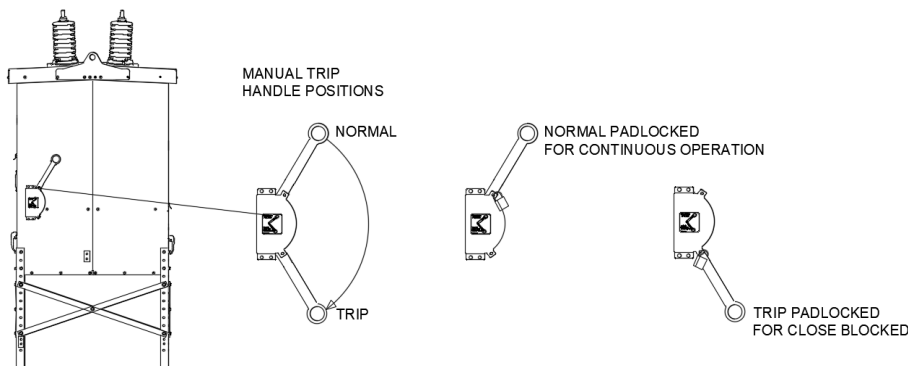


Figure 17. Functioning of external manual trip handle for 38kV

## 6.4. R-MAG housing: NEMA3R

The R-MAG breaker is segregated in two main compartments (Low Voltage compartment where the mechanism, the control board and control/protection elements are installed and the High Voltage compartment where the power parts (Vacuum Interrupters) are located).

These two compartments are enclosed in a self-supporting enclosure which size varies across the different ratings. However, in all cases, the housing has two set of doors for LV compartment at each side of the breaker, and either two doors or covers for the HV compartment.

The basic R-MAG housing is rated NEMA3R, meaning protection against raining water, icing formation and some level of dust ingress protection. Picture below shows the most recent NEMA3R design, which includes new set of latches and hinges, new set of gasketing to seal the doors and body to roof interface.

To ensure the internal components are well protected, regular inspections are needed to confirm all gasketing and sealers are in good shape and in their location.



**Figure 18.** NEMA3R housing

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## 7. Installation



### CAUTION

Follow your company guidelines and codes for setting the height of the breaker, securing the frame to foundation, and making connections. Make sure the breaker is fully vertical, level and securely fastened.

### 7.1. Mounting

The breaker is normally shipped suitable for substation mounting. The following is the recommended installation procedure:

1. With the lifting brackets mounted to the breaker roof, lift the breaker off the pallet and move into position
2. Bolt the legs to the pad and raise the upper portion to the desired height
3. Bolt the legs to the sides of the breaker
4. Install the cross braces, if the breaker has been shipped with them (find them mounted in the shipping pallet). Applicable for 38kV and seismic rated R-MAG.
5. Make sure all hardware is tight

### 7.2. Grounding

The breaker cabinet includes two ground parts, one on each side sheet, legs and on the roof (optional). To ensure proper operation of the R-MAG breaker and internal components both of these should be connected to the ground grid with #6 or larger wire. If the ground pad is provided on the roof, it should be connected to the ground pad too.

### 7.3. Arrester protection

ABB recommends that surge arresters be properly applied in the substation.

### 7.4. Control power

Supply the control power as indicated on the wiring diagram. Make sure the correct voltage is applied to the control circuit. Check all terminal block connections for proper tightness. For details of the overall control circuit, refer to the specific wiring diagrams supplied with the breaker.

## 7.5. Space heaters

Heaters are used inside the R-MAG breaker to ensure the internal temperature stays within safe limits to avoid condensation.

These heaters avoid the condensation by keeping the internal temperature above the dew point of the internal air of the R-MAG breaker; dew point depends on location, altitude, pressure, air humidity, etc.

Experience has shown that the two resistors always installed inside the R-MAG breaker and thermostatically controlled are enough to ensure the internal temperature avoids internal condensation.

Additionally, to ensure heaters work well, user should ensure the doors and covers are well installed and sealed to breaker's body.

## 7.6. Final inspection



### WARNING

When the breaker has been installed and all mechanical and electrical connections completed, **EXCEPT ENERGIZING THE POWER LINE**, the following points of inspection are recommended: **DO NOT REMOVE** the high voltage covers unless the breaker is visible disconnected and grounded.

1. Ensure the R-MAG is properly leveled and securely anchored
2. Make a final check of tightness of all hardware
3. Securely tighten terminal and ground connections.
4. Check that the heaters work properly
5. Check control cable entrance fittings for tightness, make sure the floor entry and cable entries are well sealed
6. Ensure the R-MAG is correctly grounded by using some of the ground pads in the sides and legs
7. Operate the R-MAG locally and remotely to verify normal operation
8. An A/C Hi-Pot test should be performed to verify the vacuum integrity. A successful withstand indicates satisfactory vacuum integrity. Replace interrupters that fail to maintain voltage across the open contacts. Refer to section 10.3 for procedure.
9. Make a continuity check, preferably one measuring contact resistance. Measure contact resistance with suitable equipment rated not less than 100 A. The resistance value should not exceed 100 micro ohms for 15kV/27kV and 150 micro-ohms for 38kV R-MAG.
10. If the R-MAG has been improperly stored or it is suspected that the unit was handled roughly during shipping, it is advisable to check the R-MAG alignments (Vacuum Interrupter (VI) contact wipe, etc.) Contact your ABB representative if necessary.
11. Ensure that all tools, measuring and testing equipment is removed
12. Secure all doors

## 8. Inspection, maintenance and adjustment

The R-MAG circuit breaker is an extremely simple device and requires minimal maintenance, depending on the frequency of operation and local environmental conditions.

The safety and successful functioning of any apparatus or system connected with the breaker largely depends on the proper and reliable operation of the unit.

To provide long reliable service, the breaker must have systematic inspections at regular intervals. Operating experience based on environmental conditions, the number of operations, magnitude of current and any unusual operation, will establish a maintenance schedule that gives assurance of proper breaker reliability.

The following actions listed in sections 10.1 to 10.7 is a minimum guide to inspect and maintain the R-MAG breaker.

### 8.1. Mechanical inspection and adjustment

1. Check the phase assemblies for external damage and clean if contamination is evident.
2. Check the bushings are not damaged (broken, cracked, punctured).
3. Lubricate wear points and all pins in linkage assemblies with grease (Dow Corning 55 silicone lubricant).
4. Verify torque on current carrying parts are within tolerances:

Parts	Torque
Flexible connectors (0.250-20)	10-11 ft-lbs
Bus connections (0.375-16)	27-35 ft-lbs
Vacuum interrupter clamp (0.500-13)***	55-62 ft-lbs
Interrupter rear bolt	44ft-lbs max

\*\*\*Note: Contact block (clamp) must be supported when tightening. Do not exert a torque on the movable contact of the vacuum interrupter, as damage may result.

Note: Values listed above are for grade 5 hardware. Contact the factory for other torque values.



## 8.2. Control elements inspection

1. Verify that the breaker operates correctly using the electrical controls.
2. Verify correct functioning of heater circuitry to ensure thermostat and heaters operate correctly according to thermostat settings.

## 8.3. High-Pot test

A Hi-Pot test can be performed to verify the vacuum integrity of vacuum interrupters.



### **WARNING**

#### **RADIATION WARNING**

High voltage applied across an open gap in a vacuum can produce X- radiation. No radiation is emitted when the breaker is closed, since no gap exists. Also, when the breaker is open to the specified contact spacing in service or tested within the voltages specified, X-radiation at one meter is below the level of concern. A danger could exist at voltages above or contact spacing below that specified on the nameplate.

1. With the breaker in the open position, jumper both sets of three top terminals. Ground one set of terminals and the housing. Connect the high voltage to the other set of terminals.
2. Stand clear more than one meter before energizing the high voltage source.
3. Do not exceed 37.5 kV for 15kV, 64kV for 38kV R-MAG breakers.
4. If internal flashover occurs, isolate the phases and test each one independently to identify the defective interrupter. Any defective pole assembly must be replaced prior to the breaker being in service.

## 8.4. Contact resistance measurement

Measure contact resistance with suitable equipment rated not less than 100 A. The value should not exceed 150 micro ohms in each phase.

## 8.5. Check contact wear

As a vacuum interrupter continues to perform, material from the internal contacts is gradually eroded away, and the moving contact is driven deeper into the interrupter by the operating mechanism.

The over-travel spring at the upper end of the operating rods ensures that proper contact pressure is maintained in the closed position. Contact erosion reduces the compression of the over-travel spring, which in turn increases the contact travel.

Follow next section instructions for minor adjustments. Contact wear can be visually inspected in 15kV and 27kV R-MAG breakers and can be measure by means of vernier ruler. Best way to monitor contact wear is by means of measuring interruption magnitudes and quantity of operations and compare these values to vacuum interrupter lifespan curve.

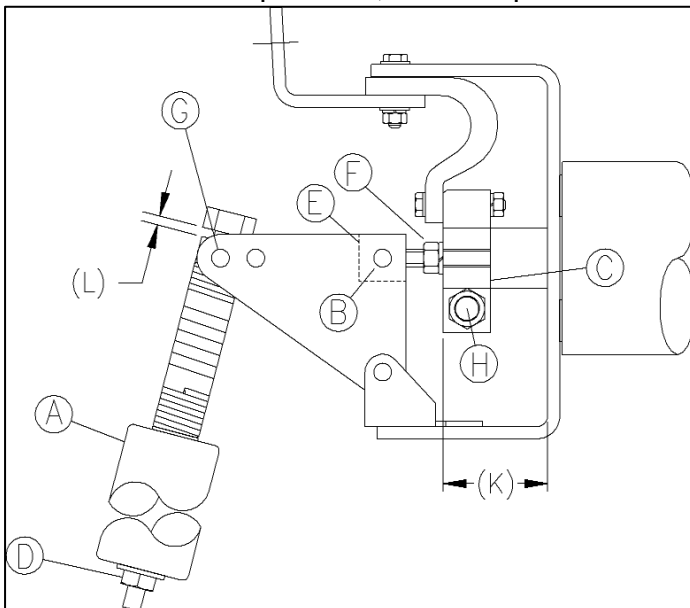
## 8.6. Contact travel and over-travel adjustment (15/27kV)

Travel measurement:

1. With the breaker in open position measure the distance between the copper contact block and the copper bar (K)
2. With the breaker in closed position measure the distance between the copper contact block and the copper bar (K)
3. Subtract the measurement of the step 1 and the measurement from the step 2 to find the contact travel value.
4. Confirm the breaker travel is within the limits by voltage rating:
  - For 15.5 kV breakers = 0.374" to 0.492" (9.5 mm - 12.5 mm)
  - For 27 kV breakers = 0.591" to 0.630" (15.0 mm - 16.0 mm)
5. If the travel measure is outside the limits, minor adjustments can be made by loosening the nut (D) and rotating the pullrod (A). Make sure all hardware is tightened before operating the breaker and measure the travel again as per steps 1, 2 and 3 to confirm the travel is within the limits.

Overtravel measurement:

1. Over-travel gaps (L) (produced at top of each pullrod while the breaker is in the closed position) are recommended to be set from 0.170" to 0.260" (when measuring breakers in operation, it is acceptable to be 0.125").



**Figure 19.** Contact Travel and Over-Travel Adjustment 15.5 and 27kV

## 8.7. Contact travel and over-travel adjustment (38kV)

The desired overtravel (wipe) for 38 kV R-MAG breakers should be within 0.157 in – 0.177 in (4.0 mm – 4.5 mm). The following steps must be performed to measure the contact travel.

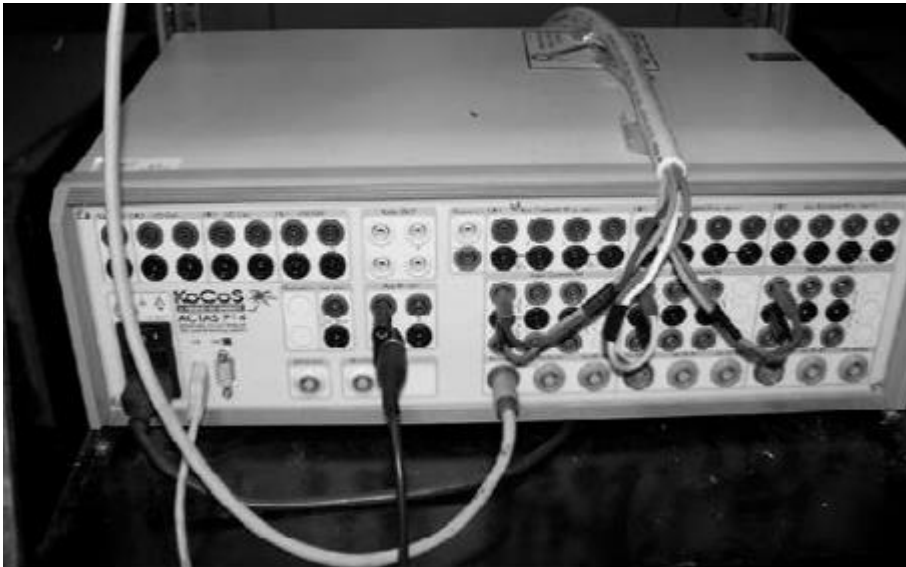
1. The faceplate from the mechanism covers one of the rod's ends. Remove the front panel to access the rod.



2. Connect the transducer to the rod's end as shown below:



3. Connect the transducer to the motion analyzer. ABB utilizes a Kocos – ACTAS P14:



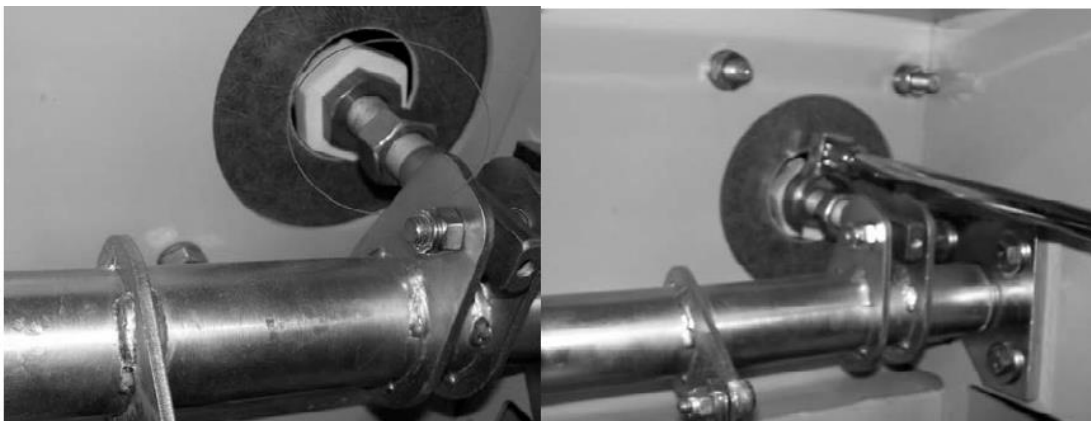
4. Connect the AMP meter to the actuator coil cables:



5. Connect the Kocos probes to the breaker contacts/bus, to allow the Kocos measure the conducting path.  
Perform the Travel and Overtravel measurement following the Kocos (or other measuring equipment) following the applicable instructive.



6. If the result is different from the suggested range of 0.157 in – 0.177 in (4.0 mm – 4.5 mm), turn the pushrod's end clockwise to increase wipe, or counter-clockwise to decrease wipe, depending on the adjustment needed to achieve a measurement within the specified range.



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## **ANNEX 1 – ED2.0 Control board**

### **Table of contents**

<b>039</b>	<b>OVERVIEW</b>
<b>040</b>	<b>Binary inputs</b>
<b>043</b>	<b>Binary outputs</b>
<b>045</b>	<b>Additional features</b>
<b>047</b>	<b>Power considerations</b>
<b>052</b>	<b>ED2.0 board replacement procedure</b>

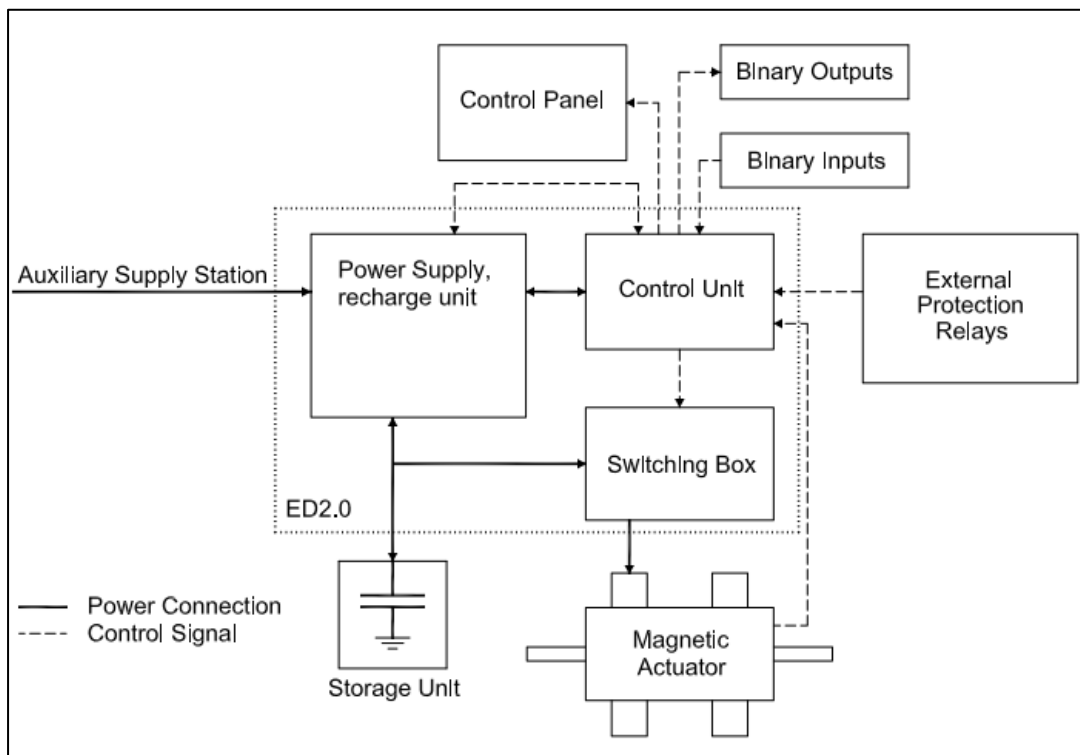
# I. Overview

The ED2.0 electronic control board is comprised of a Power Supply Recharge Unit, Control Unit, and FET Switching circuit which connects the Storage Unit Capacitors to the Magnetic Actuator coils.

The power supply recharge circuitry adapts whatever input voltage, within the specified range (Section 2.0), is supplied to maintain an 80 V charge voltage across the capacitors. The Control Unit monitors binary inputs and outputs, hardware and software configurations, breaker position (through inductive sensors or auxiliary switches in recent models), capacitor charge, and switches the FET circuit to connect the capacitor voltage to the Magnetic Actuator coils following an open or close command.

The Capacitor Storage Unit consists of two, three or four (depending on rating) 0.1 farad Aluminum Electrolytic capacitors connected in parallel. The energy stored is approximately 640 Joules on 15 kV and 960 Joules on 27 kV. When called to energize the Magnetic Actuator coils, the capacitors will deliver a peak current of approximately 35A and a pulse width of 45 milliseconds for opening operations and 60 milliseconds for closing operations (15kV R-MAG actuator).

The ED2.0, with external circuitry, system Block Diagram is given in Illustration 1 below.



**Annex Figure 1.** Electrical system block diagram

---

## II. Binary inputs

There is a removable filter card plugged into the ED2.0 board. This filter card has five metal jumpers on it. When the jumpers are cut, the binary input threshold is raised by 20 V. It is recommended that these be cut for 125 VDC operation.

Binary input channels work properly with a voltage range of 24 to 264 VAC/DC regardless of which board is used. All inputs have a low threshold at about 18 VDC and 19 VAC with the exception of the Protection Relay input, which has a low threshold of about 7 VDC. To avoid false triggering by noise, the inputs must be active for at least 6 milliseconds. The current draw for most inputs is < 2 milliamperes. The exception is the Remote Open and Close inputs, which draw up to approximately 20 milliamperes. The input impedance (Z) is 300kOhms except for binary inputs 1 and 2 (Remote open and close) which are around 14kOhms input Z.

There are seven different input channels. Only six of them are used for the R-MAG breaker (channel 5 is not used).

### II.1. Remote Close (KM1005, CH 1, Pins 1 and 2)

The Remote Close input is used to close the breaker remotely. The input impedance is approximately 14 kOhms.

### II.2. Remote Open (KM1005, CH 2, Pins 3 and 4)

The Remote Open input is used to trip breaker remotely. The input impedance is approximately 14kOhms. When tripping with electromechanical relays, an additional resistor will be required to drop the trip flags



### II.3. Auxiliary Open / Safe Open (KM1005, CH 3, Pins 5 and 6)

This input can be configured as either an Auxiliary Open function or a Safe Open function. The position of dip switch I1002 determines which is selected. If it is Off, it is used as Auxiliary. If the dip switch is On, it is used as Safe Open.

The Auxiliary Open functions the same as the Remote Open function, with the exception of the input impedance which is approximately 300kOhms.

The Safe Open function allows the user to open the circuit breaker when the on board microcontroller is faulty. During normal conditions, all opening inputs work, but if the microcontroller is damaged, only the Safe Open input can perform the opening command. When the microcontroller is damaged, capacitor monitoring is not active so other inputs will be ignored. In order for the breaker to open correctly, there must be sufficient energy in the capacitors.

### II.4. Protection Trip / Second Trip (KM1005, CH 4, Pins 7 and 8)

This input can be configured as either a Protection Trip or Second Trip function. It is programmed via Jumper JP1001 Pins 1 and 2 or as a normal input by jumpering JP1001 pins 2 and 3.

The Protection Trip input is designed to work at a lower threshold of 7 VDC. This input is provided to use with special protection relay requirements. It can also be used as a normal trip input.

The Second Trip is often referred to as “Shunt Trip.” It functions the same as the Remote Input with the exception of the input impedance which is 300kOhms.

### II.5. Circuit Breaker Locked Open (KM1005, CH 6, Pins 11 and 12)

The Circuit Breaker Locked Open feature functions like the familiar 69 switch. The circuit is deenergized when the external trip handle is moved from its normal position (i.e., in the trip position). In this position the breaker cannot be either locally or remotely closed.

When the circuit breaker is tripped, by operating the manual trip handle, the breaker will go into the Open Lock mode. This prevents any future closings until the Trip Handle is returned to the Normal Position. The Manual Trip Handle must be left in the down position for the switch to remain open (i.e., locked open). It is important that the handle be moved all the way to the bottom of the trip position to enable this function.

**Note:** There is a padlock provision for locking the manual lever in the Locked Open position.

## II.6. Under Voltage Trip (KM1005, CH 7, Pins 13 and 14)

The UnderVoltage Trip input will perform an auto trip in the event the voltage source being monitored, by this input, falls between 35% to 70% of nominal. It is enabled through DIP Switch I1004/2-3-4. The response of this input also has a programmable time delay from 500 milliseconds to 5 seconds. The delay is set by the various combinations of DIP Switch I1004/2-3-4. The UnderVoltage Threshold is set by I1001. See Table below.

Dip Switch I1001 Position	Threshold
1	100 – 127 VAC/VDC
2	48 – 60 VDC
3	24 – 30 VDC
None	220 240 VAC/VDC

### Dip switch positions:

Position 1, for 100 – 127 VAC/VDC

ON	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
OFF	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Position 2, for 48 – 60 VDC

ON	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
OFF	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Position 3, for 24 – 30 VDC

ON	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
OFF	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Position None, for 220 240 VAC/VDC

ON	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
OFF	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

---

## III. Binary Outputs

Binary outputs are simply pairs of mechanical wipe relay contacts. They can be employed to switch in other circuitry or to an alarm indicator. See Illustration 3 and 4 for the power limitations of the contacts. Notice the flat curve for AC voltage in Illustration 4. On the inside of the low voltage cabinet there is a membrane style button plate that contains a “Ready” LED. The Ready light will either flash or turn off depending on the state of the Capacitor voltage, Coil continuity, and the state of the position sensors. The “Unit Ready” output contact can be used to alarm for more serious of the three types of problems but will not signal for all levels of the above problems. See Illustration 6.

### III.1. Circuit Breaker Opened (KM1004 Pins 1 and 2)

The Circuit Breaker Opened contacts are normally open. They close only when the circuit breaker is in the Open position.

### III.2. Circuit Breaker Closed (KM1004 Pins 3 and 4)

The Circuit Breaker Closed contacts are normally open. They close only when the circuit breaker is in the Closed position.

### III.3. Circuit Breaker Auxiliary Open (KM1004 Pins 5 and 6)

The Circuit Breaker Auxiliary Open contacts which close whenever the breaker is in the Open position.

### III.4. Circuit Breaker Auxiliary Closed (KM1004 Pins 7 and 8)

Additional set of normally open contacts which close whenever the breaker is in the Close position

### III.5. Unit Ready (KM1004 Pins 9 and 10)

These contacts are normally open. They close when the breaker is ready. They are used to monitor capacitor charge (O-CO operation ready), valid circuit breaker position, and coil continuity.

### III.6. Unit Not Ready (KM1004 Pins 11 and 12)

The Unit Not Ready contacts are normally closed. They open when the Unit is Ready. These contacts are the inverse (negative) of the Unit Ready contacts.

When using the Not Ready contacts to provide an alarm to SCADA, an 8 second delay is recommended since the unit will go to Not Ready when the capacitors are below 49 V. The 8 seconds delay allows the capacitors to charge prior to alarming.

### III.7. Breaker Ready / Not Ready Binary Output Contacts and Ready Light Status

Condition	Circuit breaker position	
	Close	Open
<b>Capacitor Energy sufficient for O-CO operations</b>	Ready LED: on Ready contact: closed Not ready contact: opened	Ready LED: on Ready contact: closed Not ready contact: opened
<b>Capacitor Energy sufficient for CO operations</b>	Ready LED: blinking Ready contact: closed Not ready contact: opened	Ready LED: blinking Ready contact: closed Not ready contact: opened
<b>Capacitor Energy sufficient for O operations</b>	Ready LED: blinking Ready contact: closed Not ready contact: opened	Ready LED: off Ready contact: opened Not ready contact: closed
<b>Capacitor Energy insufficient for any operations</b>	Ready LED: off Ready contact: opened Not ready contact: closed	Ready LED: off Ready contact: opened Not ready contact: closed
<b>Close Coil continuity not right</b>	Ready LED: blinking Ready contact: closed Not ready contact: opened	Ready LED: off Ready contact: opened Not ready contact: closed
<b>Open Coil continuity not right</b>	Ready LED: off Ready contact: opened Not ready contact: closed	Ready LED: off Ready contact: opened Not ready contact: closed

### III.8. Circuit Breaker Remote Open (KM1004 Pins 13 and 14)

The Circuit Breaker Remote Open contacts are referred to as the “Fleeting Output Contacts.” This means that they only close for 100 milliseconds after a Remote Operation is performed.

---

## IV. Additional features

### IV.1. Temperature Protection

The Temperature Protection circuit monitors the average temperature of a critical area on the ED2.0 power supply. The output power will be linearly reduced to zero as the temperature increases from 78 degrees C to 95 degrees C.

### IV.2. Actuator Close and Trip Coil Continuity Monitor

See Illustration 10 - Troubleshooting Guide.

### IV.3. Wrong Position Auto Trip

An Auto Trip command will be issued in the event the breaker does not perform a successful close operation within 95 milliseconds after the close command is issued.

### IV.4. Energy Failure Auto Trip



#### CAUTION

If power is removed from unit, and the Dip Switch I1004-1 is placed in the “on” position, the breaker will automatically trip in approximately 3 minutes. Make sure personnel and tools are clear from breaker.

The Energy Failure Auto Trip function is selected by Dip Switch I1004-1 and will cause the breaker to auto trip in the event the capacitor voltage falls below 49 volts. Necessary precautions must be taken when power is removed (e.g., power removed for maintenance) as the breaker will automatically trip if I1004-1 is in the “On” position.

## IV.5. Reduced Power Consumption

The Reduced Power Consumption setting will lower the power output of the power supply recharge unit, on the ED2.0 board, from 75 W power to 33 W. This enables the ED2.0 board to be supplied with the energy delivered by a voltage transformer if necessary. The Power Supply Recharge Unit is 80% efficient.

This means that the Auxiliary Power supply input must be at least 93.75 W for the 75 W setting or 41.3 W for the 33 W setting.

The 33 W option is hardware selectable with Jumper JP1019.

## IV.6. RS-232 Port / JTAG Communication

Used by ABB factory only.

## V. Power considerations

The ED2.0 power supply recharge unit adapts any voltage within the specified range of the board to maintain 80 V across the capacitors. The following voltage thresholds must be reached to complete the specified operations:

- The capacitor voltage threshold for an Open operation is 49 Volts
- The capacitor voltage threshold for a Close-Open operation is 72.5 Volts
- The capacitor voltage threshold for a Open-Close-Open operation is 78 Volts

Check troubleshooting section to identify the states of the Ready LED, Ready and Not Ready output contacts.

### V.1. Circuit breaker operations vs available capacitor charge:

Capacitor charge	Circuit Breaker Position	
	CLOSE	OPEN
Energy sufficient for O-CO operations	Open allowed	Close allowed
Energy sufficient for CO operations	Open allowed	Close allowed
Energy sufficient for O operations	Open allowed	Blocked in open position
Energy insufficient for any operation	Blocked in closed position or CB opened (depending on dip switch setting I1004)	Blocked in open position

### V.2. Recharge time

As with all energy storage devices, there is a recharge time required for operation of the breaker. A fully charged unit will do an Open-Close-Open operation. Average values for recharge on 15kV units are listed below. The 27 kV units require additional recharge time. The values shown are minimums and will change as capacitor life and operation conditions vary.

- Open-1.0 sec
- Close-2.2 sec
- Close-Open-3.4 sec
- Open-Close-Open-5 sec

### V.3. Discharging Storage Unit Capacitors



#### WARNING

Make sure ED2.0 Control Power is removed before attempting to discharge the capacitors. See paragraph below

The ED2.0 board provides access through KM1003 for discharging the Storage Unit capacitors. Make sure the ED2.0 Control Board Power is removed before attempting to discharge the capacitors.

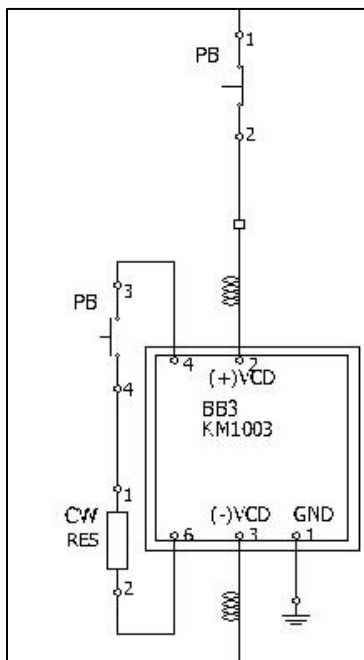
All R-MAG breakers are equipped with a circuit to discharge the capacitors, a resistor is added in the wiring panels to burn the capacitors energy. The discharge function is operated by pressing a button also located in a wiring panel.



#### CAUTION

Make sure the resistor is not touched while discharging the capacitors using the discharge button, as the resistor heats up considerably and can cause skin burns.

Following illustration shows the standard circuit provided in all R-MAG breakers to allow the user the safe capacitors discharge



**Annex Figure 2.** Electrical system block diagram of capacitor discharge circuit



### V.3.1. Procedure

A 10kOhm capacitor discharge resistor is mounted on the circuit board. Discharging is done by jumpering KM1003 pins 4 and 5. The time constant is 33 minutes.

An external resistor can be used for quicker discharging, but the discharge current should be restricted to 10A maximum. This means that no lower than 10Ohms external resistance should be used to perform capacitor discharging. In this case an external 10Ohm, 25W resistor can be connected to KM1003 Pins 4 and 6.

Approximately 30 seconds is needed to discharge the capacitors using the 10Ohm external resistor.

### V.4. Electrolytic capacitors

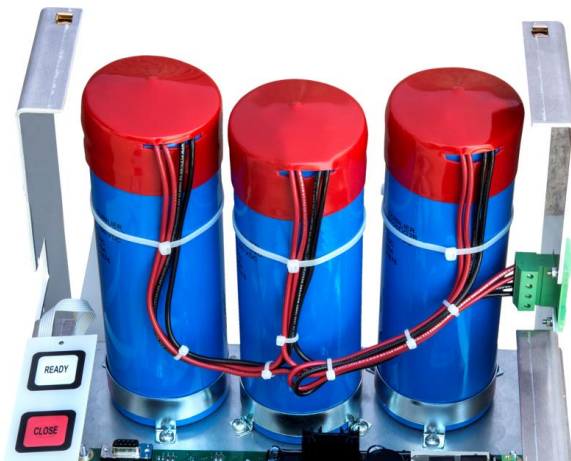
The 0.1Farad electrolytic capacitors are designed to be operated in the temperature range of 40°F to 185°F (-40°C to 85°C). In the case an operating temperature below -40°F (-40°C) is required an alternative set of capacitors able to operate in the range of -67°F to 221°F (-55°C to 105°C) are provided.

The number of capacitors provided within the R-MAG depends on the rating of the unit, following these rules:

- R-MAG 15kV 25kA: 2 capacitors
- R-MAG 27kV 25kA: 3 capacitors
- R-MAG rated as 31.5kA or 40kA: 4 capacitors

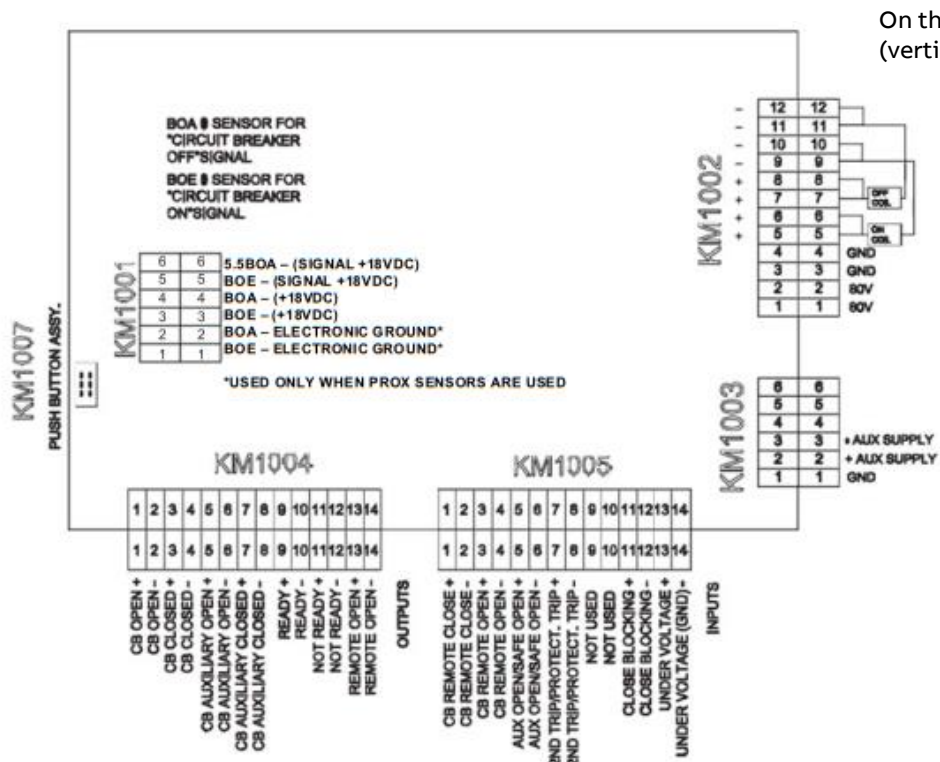
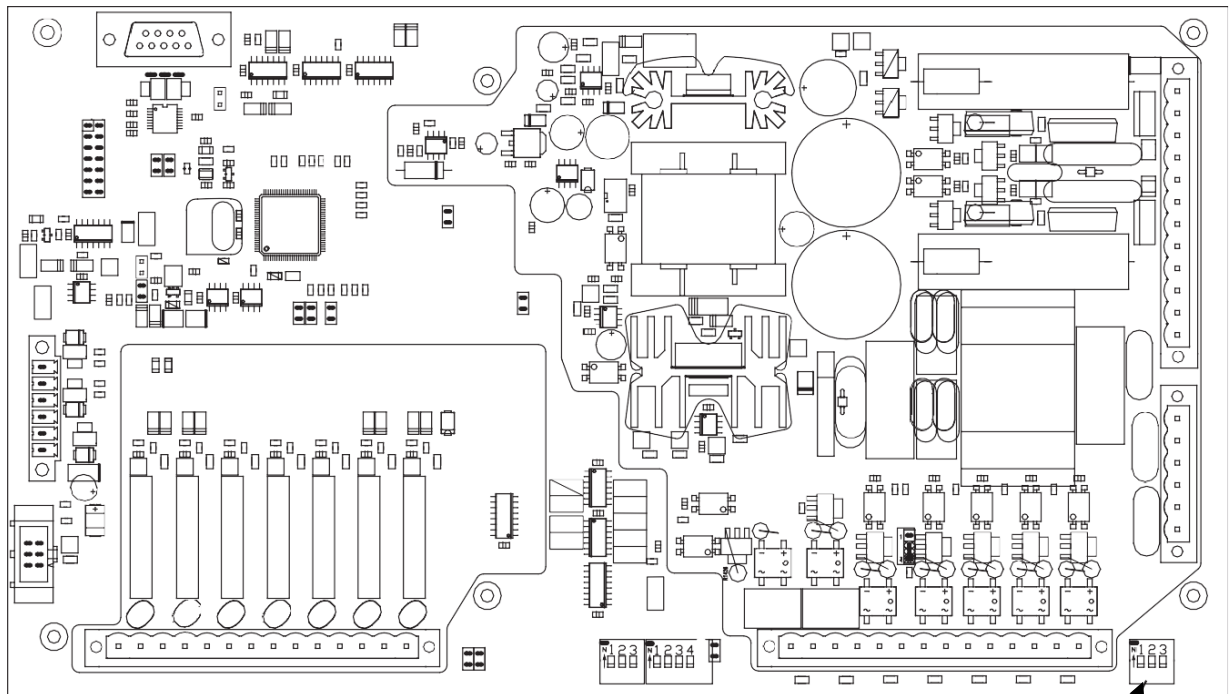
The end of life corresponds to the point at which the capacitance decreases by 20% or more.

It is recommended that replacement of capacitors be performed every 15 years for tropical climates and 20 years for an average yearly temperature (in the outdoor breaker enclosure) of less than 122°F (50°C).



Annex Figure 3. Electrolytic capacitors

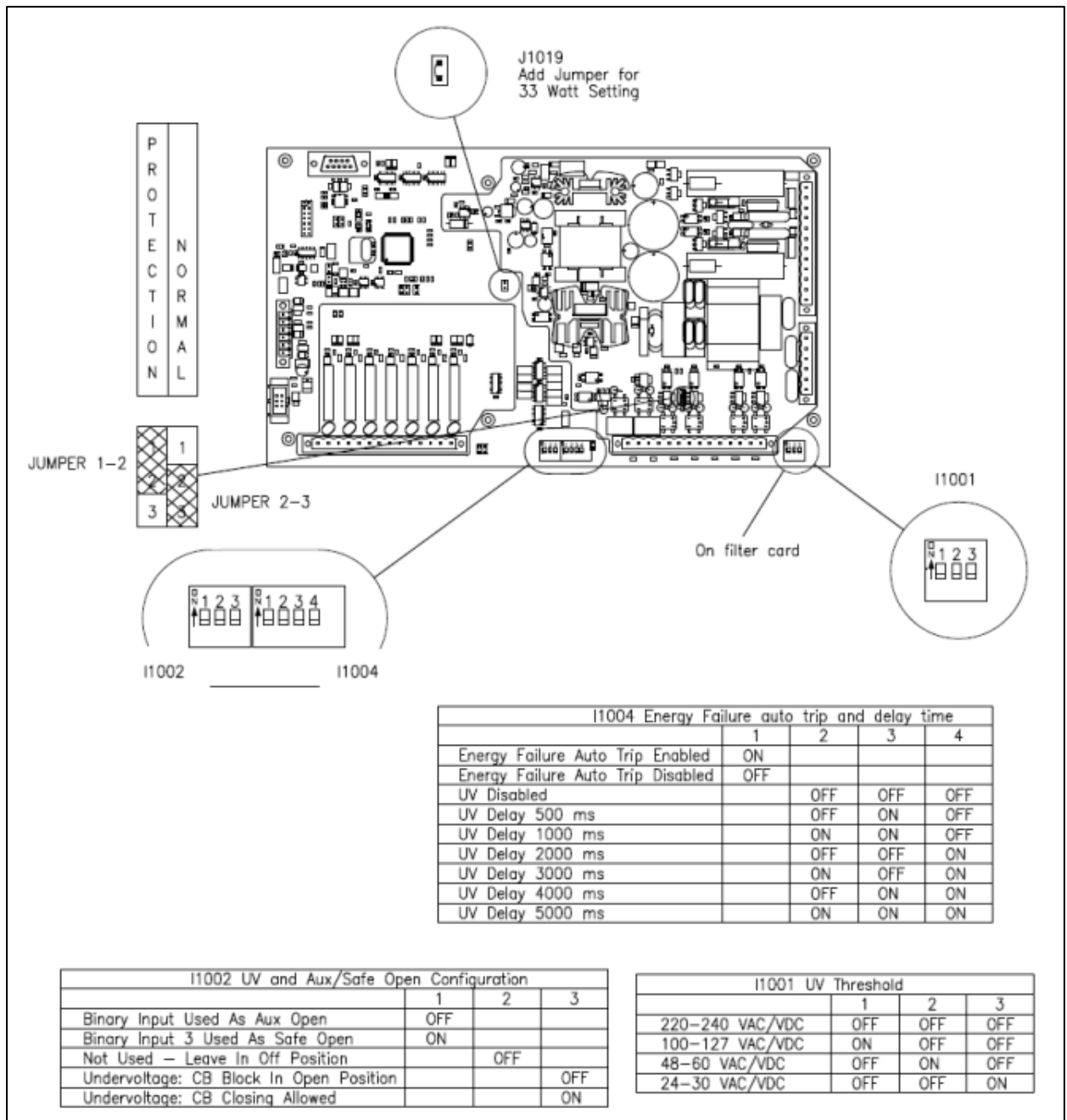
### V.5. Standard ED2.0 circuit board and connecting diagram



Annex Figure 4. ED2.0 circuit board and connections

## V.6. Default jumper and dip switch settings Rev 02 and greater ED2.0

Unless specified by the customer, the Low Energy and Under Voltage trip functions are disabled. Input three is set for Auxiliary trip mode as opposed to the Protection Relay trip mode. The following represents the functional Jumper and Dip Switch settings which are the shipped configuration.



Annex Figure 5. ED2.0 circuit board and connections

## VI. ED2.0 board replacement procedure



### WARNING

Removing the cover of ED2.0 board assembly exposes live voltage. Make sure the power is off and the capacitors are discharged via the discharge button function



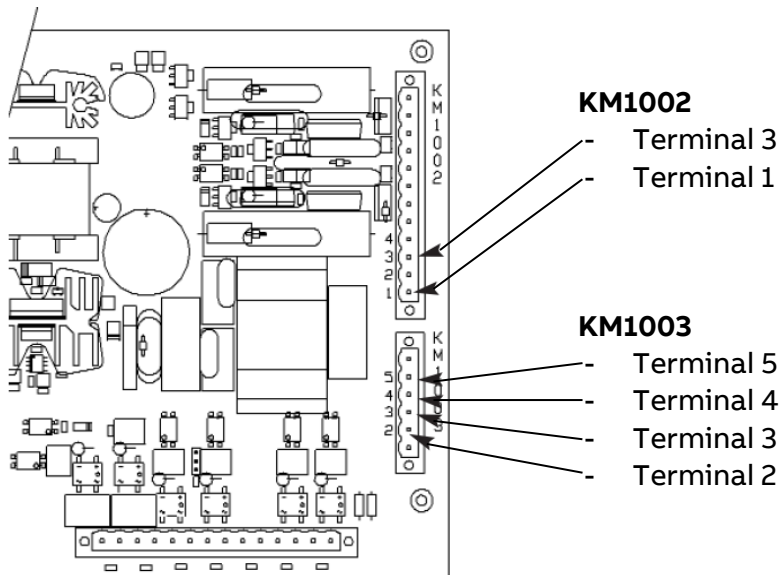
### CAUTION

#### SENSITIVE ELECTRONIC DEVICES

The ED2.0 control board is an ESD sensitive electronic device. It is necessary to take precautions in order to avoid the damage of these components during the handling of the board in case an operator touches the control board (in particular during service operation).

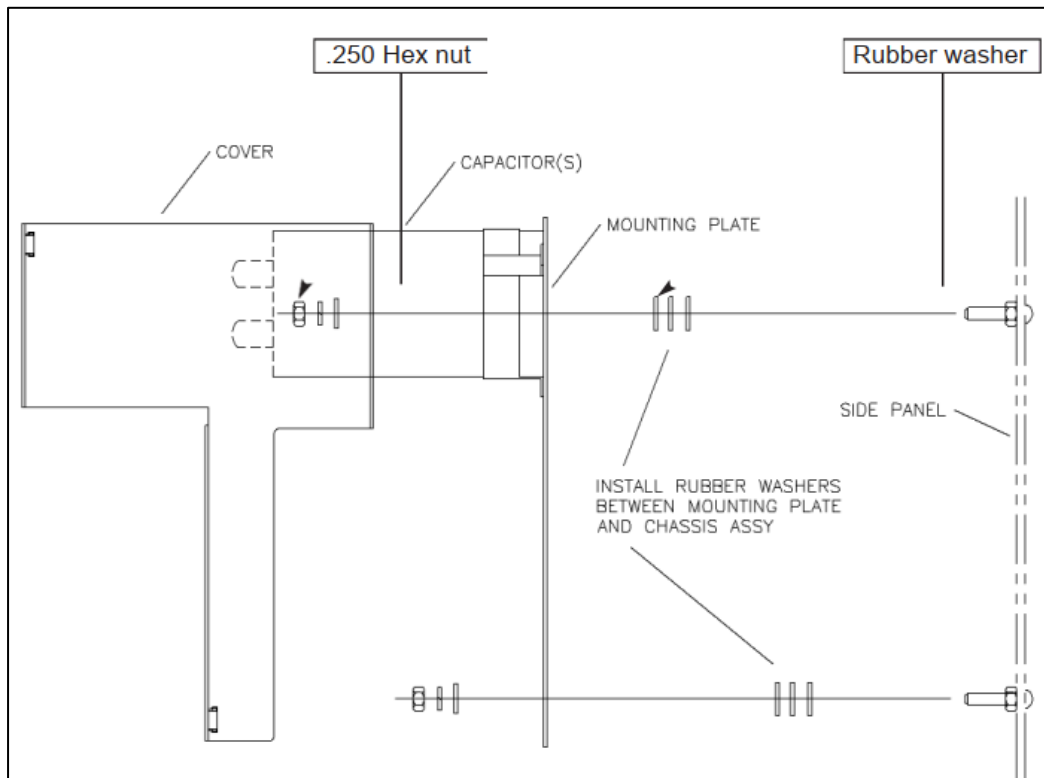
Proper ESD protection must always be applied when handling the ED2.0 board. ABB can supply a document regarding ESD protection.

- 1) Disconnect the source power to the R-MAG.
- 2) Remove the two #4 screws holding on the Push button plate and let it hang down.
- 3) Remove the four .250 X 20 screws from the corners of the ED2.0 cover.
- 4) With the cover removed, verify the voltage input to the board is off by measuring the voltage at KM1003 terminals 2 and 3. It should be zero.



Annex Figure 6. ED2.0 circuit board and terminals location

- 5) Before proceeding, discharge the capacitors by jumpering KM1003 pins 4 and 5. The time constant is 33 minutes. A smaller external resistor can be used for a quicker discharge, but the discharge current should be restricted to 10 amperes maximum. This means that no lower than 10 ohms 25 watt external resistance should be used to perform capacitor discharging. When discharging with an external capacitor, connect to pins 2 and 3 on KM1002.
- 6) After the capacitors are discharged, take a small screwdriver and remove the capacitor plug.
- 7) Remove five plugs: KM1001, KM1002, KM1003, KM1004, KM1005, and KM1007. To remove, loosen hold down screws from each plug
- 8) Remove plug for push button plate. This is not held by retainers.
- 9) Remove four .250-20 nut, lock and flat washer from the four corners. Keep the three rubber washers behind each screw.
- 10) Perform this process in reverse order to reinstall the board.



**Annex Figure 7.** ED2.0 circuit board removal process

---

## **ANNEX 2 – R-MAG Troubleshooting & Spare parts**

### **Table of contents**

<b>055</b>	<b>R-MAG troubleshooting</b>
<b>059</b>	<b>Recommended spares for R-MAG</b>

# I. R-MAG troubleshooting

Fault	Cause	Possible solutions
	<ul style="list-style-type: none"> <li>The circuit breaker is closed and the close coil is disconnected or broken</li> </ul>	<ul style="list-style-type: none"> <li>In this case, only the opening operation is available; open the circuit breaker (the ready LED will be turned off) and check the closing coil circuit. Unplug the magnetic actuator from the plug to the left of the mechanism (MA). There are two Phillips head screws that keep the plug held together. The top two wires are red the bottom two wires are blue. The bottom red (43) and bottom blue (45) wire go to the "On" (close) coil. The coil should read between 0.6 -1.0 ohms.</li> </ul>
<b>Ready LED is blinking</b>	<ul style="list-style-type: none"> <li>The circuit breaker is closed</li> </ul>	<ul style="list-style-type: none"> <li>The energy stored in capacitors is sufficient only for CO or O operation</li> </ul>
	<ul style="list-style-type: none"> <li>The circuit breaker is open</li> </ul>	<ul style="list-style-type: none"> <li>The energy stored in capacitors is sufficient only for CO operation</li> </ul>
	<ul style="list-style-type: none"> <li>The auxiliary supply voltage has been turned off</li> </ul>	<ul style="list-style-type: none"> <li>If the circuit breaker is closed you can perform a CO-operation; connect the auxiliary supply. Check pins 2 and 3 on KM1003 to confirm proper input voltage is applied</li> </ul>
	<ul style="list-style-type: none"> <li>The capacitor bank is charging during start up or after an operation.</li> </ul>	<ul style="list-style-type: none"> <li>&lt;15s since any operation or power-up, then wait a few seconds</li> </ul>

Fault	Cause	Possible solutions
	<ul style="list-style-type: none"> <li>The auxiliary supply voltage is absent</li> </ul>	<ul style="list-style-type: none"> <li>Check pins 2 and 3 on KM1003 to confirm proper input voltage is applied.</li> </ul>
	<ul style="list-style-type: none"> <li>The magnetic actuator is damaged or not connected</li> </ul>	<ul style="list-style-type: none"> <li>Check the magnetic actuator circuit. Unplug the magnetic actuator from the plug to the left of the mechanism (MA). The top two wires are red the bottom two wires are blue.</li> <li>The bottom red (43) and bottom blue (45) wire go to the "On" (close) coil. The other two wires go to the off (open) coil. Each of these coils should read between 0.6 - 1.0 ohms.</li> </ul>
<p><b>Ready LED is off (unit not ready)</b></p>	<ul style="list-style-type: none"> <li>The inductive position sensors or auxiliary contacts are damaged or not connected correctly</li> </ul>	<p>R-MAG with Inductive position sensors:</p> <ul style="list-style-type: none"> <li>There are 3 wires connected to the proximity sensors- Black is the signal wire, Brown is connected to +18 volts and Blue is connected to ground.</li> <li>When metal is placed in front of a sensor, it will be picked up and you will see the yellow LED lit on the back of the sensor. From the black wire to the blue wire verify it reads +18V. When the metal is removed the voltage should drop to near 0.</li> </ul> <p>R-MAG with Auxiliary switches:</p> <ul style="list-style-type: none"> <li>Confirm wires going to auxiliary switch are well connected, confirm auxiliary switch commutates correctly</li> </ul>
	<ul style="list-style-type: none"> <li>The Under Voltage (UV) function is enabled and input is open</li> </ul>	<ul style="list-style-type: none"> <li>Inspect dip switch I1004. Ensure switches 2, 3, 4 and 5 are in the off (down) position (disables UV), or apply correct input voltage to pins 13 and 14 on KM1005</li> </ul>
	<ul style="list-style-type: none"> <li>The UV function is enabled and the voltage is connected to the UV input, but the voltage is lower than the threshold</li> </ul>	<ul style="list-style-type: none"> <li>Set the correct UV threshold level via DIP switch I1001 or disable UV by putting switches 2, 3, 4 and 5 in the off (down) position on I1004.</li> </ul>
	<ul style="list-style-type: none"> <li>The auxiliary supply voltage has been turned off and the voltage on the capacitor is under the O-CO levels</li> </ul>	<ul style="list-style-type: none"> <li>Check pins 2 and 3 on KM1003 to confirm proper source input voltage is applied.</li> </ul>
	<ul style="list-style-type: none"> <li>The control panel is damaged or not connected correctly</li> </ul>	<ul style="list-style-type: none"> <li>Verify the control panel 6-pin plug is plugged into KM1007</li> </ul>



Fault	Cause	Possible solutions
<b>The closing command is not performed</b>	<ul style="list-style-type: none"> <li>The closing coil is broken or damaged</li> </ul>	<ul style="list-style-type: none"> <li>Check the closing coil circuit. Disconnect the magnetic actuator from the plug to the left of the mechanism. There are two Phillips head screws that keep the plug held together. The top two wires are red and the bottom two wires are blue. The bottom red (43) and bottom blue (45) wire go to the "On" (close) coil. The coil should read between 0.6 -1.0 ohms</li> </ul>
	<ul style="list-style-type: none"> <li>One open (trip) input is active</li> </ul>	<ul style="list-style-type: none"> <li>Verify there is not a held trip signal on the ED2.0 board. Verify the voltage across TB1-8 and TB1-3 is "0" (KM1005 3, 4), and also across KM1005 5, 6 Safe open (if used), and KM1005 7, 8 second trip (if used).</li> </ul>
	<ul style="list-style-type: none"> <li>The block in open input is open (manual trip lever) Function 69 active</li> </ul>	<ul style="list-style-type: none"> <li>Check the manual trip lever to verify it is in the up (normal) position. If it is, verify the microswitch (mounted on the mechanism side) has continuity across the wires</li> </ul>
	<ul style="list-style-type: none"> <li>The capacitor bank is not connected</li> </ul>	<ul style="list-style-type: none"> <li>Check the capacitor bank circuit. Verify the capacitors are connected to the control board. Ensure that there is 80 VDC</li> </ul>
	<ul style="list-style-type: none"> <li>The ready LED on control panel is off</li> </ul>	<ul style="list-style-type: none"> <li>See conditions under "Ready LED is off (unit not ready)"</li> </ul>
	<ul style="list-style-type: none"> <li>The control panel is damaged or not connected properly.</li> </ul>	<ul style="list-style-type: none"> <li>Verify the control panel 6-pin plug is plugged into KM1007</li> </ul>
	<ul style="list-style-type: none"> <li>The energy in the capacitor bank is not enough for a CO-operation.</li> </ul>	<ul style="list-style-type: none"> <li>Ensure the auxiliary supply voltage is connected. See "ready light blinking" section.</li> </ul>
	<ul style="list-style-type: none"> <li>Close input is not supplied</li> </ul>	<ul style="list-style-type: none"> <li>Verify close command is wired to input.</li> </ul>
	<ul style="list-style-type: none"> <li>ED2.0 switching circuit board</li> </ul>	<ul style="list-style-type: none"> <li>Replace ED2.0 board</li> </ul>

Fault	Cause	Possible solutions
<p><b>The opening command is not performed</b></p>	<ul style="list-style-type: none"> <li>The opening coil is broken or damaged</li> </ul>	<ul style="list-style-type: none"> <li>In this case, only the closing operation is available; open the circuit breaker (the ready LED will be turned off) and check the closing coil circuit. Disconnect the magnetic actuator from the plug to the left of the mechanism. The top two wires are red and the bottom two wires are blue. The top red (43) and top blue (45) wire go to the "Off" (open) coil. The coil should read between 0.6 -1.0 ohms.</li> </ul>
	<ul style="list-style-type: none"> <li>The capacitor bank is not connected</li> </ul>	<ul style="list-style-type: none"> <li>Check the capacitor bank circuit. Verify the capacitors are connected to the control board. Ensure that there is 80 VDC across KM1002 terminals 1 and 3.</li> </ul>
	<ul style="list-style-type: none"> <li>No external opening input is connected</li> </ul>	<ul style="list-style-type: none"> <li>Verify opening input is wired</li> </ul>
	<ul style="list-style-type: none"> <li>The control panel is either damaged or not connected correctly.</li> </ul>	<ul style="list-style-type: none"> <li>Verify the control panel 6-pin plug is plugged into</li> </ul>
	<ul style="list-style-type: none"> <li>ED2.0 switching circuit board</li> </ul>	<ul style="list-style-type: none"> <li>Replace ED2.0 board</li> </ul>

Fault	Cause	Possible solutions
<p><b>All indication output contacts are open</b></p>	<ul style="list-style-type: none"> <li>The voltage on the capacitor bank is under 46 VDC</li> <li>Capacitor bank is not connected</li> </ul>	<ul style="list-style-type: none"> <li>Connect the auxiliary power supply voltage</li> <li>If it happens immediately when the supply voltage is switched off and the</li> </ul>
<p><b>The circuit breaker closes and then opens during a close operation</b></p>	<ul style="list-style-type: none"> <li>Verify the close position sensor circuit.</li> <li>Verify the presence of unwanted objects under the magnetic actuator plunger</li> </ul>	<ul style="list-style-type: none"> <li>Verify the close position sensor circuit.</li> <li>Verify the presence of unwanted objects under the magnetic actuator plunger.</li> </ul>
<p><b>The circuit breaker opens if the auxiliary supply is switched off</b></p>	<ul style="list-style-type: none"> <li>Either disable the UV function or connect to a different voltage source</li> </ul>	<ul style="list-style-type: none"> <li>Either disable the UV function or connect to a different voltage source</li> </ul>
	<ul style="list-style-type: none"> <li>If possible, disable the function via I1004-1. Switch 1 should be in the off position.</li> </ul>	<ul style="list-style-type: none"> <li>If possible, disable the function via I1004-1. Switch 1 should be in the off position.</li> </ul>

## II. Recommended spares for R-MAG

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### Spare

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ED2.0 control board	<b>1B09551G01</b> - ED 2.0 control assembly, LV (24-77VDC) for 15kV <b>1B09551G02</b> - ED 2.0 control assembly, HV (77-180VDC) for 15kV <b>1B09551G07</b> - ED 2.0 control assembly, LV (24-77VDC) for 27kV <b>1B09551G08</b> - ED 2.0 control assembly, HV (77-180VDC) for 27kV <b>2RGA015874A0001</b> – ED 2.0 control assembly, LV (24-77VDC) for 38kV <b>2RGA015874A0002</b> - ED 2.0 control assembly, HV (77-180VDC) for 38kV
Bushing	<b>1VAF203753A0001</b> - Bushing kit 15kV 1200A <b>1VAF203751A0001</b> - Bushing kit 15kV 2000A <b>1VAF203750A0001</b> - Bushing kit 15kV 3000A <b>1VAF203752A0001</b> - Bushing kit 27kV 1200A <b>1VAF203751A0001</b> - Bushing kit 27kV 2000A <b>1VAF203748A0001</b> - Bushing kit 38kV 1200A <b>1VAF203749A0001</b> - Bushing kit 38kV 2000A
Actuator	Contact ABB
Electrolytic capacitor	<b>12A01272G04</b> – Electrolytic capacitor
Auxiliary switch	<b>1C09396H04</b> - 16 deck auxiliary switch <b>1C09396H05</b> - 20 deck auxiliary switch
Operation counter	<b>628A547H02</b> - Operation counter mechanism
Pushbutton switch	<b>751017/804</b> - Pushbutton switch for local operation
ED2.0 board	<b>2RGA014458P0001</b> - ED 2.0 control assembly, LV (24-77VDC) <b>2RGA014458P0002</b> - ED 2.0 control assembly, HV (77-180VDC)

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More product information:

**[abb.com/mediumvoltage](http://abb.com/mediumvoltage)**

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