GE
Grid Solutions

MCAG 14/34

High Stability Circulating Current Relay

The MCAG relay, used with a stabilizing resistor, is designed for applications where sensitive settings with stability on heavy through faults are required, and is recommended for balanced and restricted earth fault, bus-zone and certain forms of differential protection for generators, auto-transformers, reactors and motors. The relay operates as a high impedance unit protection scheme.

Description

The relay is an attracted armature unit of simple and robust construction. The operating coil of this unit is connected in series with a small choke and capacitor, forming a series resonant circuit. These components are energized from an auto-transformer which is tapped to provide seven current settings.

Due to the simple electromechanical construction, the detection element and the output contacts are one and the same device. Operation is therefore fast and highly reliable.

The relay circuit, tuned to the supply frequency, rejects the harmonics produced by current transformer saturation. The total impedance of the relay and series stabilizing resistor is usually low enough to prevent the current transformers developing voltages over 2 kV during maximum internal faults, but in some applications a non-linear resistor is required to limit this voltage.

Types MCAG 14 and MCAG 34 relays are single and triple pole, respectively.

Application

When circulating current protection schemes are subjected to heavy through faults, the sudden and often asymmetrical growth in the system current can cause the protective current transformers to approach or even reach saturation level. This may result in a high unbalancing current due to the variations in the magnetizing characteristics of the current transformers. To ensure stability under these conditions, it is common practice to use a high impedance relay, set to operate at a voltage slightly higher than that developed by the current transformers under maximum external fault conditions.

Key Benefits

- High stability with through faults
- Tuned to rated frequency
- Operates in 25ms at 5 times setting

Protection & Control

- Differential and restricted earth fault protection for busbars, generators, reactors, motors, autotransformers and transformer windings
- Stability during through faults with fast operation (25ms at 5 x setting)
- Relay circuit tuned to supply frequency, ensuring reliable protection under CT saturation conditions

Ease-of-Use

- Suitable for use with 0.5 A, 1 A and 5 A current transformers at 50 or 60 Hz
- Simplified integration into 4U height MIDOS panel schemes
- Compact case design (30TE) supporting three element relay

Current Transformer Requirements

MCAG relays are suitable for use with 0.5 A, 1 A and 5 A current transformers, at 50 Hz or 60 Hz. Since selection of the optimum relay setting is based on the loop resistance of the secondary circuit, there are advantages in using current transformers with either of the lower secondary ratings. The current transformers used in high impedance circulating current differential protection systems must have equal turns ratios and have reasonably low secondary winding resistance. Current transformers of similar magnetizing characteristics with low reactance construction such as IEC 60044 Class PX, or similar, are preferred. The relay requirements are based upon a calculation of the required knee-point voltage with the IEC definition of the knee-point voltage being the point on the magnetisation curve at which a 10% increase in excitation voltage produces a 50% increase in excitation current. The required stability voltage setting (Vs') and minimum knee-point voltage (Vk) are calculated as follows:

$$Vs' \geq If\,(Rs+Rp)$$

$$VsA = \frac{VA}{Ir} + Ir\,Rsr$$

$$Vk \geq 2VsA$$

where: If = maximum secondary through fault current

Ir = relay setting current
Rct = CT secondary winding resistance
Rp = maximum loop lead resistance between CTs and relay
Rsr = external stabilizing resistance
VA = relay burden at setting
VsA = actual voltage setting

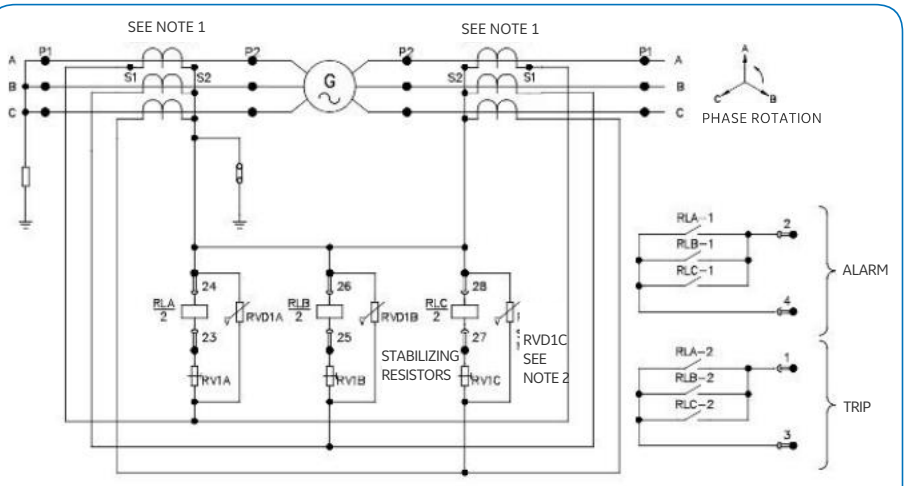

Figure 1: Internal and external circuit diagram for unbiased differential protection of generators, reactors and synchronous motors using type MCAG 34 relay

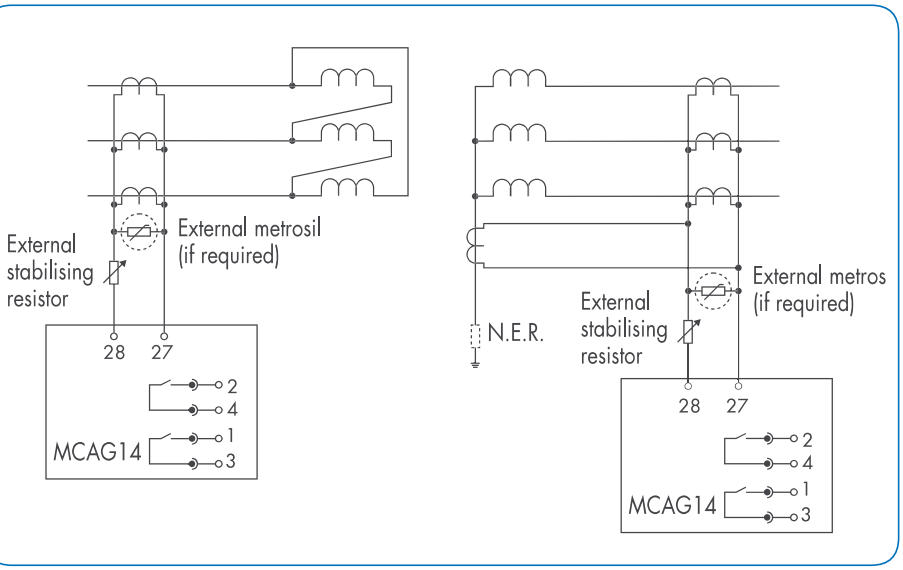

Figure 2: Type MCAG14 relays applied to restricted earth fault protection of power transformer

Simple, reliable and secure unit protection

Stabilizing Resistance

Externally mounted, continuously variable resistors of 470, 220 and 47 for 0.5 A, 1 A and 5 A CT secondaries respectively are supplied as standard.

The appropriate value of series resistance (Rsr) required to ensure stability is calculated as follows:

$$Rsr = \frac{Vs' - VA / Ir}{Ir}$$

where:
Vs' = minimum required stability voltage
VA = relay burden
Ir = relay setting current

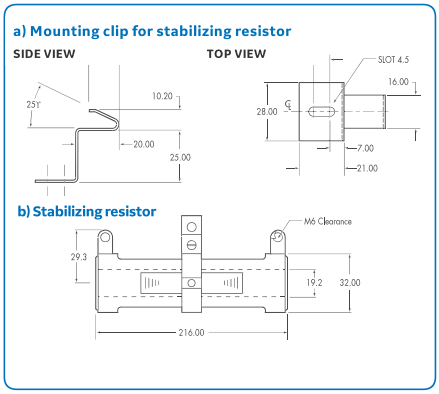

Figure 3: External stabilizing resistor assembly

To ensure that the thermal rating of the stabilizing resistor is not exceeded, it is recommended that the resistor is not set to a value less than 65% of its maximum rated value. For example, a 220 variable resistor should not be used when the required stabilising resistance is less than 140.

In certain applications there is no need to utilise stabilizing resistors in series with the MCAG14/34 (indicated by negative stabilizing resistor value) because the impedance of the relay elements alone will offer sufficient stabilization.

The outline and mounting arrangement drawing for the external stabilizing resistor is shown in Figure 3.

Effective Primary Operating Current

During internal fault conditions, the relay and Metrosil current and the magnetising current of all connected current transformers are supplied from fault current. The primary operating current is given by:

$$I_{op} = n (I_R + NI_\mu)$$

where:
I_R = relay setting current (plus Metrosil current at setting voltage if used)
I_μ = current transformer magnetizing current at setting voltage (A)
N = number of connected current transformers
n = current transformer turns ratio

Metrosil (Non-Linear Resistors)

A Metrosil is required to limit the CT output voltage under an internal fault condition if the peak voltage developed (Vp) is greater than 3 kV. The voltage spike (Vp) due to CT saturation is calculated from:

$$Vp = \sqrt{2VkA(Vf-VkA)}$$

$$Vf = If_{int} (Rs+Rp+Rsr+\frac{VA}{Ir^2})$$

where:
If_{int} = maximum secondary internal fault current
VkA = actual CT knee-point voltage

The exact Metrosil rating will depend upon the application and is based on the following details:

- CT secondary current rating
- Relay stability voltage (VsA)
- Maximum secondary internal fault current in Amps (If_{int})

The outline and mounting arrangement drawings for the external Metrosil units are shown in Figure 4.

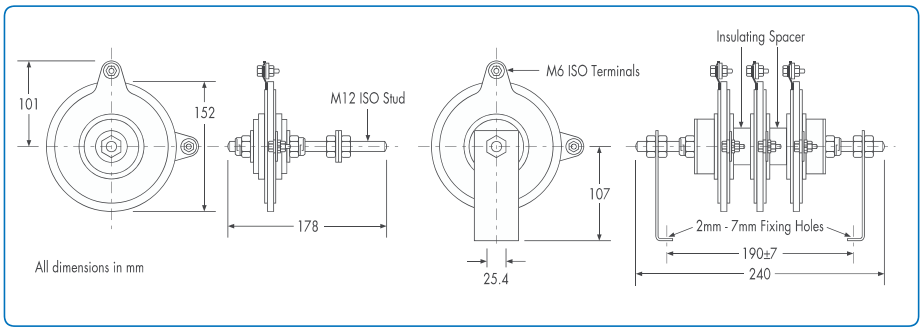

Figure 4: Outlines of external Metrosil units

Technical Data

Rated Frequency
50 Hz and 60 Hz

Burdens
1 VA at setting

Standard Current Settings
5% - 20%, 10% - 40% or 20% - 80% of 0.5 A, 1 A or 5 A (CT secondary), adjustable by plug setting bridge in seven equal steps.

Operating Time
Typically 25 ms at 5 x current setting. See figure 5.

Thermal Withstand
Relay
- 5 times tap setting continuous
- 20 times tap setting for 3 stabilizing resistor

Contacts
Two pairs of make self-resetting contacts are provided on single element relays and two on three element relays. In three element relays the contacts are connected in parallel, as shown in Figure 1, or brought out to separate case terminals if required.

Contact Rating
- Make and carry continuously

AC 1250 VA with maxima of 5 A or 300 V DC 1250 W with maxima of 5 A or 300 V

- Make and carry for 3s

AC 7500 VA with maxima of 30 A or 300 V DC 7500 W with maxima of 30 A or 300 V

- Break

AC 1250 VA with maxima of 5 A or 300 V DC 100 W (resistive) 50 W (inductive) with maxima of 5 A or 300 V.

Resistor value (O)(1)	Maximum current withstand (A)		
	Continuous	3 second (2)	1 second (2)
24	2.45	9.00	11.50
47	1.76	7.70	10.00
100	1.20	5.30	6.90
150	0.98	4.30	5.60
220	0.81	3.60	4.60
270	0.73	3.20	4.20
470	0.56	2.40	3.20
820	0.42	1.80	2.40
1000	0.38	1.67	2.20
1500	0.31	1.36	1.80
2700	0.23	1.00	1.30
5600	0.16	0.71	0.92

(1) - The resistance tolerance is ±10%
(2) - The 3 second & 1 second rating values are Grid Solutions calculated values

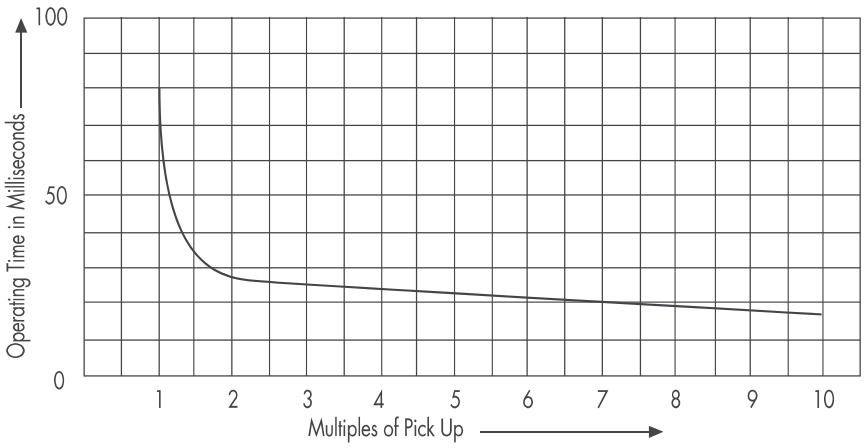

Figure 5: Time/current characteristic

Simple, reliable and secure unit protection

High Voltage Withstand

- Dielectric withstand

IEC 60255-5:1977
2 kV rms for 1 minute between all terminals and case earth 2 kV rms for 1 minute between terminals of independent circuits, with terminals on each independent circuit connected together 1 kV rms for 1 minute across open contacts of output relays.

- High voltage impulse

IEC 60255-5:1977
Three positive and three negative impulses of 5 kV peak, 1.2/50 s, 0.5 J between all terminals of the same circuit (except output contacts) between independent circuits, and between all terminals connected together and case earth.

Electrical Environment

- High frequency disturbance

IEC 60255-22-1
Class III
2.5 kV peak between independent circuits and case. 1.0 kV peak across terminals of the same circuit. No additional tolerances are required for the operating time of the unit's thresholds.

- EMC Compliance

CE 89/336/EEC

Compliance to the European Commission Directive on EMC is claimed via the Technical Construction File route. Generic Standards were used to establish conformity.

EN 50081-2:1994
EN50082-2:1995

Product Safety

CE 73/23/EEC

Compliance with the European Commission, Low voltage directive EN61010-1:1993/A2:1995, EN60950:1992/A11:1997. Compliance is demonstrated by reference to generic safety standards.

Atmospheric Environment

- Temperature
  IEC 60255-6 Storage and transit -25ºC to +70ºC, Operating -25ºC to +55ºC,
  IEC 60068-2-1 Cold
  IEC 60068-2-2 Dry heat
- Humidity
  IEC 60068-2-3 56 days at 93% RH and +40ºC
- Enclosure protection
  IEC 60529 IP50 (dust protected)

Mechanical Environment

- Vibration
  IEC 60255-21-1 0.5g between 10 Hz and 150 Hz
- Mechanical durability
  Loaded contact 10,000 operations minimum
  Unloaded contact 100,000 operations minimum

Cases

Type MCAG 14 (single element) and MCAG 34 (three element) relays are supplied in 15TE (size 3) and 30TE (size 6) cases respectively. These are shown in Figures 6 and 7.

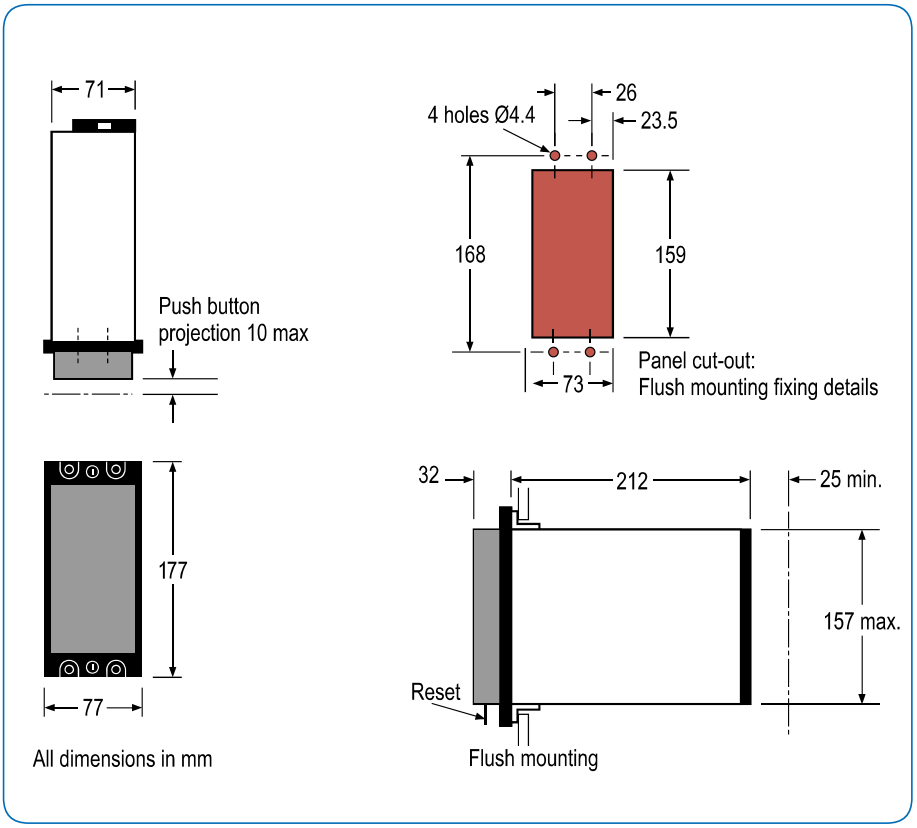

Figure 6: Case outline 15TE (size 3)

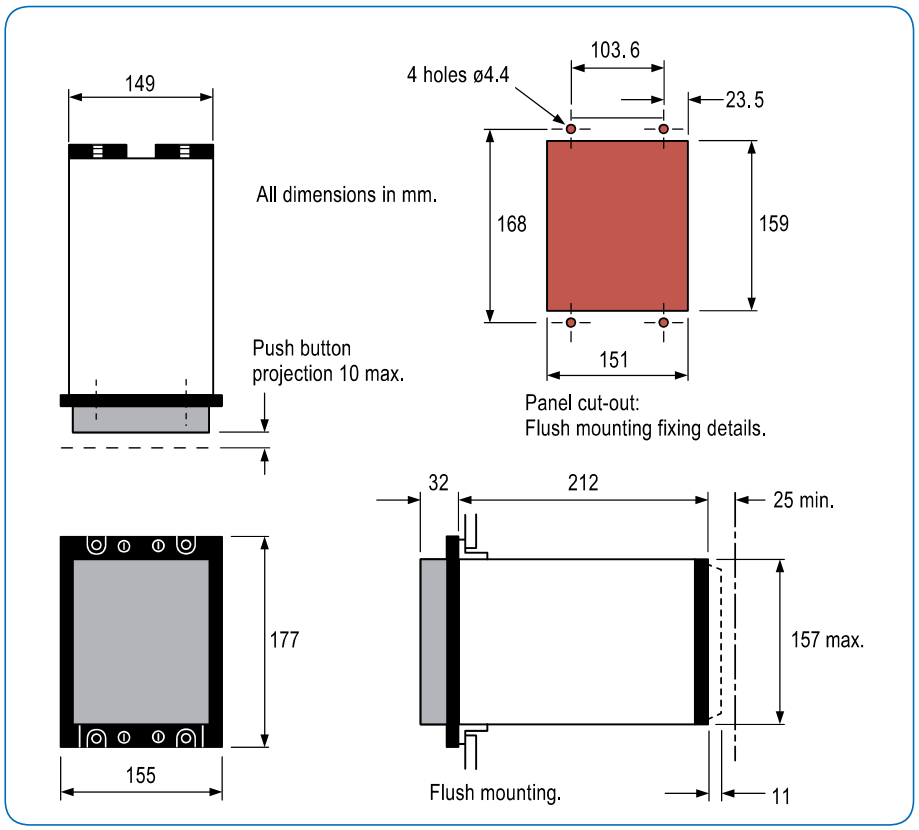

Figure 7: Case outline 30TE (size 6)

Information Required With Order

Relay Type MCAG — 4

One	1
Three	3

Case Size

15TE (Size 3) Case for MCAG14 only	S
30TE (Size 6) Case for MCAG34 only	V

Contact Wiring

Segregated contacts	S
Common contacts (MCAG34 only)	C

Frequency & Flagging

	50Hz	60Hz	
Without Flag	●		A
With Hand Reset Flag	●		B
Without Flag		●	C
With Hand Reset Flag		●	D

CT Secondary & Setting Range

	0.5A	1A	5A	
5 - 20% Setting	●			A
10 - 40% Setting	●			B
20 - 80% Setting	●			C
50 - 200% Setting	●			D
5 - 20% Setting		●		B
10 - 40% Setting		●		C
20 - 80% Setting		●		E
50 - 200% Setting		●		F
20 - 80% (A & C) / 10 - 40% (B)		●		J
50 - 200% (A & C) / 20 - 80% (B)		●		K
5 - 20% Setting			●	D
10 - 40% Setting			●	F
20 - 80% Setting			●	G

Stabilising Resistor

No Resistor Supplied	0	0	0	0
Standard Resistor for 0.5A CT Rating	0	4	7	0
Standard Resistor for 1A CT Rating	0	2	2	0
Standard Resistor for 5A CT Rating	0	0	4	7
Non-standard Resistor (24 ohms)	0	0	2	4
Non-standard Resistor (47 ohms)	0	0	4	7
Non-standard Resistor (100 ohms)	0	1	0	0
Non-standard Resistor (150 ohms)	0	1	5	0
Non-standard Resistor (220 ohms)	0	2	2	0
Non-standard Resistor (270 ohms)	0	2	7	0
Non-standard Resistor (470 ohms)	0	4	7	0
Non-standard Resistor (820 ohms)	0	8	2	0
Non-standard Resistor (1000 ohms)	1	0	0	0
Non-standard Resistor (1500 ohms)	1	5	0	0
Non-standard Resistor (2700 ohms)	2	7	0	0
Non-standard Resistor (5600 ohms)	5	6	0	0

Hardware Issue Suffix

Factory Defined

Device Track Record - High Impedance Differential Protection

Over 43,000 MCAG schemes delivered since 1984
Over 21,500 MFAC schemes delivered since 1983

Simple, Reliable, Secure

For more information please contact
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