



Grid Solutions
a GE and Alstom joint venture

MFAC

High impedance differential relay

MFAC relays provide high speed differential protection for various types of power systems plants including generators, reactors, busbars, motors and the individual windings of power transformers.



CUSTOMER BENEFITS

- High speed operation
- Wide range of settings
- Simple application technique
- High stability for through faults
- Compact robust design

The single element version

Type MFAC 14, is applied when protection is required for earth faults only. Applications for protecting power transformer windings are shown in Figure 1. The three element version, Type MFAC 34, provides both phase and earth fault protection. A typical application for generator protection is shown in Figure 2.

An external Metrosil unit having a non-linear resistance characteristic is recommended for each relay element, to limit the peak voltage appearing across the secondary differential circuits under internal fault conditions.

APPLICATION

When circulating current protection schemes are subjected to through faults, the sudden and often asymmetrical growth in the system current can cause the line current transformers to reach saturation. In this condition, variation in transformer magnetising characteristics can cause large ratio errors with a consequent circuit imbalance and maloperation of the protective relays.

To ensure stability, it is common practice to employ high impedance relays set to operate at a slightly higher voltage than that developed in the worst theoretical case of this condition for a given through fault current. On a balanced earth fault system for example, this is when one current transformer of a group is saturated whilst the others remain unaffected.

The saturated transformer presents a low impedance path in parallel with the relay and limits the voltage applied. On internal faults this limitation does not exist and voltages of twice the setting are easily reached.

DESCRIPTION

The relay measuring element is an attracted armature unit of simple and robust construction, supplied from a bridge rectifier. Settings are determined by a series of resistors, selected on a seven-way plug bridge. Relays with a fine control facility have an additional plug bridge, which is calibrated in intermediate settings. An overall setting is obtained by adding together each plug bridge reading. A capacitor is connected in series with the operating coil to make the relay insensitive to the DC component of fault current. The setting voltage can thus be calculated in terms of RMS alternating quantities, without regard for the degree of offset produced by the point on wave at which the fault occurs. A reactor connected in series with the capacitor forms a resonant circuit tuned to the relay rated frequency.

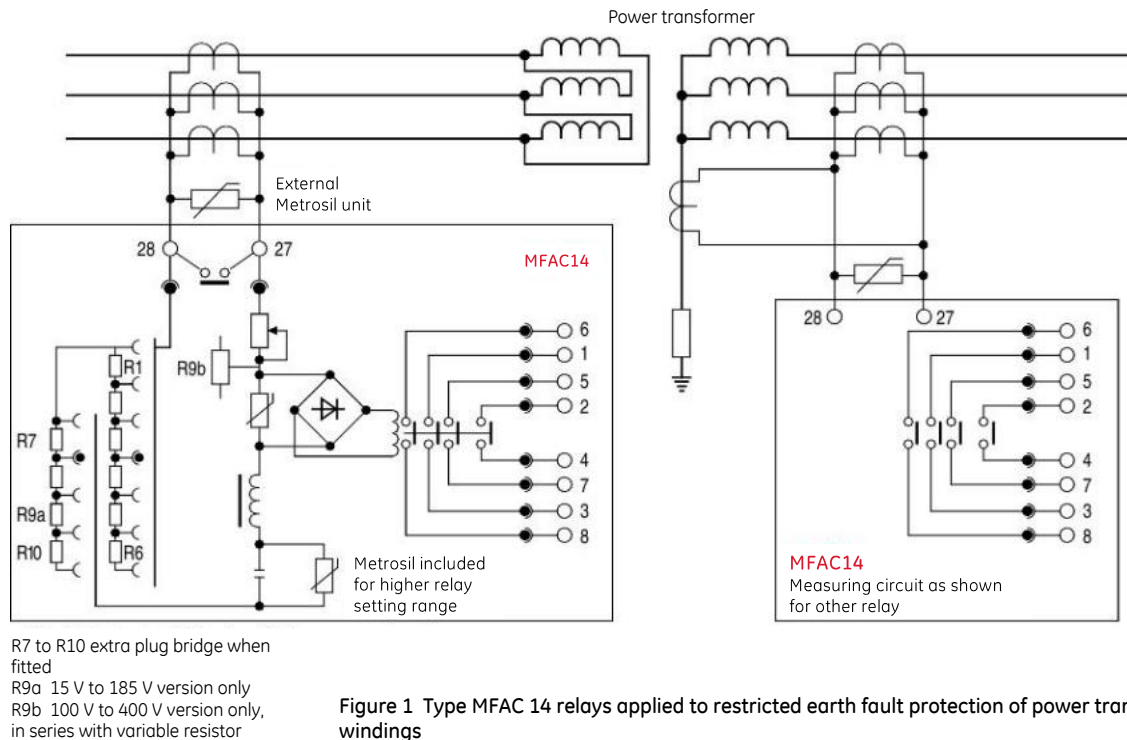


Figure 1 Type MFAC 14 relays applied to restricted earth fault protection of power transformer windings

EXTERNAL METROSIL UNITS

Single element or three element Metrosil units are provided with single element or three element relays respectively. The type of Metrosil characteristic differs for each of the alternative relay setting ranges. The nominal characteristic for a Metrosil unit is conventionally of the form $V = C I^\beta$, specified in DC quantities for convenience in some applications and also to facilitate testing during manufacturing.

The constant (C) and the index (β) are nominally fixed for a particular Metrosil design. Hence, when a sinusoidal voltage is applied across the Metrosil, the rms current drawn by the Metrosil is given by:

$$I_{(rms)} = \frac{0.52 (V^2 V1)^{1/\beta}}{C}$$

V1 = voltage (V, rms sinusoidal)

This approximates the circuit conditions at the voltage setting. Details of the alternative Metrosil designs used with MFAC relays are given in the Technical Data section.

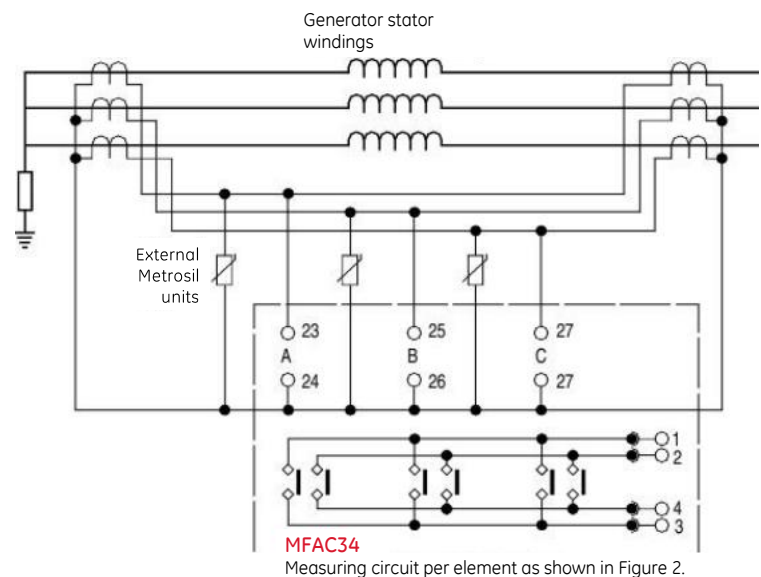


Figure 2 Type MFAC 34 relay applied to phase and earth fault protection of a generator

Reliable and secure
high impedance unit protection

TECHNICAL DATA

Rated frequency

50/60 Hz

Operating time

The operating time characteristics are shown in Figures 3 & 4

Operating current

Setting range	Setting selections	Nominal operating current for relay alone:
15 to 185 V	35 equal 5 V steps	38m A at setting
25 to 175 V	7 equal 25 V steps	19m A at setting
25 to 325 V	7 equal 50 V steps	19m A at setting
100 to 400 V	7 equal 50 V steps	19m A at setting

METROSIL CHARACTERISTICS

Standard with a single 152.4 mm disc per element (maximum secondary internal fault current <50 A [rms])

Relay setting range	Nominal characteristics	
	C	
15 V to 185 V	450	0.25
25 V to 175 V	450	0.25
25 V to 325 V	900	0.25
100 V to 400 V	1100	0.25

Each characteristic is shown graphically in detail in Figure 5.

Contacts

Four 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 2, or brought to separate case terminals if required.

Contact ratings

- Make and carry - AC 1250 VA with maxima of 5 A continuously and 660 V
DC 1250 W with maxima of 5 A and 660 V
- Make and carry for 3 seconds - AC 7500 VA with maxima of 30 A and 660 V
DC 7500 W with maxima of 30 A and 660 V
- Break - AC 1250 VA with maxima of 5 A and 660 V
DC 100 W (resistive) 50 W (inductive)
with maxima of 5 A and 660 V

Durability

Load contact 10,000 operations minimum

Unloaded contact 100,000 operation minimum

Operation indicator

A hand reset operation indicator is fitted to each element as standard.

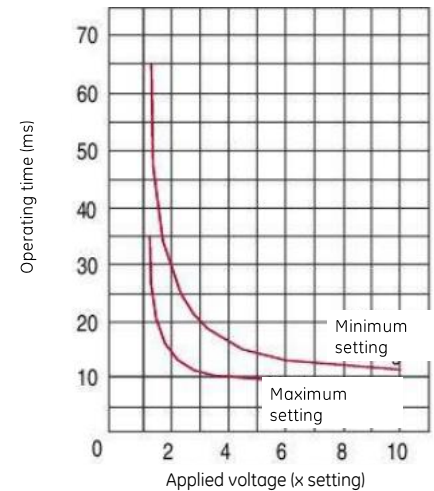


Figure 3
Typical time operating characteristics

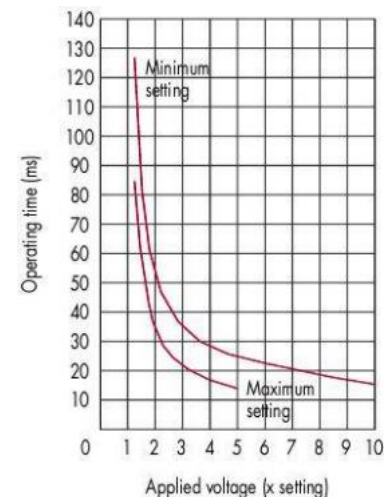


Figure 4 Typical time operating characteristics for 15-185 V relays only

Current transformer requirements

Type MFAC 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. The knee-point voltage is defined as the point on the magnetisation curve at which a 10% increase in excitation voltage produces a 50% increase in excitation current. For use with type MFAC relays, the knee-point voltage (V_k) should be at least twice the voltage setting, thus $V_k = 2 V_s$ actual.

Selection of optimum relay setting

The required voltage setting (V_s) is calculated using the formula:

$$V_s = I_f (R_{ct} + 2R_w) \text{ volts } n$$

where

I_f = maximum primary through fault current for which stability is required (A rms)

n = current transformer turns ratio

R_{ct} = current transformer secondary winding resistance (ohms)

R_w = resistance of each lead between the relay and current transformer (ohms)

A value of V_s is calculated for each current transformer circuit in the differential system, and the relay setting finally chosen (V_s actual) is made equal to, or nearest above the highest of these calculated values.

Effective primary operating current

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

$$I_{op} = n (I_R + N I_m)$$

where

I_R = relay operating current and Metrosil current at setting voltage, as given in the table below

I_m = current transformer magnetizing current at setting voltage (A)

N = number of connected current transformers

n = current transformer turns ratio

Setting range (V)		15	50	75	100	125	150	175	185
I_R	Nominal (mA)	38	38	39	42	46	55	72	81
	Limits (mA)	37 - 39	37 - 39	37 - 42	38 - 47	39 - 58	43 - 79	52 - 114	62 - 125
Setting range (V)		25	50	75	100	125	150	175	
I_R	Nominal (mA)	19	19	20	23	27	36	53	
	Limits (mA)	18 - 20	18 - 20	18 - 23	19 - 28	20 - 39	24 - 60	33 - 95	
Setting range (V)		25	75	125	175	225	275	325	
I_R	Nominal (mA)	19	19	20	22	24	31	44	
	Limits (mA)	18 - 20	18 - 20	18 - 22	19 - 25	19 - 33	22 - 48	28 - 76	
Main setting range (v)		100	150	200	250	300	350	400	
I_R	Nominal (mA)	19	19	20	20	23	27	36	
	Limits (mA)	18 - 20	18 - 20	18 - 23	18 - 23	19 - 28	20 - 39	24 - 60	

Should the natural effective operating current after applying the above formula be lower than designed, it can be raised to the required level by adding a shunt resistor across the differential relay input circuit.

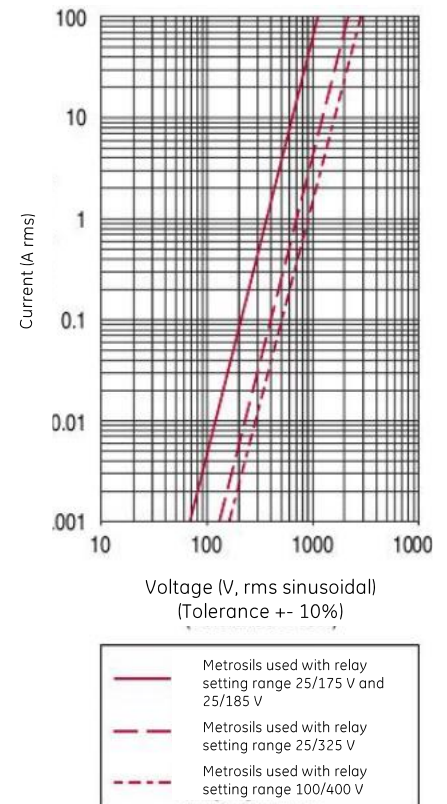


Figure 5 Nominal and extreme AC characteristics of external Metrosils for use with MFAC relays

Thermal withstand ratings

- Continuous ratings: MFAC relays
- Relay setting range: 15 - 185 V and 25 175 V
- Continuous rating: 2x the selected setting

Relay setting range		25 - 325 V							
Setting		25	75	125	175	225	275	325	
Continuous Rating	As multiple of setting	2	1.7	1.7	1.7	1.7	1.6	1.5	
	As voltage	50	128	213	297	383	440	487	
Relay setting range		100 - 400 V							
Setting		100	150	200	250	300	350	400	
Continuous rating	As multiple of setting	1.7	1.7	1.7	1.65	1.55	1.5	1.45	
	As voltage	170	255	340	413	465	525	580	

Continuous ratings - Metrosil units (Standard, with single 152.4 mm disc per element)

'C' characteristic	Continuous rating (V)
450	225
900	400
1100	480

Short-time rating - Metrosil unit:

Metrosil arrangement	'C' characteristic	Short time rating
Standard		
Single 152.4 mm disc per element, (maximum secondary internal fault current <50 A [RMS])	450	22 A for 3 s 45 A for 1 s
	900	17 A for 3 s 39 A for 1 s
Special		
Each element comprising two special discs in parallel	900	30 A for 3 s 90 A for 1 s
Single 152.4 mm disc per element, (maximum secondary interval fault current <30A [RMS])	1100	19 A for 3 s 26 A for 2 s *46 A for 1 s

* At this level the maximum protection level is 3400 V peak

The Metrosil unit is the limiting component with respect to short time rating. Where higher ratings are required, special Metrosil units can be provided with more discs in parallel per element, to suit a particular application.

High voltage withstand

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

Simple to set,
simple to use

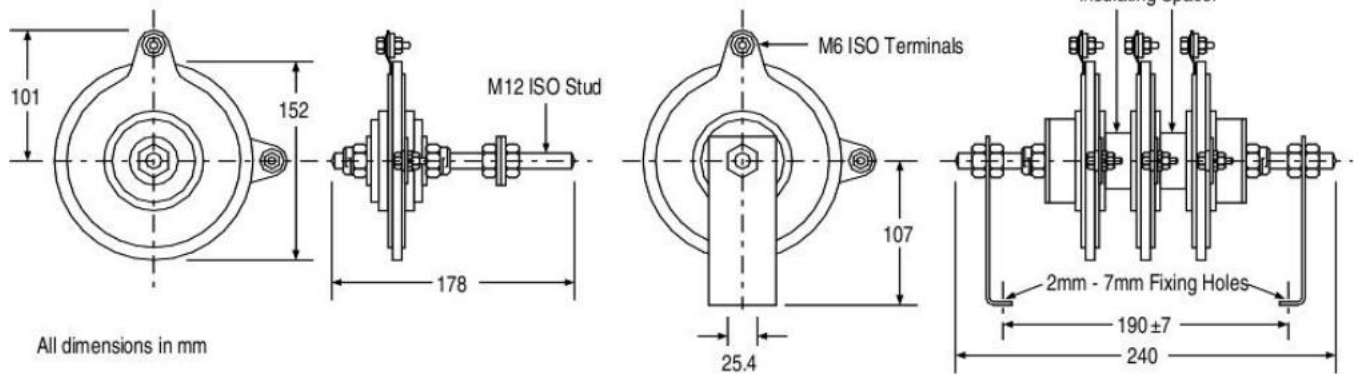


Figure 6 Outlines of external Metrosil units

Electrical environment

- EMC compliance -89/336/EEC
Compliance with the European Commission Directive on EMC is claimed via the Technical Construction File route.
- EN 50081-2:1994,
EN 50082-2:1995 Generic standards were used to establish conformity.
- Product safety - Compliance with the European Commission Low voltage directive claimed via the Technical Construction File route. 73/23/EEC
- EN61010-1:1993/A2:1995
EN60950:1992/A11:1997
Compliance is demonstrated by reference to generic safety standard.

Atmospheric environment

- Temperature IEC 60255-6:1988
Storage and transit -25°C to +70°C,
Operating -25°C to +55°C
- IEC 60068-2-1:1990 - Cold
- IEC 60068-2-2:1974 - Dry heat
- Humidity IEC 68-2-3:1969 - 56 days at 93% RH and +40°C
- Enclosure protection IEC 60529:1989 - IP50 (dust protected)

Mechanical environment

- Vibration IEC 60255-21-1:1998 -
Response Class 1

Metrosils

The outline and mounting arrangement drawings for the external Metrosil units are shown in Figure 6.

Cases

Type MFAC 14 (single element) and MFAC 34 (three element) relays are supplied in 15TE (size 3) and 30TE (size 6) cases respectively. These are shown in Figures 7 and 8.

Figure 7 Case outline 15TE (size 3)

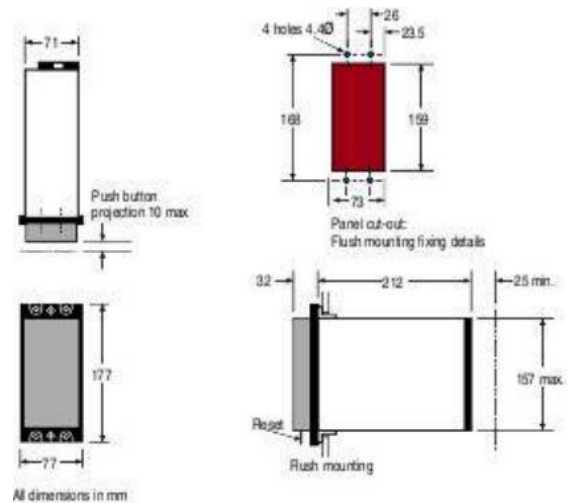
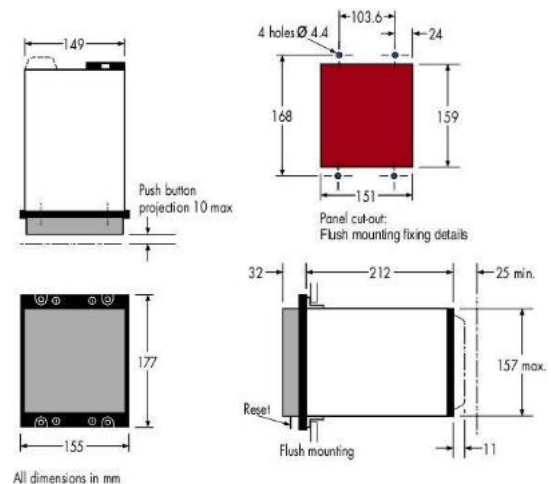


Figure 8 Case outline 30TE (size 6)



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

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