



ICE



TECHNIREL

DMS 7000

DIGITAL DIFFERENTIAL PROTECTION RELAYS

**Protection and Control for Electrical Networks
HV and EHV . MV . Industrial . Railway**

INDUSTRIELLE DE CONTÔLE ET D'EQUIPEMENT

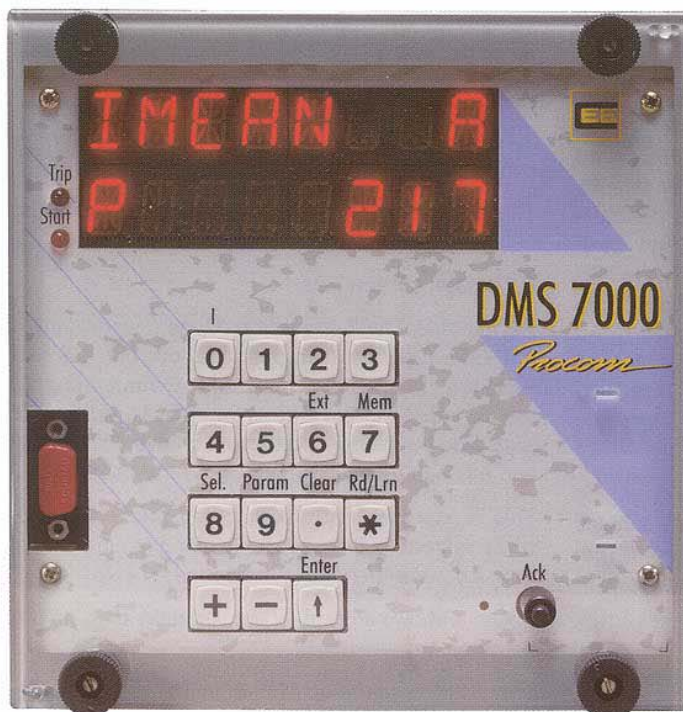
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DMS 7000

Procom



**DIGITAL
DIFFERENTIAL
PROTECTION
RELAYS**



The ultimate in power network supervision

The optimum performance of electrical power systems depends particularly upon the reliability, the availability and communications aptitude of the protection, measuring and automation devices.

PROCOM, C.E.E.'s modular system, satisfies these criteria and offers, either separately or in an integrated system, all of the intelligent functions of an electrical switchboard cubicle: Protection, Measurement, Automation and Communications to PROSATIN supervisory systems.

C.E.E.'s exceptional experience in the field of power system protection using static relays (more than 450,000 units in operation throughout the world) has enabled our engineers to define, develop and manufacture PROCOM to the standards of quality and concepts of technical innovation which have been the foundation of C.E.E.'s reputation over the past 30 years.

PRINCIPLES AND APPLICATIONS

DMS 7000 series relays are designed to provide differential protection to two winding transformers, rotating machines (motors or generators) as well as generator-transformer or motor-transformer units connected to 50/60 Hz three phase electrical networks. In certain circumstances, they can also be used to protect three-winding three-phase transformers.

Being of a modular design, they fit perfectly into the PROCOM architecture or can be used separately in any traditional relay scheme.

Using digital microprocessor technology, the DMS 7000 samples the applied signals 16 times per cycle and calculates by FFT (Fast Fourier Transform) the currents I_P and I_S entering and leaving the protected zone, as well as calculating their vectorial difference $I_D = I_P - I_S$ which is the differential current. Depending upon the application, the DMS 7000 may calculate the percentage of 2nd and 5th harmonics present in the differential current I_D . Under normal circumstances, the differential current is zero (Kirchoff's law). An instantaneous trip command is given if the differential current I_D exceeds the setting threshold. As a result, the DMS 7000 provides high speed protection against all types of severe phase or earth faults.

The DMS 7000 is remarkable because of its wide operating frequency range (8 Hz - 70 Hz) making it particularly suitable to supervise machines whose frequency can vary widely (run up or over speed of hydro generators, low short circuit power island networks, ...).

The DMS 7000 series is made up of two families :

- The DMS 7001, designed for the protection of synchronous or asynchronous generators or motors.
- The DMS 7002, designed for the protection of two winding transformers and generator-transformer or motor-transformer units

.Amplitude and phase correction

Very often interposing current transformers are required to correct the amplitude and/or phase angle of the currents supplied by the line current transformers to a differential relay.

The DMS 7000 eliminates the need for interposing current transformers in normal applications.

The amplitude of the currents I_P and I_S supplied by the current transformers on each side of the protected zone can be corrected separately (50 to 150% I_N) in order to obtain $|I_P| = |I_S|$ under normal operating conditions.

The DMS 7002 corrects the amplitude errors and phase angle shifts caused by power transformer vector group connections (YY, YD, DY, DD, or YdY). In addition, it filters out the zero sequence currents which may only appear on one side of the equipment.

.Low set $I_{D>}$ [87-1] element

The low set $I_{D>}$ element gives the DMS 7000 a very sensitive detection of fault conditions (a few percent of rated current). But, in actual operating conditions, the accuracy limits of the line current transformers or power transformer magnetising currents can compromise the stability of a differential protection.

This is why the DMS 7000 has several methods aimed at optimising the ratio sensitivity/stability :

- Through current bias.

Asymmetrical fault currents produce a significant increase in the operating flux around the current transformer (ct) windings. In such circumstances, the operating accuracy of the cts supplying the differential relay is reduced. If the fault is outside the zone of protection, a false differential circulates and this can result in an unwanted trip command.

This is why the DMS 7000 is designed with a bias feature which increases the apparent setting $I_{D>}$ in proportion to the average current crossing the zone $I_Z = (|I_P| + |I_S|)/2$.

Figure 1 shows a graph of the variation in $I_{D>}$ as a function of I_Z .

This graph is made up of 3 regions:

- Region 1, corresponds to the equipment's normal operating range ($0 < I_Z < I_N$).
The relay is at its most sensitive in this range, as the $I_{D>}$ setting threshold remains constant
- Region 2, corresponds to the equipment's overload range or moderate level through fault currents ($I_N < I_Z < K_B I_N$).
The line cts operating inaccuracies start to become significant.
The $I_{D>}$ threshold increases linearly, defined by a slope $s1\%$ adjustable from 10 to 50% (DMS 7002) or 5 to 50% (DMS 7001). The operator can adjust the extent of this region using the K_B setting.
- Region 3, corresponds to high level through fault currents ($K_B I_N < I_Z$). The line cts are subject to a loss of accuracy, resulting in significant levels of false differential currents.
The $I_{D>}$ threshold increases linearly, defined by a slope $s2\% = 65\%$.

To improve its stability, the DMS 7001 can also use stabilising resistors.

- Energising magnetising inrush currents [DMS 7002].

Power transformer magnetising inrush currents can exceed, depending upon the moment of switch-on, a level of 10 I_N and then die away exponentially depending upon natural time constants (some tenths to tens of seconds). As these currents only appear on one side, they are seen as differential currents above the setting threshold. In order to prevent such unwanted trips, the DMS 7002 inhibits the low set element $I_{D>}$ when the 2nd harmonic current, characteristic of magnetising currents, is above a predetermined level with respect to the fundamental component of the differential current.

- Magnetising currents resulting from over voltage [DMS 7002].

When a power transformer is subjected to an over voltage, it goes into saturation and absorbs a high level of magnetising current, seen as a differential current by the differential relay. Analysis of the waveform of these magnetising currents shows a high level of 5th harmonic. Under these conditions, the detection of these currents is used to stabilise the relay.

However, above a certain voltage, the level of 5th harmonic can fall away to the point that this method of inhibition may not operate correctly: In this case, it is generally accepted that the magnetising currents are so high that it is best to disconnect the power transformer as quickly as possible.

The DMS 7002, thanks to its 5th harmonic detection feature, puts the decision to inhibit or not to inhibit the relay in the presence of magnetising currents caused by over voltages in the hands of the user. In any case, the application criteria used with this inhibition need to be checked.

.High set $I_{D>>}$ [87-2] element

The DMS 7000 high set $I_{D>>}$ element is used to eliminate severe faults as rapidly as possible, even if the line cts are partially saturated. This is why the $I_{D>>}$ element does not have any bias and uses a reliable peak measurement method on the differential currents (acquisition and immediate processing of 16 samples per cycle on each phase).

To ensure that the relay remains stable, the $I_{D>>}$ setting must take into account the false differential currents likely to appear under normal operating conditions (magnetising currents, caused by through zone currents, etc...).

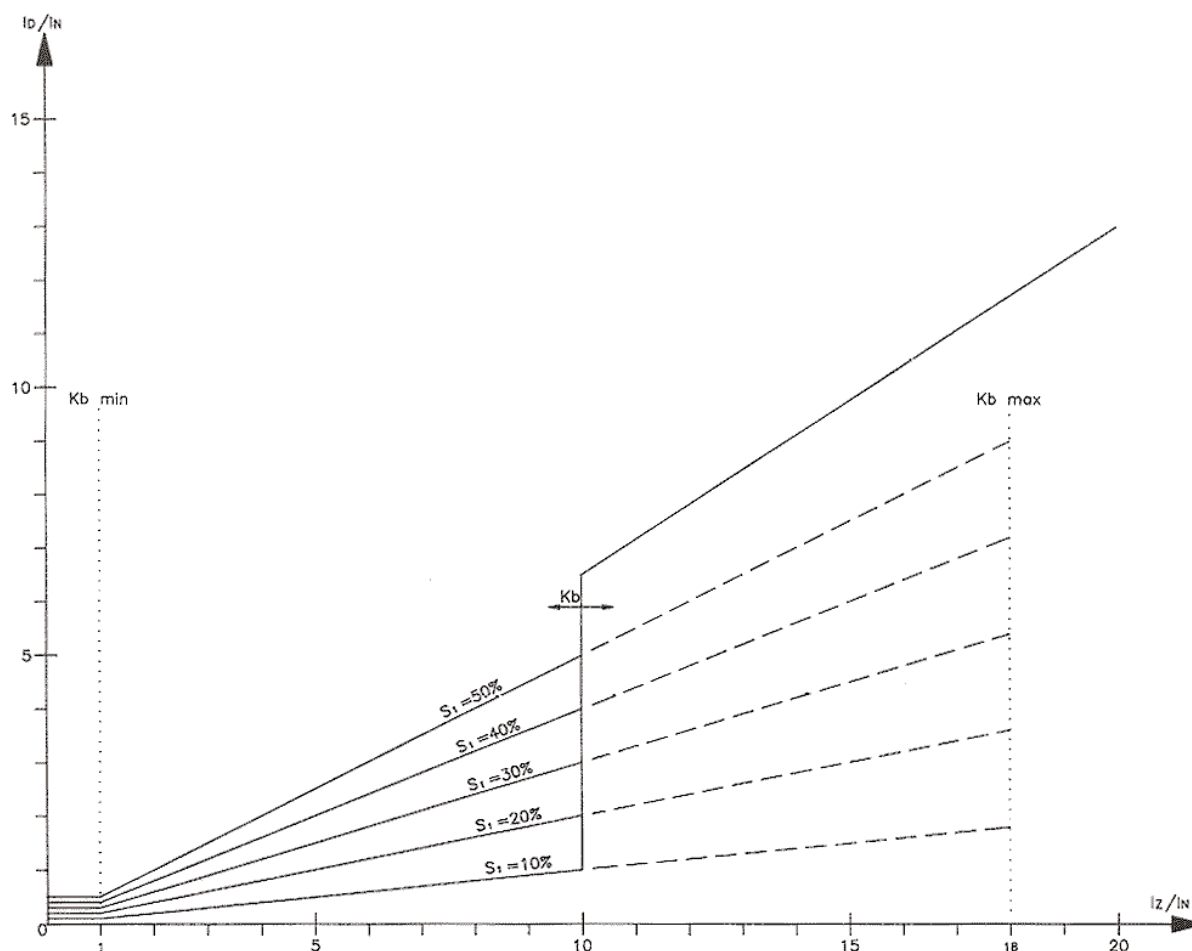


Figure 1 : $I_{D>}$ Setting as a function of the through zone current I_Z (DMS 7001 : $s1\% = 5-50\%$)

*Please contact us.

MAIN ADVANTAGES

DMS 7000 relays offer the following three main sets of advantages:

- Reliability and availability

The design and construction of this equipment meet the same standards of reliability and safety used by C.E.E. for the manufacture of conventional static protection devices:

- Compliance with I.E.C.255 recommendations and standards;
- Mechanical, fool-proof fouling pins on cases and bases;
- Debugging and individual testing of certain critical components;
- Component selection based upon not only thermal withstand but also over voltage considerations, etc...;
- Withstand to severe environmental conditions: heat/humidity 56 days, 40°C, 93% relative humidity.

In addition to these basic construction details, DMS 7000 relays incorporate an automatic self-supervision system which, together with the plug-in case facility, optimises their availability.

The automatic self-supervision system intervenes at three different levels:

- Detection of loss of auxiliary supply;
- Detection of a microprocessor failure using a "watchdog";
- Detection of a breakdown in a microprocessor peripheral (such as RAM, EEPROM, etc...) by executing microdiagnostic programs.

The user is notified that the automatic self-supervision system has operated by the closure of a volt free contact brought out to terminals and/or, if the case arises, by the interruption of the digital communication channel.

- Power and flexibility of the communications

DMS 7000 series devices communicate with the external world in three major ways:

.Local communication

Dialogue between the user and the equipment is ensured by means of a keyboard on the device itself, which may be used to set up and read back all of the quantities, recorded, calculated or measured by the DMS 7000. The user is also provided with a serial port for connection to a PC to assist in direct communication with the relay thanks to the "PROSETTING" program which is available separately*.

A password supervises any setting changes.

An easy to read LED display unit enables the user to have direct readout of the electrical quantities in true primary values.

Measured values greater than the operating thresholds and trip conditions are indicated by LEDs; orange and red

respectively. In the event of a trip, the display shows the function that initiated the trip, and then if requested by the operator the level of differential current measured by $I_{D>}$ or $I_{D>>}$.

The last 5 individual events of each type : $I_{D>}$ or $I_{D>>}$ trip and, alarm or trip via the two external contacts (see communications by "all or nothing" channels) can be interrogated using the Mem key.

The currents measured on each side of the zone of protection are displayed in primary values (before phase and amplitude correction) or in secondary values (after phase and amplitude correction). The default display is the three phase mean current.

.Communication by digital channels

The DMS 7000 case is equipped with 2 serial digital communications channels, RS-232-C/DB9 and current loop (0-20mA).

The RS-232-C/DB9 socket on the face plate enables the relay to be directly connected to a PC, either by emulating a terminal for local monitoring without interrupting the current loop communications, or by connection to a system using a data exchange protocol such as J-Bus or others.*

The (0-20mA) current loop plugs enable the relays to be connected into a network controlled by a PC or other equipment.*

All data available locally, measurements, alarms or settings, may be transmitted to a remote location.

When an event, such as the relay tripping, occurs or upon receipt of a command via the communications, the IP and IS measurement samples (before phase and amplitude correction) and those of the three-phase differential currents I_D are recorded for 1 second (approximately 2/3 prior to the event and 1/3 after it). Given that the DMS 7000 samples 16 times per cycle, it acts as a mini disturbance recorder monitoring the protected equipment.

When used in a PROSATIN system, the DMS 7000 time stamps any setting changes, when any thresholds are exceeded, alarms, trips and the two contact inputs.

.Communication by "all or nothing" channels

- Inputs

DMS 7000 relays include two isolated volt free contact inputs which can be used to temporarily inhibit certain functions or to accept trip commands coming from external devices such as thermostats, Buchholz, etc ...

- Outputs

DMS 7000 relays are fitted with 6 electromagnetic output units for self-supervision, alarm, trip or close signals:

- Self-supervision : a volt free contact from the "watchdog" device (unit W).
- Alarm and tripping via the A, B, C, D, E relays.

*Please consult us

The configuration of $I_{D>}$ or $I_{D>>}$ functions and of external alarms or trips to the A, B, C, D relays is completely under the control of the user. The high speed relay E can only be initiated by the $I_{D>>}$ function.

- Adaptability and autonomy

As they are mounted in modular, plug-in, metallic type R cases, DMS 7000 series devices may be used either:

- as independent modules.
- as modules integrated into a rack incorporating conventional static relays from the 7000 series.

- as modules integrated into a rack as an element of a PROCOM/PROSATIN structure.

This flexible presentation means that the DMS 7000 devices may be easily adapted to the user's actual technical and economic requirements and can, for example, be inserted into existing installations.

The DMS 7000's autonomous and flexible nature is further reinforced by the fact that it can, without the use of special devices, be connected to a source of ac or dc auxiliary supply having a very wide operating range (48 to 250V, or 24 to 70V).

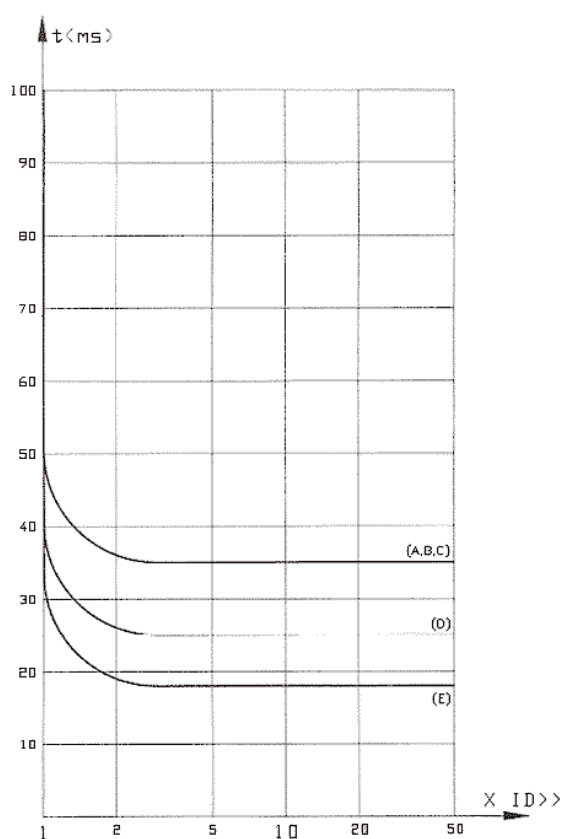


Figure 2 : $I_{D>>}$ setting operating time

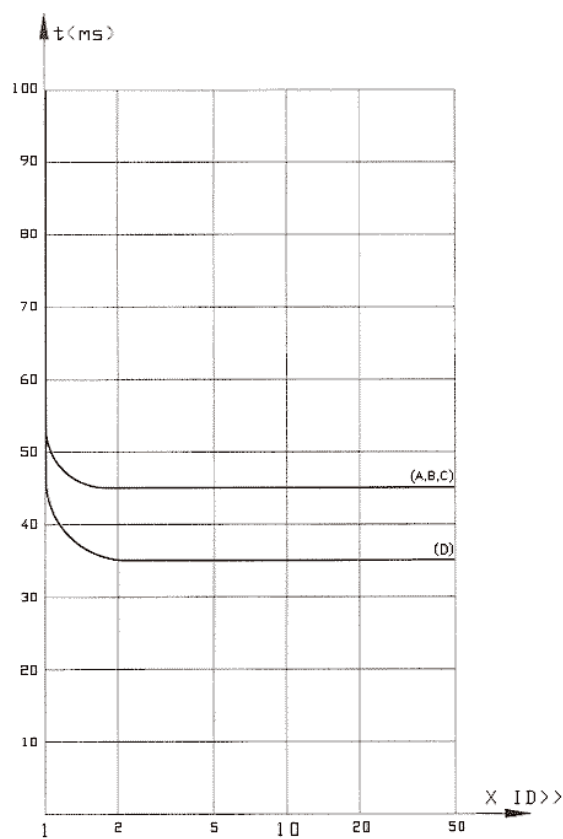


Figure 3 : $I_{D>}$ setting operating time

GENERAL CHARACTERISTICS

1 - Input and output quantities

Current

current transformer rated current	
line side (DMS 7001)	
primary side (DMS 7002).....	I_n : 1A or 5A
neutral side (DMS 7001)	
secondary side (DMS 7002)	I_n : 1A or 5A
machine or transformer rated current.....	I_N
machine or transformer current	
line or primary side	I_P
neutral or secondary side	I_S
differential current I_D	$I_D = I_P - I_S$
through zone current I_Z	$I_Z = (I_P - I_S)/2$
line currents	Line or primary side I_{AP}, I_{BP}, I_{CP}
.....	Neutral or secondary side I_{AS}, I_{BS}, I_{CS}
mean current I_{mean}	$I_{mean} = (I_A + I_B + I_C)/3$
• display :	
Transformer or machine rated current setting	I_N : adjustable from 10A to 10000A (1A step)
measurement range.....	0 to 20In (DMS 7001), 0 to 40In (DMS 7002)
resolution	1A or in secondary values : 0.1%
display in Amps or in secondary values (% of In)	$I_{mean}, I_{AP}, I_{BP}, I_{CP}, I_{AS}, I_{BS}, I_{CS}$
display in secondary values (% of In).....	I_{AP}, I_{BP}, I_{CP} (after correction)
	I_{AS}, I_{BS}, I_{CS} (after correction)
	I_D (per phase)
• overload :	
short time.....	20In/3s - 80In/1s
continuous	2In
• burden.....	<0.2VA at In on each current input
• recommended current transformers:	$V_k = 4 I_f (R_{ct} + R_s)$
	V_k : magnetising curve knee point voltage
	or saturation emf of the line cts.
	I_f : Maximum current crossing the protected zone.
	R_{ct} : Line ct internal resistance.
	R_s : Secondary resistance (go and return wiring + relay)

Frequency

rated frequency.....	f_n : 50 Hz or 60 Hz (selectable)
operational range.....	8 to 70 Hz
frequency measurement.....	based upon I_{BP} and I_{CP}
	(measurement threshold approx 5% In)

Auxiliary voltage

range.....	24 to 70 Vdc or Vac - 50/60 Hz
	48 to 250 Vdc or Vac - 50/60 Hz
burden.....	approx 11 W - DC auxiliary supply
	approx 16 VA - AC auxiliary supply

Output contacts

units A, B, C.....	2 NO or 1NO + 1 NC
units D, E	1 NO
unit W (watchdog relay)	1 NC
maximum voltage.....	A, B, C 600V
	D, E, W 250V
maximum continuous current	A, B, C 5 A
	D, E, W 2.5 A
closing capacity 0.2s	A, B, C 10 A
	D, E, W 5 A
rupturing capacity	
dc (L/R = 40 ms).....	A, B, C 50W (1A/48VDC - 0.5A/110VDC)
	D, E, W 25W (0.5A/48VDC - 0.25A/110VDC)
ac (cos ϕ = 0.4)	A, B, C 1250VA : I<3A
	D, E, W 625VA : I<1.5A

All or nothing inputs :

operating voltage	same as the auxiliary supply range
operational logic for the 2 T & V inputs	
T input	responds to permanent condition
V input	responds to change of state (1s time delay after command reset)

GENERAL CHARACTERISTICS (CONT'D)

T input operation (2 possible functions)	
T configured as T1	responds to alarms or trip commands from protections associated with the equipment
T configured as T2	ID> and ID>> elements temporarily put out of service
V input operation	responds to alarms or trip commands from protections associated with the equipment
burden	<5mA per input
operating level	approximately 24V
watchdog condition	Relay picked up under normal conditions (contact open), drops off in the event of an abnormal condition (contact closed)
2 - Protection	
• Functions	
motor or generator differential protection	DMS 7001
two winding transformer differential protection	
generator-transformer unit differential protection	
motor-transformer unit differential protection	DMS 7002
low-set differential $I_{D>}$	Ansi code :[87-1]
high-set differential $I_{D>>}$	Ansi code :[87-2]
• Characteristic values	
$I_{D>}$	differential rms current
$I_{D>>}$	differential peak current
• Routing to output relays	
$I_{D>}$	units A, B, C, D
$I_{D>>}$	unit E + units A, B, C, D
functions controlled by T(T1) and V inputs	units A, B, C, D
• Through fault stability range	
DMS 7001	0 to 20In
DMS 7002	0 to 40In
• Operating logic	
$I_{D>}$	operation when one of the differential currents calculated for the 3 phases exceeds the threshold
through zone bias I_z	see figure 1
harmonic restraint (DMS 7002)	operation blocked when the level of 2 nd and/or 5 th harmonic exceeds a threshold
$I_{D>>}$	operation when one of the differential currents calculated for the 3 phases exceeds the threshold
• Phase and amplitude correction	
- input current amplitude correction	
line or primary side	K_p : 50 to 150% (1% step)
neutral or secondary	K_s : 50 to 150% (1% step)
- input current phase angle correction (DMS 7002)	
primary side : allowable vector groups ICTP	YD1 - YD3 - YD5 - YD7 - YD9 - YD11 - YY0 - YY2 - YY4 - YY6 - YY8 - YY10 - YdY0
secondary side : allowable vector groups ICTS	YD1 - YD3 - YD5 - YD7 - YD9 - YD11 - YY0 - YY2 - YY4 - YY6 - YY8 - YY10 - YdY0
• Current settings	
- $I_{D>}$: DMS 7001	
bias s1% : region 2 bias slope (fig 1)	2% to 20% of I_N (1% I_N step)*
K_B : setting for the start of bias region 3 (fig 1)	or 5% to 20% of I_N (1% I_N step)
bias s1% : region 2 bias slope (fig 2)	5% to 50% (5% step)
K_B : setting for the start of bias region 3 (fig 2)	1-18 I_N (1 I_N step)
harmonic restraint	*(with stabilising resistors minimum setting : 2% I_N CT)
- $I_{D>}$: DMS 7002	
bias s1% : region 2 bias slope (fig 2)	10% to 50% of I_N (10% I_N step)*
K_B : setting for the start of bias region 3 (fig 2)	10% to 50% (5% step)
harmonic restraint	1-18 I_N (1 I_N step)
$I_{D>H2}$: 2 nd harmonic inhibition setting	15 to 30% of the fundamental (1% step). It is possible to temporarily remove this inhibition during testing (15 minutes)
$I_{D>H5}$: 5 th harmonic inhibition setting	30 to 40% of the fundamental (1% step). It is possible to permanently remove this inhibition
- $I_{D>>}$: DMS 7001	
$I_{D>>}$: DMS 7002	2 to 10 I_N (1 I_N step)
$I_{D>>}$: DMS 7002	2 to 18 I_N (1 I_N step)

GENERAL CHARACTERISTICS (CONT'D)

• Reset percentage on the operating levels	$I_{D>}$ approximately 85% of the threshold $I_{D>>}$ approximately 90% of the threshold
• Operating times	
- output relay	E D A,B,C
$I_{D>}$ greater than 2 x the setting (in ms)	- 35 45
$I_{D>>}$ greater than 2 x the setting (in ms)	18 25 35
- operating time curve	see figures 2 & 3
• Accuracy	
- absolute accuracy :	
- thresholds	
$I_{D>}$	
for through current $I_Z < I_N$	1% of the ct rated current or 5% of the $I_{D>}$ setting for through current
$I_Z > I_N$	10% of the theoretical value
$I_{D>>}$	5% of the $I_{D>>}$ setting
- operating times	+/- 12ms for A, B, C and D relays +/- 8 ms for the E relay
- relative accuracy within the claimed ranges of influencing quantities (temperature, frequency, V aux)	
- thresholds	
$I_{D>}$	
for through current $I_Z < I_N$	0.5% of the ct rated current or 2.5% of the $I_{D>}$ setting for through current
$I_Z > I_N$	5% of the theoretical value
$I_{D>>}$	2.5% of the $I_{D>>}$ setting
- operating times	5ms for $I_{D>}$ and $I_{D>>}$

3 - Influencing quantities nominal ranges

• Temperature	-10°C to 55°C
• Frequency	40 Hz to 70 Hz
• Auxiliary supply	as per the above ranges

4 - Environmental conditions (IEC 68-2)

• Storage	-25°C to 70°C
• Humidity	93% RH at 40°C; 56 days
• Saline mist	96 hours

5 - Dielectric withstand (IEC 255-5)

• Industrial frequency dielectric withstand	2kV 50Hz 1mn except DB9 port : 500V 50Hz 1mn
• Insulation resistance at 500V dc	>10000 MΩ
• Impulse voltage withstand	5kV - 1.2/50μs - 0.5J except DB9 port

6 - Withstand capability to electromagnetic interference

6.1 Conducted high frequency disturbances (IEC 255-22-1)

(Except DB9/RS232C port)

Common mode 1MHz decay : repetition 400Hz	2.5kV - Class III
Transverse mode 1MHz decay : repetition 400Hz	1kV - Class III

6.2 Fast transients (IEC255-22-4 + EN 50082-2)

5/50 ns waveform , repeated at 5KHz	2kV
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6.3 Electrostatic discharge (IEC255-22-2 + EN 50082-2)

Contact	4kV
Air	8kV

6.4 Radiofrequency (IEC255-22-3 + EN 50082-2)

6.4.1 Radiated radiofrequencies

frequency sweep 80 - 1000 MHz	
with amplitude modulation (80%) at 1KHz	10V/m
test at 900 MHz fixed, repeated at 200Hz	
cycle ratio $1/2$	10V/m

GENERAL CHARACTERISTICS (CONT'D)

6.4.2 Conducted radiofrequencies (ENV 50141)

frequency sweep 0.15 - 80 MHz
with amplitude modulation (80%) at 1KHz 10V/m rms at 150Ω

7 - Emission of electromagnetic interference

Electromagnetic fields radiated by the device (EN 55011)

Measured at 30 metres
Frequency range 30 MHz to 230 MHz 40 db (μV/m) - (quasi peak value)
Frequency range 230 MHz to 1000 MHz 47 db (μV/m) - (quasi peak value)

8 - Digital communications

Hardware 2 switchable channels each having output sockets:
-current loop 0-20 mA
-DB9 / RS232C
Protocol Master/slave to J-Bus/MODBUS or other
Operating speed adjustable between 1200 - 2400 - 4800 Bauds

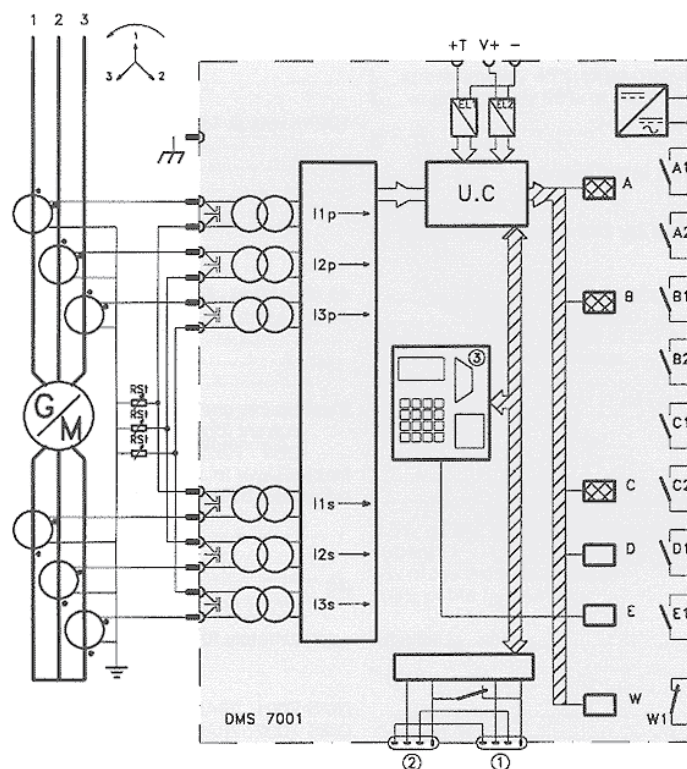
9 - Case

Size R4

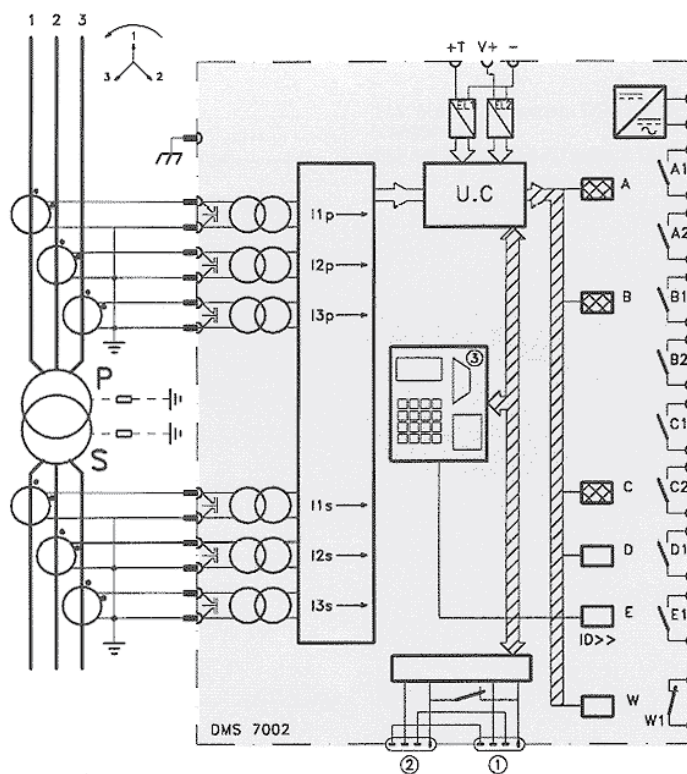
10 - Weight approximately 5Kg

11 - Identifying drawings

..... DMS 7001 : 28A6
..... DMS 7002 : 28A8



DMS 7001 - Simplified and connection diagram



DMS 7002 - Simplified and connection diagram

IDENTIFICATION CODE

DMS 7001		A	B	C	D	E	F	G	H
Frequency	50 Hz 60 Hz	a b							
Primary nominal Current	1 A 5 A		a b						
Secondary nominal Current	1A 5A			a b					
Auxiliary supply DC/AC	24 70 V 48 250 V				a b				
Case R4	projecting rear connection flush rear connection					b c			
Connection Diagram	Index						a		
Contacts Relays A, B, C	3 NO 3 NC							a b	
I _{D>} Setting	0.02 - 0.2 I _N 0.05 - 0.2 I _N								a b

DMS 7002		A	B	C	D	E	F	G
Frequency	50 Hz 60 Hz	a b						
Primary nominal Current	1 A 5 A		a b					
Secondary nominal Current	1A 5A			a b				
Auxiliary supply DC/AC	24 70 V 48 250 V				a b			
Case R4	projecting rear connection flush rear connection					b c		
Connection Diagram	Index						a	
Contacts Relays A, B, C	3 NO 3 NC							a b

CASE DIMENSIONS		
	Projecting rear connection	Flush rear connection
SCREW CONNECT. #M4		
R4		
DRILLING AND CUT-OUTS		
R4	<p>FRONT VIEW</p>	<p> $X = 89$ for panel th. ≤ 2 $X = 90,5$ for panel th. > 2 </p>