CEE Relays Ltd
87C Whitby Road, Slough, Berks, SL1 3DR (Registered Office)
Telephone: (01753) 576477 Fax: (01753) 825661
Website: www.ceerelays.co.uk

INSTRUCTIONS FOR THE SETTING, TESTING AND COMMISSIONING OF

IMM 7960 and IMM 7990

MOTOR PROTECTION RELAYS

1. IMM 7900 RELAY FUNCTIONS

2. RELAY DESCRIPTION
- 2.1 Digital display
- 2.2 Nomenclature of the symbols used on the face-plate
- 2.3 Operating curves and block drawing

3. RELAY SETTINGS
- 3.1 How to select suitable settings

4. RELAY CHECKING AND COMMISSIONING
- 4.1 Recommendations
- 4.2 Pre-commissioning checks
  - 4.2.1 Thermal unit at twice setting
  - 4.2.2 Short-circuit (threshold and operating time) and unbalance (operating curve)
  - 4.2.3 Earth fault (threshold and operating time)
  - 4.2.4 Starting characteristic and locked rotor
  - 4.2.5 Starts frequency limitation
  - 4.2.6 Undercurrent
  - 4.2.7 Communications
- 4.3 Commissioning

5. ANNEX
- 5.1 Testing a 60Hz relay on a 50Hz supply
- 5.2 Checking the thermal characteristics

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PREFACE

This manual only applies to IMM 7960 relays, drawing 25A4, and to IMM 7990 relays, drawing 9987.

1. IMM 7900 RELAY FUNCTIONS

The IMM 7960 and 7990 series of relays have been specifically designed to ensure the electrical protection of high voltage and large low voltage motors.

These relays can be used to protect circuit breaker controlled motors and also those controlled by fuse/contactor combinations, as a switch is provided to disable the high-set unit function (50) and simultaneously increase the earth fault unit operating time. They include the following protective functions and alarms *:

- Thermal overload,
- Too long start,
- Locked Rotor,
- Short-circuit (high-set unit),
- Unbalance, loss of one phase,
- Earth fault,
- Start authorisation (θ°),
- Starts frequency limitation (IMM 7990 only),
- Undercurrent (pump unpriming).

IMM7990 relays can be integrated into a digital communications network (see § 4.2.7). They may also be configured to overcome various specific protection problems (Options - see Table 2).

* Only IMM 7990 relays have an output unit operated by thermal alarms (or earth fault depending upon the model).

2. RELAY DESCRIPTION

2.1 Digital display

The digital display provides a readout of certain important data. See table n° 1 for the list of the different elements.
Passing from one code value to the next is achieved by pressing the push-button
If this push button is held down, the displayed value corresponds to the value of the setting. After releasing the push-button a new value appears, corresponding to a measured or calculated value.

NOTE: Code values 8 and 9 correspond to special functions. This is why a continuous pressure of longer duration is required. In particular, position 9 is the Test mode (negative sequence I↓ and all its effects out of service), the push button needs to held down for at least 10 seconds.
The Test mode is indicated by the appearance 9 15" on the display. The value 15" decreases minute by minute (i.e. 9 14 , 9 13", etc).
THIS FUNCTION MUST BE USED ONLY WHEN TESTING THE RELAY.

It should be noted that Test mode can be exited by operation of the trip relay t or by holding down the push-button once more for 10 seconds whilst in position 9 , or at the end of the allowed time (15min).
A flashing code value enables partial identification of the type of fault which caused the trip: for example, a flashing 3" signifies I ↓ fault (negative sequence I).

2.2 Nomenclature of the symbols used on the face-plate

In	Rated CT secondary current
Io	Earth fault current
I↑	Positive phase sequence current
I↓	Negative phase sequence current
I↓>	Negative sequence unit threshold
I>>	High-set unit (short-circuit) threshold
Id	Starting current
ILR>	locked rotor unit threshold
Ith	Relay base setting current
Io>	Zero sequence (earth fault) unit threshold
K	Coarse adjustment of base setting current
K1	Fine adjustment of base setting current
Ko	Zero sequence (earth fault) unit setting
t	Reference period for the 66 function
T	Blocking period of 66 function (start inhibition)
Td	Starting time
t (ILR>)	locked rotor unit operating time
N	Number of starts allowed during time t
τ	Thermal time-constant setting
τa	Learnt thermal time-constant
θ%	Thermal condition
θd%	Thermal condition above which a motor restart is inhibited
V aux.	Auxiliary supply voltage
R ext.	External resistor
s	Second
Min.	Minute
A	Ampère (amp)

TABLE No. 1

Code	With push button held down	With push button released
0	Product K.K1	Thermal condition (%θN)
1	τ setting	τa learnt (a display of 88 signifies an out-of-range value)
2	Locked rotor I> operating	Measured current (limited to 12.5Ith)
3	Negative sequence operating threshold I↓	Negative sequence current = 0 in the absence of a fault (limit = 4.2Ith)
4	Zero Sequence (earth fault) operating threshold Io	Zero sequence (earth fault) current = 0 in the absence of a fault (limit = 1.4Io>)
5	Setting Td	Measured starting time for the last start
6	Setting Id	Measured current drawn during the last start (recorded after 0.5 secs)
7	Setting t (Ir>)	7 tp.N with : N = number of allowable starts If N>0 : tp indicates time available for starts If N=0 : tp indicates the waiting time remaining before a new start will be allowed 7-- indicates that function [66] is out of service
8	RESET Hold down for 3 secs resets the flashing fault value and the event memory described opposite. This is required in order for the next fault to be indentified.	In this position (after identification of the type of fault) the display shows the value of the quantity which caused the trip
9*	Hold down for 10 secs to enter the Test mode, or to return back to normal operation	The Test mode (initial readout 9 15") on the display puts out of service the negative sequence unit and all its effects for a period of 15 min. The operator is free to use the display functions.
A	IMM address code in the communications network (§ 4.2.7)	Options code (Table No. 2)

9* Test mode enables the relay to be tested using a single phase supply
IT MUST ONLY BE USED WHEN TESTING

2.3 Operating curves and block drawing

Figure 1a - IMM 7990 Face-plate

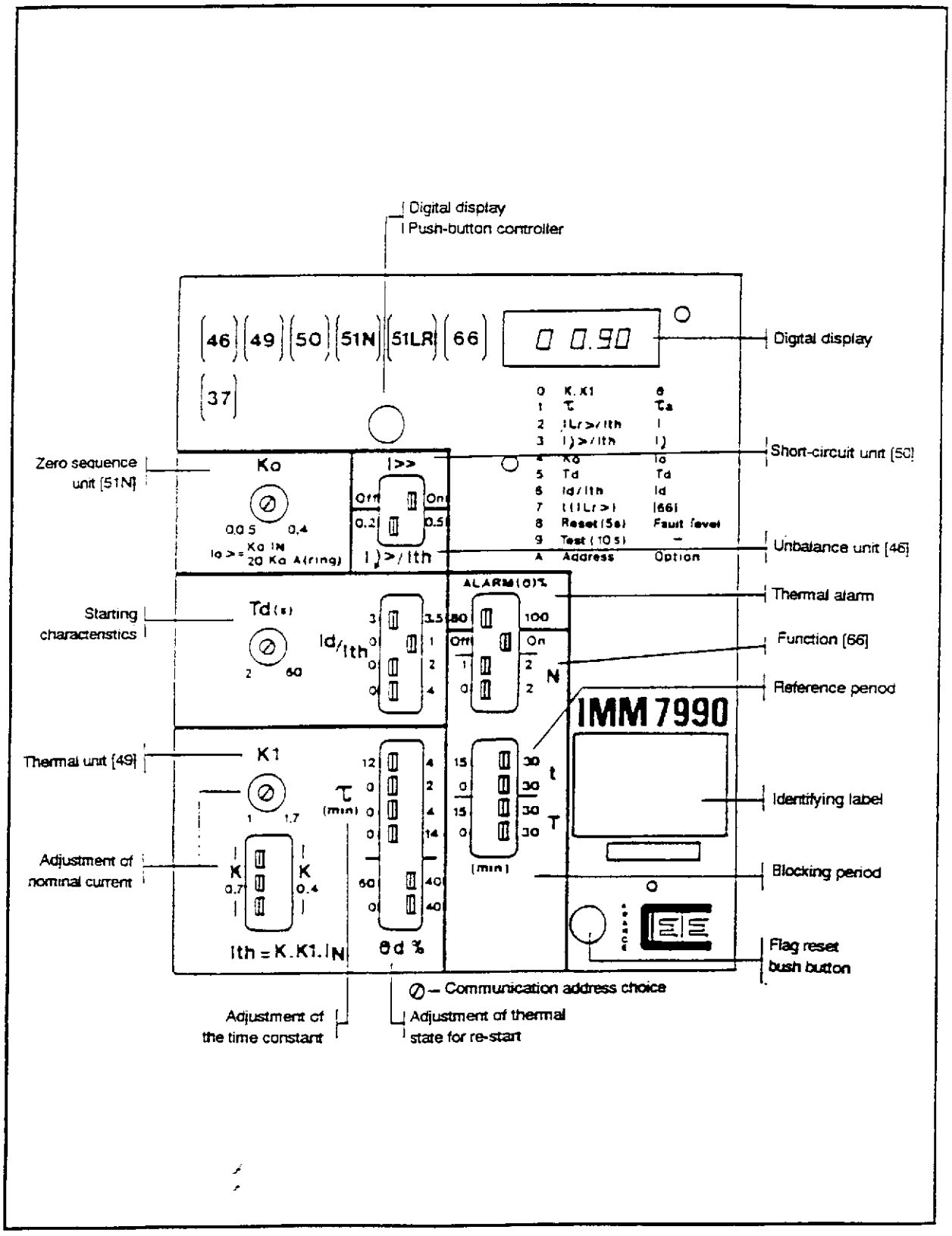
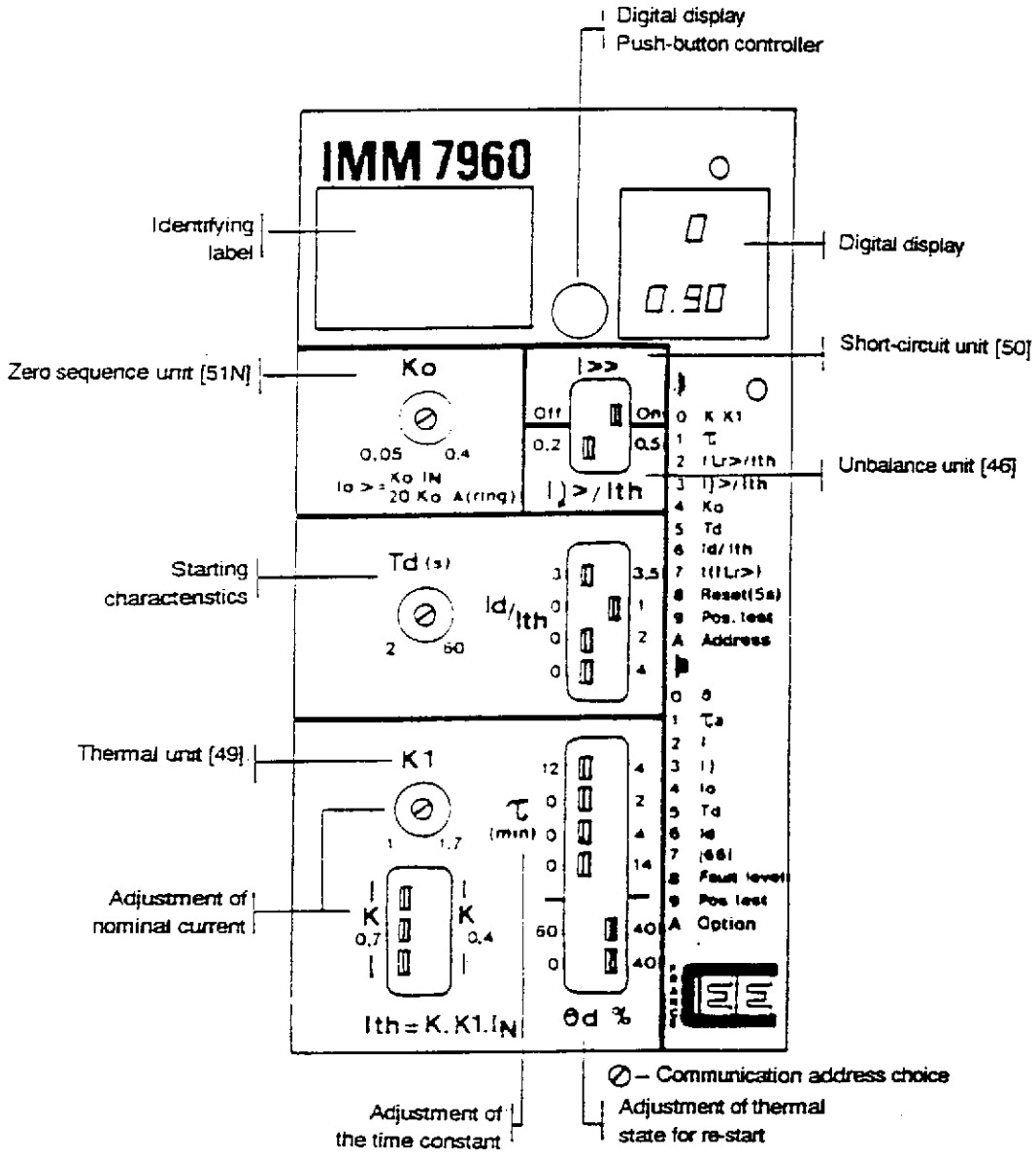


Figure 1b - IMM 7960 Face-plate



2.3 Operating curves

Figure 2 - Thermal unit

Cold characteristic for **different thermal time-constants**

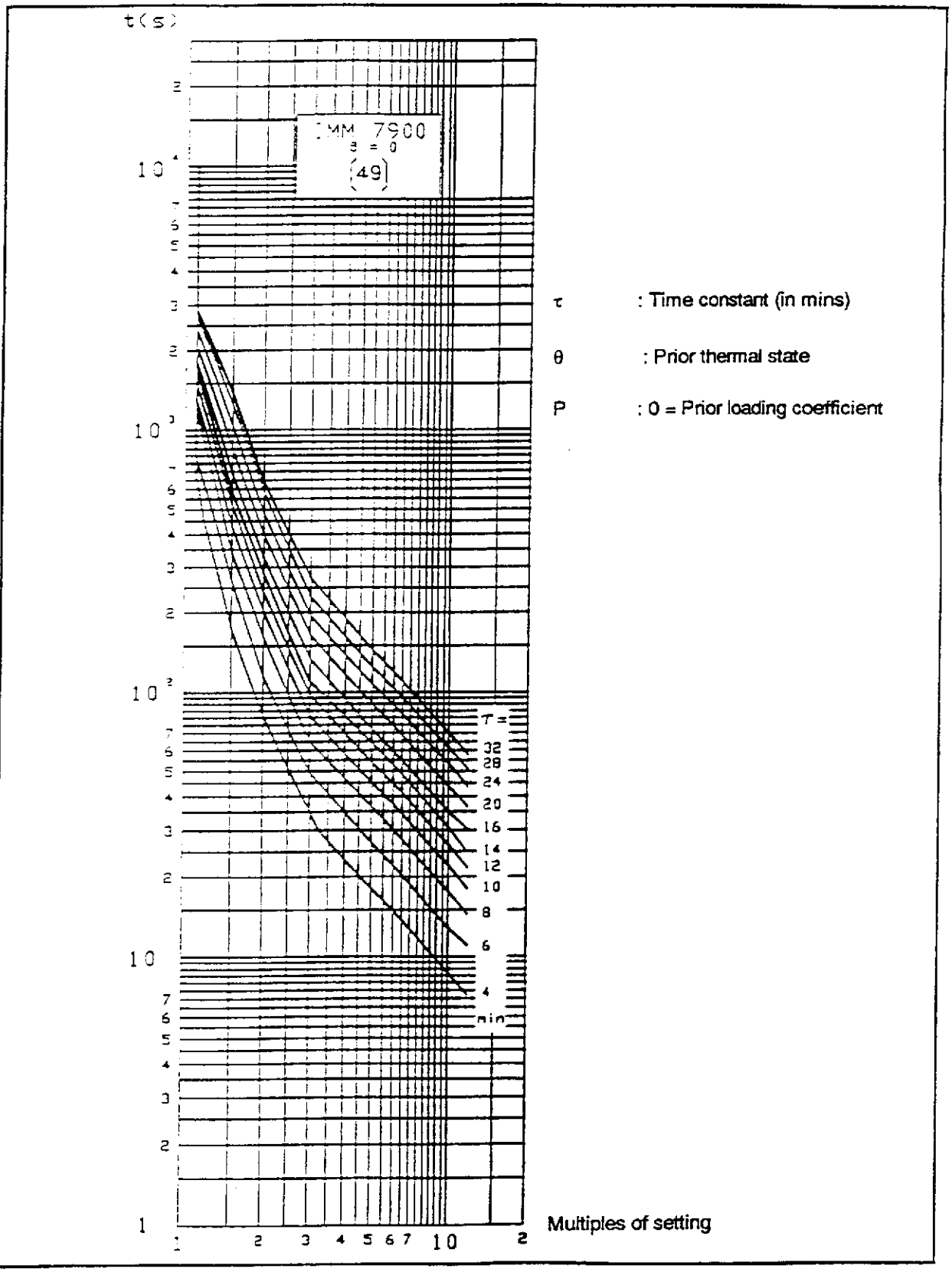
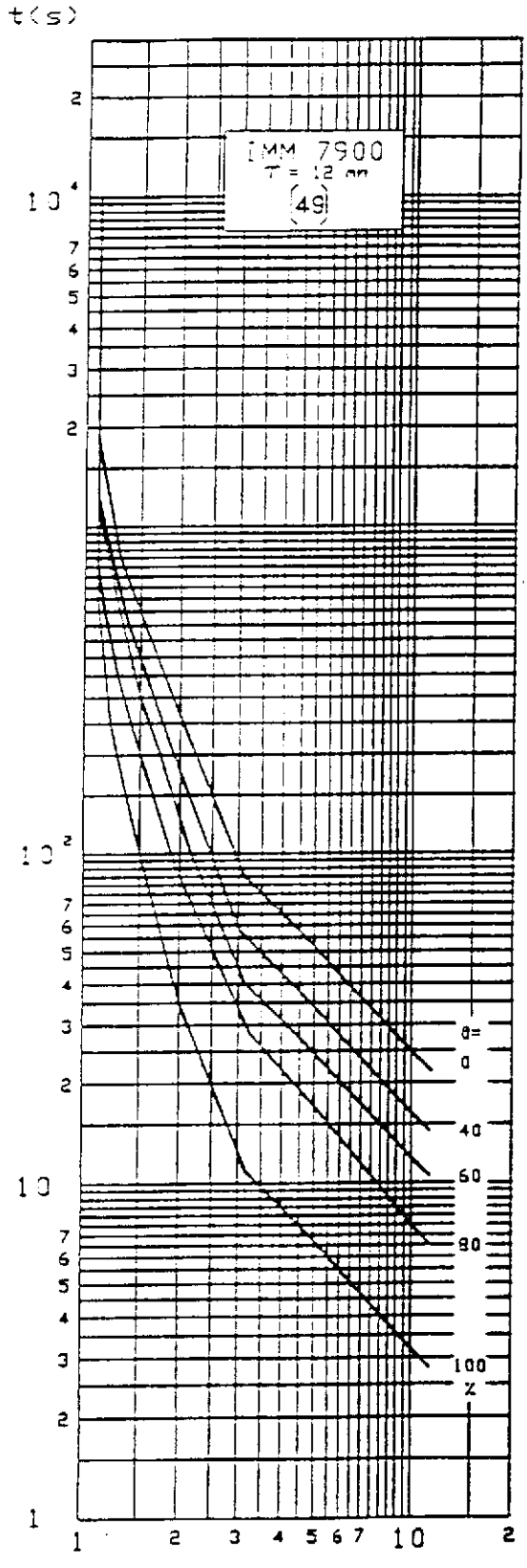


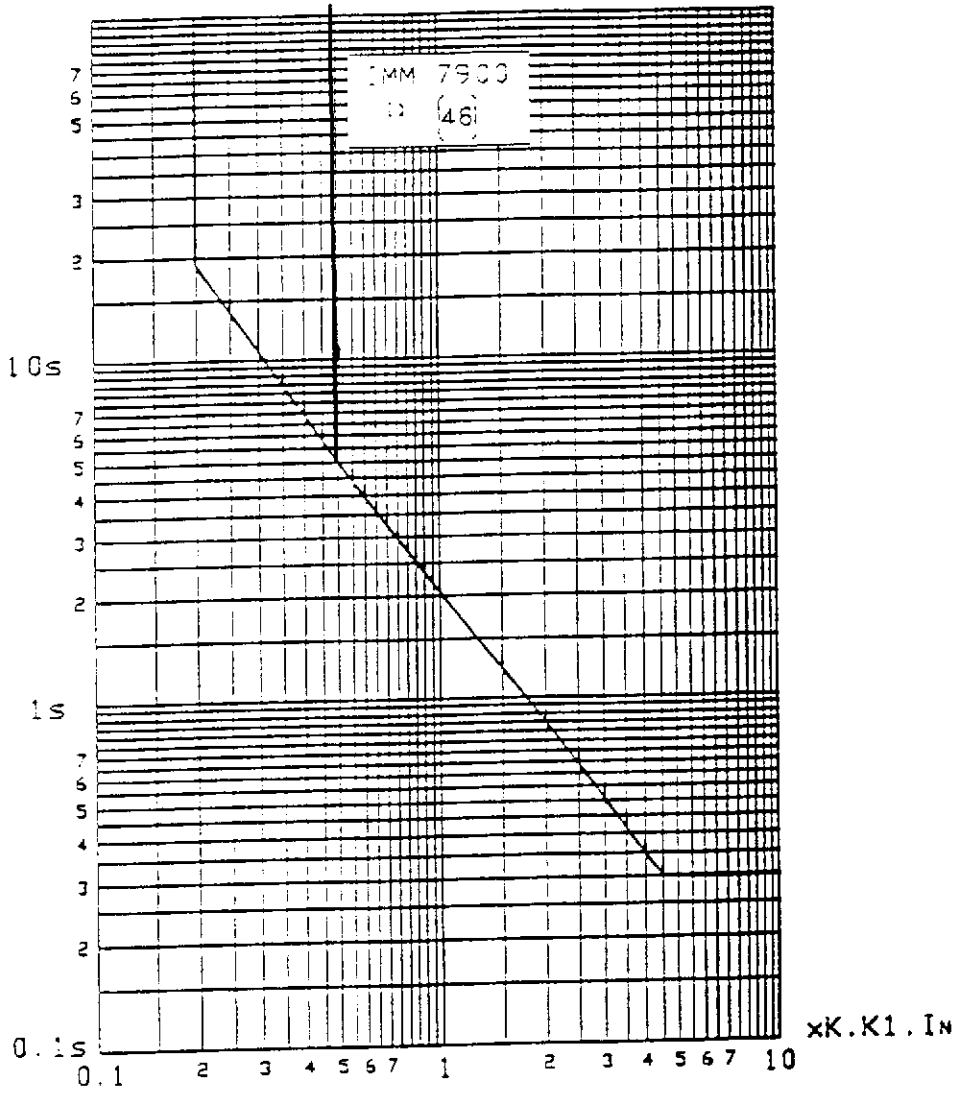
Figure 3 - Thermal unit

τ = 12 min. characteristic at different pre-load conditions



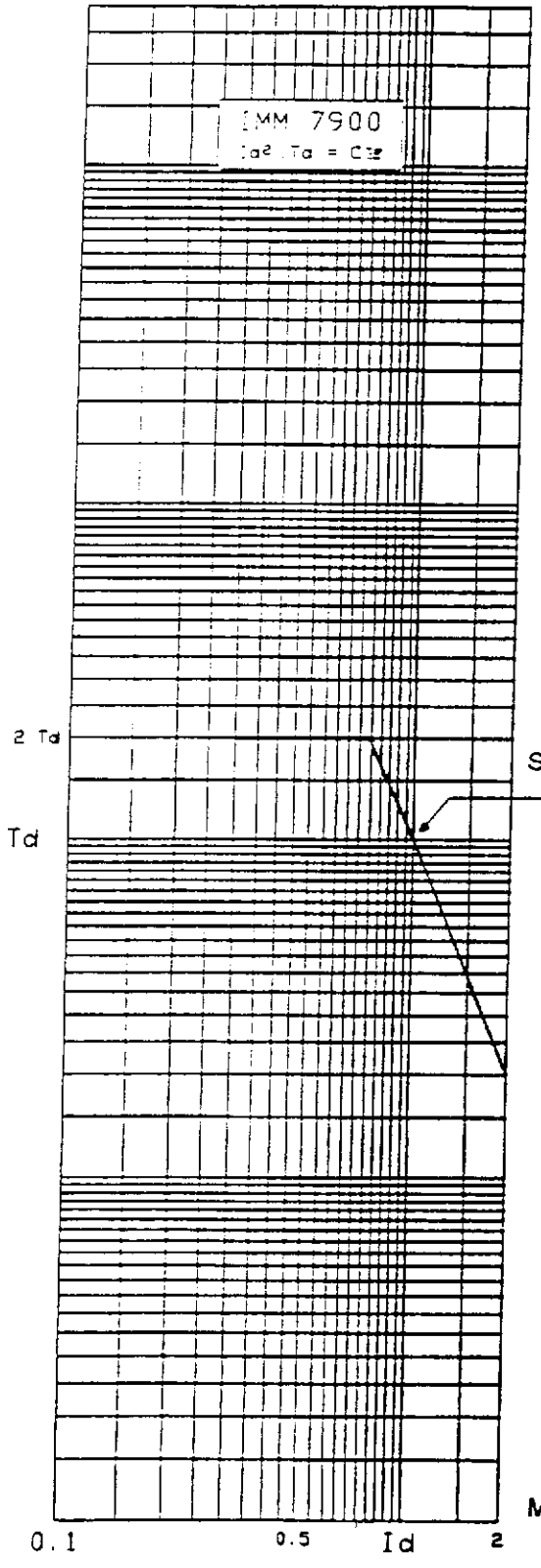
To obtain the operating time corresponding to the other values of τ mulitply the times read from these curves by τ setting/12

Figure 4 - Negative sequence unit



CORRECTION THE ABOVE CURVE SHOULD GO TO DEFINITE TIME AT 500ms.

Figure 5 - Too long start unit



Id : real motor start current

Td : real motor start time

Starting point of the motor at 100% UN

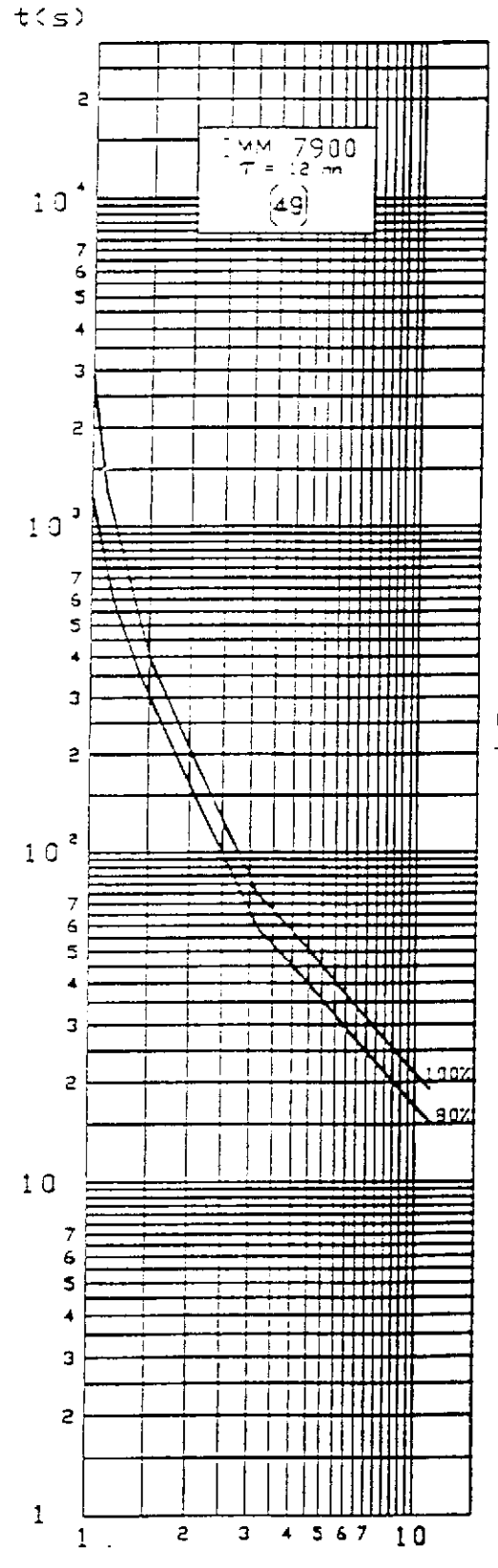
CORRECTION:

THIS CURVE ACTUALLY OBEYS THE FORMULA:

$I^2t = 108$

Figure 6

Thermal alarm unit characteristic for 80% and 100% settings and τ = 12 min.



To obtain the operating time corresponding to the other values of τ mulitply the times read from these curves by τ setting/12

Multiples of setting

Table No. 2

DEFINITION OF THE OPTIONS

The 3-digit code is displayed in position A with the push-button released.

OPTIONS	CODE
I↓> out of service	X 01
IL/> out of service	X 02
Thermal unit out of service	X 03
Output unit hand reset for all functions	X 04
Output unit hand reset for all functions except thermal	X 05
t Io = 0.5 secs	X 06
t Io = 0.25 secs	X 07
t I↓ x 2 for a period of 2Td	X 08
t I↓ x 2	X 09
Zero sequence (earth fault) and thermal on alarm (*)	X 11
Zero sequence (earth fault) only on alarm (*)	X 12
I↓> and IIr> out of service	X 20
Output unit hand reset for all functions + I↓> out of service	X 21
Output unit hand reset for all functions + IIr> out of service	X 22
Output unit hand reset for all functions except thermal + I↓> out of service	X 23
Output unit hand reset for all functions except thermal + IIr> out of service	X 24
tIo = 0.25 secs + I↓> out of service	X 25
tIo = 0.25 secs + IIr> out of service	X 26
tIo = 0.25 secs + output unit hand reset for all functions except thermal	X 27
t I↓ x 2 for a period of 2Td + IIr> out of service	X 28
t I↓ x 2 for a period of 2Td + output unit hand reset for all functions except thermal	X 29
t I↓ x 2 + IIr> out of service	X 30
t I↓ x 2 + hand rest for all functions except thermal	X 31

NB: A relay with no particular characteristic would display 032

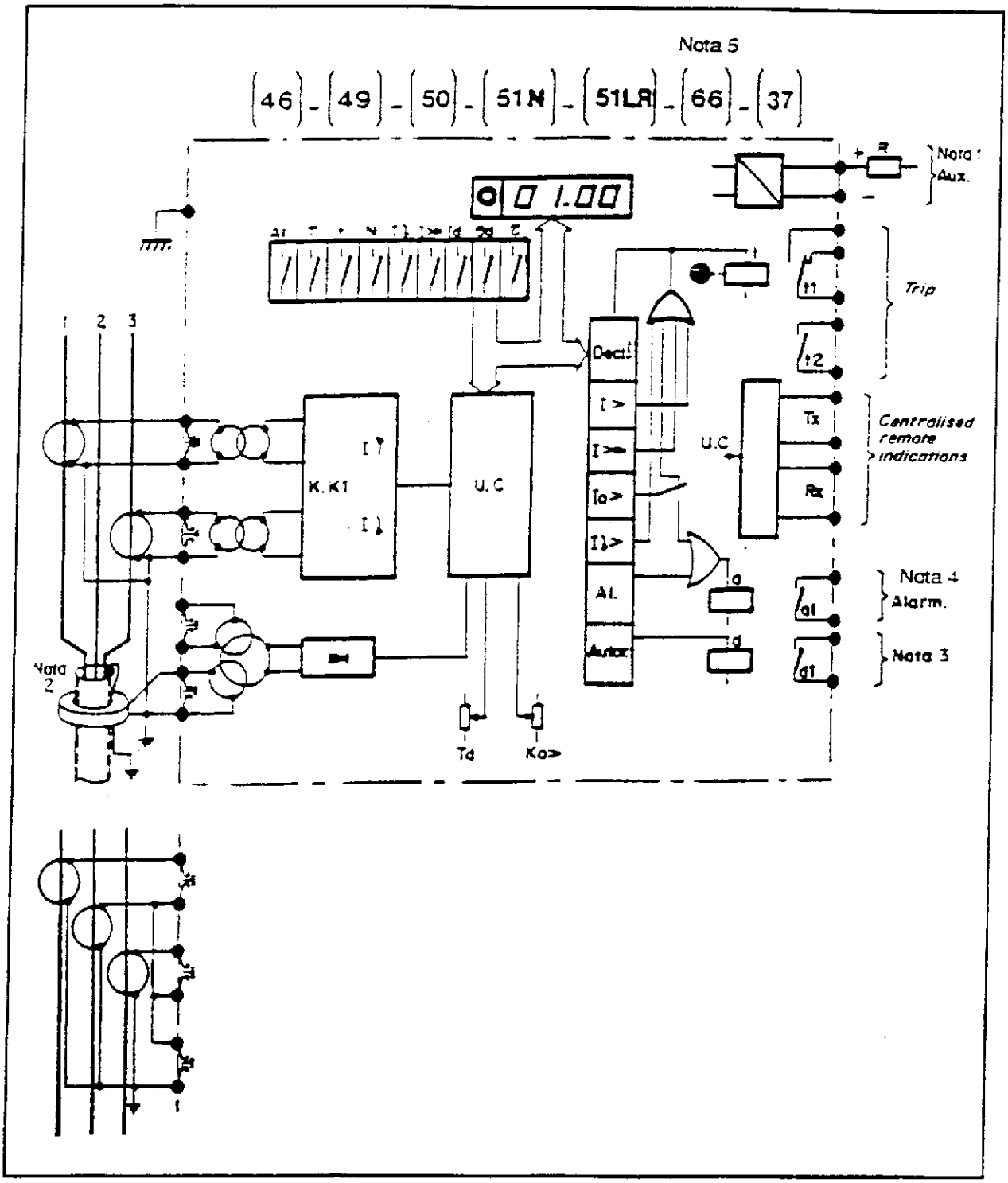
(*) Alarm only available across the communications network for the IMM 7960

Significance of the 1st digit, see the following table:

UNDERCURRENT FUNCTION (37)		OUT OF SERVICE	IN SERVICE
Cooling thermal time-constant:	1.τ	0	4
	2.τ	1	5
	4.τ	2	6
	6.τ	3	7

Figure 7

IMM 7900 Simplified operating and connection drawing



NB:
1) R = external resistor supplied with the relay (if V.aux. > 48V)
2) See drawing No 142941
3) d1: should be connected in the close circuit (closed when the IMM will permit a start)
4) Alarm unit is not available on IMM 7960 relays
5) [66] function is not available on IMM 7960 relays

3. RELAY SETTINGS

3.1 How to select suitable settings

FUNCTION	ANSI CODE	SET BY	PERSONAL NOTES	RECOMMENDATIONS AND HOW TO ACHIEVE SETTINGS
Relay base current setting		Switch K Potentiometer K1		K.K1 = Motor In / CT In (Ith = K.K1.In CT) (All three 3 K switches must be in the same position)
Too long start and locked rotor	(51LR)	Switch Id/Ith		Id/Ith = Id/In of the machine Td = machine starting time
Thermal overload operating curves and thermal re-start limit	(49)	Switch τ Switch 0d%		Set 0d% = 100 - if τ is known use it, if not set to 12 min. Confirm that the displayed value for τa is less than or equal to the actual τ setting. If it is not then see note * (at beginning of next page)
Short - circuit	(50)	Switch I >>		Set to OFF for fus e/contactor control Set to ON for circuit breaker control: setting = 1.4Id/Ith. In ON position, the circuit breaker breaking capacity needs to be adequate
Unbalance	(46)	Switch I↓		Set to 0.2 as a general rule. Set fo 0.5 if the supply quality of the network or of the CTs do not allow a setting of 0.2
Earth fault	(51N)	Potentiometer Ko		Setting depends upon the network earthing/grounding and coordination. Operating threshold : Ko In for residual connected cts; 20Ko in primary amps for a core-balance CT. Core-balance CT identification : TO or TF followed by a number which corresponds to the internal diameter and a code representing the number of secondary turns (15 for IMM 7990 relays) eg : TF 80-15
Alarm (IMM 7990 only)		Switch A1 (0)%		
Start frequency (IMM 7990 only)	(66)	Switch ON-OFF Switch t Switch N Switch T		If ON t should be set to the time during which N starts are allowed. Time T corresponds to the time during which any new start is prevented and begins after the last authorised start took place.

NB:
* τa is the thermal time-constant advised learnt by the relay, allowing for the values of (Td, Id, θd) which determine the conditions under which the motor is required to start without tripping.

When hot re-starts are required this could mean that the thermal time-constant τ needs to be $>\tau a$, but it should be remembered that the use of a value of τ above the time-constant of the machine will mean that the relay no longer provides truly efficient protection against overloads.

ATTENTION: When setting has been completed, it is essential that every switch on the face-plate is checked to ensure that they are all fully pushed over towards the required setting.

4. RELAY CHECKING AND COMMISSIONING

4.1 Recommendations

All relays are delivered complete with a lead seal applied after the final factory inspection. The lead seals should only be broken when units are put into service by suitably qualified personnel.

It is important to ensure that the relays have not suffered any mechanical damage before proceeding with any tests.

IMPORTANT: WE STRONGLY ADVISE AGAINST TESTING THE RELAY WITHOUT ITS BASE BY USING STANDARD COMMERCIALLY AVAILABLE PLUGS OR LEADS DIRECTLY PLUGGED INTO THE FEMALE CONNECTORS AT THE BACK OF THE RELAY

4.2 Pre-commissioning checks

These obligatory tests confirm correct operation at the set values, and are also intended to ensure that the equipment has not suffered any damage during transport or storage.

The tests require a minimum amount of test equipment, namely:
- a current generator fitted with a timing device and a system to automatically trip the current, as well as a source of auxiliary supply.
- test results all carry a general tolerance of ±10%, taking account of the test conditions.

If the test equipment does not incorporate an automatic tripping system, it is advisable to stop the current injection as soon as the expected result is obtained.

Since the tests are performed single phase, a multiplying factor of √3 is required in the calculation of the injected current. The values displayed by the relay will however remain correct. Eg: for a test at 2Ith, a current of 2.√3.Ith must be injected, but the relay when in position 2 with the button released will indicate 2 02.0".

4.2.1 -Thermal unit at twice setting
4.2.2 -Short-circuit (threshold and operating time) and unbalance (operating curve)
4.2.3 - Earth fault (threshold and operating time)
These three tests are sufficient to demonstrate that no element in the input/output circuits has been damaged.
-Supplementary tests
4.2.4 -Starting characteristic and locked rotor
4.2.5 -Starts frequency limitation
4.2.6 -Undercurrent
4.2.7 -Communications

4.2.1 Test the thermal unit (49) at twice setting

Trip relay output contact : t
Alarm relay contact : a (IMM 7990 only)
Start authorisation relay contact : d

With the IMM 7960, the thermal alarms are only available on the communications network. The alarm threshold is fixed at 100%.

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Apply V.Aux. NOTE: External resistor is supplied with the relay if V.aux.> 48V. - Connect the current source to 10-11 - Preset the current to 3.46 Ith then switch it off - Use the state of contact a - Check the state of contact d - Remove and re-connect V.aux. - Go to the Test position - Inject the current	- 0 0.00" on display - Contact open - 0 0.00" on display - 9 15" - a closes after X. τ set (1) - d operates after X. τ set - t operates after 10 τ set (1) - Display flashes 0" (1) - Times are given in seconds

Values of X as a function of the setting:

θd%				
A1%				
Setting	100	80.	60	40
Value of X	17	13	10	6

PRINTING ERROR.
SHOULD BE $2\theta \times t_{SET}$

Eg : For τ = 12 min. and an alarm setting A1 = 80%, the operating time of the alarm unit will be τ.X = 12 x 13 = 156 secs

(1) Option x12 inhibits the thermal alarm
(*) If option x03 is selected, the relay t is not connected to the thermal unit
The value 1.14 read on the display at the instant that a trip occurs corresponds to the square of the thermal unit operating threshold θ = F(12)..

4.2.2 Testing the short-circuit and unbalance units (50) (46)

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Connect the current source to 10-11 Preset the current to 2.25 Id .Ith then switch it off (Id/Ith)	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Connect contact t to trip source	
- Inject the current	- Trip in 0.5 secs by I↓> (2) - Display flashes 3"
- Preset the current to 2.6 Id .Ith then switch it off (Id/Ith)	
- Remove and re-connect V.aux.	-0 0.00" on display
- Inject the current	-If I>> is ON I>> trip in 0.12 secs - Display flashes 2" - If I>> is OFF , I ↓> trip in 0.5 secs
- Connect the current source 6-7	
- Preset the current to 1.73 Ith then switch it off	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Inject the current	- I↓> trip in 2.2 secs - Display flashes 3"

* Do not forget that the maximum display value of I>> is limited to 12.5 Ith, if Id/Ith > 9, preset the current at 20,3Ith.

(2) - For option x08, x09, x28, x29, x30, x31, the time obtained will be 1 sec
- For option x01, x20, x21, x22, x23, x25, the trip could be caused by the thermal unit or by the locked rotor unit depending upon the settings.

4.2.3 Testing the earth fault unit (51N)

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Connect the current source to 2-3 or to the primary of the core-balance CT whose secondary is connected to 14-15	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Slowly increase the current	
- When the injected current reaches the Io> setting threshold	- Display flashes 4"
- Preset the current to 2Io>	
- Remove and re-connect V.aux.	
- Connect t to trip the source	
- Inject the current	- Trip (3): (*****) in 0.1 secs if I>> is ON in 0.25 secs if I>> is OFF - Display flashes 4"

(3) - For option x06, x07, x25, x26, x27, the time obtained will be either 0.25 secs or 0.5 secs, independent of the position of the switch I>>.
- For option x11 and x12 , the earth fault unit will give a trip but only an alarm.

4.2.4 Testing the too long start and locked rotor unit (4) - (51 LR)

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Connect the current source to 10-11 - Preset the current to 1.73 Id. Ith then switch it off	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Connect t to trip source	
- Go to Test position	- 9 15"
- Inject the current	- Trip in Td - Display flashes 5"
- Check values in memory	- In 5 : Td = injection time - In 6 : Id = Id/Ith
- Preset the current to 2.08 Ith then switch it off	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Connect t to trip source	
- Go to Test position	- 9 15" on display
- Inject the current	
- Wait at least 2.Td	
- Slowly increase the current	- When the current goes above Ir √3 Ith, a trip will occur in t(Ir) - Display flashes 2"

* The indicated results will be obtained if the relay is set as advised above. If this is not the case then the thermal unit may cause a trip.

(4) For option x02, x22, x24, x26, x28, x30 , this unit will not give a trip signal.

4.2.5 Testing the starts frequency function (66) - (IMM 7990 only)

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Connect the current source to 10-11	
- Preset the current to 2.08 Ith	
- Remove and re-connect V.aux.	- 0 0.00" on display
- Go to code 7 position, push button released and note the reading	- Before the point: value of t - After the point: value of N
- Inject the current for about 5 secs then switch it off	- Display flashes 3"
- Go back to code 7 position, push button released and note the reading	- Before the point : value of t counting down - After the point : initial value of N - 1
- Repeat the injection N times, between each injection :	N should count down to 0. At this instant, the d contact should open and remain open during time T. The display will now indicate: - before the point: value of T - after the point: 0. The value of T will count down to 0. At this instant, a new sequence will start and the display will indicate: before the point: value of t after the point : value of N

4.2.6 Undercurrent

The undercurrent function is in operation when the 1st digit of the code indicating the relay option is greater than 4 (see Table No. 2).

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Connect the current source to 10-11	
- Preset the current to 1.73 Ith	
- Remove and re-connect V.Aux.	- 0 0.00" on display
- Go to Test position	- 9 15"
- Inject the current	
- Slowly decrease the current	- When the current goes below 0.7 Ith, relay t will operate after 3 secs (40% threshold)
- Continue to decrease the current	- When the current goes below 0.26 Ith the relay will reset (15% threshold)

As this unit responds to the positive sequence component of currents, the display will flash 2" when it operates.

4.2.7 Communications

If the IMM 7900 is connected to a communications network, its address is defined via a trim-pot on the face-plate (see figure 1).

IMM 7900 series relays communicate using the J.Bus/Modbus protocol in current loop (0-20mA).
The default configuration is as follows:

- speed : 1200 bauds
- data : 8 bits
- control bits : 1 stop bit, no parity
- address : 1 to 32

4.3 Commissioning

Before starting the motor, it is important to check that:

- the current transformers have a secondary rated current corresponding to that shown on the relay rating plate, and are at least rated to 5VA, 5P10,
- the network frequency is the same as that shown on the relay rating plate
- the wiring complies with connection drawing. Particular ATTENTION needs to be paid to the phase rotation and to the CT polarities,
- the auxiliary supply corresponds to that shown on the rating plate (operation is ensured over the range 0.8 to 1.2 Vn), and that the external resistor is correctly connected if V.aux. > 48V,
- the relay is correctly plugged in, and the fixing rods are fully screwed in,
- the trip circuit is correct

Carry out a normal starting sequence:

- if the start is successful, check that the values of Td and Id/Ith set on the relay correspond to the memorised results (see § 4.2),
- if the start is not successful, analyse the cause of the trip using the display

The most likely causes of a spurious trip are:

- an error in the CT connections,
- relay not completely plugged in,
- error in the contact connections,
- partial saturation of the CTs,
- a missing phase,
- motor too hot (if d1 contact is not wired).

Diagnostic assistance in the event of incorrect operation

CONNECTION	I↑ READ IN 2	I↓ READ IN 3
- Correct connection	1.0	0.0
- Reverse phase rotation	0.0	1.0
- Shorted phase	0.6	0.6
- Reversal of one phase	0.6	1.2
- Reversal of one phase + reverse phase rotation	1.2	0.6

The above values correspond to a relay carrying a current equal to Ith = K.K1.In. If the current is different, the values in the table should be multiplied by $\frac{I\ actual}{Ith}$ (flowing in tthe relay)

5. ANNEX

5.1 Testing a 60Hz relay on a single phase 50 Hz supply

The tests outlined above apply, but, in order to obtain results complying to the operating curves, the current source must be connected to the phase stated in the text.
However, if the other phase input is used, it is necessary to apply a multiplying coefficient equal to 1.16 to the injected current.
The test procedure described in the text remains unchanged.

5.2 Testing thermal unit (49) operating curve at $\theta = 0$ using the alarm unit

SEQUENCE OF OPERATIONS	EXPECTED RESULTS
- Apply V.aux. NOTE : R.ext. if V.aux. > 48V	- 0 0.00" on display
- Connect the current source to 10-11	
- Preset the current to x times 1.73 Ith then switch it off	
- Connect contact a to trip	
- Remove and re-connect V.aux.	
- Go to Test mode	- 0 0.00" on display
- Inject the current	- a operates after a time delay dependent upon the level of current injected and τ (see figure No 6)