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INSTRUCTIONS FOR SETTING, TESTING AND COMMISSIONING OF DEPENDENT OR INDEPENDENT TIME OVERCURRENT RELAYS SERIES ITG 7XX5 - 7XX6

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1. FUNCTIONS OF THE ITG 7XX5 - 7XX6 RELAYS

GENERAL

The ITG 7XX5 and 7XX6 consist of a complete range of overcurrent relays of the independent or dependent (inverse, very inverse, extremely and moderately/slightly, inverse time) types, with or without high-set units. Relays of the 7XX6 series provide the possibility of switching the different functions to the two output relays using a switch on the relay faceplate. They are also capable of having a time-delayed high-set unit.

With respect to earth fault protection these relays may be residually connected using 3 line cts or feed from a 100 turn core balance ct.

TABLE N°1

PROTECTION	FUNCTIONS	DEFINITE TIME	INVERSE TIME	VERY INVERSE TIME	EXTR INVERSE TIME	MOD INVERSE TIME	CASE TYPE
1 PH or E/f	t I >	ITG 7105	ITG 7205	ITG 7305	ITG 7405	ITG 7505	R2
2 or 3 Ph	t I >	ITG 7135	ITG 7235	ITG 7335	ITG 7435	ITG 7535	R2
2/3Ph + E/f	t I > + tIo>	ITG 7185	ITG 7285	ITG 7385	ITG 7485	ITG 7585	R3
1 Ph or E/f	*1 I > + t I > I>>+tI>>	ITG 7116	ITG 7216	ITG 7316	ITG 7416	ITG 7516	R2
2 or 3 PH	*1 I > + t I > I>>+tI>>	ITG 7166	ITG 7266	ITG 7366	ITG 7466	ITG 7566	R2
2/3 Ph + E/f	*2 t I > + t I >> t Io > + Io>>	ITG 7196	ITG 7296	ITG 7396	ITG 7496	ITG 7696	R3

*1 Selection of the 4 functions towards the 2 output units "a" and "b" is obtained using a 4-position switch (a/b selection) on the faceplate, according to the combinations given in table N°2.

TABLE N°2 - FUNCTIONAL VARIANTS FOR THE OUTPUT UNITS OF ITG 7XX6 IN R2 CASE

Position of a/b selection switch	Functions associated with unit	
	"a"	"b"
1	t I > + t I >>	I >>
2	t I >	t I >>
3	t I >	I >>
4	t I > + t I >>	I >

*2
Selection of the 4 functions towards the "a" and "b" units is obtained using the switch (a/b selection) on the faceplate, according to table N°3

TABLE N°3 - FUNCTIONAL VARIANTS FOR THE OUTPUT UNITS OF ITG 7X96 RELAY

Position of a/b selection switch	Functions associated with unit	
	"a"	"b"
1	t I > + t I o >	t I o > + I o >>
2	t I > + t I o >	t I >> + I o >>

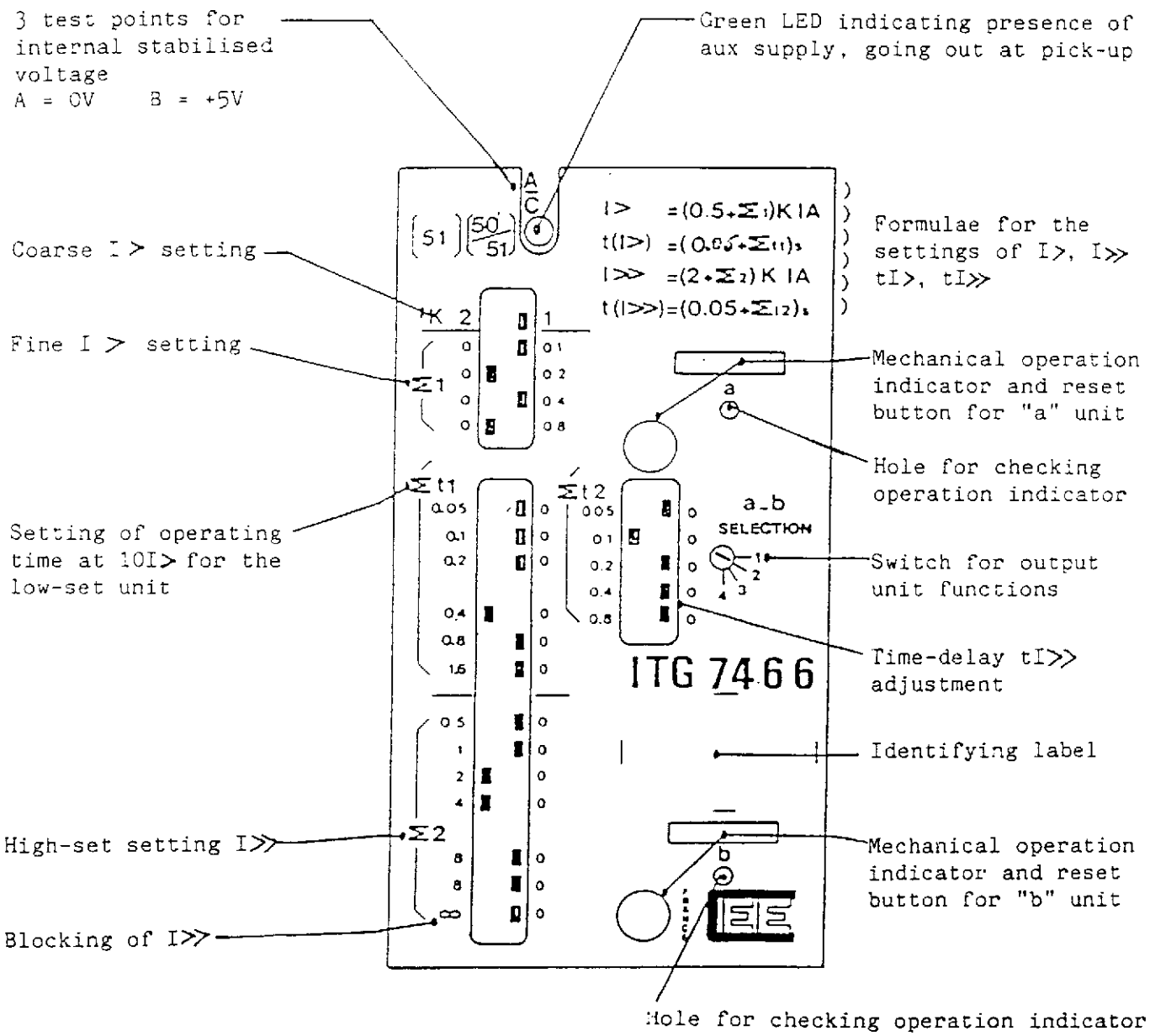
2. DESCRIPTION OF THE RELAYS

2.1 SYMBOLS USED ON THE FACEPLATE

[50] / [50N]	ANSI code used for instantaneous phase/earth (ground) units
[51] / [51N]	ANSI code used for time-delayed phase/earth (ground) units
I > Io >	Phase / earth (ground) low-set unit
I >> / I o >>	Phase / earth (ground) high-set unit
t I > / tIo >	Phase / earth (ground) low-set unit time-delay
t I >>	Phase high-set unit time-delay
K/Ko	Coarse setting of low and high-set phase/earth (ground) units
Σ1 / Σ3	Fine setting of low-set phase I> / earth (ground) Io> units
Σ2 / Σ4	Fine setting of high-set phase I>> / earth (ground) Io>> units
Σt1 / Σ t3	Setting of low-set phase I> / earth (ground) Io> unit time
Σ t2	Setting of high-set phase time-delay
a / b selection	Switch for output unit functions (tables N° 2 and 3)
s	Second
a	Identification of the "a" unit
b	Identification of the "b" unit
∞	Infinity : position where high-set units is out of service
IN	CT nominal secondary current
IA	Relay characteristic current (the value is indicated on the relay identifying label)
FN	Nominal frequency
V aux	Auxiliary supply voltage
R ext	External resistor
A or B	Type of output unit contacts

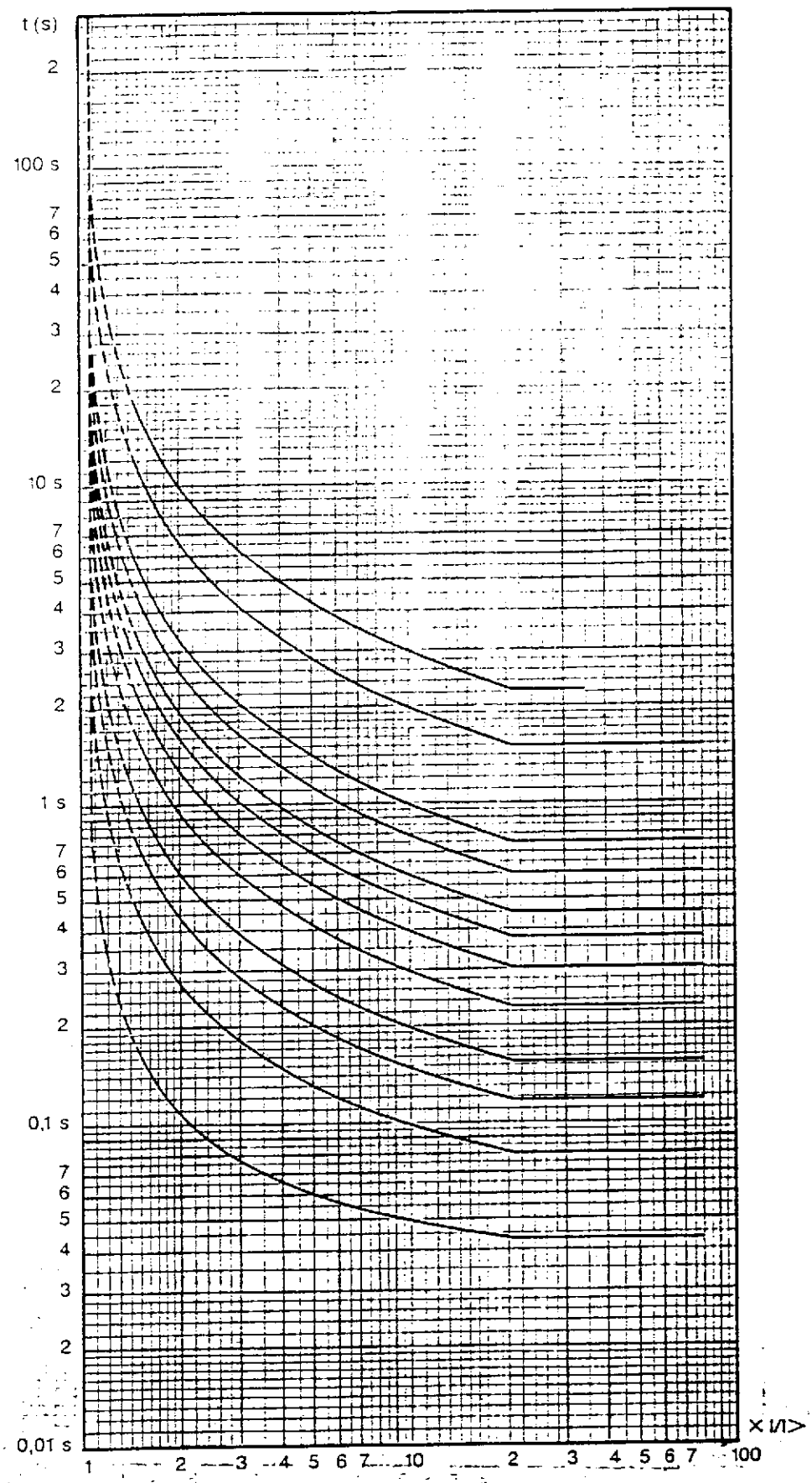
2.2 FACEPLATE - ADJUSTMENTS AND INDICATIONS

Figure 1



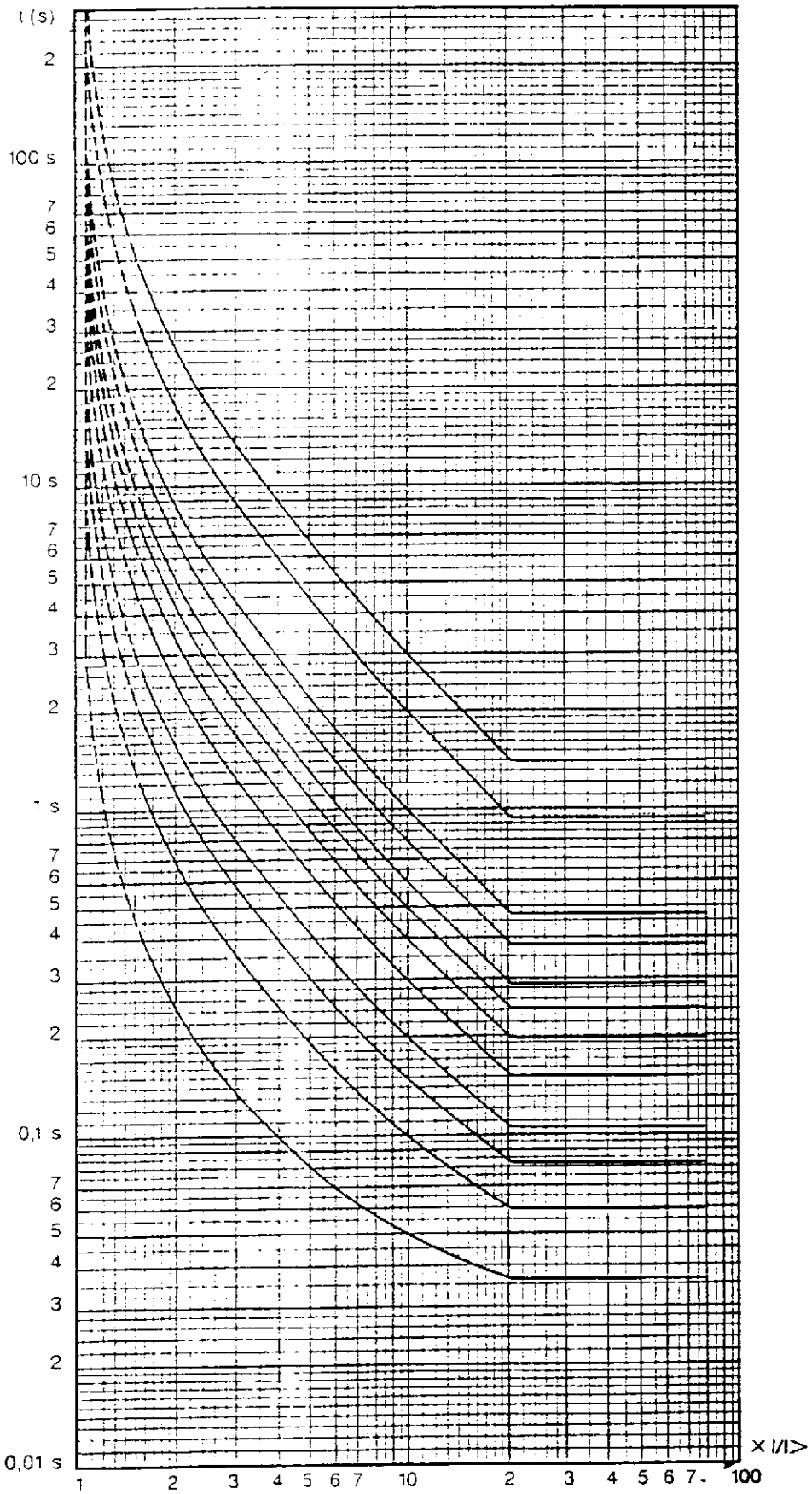
2.3 OPERATING CURVES

Figure 2 : Inverse time curves type A - IEC 255-4



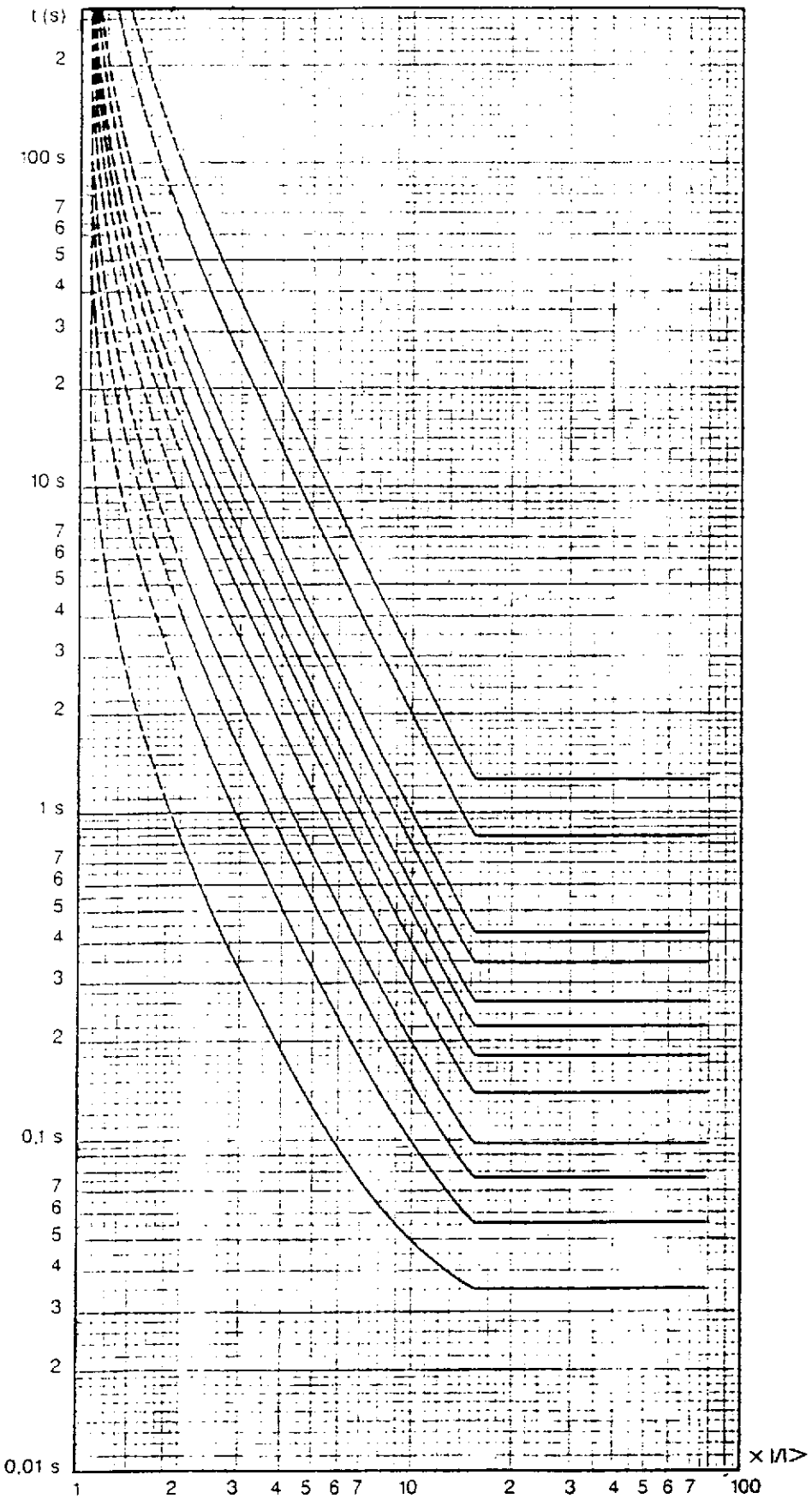
2.3 OPERATING CURVES

Figure 3 : Very inverse time curves type B - IEC 255-4



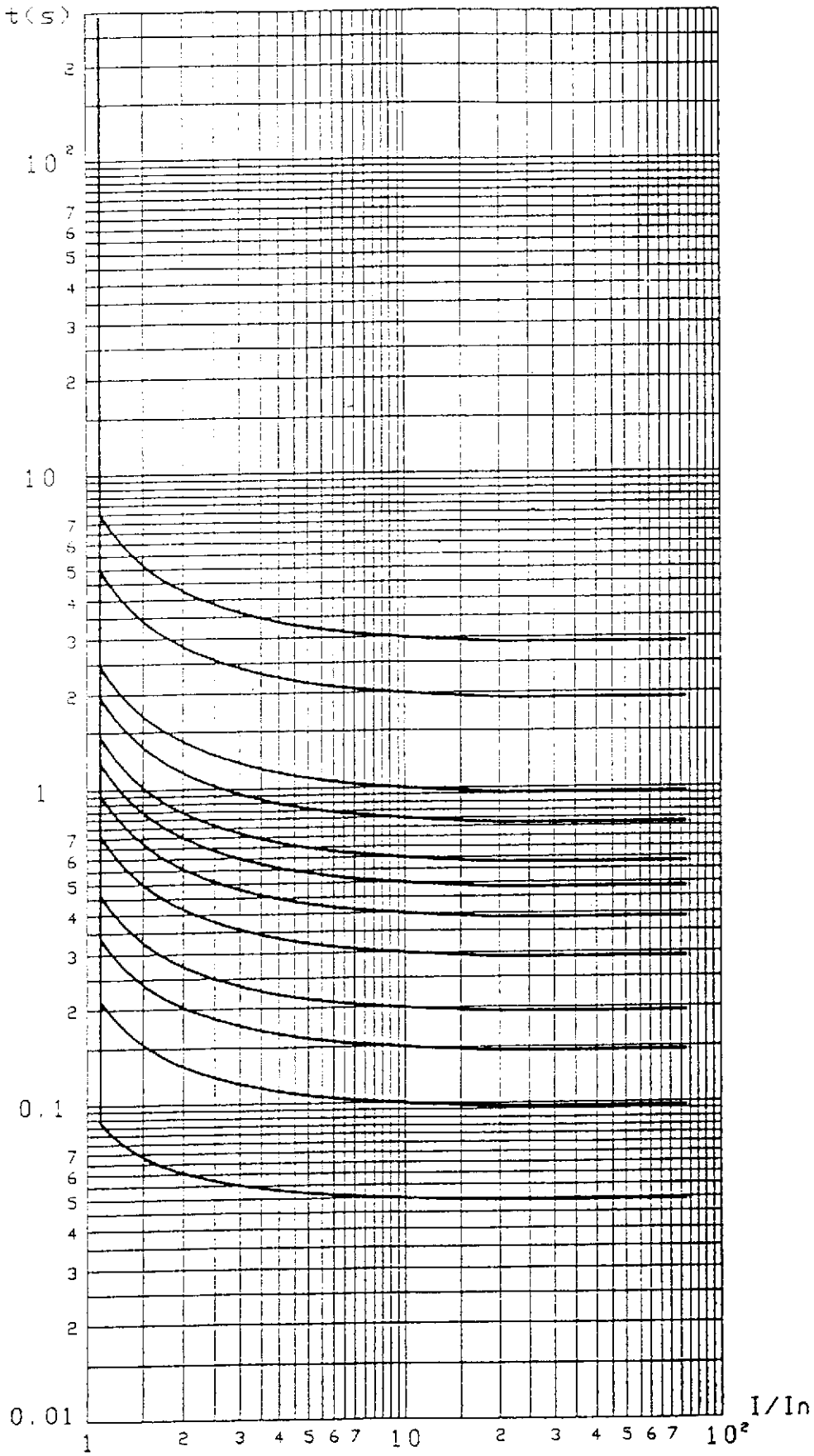
2.3 OPERATING CURVES

Figure 4 : Extremely inverse time curves type C - IEC 255-4

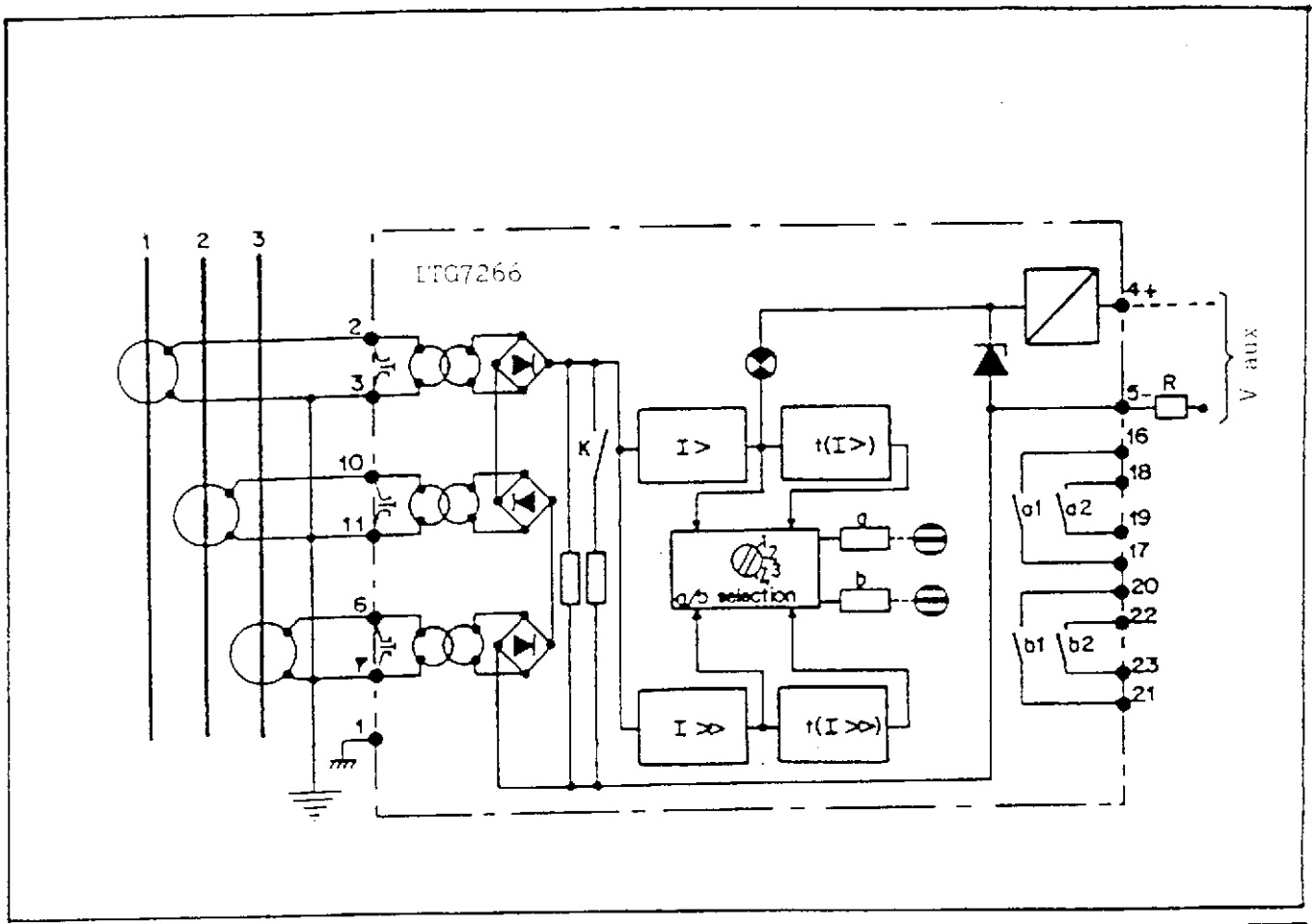


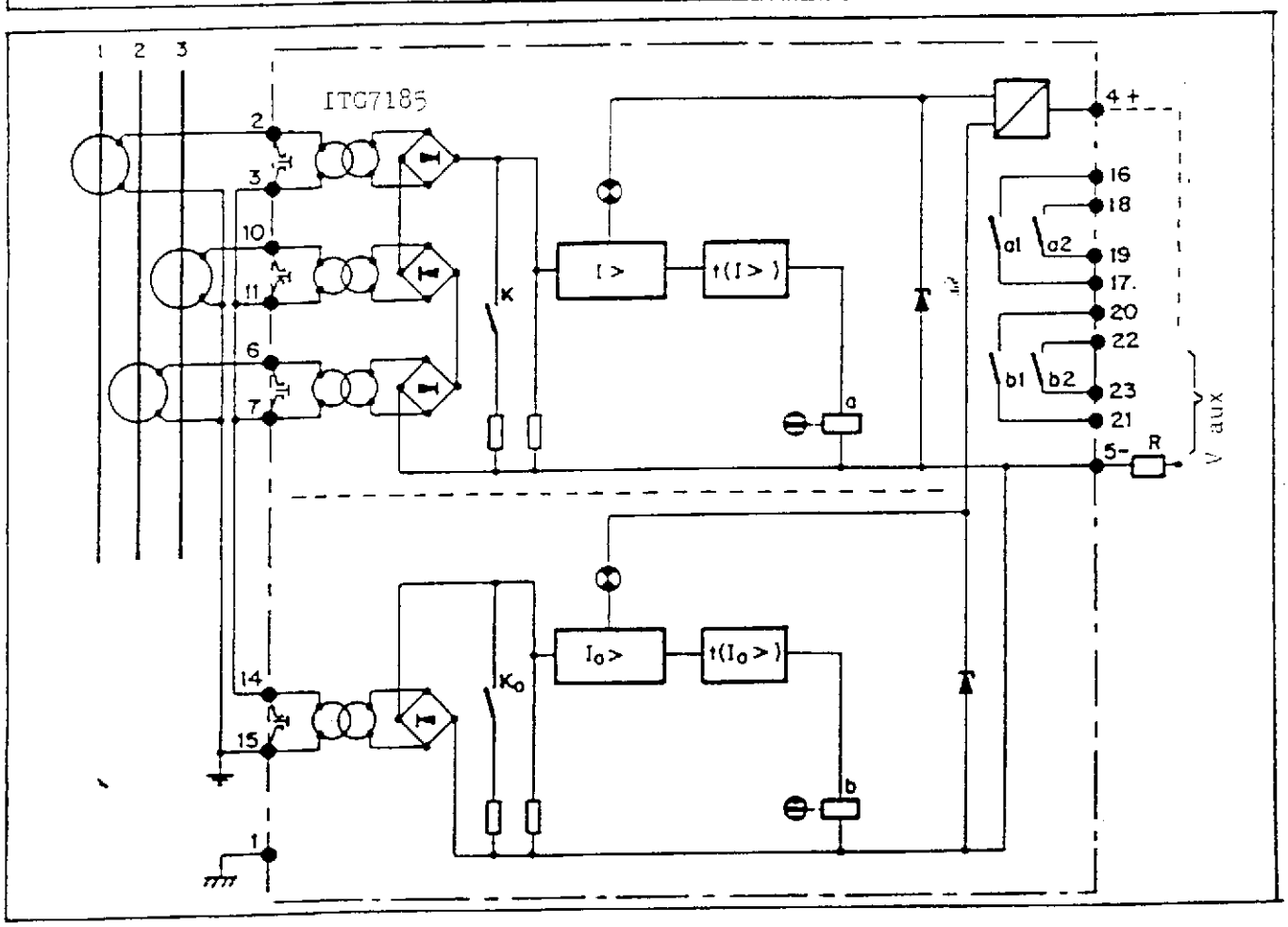
2.3 OPERATING CURVES

Figure 5 : ITG 75-5.75-6 Moderately slightly inverse



2.4 BLOCK DIAGRAMS FOR ITG 7266 & ITG 7185





2.5 ROLE OF THE GREEN LED(S) ON THE FACEPLATE

A green LED is associated with the I> and, where applicable, the Io> units. It allows the operator :

- to check that auxiliary supply is present (LED Lit)

- to have visual indication of the low-set I> and / or Io> operating levels (the LED goes out instantaneously at the pick-up level). The LED goes out at approximately :

100% of setting for independent time relays
110% of setting for dependent time relays

3. SETTING THE RELAYS

3.1 CURRENT SETTING RANGES

3. 1.1 Overcurrent Protection

The formulae for the setting levels I> and I>> use a concept of base current IA whose value, which is a function of the nominal current and of the chosen ranges, is given on the relay identifying label. For the phase-fault level the K switch always takes the values 1 or 2 matter what the chosen range.

Low-set unit I>
Formula on the faceplate : I> = (0.5 + Σ1) K.IA

IA VALUES FOR IN = 1 OR 5A	TOTAL RANGE	K = 1		K = 2	
		RANGE	STEP	RANGE	STEP
0.1 IN	0.05 to 0.4 IN	0.05-0.2	0.01	0.1-0.4	0.02
0.2 IN	0.1 to 0.8 IN	0.1-0.4	0.02	0.2-0.8	0.04
0.5 IN	0.25 to 2 IN	0.25-1	0.05	0.5-2	0.1
1 IN	0.5 to 4 IN	0.5-2	0.1	1-4	0.2

High -set I >>
Formula on the faceplate : I >> = (2 + Σ2) K . IA

IA VALUES FOR IN = 1 OR 5A	TOTAL RANGE	K = 1		K = 2	
		RANGE	STEP	RANGE	STEP
0.1 IN	0.2 to 5 IN	0.2-2.5	0.05	0.4-5	0.1
0.2 IN	0.4 to 10 IN	0.4-5	0.1	0.8-10	0.2
0.5 IN	1 to 25 IN	1-12.5	0.25	2-25	0.5
1 IN	2 to 50 IN	2-25	0.5	4-50	1.0

Note 1 : The effective limits of a high-set range I>> depend on the low-set setting (the value of switch K).

Note 2 : If the switch is set to the position, the high-set unit is out of service.

3.1.2. Earth fault

a) Residual connection.

The formulae for the Io > and Io >> settings make direct use of IN, and the Ko switch takes values 0.1/0.2 or 0.2/0.4 according to the version chosen

Low-set Io>
Formula on the faceplate : Io > = (0.5 +Σ3) Ko.IN

TOTAL RANGE	KO = 0.1		Ko = 0.2		Ko = 0.4	
	RANGE	STEP	RANGE	STEP	RANGE	STEP
0.05 to 0.4 IN	0.05-0.2	0.01	0.1-0.4	0.02		
0.1 to 0.8 IN			0.1-0.4	0.02	0.2-0.8	0.04

High-set Io>>
Formula on the faceplate : Io>> = (2 + Σ4) Ko.IN

TOTAL RANGE	Ko = 0.1		Ko = 0.2		Ko = 0.4	
	RANGE	STEP	RANGE	STEP	RANGE	STEP
0.2 to 5 IN	0.2-2.5	0.05	0.4-5	0.1		
0.4 to 10 IN			0.4-5	0.1	0.8-10	0.2

b) 100 turn core balance Ct

The formulaes for the Io> and Io>> settings are expressed in primary amps (A), the Ko switch takes the values 0.1 or 0.2.

Low-set Io>
Formula on the faceplate : Io> = 100 A (0.5 + Σ3) Ko.

TOTAL RANGE	RANGE WITH K = 0.1	RANGE WITH K = 0.2
5 to 40 A	5 to 20 A, step 1A	10 - 40A, step 2A

High-set Io>>
Formula on the faceplate : Io>> 100A (2 + Σ4) Ko.

TOTAL RANGE	RANGE WITH K = 0.1	RANGE WITH K = 0.2
20 to 500A	20 to 25OA step 5A	40 to 500A step 10A

3.2 TIME- DELAY SETTING RANGES

3.2.1 Low-set time-delay tI>

Independent time relays ITG 71X5 - ITG 71X6

RANGE	STEP	FORMULA ON FACEPLATE
0.05 to 3 sec	0.5 sec	tI> = (0.05 +Σt1)s
0.5 to 30 sec	0.5 sec	tI> = (0.5 +Σt1)s

Dependent time relays ITG 72X5 - ITG 72X6
ITG 73X5 - ITG 73X6
ITG 74X5 - ITG 74X6

RANGE	STEP	FORMULA ON FACEPLATE
0.05 to 3 sec	0.05 sec	tI> = (0.05 + Σt1)s

3.2.2 Low-set time-delay tIo >

Independent time relays ITG 7285 - ITG 7296
ITG 7385 - ITG 7396
ITG 7485 - ITG 7496

RANGE	STEP	FORMULA ON FACEPLATE
0.05 to 3 sec	0.05 sec	tI> = (0.05 + Σt3)s

3.2.3 High-set time-delay tI>> ITG 7XX6

RANGE	STEP	FORMULA ON FACEPLATE
0.05 to 1.6 sec.	0.05 sec	tI>> = (0.05 + Σ t2)s

3.3 OPERATING CURVES FOR DEPENDENT-TIME RELAYS (ITG 72XX, 73XX, 74XX, 75XX)

According to the different models, these are inverse (type A), very inverse (type B), extremely inverse (type C) to IEC 255-4 or moderately/slightly inverse.

Each curve is defined by its operating time at 10 times setting (I> or Io>), a time-delay which is adjustable from 0.05 to 3 sec in steps of 0.05 sec using the switches Σ t1 for tI> and Σ t3 for tIo> (this setting is valid up to 3.2 sec on the relays).

All of the curves are asymptotic to the setting value I> or Io>, but the minimum starting value of the curves is deliberately offset to 110% of setting. It is possible to visualise this value using the corresponding green LED on the faceplate.

Defining the operating time.

Operating times may be defined in two ways :

a) by direct reading or interpolation from the curves of fig 2, 3, 4 or 5.
Twelve curves have been drawn for each relay type (corresponding to 0.05, 0.1, 0.15, 0.2, 0.3, 0.04, 0.5, 0.6, 0.8, 1, 2 and 3 sec at 10 times the setting I>).

b) using the equations for the curves whilst these are within the dependent time range i.e. between 1.5 and 20 times setting for ITG 73XX, and between 2 and 15 times setting for ITG 74XX.

Mathematical equation for types A, B and C to IEC 255-4

$$t\,(s) = \left[\frac{T}{(I/I>)^{\alpha} - 1} \times \frac{\Sigma t + 0.025}{3} \right] + 0.025$$

Where : T = 0.14 α = 0.02 for inverse time curves
T = 27 α = 1 for very inverse time curves
T = 300 α = 2 for extremely inverse time curves

Using the mathematical equation

$\frac{T}{(I/I>)^{\alpha} - 1}$ Is the general for dependent time relays types A, B and C according to IEC 255-4
- T is a coefficient corresponding to the type of curve. Its value corresponds to the base value of the curve passing through 3 sec at 10I>
- I/I > is the ratio between fault current Iand the setting I>.

$\frac{\Sigma t + 0.025}{3}$ is the multiplying coefficient which is a function of Σ t (Σt1 or Σt3) on the faceplate

+ 0.025 is a fixed time-delay of approximately 0.025 sec, corresponding to the operating time of the output unit

Example

Calculation of the point at 5I> of an extremely inverse time curve passing through 1.2 sec at 10I>

1. Finding the value of Σ t1

t (I>) = (0.05 + Σt1) = 1.2
t1 = 1.2 - 0.05 = 1.15

2. Finding the operating time at 5I>

t = 300 α = 2(extremely inverse time curve)

I/I> = 5 Σt1 = 1.15

$$t(s) = \left[\frac{300}{(5)^2 - 1} \times \frac{1.15 + 0.025}{3} \right] + 0.025$$

$$= [(300/24) \times (1.175/3)] + 0.025$$

= 4.9 sec

Mathematical equation for the moderately / slightly inverse curve

$$t(s) = \left[\frac{0.3153}{0.339 - \frac{0.236}{(I/I>)}} \times (\Sigma t + 0.025) \right] + 0.025$$

Using the mathematical equation.

I/I > : is the ratio between the fault current and the setting I>

Σ t + 0.025 : is the multiplying coefficient which is a function of Σt (Σt, or Σt3) on the faceplate.

+0.025 : is a fixed time delay corresponding to the operating time of the output unit.

3.4 OPERATING CURVES FOR INDEPENDENT-TIME RELAYS

For these relays the timer starts exactly at the set operating level. No matter how high the fault current may be the operating time remains constant.

3.5 HIGH-SET UNIT(S) I>> - Io>>

For those mdels having a high-set unit, switching to the ~ position will put this out of service.

4. CHECKING THE RELAY AND COMMISSIONING

4.1 RECOMMENDATIONS

All the relays are sealed after calibration and final inspection and before delivery. This seal should be removed only by a qualified person when commissionning.

It is important to check that :

- the relay has not been mechanically damaged
- the electromechanical output unit operates correctly (if the armature is pressed home using a convenient tool, the operation indicator should fall and the contacts operate in a normal manner).

WE STRONGLY ADVISE AGAINST TESTING THE RELAY WITHOUT ITS BASE BY PLUGGING STANDARD COMMERCIALLY AVAILABLE PLUGS DIRECTLY INTO THE TERMINALS OF THE RELAY.

4.2 CHECKS BEFORE COMMISSIONING

These are designed to check that the device has not been damaged during transport or storage and constitute proof of operation at the set values.

These simple tests require a certain minimum of equipment :

- a current generator fitted with a timing device, a device for automatically tripping the injected current , as well as a source of auxiliary supply.

- taking account of the fact that these tests are carried out on site and not in a laboratory, the precision of the operating level should be allowed a tolerance higher than indicated in the commercial publication.

- if the test equipment does not incorporate a system to trip the injected current automatically be tripped immediately after relay operation.

NOTE : for the injection of any current < 1A, we recommend that a resistor of >10 ohm be inserted in series with the source to increase the source impedance and improve the stability.

4.3 REQUIRED INFORMATION

For commissioning of relays of the ITG 7XX5/7XX6 series it is essential to check that relay and network characteristics correspond with each other. Check :

- that the relay nominal current agrees with that of the Cts supplying the protection
- the value of characteristic current IA for the phase-fault settings
- the type of relay, its characteristics, its auxiliary supply and connections
- for relays of ITG XX6 series the function of the output units "a" and "b"
- the value of the different settings to be applied; the settings are only valid when the switches are pressed completely home

NOTE : in the event of two-phase connection the relay is always a three-phase one with one phase not connected.

4.4 TESTING THE LOW-SET UNIT(S)

SEQUENCE OF OPERATIONS	RESULTS OBTAINED
- Provisionally set the high-set unit(s) to ∞ - Apply an auxiliary voltage witthin the allowable tolerance - Checking the phase-fault low-set unit I> . connect the current generator to 2-3, 6-7 or 10-11 according to relay type . apply required settings using K and Σ1 . slowly increase the injected current up to the operating level.	- the LED(s) should be lit - the LED will go out at 110% of the required setting (dependent time types) or 100% for independent time types tolerance + / - 10% - relay "b" should pick up instantaneously for 7XX6 relays in R2 cases with a/b selection = 4
- Checking the phase-fault low-set time tI> . set the time-delay of the low-set unit tI> as defined at 10 times setting I> using Σt1 for inverse relays. For definite time relays this is valid from 1.5 times setting . use a contact on the corresponding output unit to stop the timer and current injection . preset the current to 10 times setting or above 1.5 times setting for definite time types . trip the current and reset the timer . inject the current *	- the green LED should go out immediately - the output unit "a" should pick up after the time-delay - the time measured should be equal to the setting (see NOTE 1)
- Checking the earth-fault low-set unit Io> and its time-delay tIo> . connnect the current generator to 14-15 . carry out the above procedure	- similar results should be obtained but the out-put unit which operates will vary according to the a/b selection

* Other points on the different curves may be checked in a similar manner, particulary those at 2, 5,15 or 20I> (see para 3.2). Allowable tolerances are to be found in the following table.

Multiple of setting current		2	5	10	15	20
Theoretical tolerance on time of operation or +/ -15 ms	ITG 72XX ITG 73XX	+/ -12.5%	+/ -7.5%	+/ -5%	+/ - 5%	+/ - 5%
	ITG 74XX	+/ -18.75%	+/ -11.25%	+/ -7.5%	+/ -7.5%	---

NOTE 1 : These values are the theoretical tolerances when the device is maintened at nominal environmental parameters (frequency, auxiliary voltage, temperature), for a perfectly sinusoidal waveform from a pure current source source, and for a perfectly synchronised start of the timer and the current injection. For tests on site these tolerances should be multiplied by 2.

NOTE 2 : Tests on level I> should be carried out on phases not previously tested

REMINDER : For ITG 7XX6 relays, and depending on the position of the a/b selection, the time-delays tI> and tI>> could be associated with the same output unit. To differentiate between these time-delays it is necessary to set temporaly the hight-set unit to the position.

4.5 TESTING THE HIGHT-SET UNIT(S) (ITG 7XX6 ONLY)

ATTENTION : In order to avoid serious overloads on the relay, the hight-set unit is checked by two consecutive current injections, one 10% below setting and one 10% above setting. If there is no automatic tripping of the injected current, do not allow injection to continue much longer than operating time set on the relay.

SEQUENCE OF OPERATIONS	RESULTS OBTAINED
- Checking the phase- fault high-set unit I>> . temporarily put the selector on position 1 or 3 (ITG 7XX6) . connect the current generator to 2-3, 6-7 or 10-11 according to the type . set the high-set using Σ 2 . after presetting inject a current at -10% of relay setting (1s min)	- Output relay "b" should not pick up
. after presetting inject a current at + 10% of relay setting (1s min) (stop injection by "b" contact)	- Output relay "b" should pick up
-Checking the high-set time-delay tI>> (ITG 7XX6) . temporarily put the selector on position 2 . use a contact of "b" to stop injection . inject a current equal to at least 1.5 times the high-set setting	- Output unit "b" should pick up after the time set on the relay
- Checking the earth-fault high-set Io>> . connect the current generator to 14-15 . carry out the above procedure (no earth-fault unit time-delay)	- Similar results to those above
- Reset the a/b selection switch to the chosen position	

NOTE 1 : If the current generator cannot provide a current close to the chosen setting, check a lower settting point then replace Σ2 or Σ4 to their required values, or have the K or Ko settings at minimum them after testing.

NOTE 2 : Tests on the high-set unit I>> should be carried out on phases not previously tested .

4.6 COMMISSIONNING

Before commisionning it is important to check that :

- the Cts have a nominal secondary current equal to that shown on the relay identifying label and have a minimum precision power of 5VA, 5P10
- the network frequency is that indicated on the relay label, and that the external resistor is correctly connected if the auxiliary supply is above 125V
- the relay is correctly plugged in and that the fixing rods are screwed tight home
- the tripping circuit is correct
- the a/b selection switch is in the chosen position for ITG 7XX6 relays

Checking the breaker tripping circuit

During the tests the breaker tripping circuit may be checked by putting it into the "test" position. It is then only necessary to close the breaker and check that the corresponding relay output unit contacts cause the breaker to trip. If this is not possible for some reason the trip circuit should be checked element by element using an ohmmeter, starting on the relay base to ensure that the contacts change state at relay operation. Ensure that the wiring is not "live" whilst testing.

If during previous tests the relay did not function, check that current is drawn by the relay from the auxiliary supply, by inserting a milliammeter on a 300mA or 500mA range in series with the supply.

5. APPENDICES

5.1 EXAMPLES OF SETTING

Setting a dependent time relay type ITG 7266 for example

Hypotheses

- Protect a transformer of 6MVA, 15/3. 3kV, Z = 6.5%
- The 15kV network short-circuit level is 150MVA
- The highest protection settings immediately downstream are a low-set unit at 0.45 sec and an instantaneous high-set at 1000A
- The CT ratio used for the 15kV side of the transformer is 250/5A

Choosing the relay

To allow brief possible overloads on the 3.3kV side of the transformer (eg motors starting up) an inverse time curve is perhaps the best choise for this application. The relay is therefore an ITG 7266, IN = 5A, IA = 2. 5A . I> = 0.25 to 2IN of the Cts, tI> = 0.05 to 3 sec, I>> = 1 to 25 IN CT.

a/b selection = 3 (overload on "a", short-circuit on "b" - table N°2).

Setting the low-set unit

I> = transformer nominal current (for example) = 230A, or approx 0.9 IN CT

On the relay this becomes 0.9 x 5A = 4. 5A

I> = (0.5 + Σ1) K.IA with K = 1 and IA = 2.5A

I> = (0.5 + Σ1) x 2.5 = 4.5

Hence 1 = (4.5 / 2.5) - 0. 05 = 1. 3

Choosing the operating time curve

To maintain selective tripping with the downstream protection, the curve passing through 0.45 sec at times setting has been chosen

tI> = (0. 05 +Σt1) = 0.45 sec

Σtl = 0.45 - 0.05 = 0.4

Setting the high-set unit

To avoid any false tripping, the high-set unit set at approximately 15 or 20% above the 15kv equivalent of the transformer short-circuit level at 3. 3kV.

The calculation gives a short-circuit current equal to 2. 2kA at 15kV, thus a convenient setting of I>> at 2. 5kA, or 1OIN CT.

I>> = (2 + Σ2) K. IA with K = 1 and IA = 2.5A

I>> = (2 + Σ2) x 2. 5A = 5OA

Σ 2 = (50 / 2.5) - 2 =18

5.2. ITG 7335 AND ITG 7466 TYPICAL BLOCK DIAGRAMS