MSCDN – MP2B

Capacitor unbalance protection

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand
18/10/2004	R2 VTS added.
11/02/2003	R1 First version.

Software Revision History

23/03/2006	2621H80003R9c	

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1 Introduction

The MSCDN-MP2B relay provides wide bandwidth, true RMS phase-by-phase Reactor Thermal Overload Protection, Backup Overcurrent and Earth Fault Protection and Overvoltage Protection and is suitable for Capacitor Bank applications. Together with it's sister units MSCDN-MP1 and MP2A, this protection unit offers a complete solution for Main 1 and Main 2 protection of EHV/HV capacitor banks.

These notes give guidance on the application of the relay and the protection elements integrated in it, reference may be made to the Commissioning Chapter, which provides detailed set-up instructions.

2 Reactor Thermal Overload Protection

2.1 Fault Setting Principles

The operate time of the thermal elements is given by

$$t = \tau \times \ln \left\{ \frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2} \right\} \sec \quad \text{…(Eq. 1)}$$

Where

I_P = Previous steady state current level

I_B = Basic current rating of reactor

k = Multiplier resulting in the overload pickup setting $k.I_B = I_\theta$

I = The measured reactor current

τ = Thermal time constant

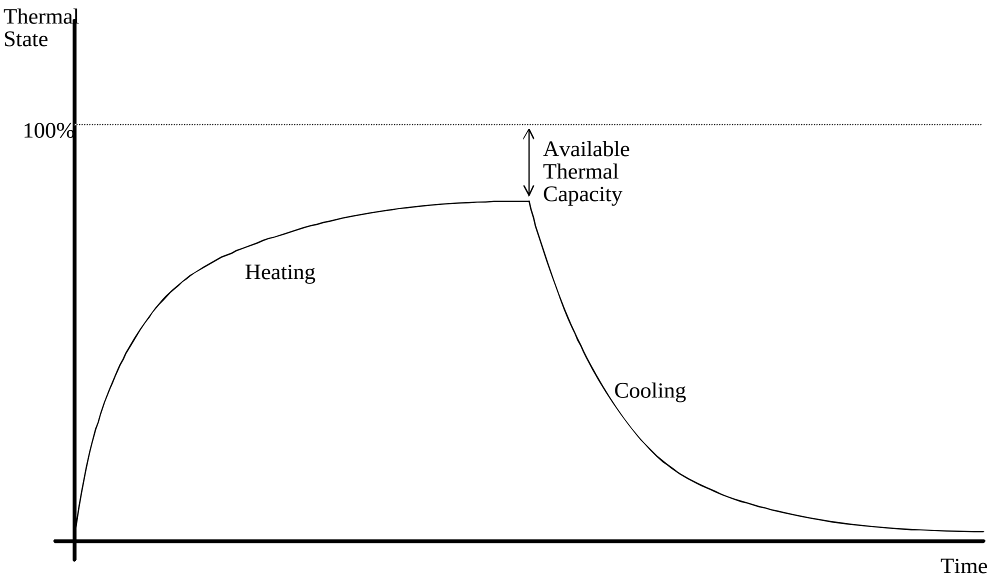

Figure 1 – Exponential heating and cooling curves

For the heating curve:

$$\theta = \frac{I^2}{I_\theta^2} \cdot (1 - e^{-t/\tau}) \times 100\% \quad \text{….(Eq.2)}$$

For the cooling curve:

$$\theta = \theta_F \cdot e^{-t/\tau} \quad \text{……(Eq.3)}$$

where: θ = thermal state at time t

θ_F = final thermal state before disconnection of device

I = measured thermal current

I_θ = thermal overload current setting (or $k.I_B$)

τ = thermal time constant

The final steady state thermal condition can be predicted for any steady state value of input current since when t>>τ,

$$\theta_F = \frac{I^2}{I_\theta^2} \times 100\% \ldots\text{(Eq. 4)}$$

The thermal overload setting I_θ is expressed as a fraction of the relay nominal current and is equivalent to the factor $k.I_B$ as defined in the IEC60255-8 thermal operating characteristics. It is the value of current above which 100% of thermal capacity will be reached after a period of time and it is therefore normally set slightly above the full load current of the protected device.

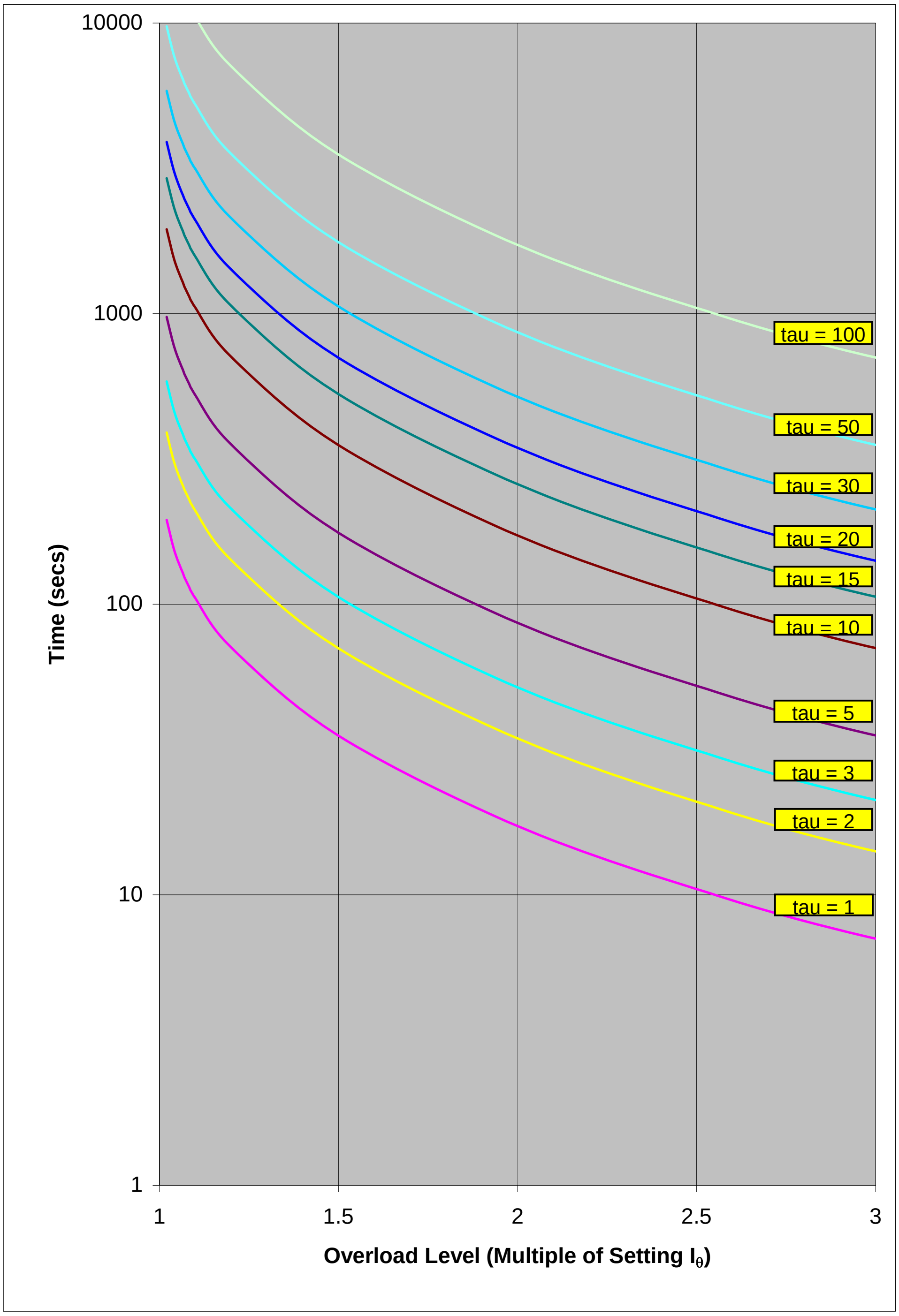

Figure 2 - IEC60255-8 Cold Curve (tau in minutes)

2.2 Setting Example

Reactor Thermal Characteristics

CURRENT IN AMPS	TIME IN MINUTES
236	Continuous
389.4	105
401.2	90
424.8	58
448.4	48
460.2	42
472	38

CT Characteristics

Ratio	400/1

Alarm & Trip Requirements

Alarm level	105 %
Trip level (Iθ = kIB)	110 %

Now I_B = 236/400 = 0.59 amps

And I_θ = k x I_B = 1.1 x I_B = 1.1 x 0.59 = 0.649 Amps

At an applied current of I = 389.4/400 = 0.9735 amps, the reactor maximum withstand time is t = 105 minutes. Using a safety margin of 50%, then

$$0.5 \times 105m = \tau \times \ln\left\{\frac{0.9735^2}{0.9735^2 - 0.649^2}\right\}$$

Thus

$$\tau = \frac{52.5}{\ln\left(\frac{0.9477}{0.5265}\right)}\min = 89.32\min$$

∴ τ = 90 minutes will be used to satisfy the 50% safety margin.

Reactor Thermal Characteristics

CURRENT IN AMPS	TIME IN MINS	RELAY CHARACTERISTICS
236	Continuous	Continuous
389.4	105	52.90
401.2	90	48.82
424.8	58	42.08
448.4	48	36.74
460.2	42	34.47
472	38	32.42

Steady state thermal energy =

$$\theta_F = \frac{I^2}{I_\theta^2} \times 100\%$$

$$\theta_F = \frac{1^2}{1.1^2} \times 100\% = 82.64\%$$

Alarm level thermal state =

$$\theta_F = \frac{1^2}{1.05^2} \times 100\% = 90.7\%$$

Re-arranging equation 1 we get

$$t = -\tau \times \ln\left\{1 - \left[\frac{\theta \times I_\theta^{\ 2}}{I^2 \times 100}\right]\right\}$$ …. (Eq.5)

The maximum operating time of the Thermal Alarm (i.e. from cold) will given by :-

θ =	91	%
τ =	90	m
I =	1.05	
I_θ =	1.1	
t =	**600.20**	**m**

To achieve steady state thermal capacity of 82.6% (i.e. from cold) will given by :-

θ =	82.6	%
τ =	90	m
I =	1.05	
I_θ =	1.1	
t =	**213.32**	**m**

Therefore the operating time from steady state at rated current of the Thermal Alarm would be
t = 600m – 213m = 387m

Thermal Protection Settings

49 Overload Setting (using 1A i/p)	1.1 x 12/20 = 0.66 xIn
49 Time Constant	90 minutes
49 Capacity Alarm	90 %

3 Backup Overcurrent And Earth Fault Protection

3.1 Fault Setting Principles

Typically Overcurrent protection is set to operate at 150% of rated current and Earth Fault protection is set to 20% of rated current, graded with a suitable time discriminating margin with other protections.

3.2 Setting Example

MVAR Rating (3P)	162.9
Voltage (L-L)	145kV
CT Ratio	600/1

Rated Current per phase = 162.9MVA/(145kV x √3) = 648.62 Amps

150% of Rated Current = 1.5 x 648.62/600 = 972.93/600 = 1.62 Amps

20% of Rated Current = 0.2 x 648.62/600 = 129.72/600 = 0.216 Amps

Phase Fault Setting	1.65
Earth Fault Setting	0.25

4 Overvoltage Protection

4.1 Fault Setting Principles

Two stages are available, a DTL stage for alarm purposes and an IDMTL characteristic for tripping purposes.

Typically the Alarm would be set to 105% of Capacitor Bank voltage rating and the Trip characteristic would be set to pick up at 110% of Capacitor Bank voltage rating.

4.2 Setting Example

Capacitor Overvoltage Withstand Characteristics

TIMES RATED VOLTAGE	TIME IN SECONDS
1.2	1800
1.25	300
1.3	60
1.4	15
1.7	1
2	0.3
3	0.02

Voltage (L-L)	145kV
VT Ratio	145kV/110V
VT Connection	Vpn

Rated Voltage Line to Ground = 145kV/√3

Vn applied to relay terminals = (145000/√3) x (110/145000) = 63.5 Volts

Alarm pickup is at 105% rated voltage = 1.05 x 63.5 = 66.68 Volts

Trip pickup is at 110% of rated voltage = 1.1 x 63.5 = 69.86 Volts

Assuming a 50% safety margin on operate times then :-

Overvoltage Protection Settings

Vn	63.5V
59DT Setting	1.05
59DT Delay	0 s
59IT X0 Pickup Setting	1.10 x
59IT Y0 Point Setting	20000s (maximum)
59IT X1 Pickup Setting	1.20 x
59IT Y1 Point Setting	1800 x 0.5 = 900s
59IT X2 Pickup Setting	1.25 x
59IT Y2 Point Setting	300 x 0.5 = 150s
59IT X3 Pickup Setting	1.3 x
59IT Y3 Point Setting	60 x 0.5 = 30s
59IT X4 Pickup Setting	1.4 x
59IT Y4 Point Setting	15 x 0.5 = 7.5s
59IT X5 Pickup Setting	1.7 x
59IT Y5 Point Setting	0.5s
59IT X6 Pickup Setting	2 x

59IT Y6 Point Setting	0.1

5 Voltage Transformer Supervision

5.1 Fuse Failure Setting Principles

The VTS uses an undervoltage element 27 VTS and a current check element 50 VTS. If both are operated for the VTS Delay period then VTS outputs are driven.

5.2 Setting Example

If the current applied per phase is greater than 0.80 of nominal current and the voltage on this phase is less than 0.75 of nominal voltage for 10 seconds then operate Output Relays 4 and 5 and Fascia LED 24.

VT SUPERVISION MENU

27 VTS Element	Enabled
27 VTS Setting	0.75 xVn
27 VTS Delay	0.00s
50 VTS Element	Enabled
50 VTS Setting	0.80 xIn
50 VTS Delay	0.00s

REYLOGIC ELEMENTS MENU

VTS Delay	10000ms

OUTPUT RELAY MENU MENU

VTS	4,5

LED MENU

VTS	24