The microLOAD Overload and Short Circuit Protection Relay

Reference Manual

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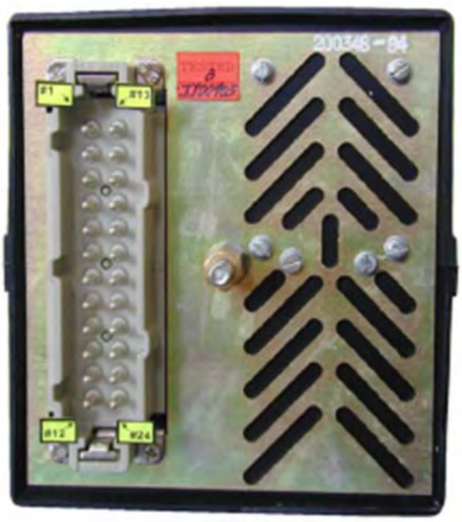
1. Introduction

The microLOAD relay is a microprocessor controlled protection relay designed to protect electrical distribution outlets and motors. The relay provides sophisticated short circuit and overload protection but at the same time remains extremely user friendly. The display is simple and allows the user to observe setting and running conditions at a glance. Setting of the relay is also extremely simple and there are a number of interfaces which allow the user to accomplish this.

The combined overload, short circuit and phase imbalance features described below make the microLOAD an excellent protection relay for the following typical applications:

- Transformer primary protection
- Transformer secondary distribution panels
- Pump and fan motors
- Hoist motors
- Conveyor motors
- Feeder motors
- Drilling machines
- Drag line motors
- 11kV and 6.6kV distribution
- Multi motored machines such as continuous miners, shuttle cars and feeder breakers.

The list is not intended to be exhaustive, but will go some way to illustrate the wide application range of the relay.



2. Advantages of the Dimako "microLOAD" Overload Protection Relay

Industry proven protection is packed into the microLOAD protection relay with the following advantages to the end-user:

- Three year guarantee.
- Maximum R250-00 repair cost.
- Maximum R480-00 service exchange cost (excluding breakdown transport).
- Tested to numerous IEC specifications.
- Robust and light weight construction
- Well proven, industry standard, connection facilities.
- Excellent repeatability and stability over the full overload current range and under severe environmental conditions.
- Accredited Laboratory tested in excess of claimed parameters, until failure, to ensure that fail to safe conditions apply.
- Phase sensitive short circuit protection as low as 150% of full load current setting.
- Quick and accurate overload setting via digital displays. The inaccuracies of antiquated dial setting methods with no feedback of actual set point are completely avoided.
- Three separate overload models: one per phase. No averaging of the phase currents to provide one thermal model.
- All parameters visible at one instant (no menus to wade through to discover set parameters).
- The relay is directly calibrated in amps (ie No CT ratios to contend with to arrive at final overload setting)
- Ergonomic and user friendly, real time status display.
- Displays are colour coded and redundant where necessary.(healthy and trip indications are also position coded to allow for colour-blind users)
- Numerous methods available for relay set up
- The relay can be set from outside flameproof enclosures (without having to open the door.) The relay can also be set whilst the unit is running.
- Relay can be set via "Intelligent Pilot", Infra-Red remote control, or via push button controls.
- Wide application base making the relay an easy standard to adopt which reduces spares stock-holding, training time / facilities for the end user.
- Excellent historic-performance service records.
- Relay can provide real time communication via RS232 port
- Relay can provide last 10 reasons for trip with dates and times.

4. Relay Indications

All indications provided by the microLOAD relay are LEDs which are robust and have very long trouble-free service lives. The main status LEDs are large and back illuminate an appropriate text block designating the status.

The front facia is depicted in figure 1 below:

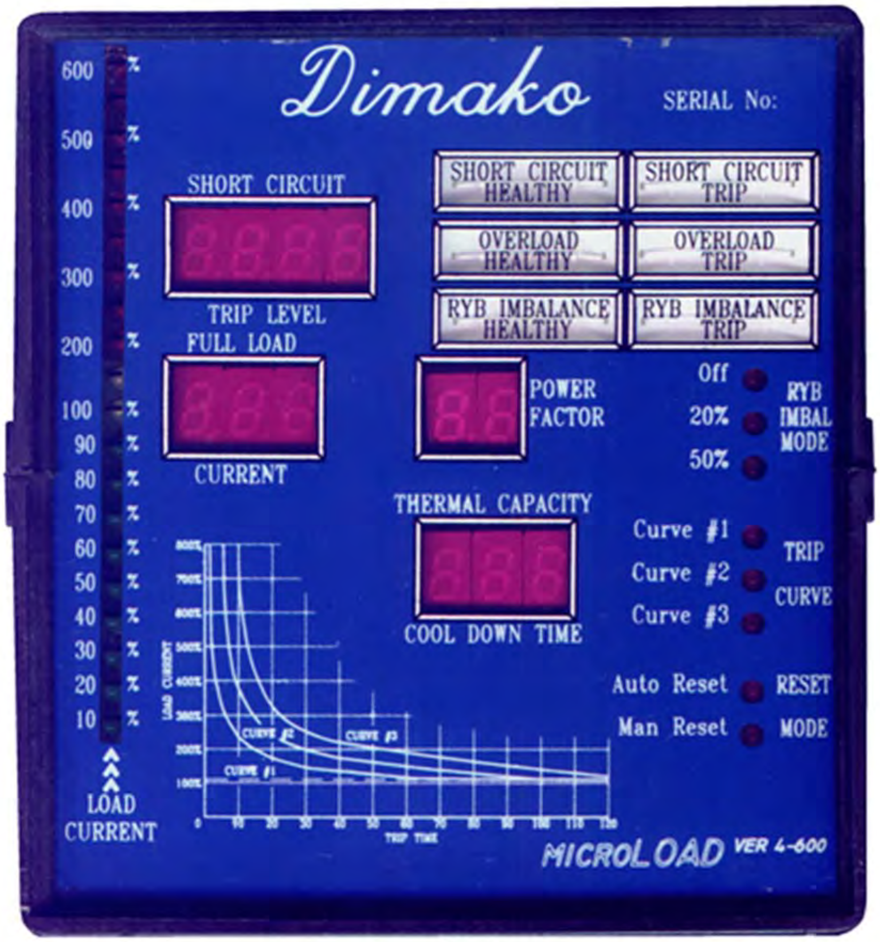


Figure 1: The general layout of the front panel of the microLOAD protection relay

a. Bar-graph ammeter.....
This is located on the left most edge of the relay facia. The bar-graph is colour coded to assist the user with acquiring fast transient readings.
   - From 0-90% the display is green. The 100% value of current corresponds to the full load setting of the relay, which is displayed adjacent to the 100% position of the bar-graph.
   - The 100-150% reading is given by yellow LEDs
   - From 200% to 600% the LEDs are red in colour.
   - The bar-graph led’s will always display the highest current of the 3 phases measured.

b. Full load current....
This is a 3 digit numerical display which can be set anywhere between 4 and 650 Amps in 1 Amp steps. This display is read directly in Amps **and is not a percentage** of the CT ratio, as found on most relays. This avoids any misinterpretation of the actual overload setting as a result of miscalculation of CT ratio. Some users may request a maximum limit of the overload setting in which case the relay will be limited to an internal maximum value.
   - *It is possible to change the setting range of the relay from 0.4 to 65 Amps in 0.1 Amp steps. To do this the decimal point must be enabled by a link on the rear terminals and the relay must be supplied from a different purpose built current transformer. This does not change any internal settings of the relay, and*

this must be remembered when downloading information from the relay, as settings and trip values stored in the relay will still be in the 4 to 650 Amp range.

c. Short circuit current...
This is a 4 digit numerical display which can be set between 150% and 600% of the full load setting. In the set mode the short circuit value will default to 150% of the new full load setting. The value can be incremented (and ultimately decremented) in 50% steps The range may seem, at first, very low for motor start applications, but the short circuit parameter in the relay is very sophisticated and allows for lower settings and correspondingly better protection. This is explained in full in the section describing the short circuit protection feature.

- *The short circuit display can be used to display the actual running current in Amps in a digital format, for a more accurate reading than that provided for by the bar-graph ammeter described above. In normal running mode the short circuit value will be displayed: to toggle the function of the display between an ammeter and the short circuit setting the reset push button must be held in for more than 5 seconds, during which time the load will be as a normal rule be disabled. Confirmation of the change to digital ammeter mode is obtained once the display reading changes to a "0". (This setting cannot be achieved as a short circuit setting so it is easily distinguishable). To revert to the short circuit setting display mode the reset must be again pressed for more than 5 seconds. The end user can distinguish between the modes by the behaviour of the display: a dynamically changing display or a steady "0" will indicate that the relay is in ammeter mode. A static non zero reading will be the short circuit setting of the relay. The short circuit level can never be set on "0".*

d. Power factor
This is a two digit display the value of which is only shown to one decimal place and is not intended to provide the user with a very accurate means of measuring power factor. It however can be used to give the user some idea of what the power factor of the load is. The display is primarily designed to assist with phasing the relay during factory testing or to assist with on-site problems where the end user may have disturbed phase sensitive wiring
The power factor displayed corresponds to the phase with the highest current.

e. Thermal Capacity.... Cool-down Time
The display serves a dual purpose:

- in the "run" mode (i.e.: while the relay has not tripped) the three digit display will display a measure of the thermal overload status or capacity actually used. This is dependent on the trip curve that has been selected and is explained in full in the section describing the overload protection feature.

- alternatively the display shows the remaining "cool down time" (number of seconds) before the relay can be reset. The maximum cool down time can be user preset to a chosen maximum value. The user however does not have complete control of this feature and the relay will override it if necessary. This is also explained in full in the section describing the overload protection feature.

f. Auto/Manual reset
The reset mode for the relay can be set in one of two possible modes.

- In manual mode the relay can only be reset after a short circuit, phase imbalance, or overload by an external reset pushbutton which is wired to contacts at the rear of the relay. The current through the CT must be zero (actually below a preset minimum in the relay).
- In Auto mode the overload trip function only can be automatically reset by the overload relay itself once the countdown trip timer has reached zero and the current through the CT feeding the relay is reduced to zero. In all cases the short circuit or phase imbalance will require a manual reset.

g. Trip Curve
Any trip curve function can be factory programmed into the relay. The relay can store three different curves. The trip curves that are programmed into the relay are printed on the faceplate of the relay. Larger format curves which are easier to read can be obtained from the factory on request. During set mode any one of the three curves can be selected.

h. Current imbalance
There are three options for the current imbalance feature
Off...... 20%.... or..... 50%

- The recommended operating mode is 20%. In this mode any imbalance of the individual phase currents that exceeds 20% for more than 2 seconds will cause the relay to trip.
  This mode not only protects the load from imbalances due to voltage differences, open circuits, and high resistance connections, but also provides protection against faulty or disconnected current transformers and or internal measurement errors.
- The "50%" mode is used essentially for detecting phase failure. This mode is more often used in distribution networks where the relay is only intended to protect outgoing cables, bus-bars and connections to multi-point distribution panels or to multi-motored machines having their own individual load protection facilities.

  There are other areas where it can also be applied such as detection of furnace element failure, but for more specific protection advice liaison with the factory will provide for the best protection for a given system.
- The current imbalance feature can be totally disabled, by turning the option off", where non-symmetrical or imbalanced single loads are employed.

i. Short Circuit , Overload and Phase Imbalance
The relay provides redundant indication for the status of the relay. Red indication is used to display a trip condition and green displays a healthy state. Either a trip or healthy state of each function will be displayed. If neither is displayed then the user can assume that either the power to the relay has failed or the actual indication is faulty. The colour coded display can be used by those who are not familiar with the English language but are accustomed to red meaning a faulty condition. The trip and healthy indications are separate and therefore can also be interpreted by those people who are colour blind.

5. Controls

The overload relay has three external push button functions that provide for external user control: These Buttons will take on different mechanical formats depending on the application or where the relay is installed.

Whilst the push button method of relay setting and resetting is generally used it is also possible to set the relay via

a) Intrinsically Safe infra-red remote control.
b) Via a single wire method called "Intelligent Pilot". Use of the relay with this option requires a remote intelligent module (and a zener barrier for Intrinsically safe applications), fitted to the prospective load, that has all the pre-programmed overload parameters stored in non-volatile memory. These parameters are uploaded and stored in the microLOAD's memory when the intelligent module is used in conjunction with a Pilot system.

Set button:
It is the best to set the unit while no current is flowing, however it is possible to set the relay when it is fully operational. The new parameters will come into immediate effect once the user has exited from the set mode of the relay. This does not happen if the relay is left to exit automatically from an incomplete set operation by the user.

When the unit is powered up the user can set the different values on the relay by pressing the set button .The following 6 displays will flash in sequence when the set button is pressed in succession.

- Full load setting (3 digits),
- Short-circuit setting(4 digits) ,
- cool-down setting (3 digits) ,
- auto/manual setting (2 leds),
- trip curve selection (3leds)
- imbalance or phase loss selection (3 leds).

When the set button is pressed the 7th time, the unit will exit the set mode. The parameters are written into non-volatile memory (the settings are retained after removal of power)
The parameters are all automatically set when the relay is set via infra-red control or via "Intelligent Pilot" methods and the set mode cannot be detected by the user.
It is important that the user establishes that no digits or led's flash when he has finished relay set-up. If left in the set mode (one parameter flashing) the relay will ignore the new parameters and after a while will automatically exit the set mode and revert to the original settings.
Should the user accidentally overshoot the exit stage of setup and find the relay still in the set mode on another parameter, he simply needs to hold in the set button and the relay will clock through all set parameters without

changing them and automatically stop on the 7th and last set sage. When the button is then released the relay will exit the set mode.

Up/down buttons:
When the unit is in set mode, the value of the flashing digit can be incremented or decremented by using the up or down buttons.

Reset button:
When the unit has tripped it can be restarted with the reset button. It is also used to toggle the short circuit display between a running digital ammeter or the actual short circuit setting. (*See the section on Indications... Short circuit current*).

Whether the relay is in auto-reset or manual-reset modes the unit will only reset from an overload trip condition once the cool down period has elapsed (*counted down to zero*) and if the current in the load has been reduced to zero. Both conditions must be true. If the load current is not entirely removed the user may well observe the countdown timer continually repeating the countdown cycle. (Removal of load current should be done automatically by the opening of the protection device... contactor or circuit breaker. However if the relay will not reset the end user should check that no current is flowing through the current transformer supplying the relay) Short circuits and phase imbalances(20% setting) or phase loss (50% setting) will always require manual resetting unless the power is removed from the relay under which condition the unit will reset.

6. Outputs

Relays
The microLOAD is provided with two output relays that each provide the user with a single change over contact. One relay is dedicated to short circuit trips and the other is dedicated to overload and phase imbalance trips. The separate short-circuit relay is used to trip an alternative device of higher interrupting capacity (a circuit breaker) under short circuit conditions. It is undesirable for items such as contactors to break the short circuits, as this could well result in destruction of the contact tips and in some cases may even cause frozen or welded contacts.

RS232
The relay can be ordered with an RS232 port which enables communication to and from the relay.

- A block of real time information is transmitted 9 times a second and every 10th transmission provides information for previous relay trips.
- Up to 10 historic trip events can be stored in the relay. As new information is written to the history log old information is overwritten on a last in first out basis. In this way the most recent information is kept in the relay.

The microLOAD Relay Terminals
The terminals used on the microLOAD relay are industry standard terminals. The contacts and their self-cleaning wiping action are well proven and have been adopted by numerous manufacturers as a standard. The contacts are well overrated for the duty for which they are employed on the microLOAD relay.

A rear view showing the terminals of the relay is depicted in figure 2 below

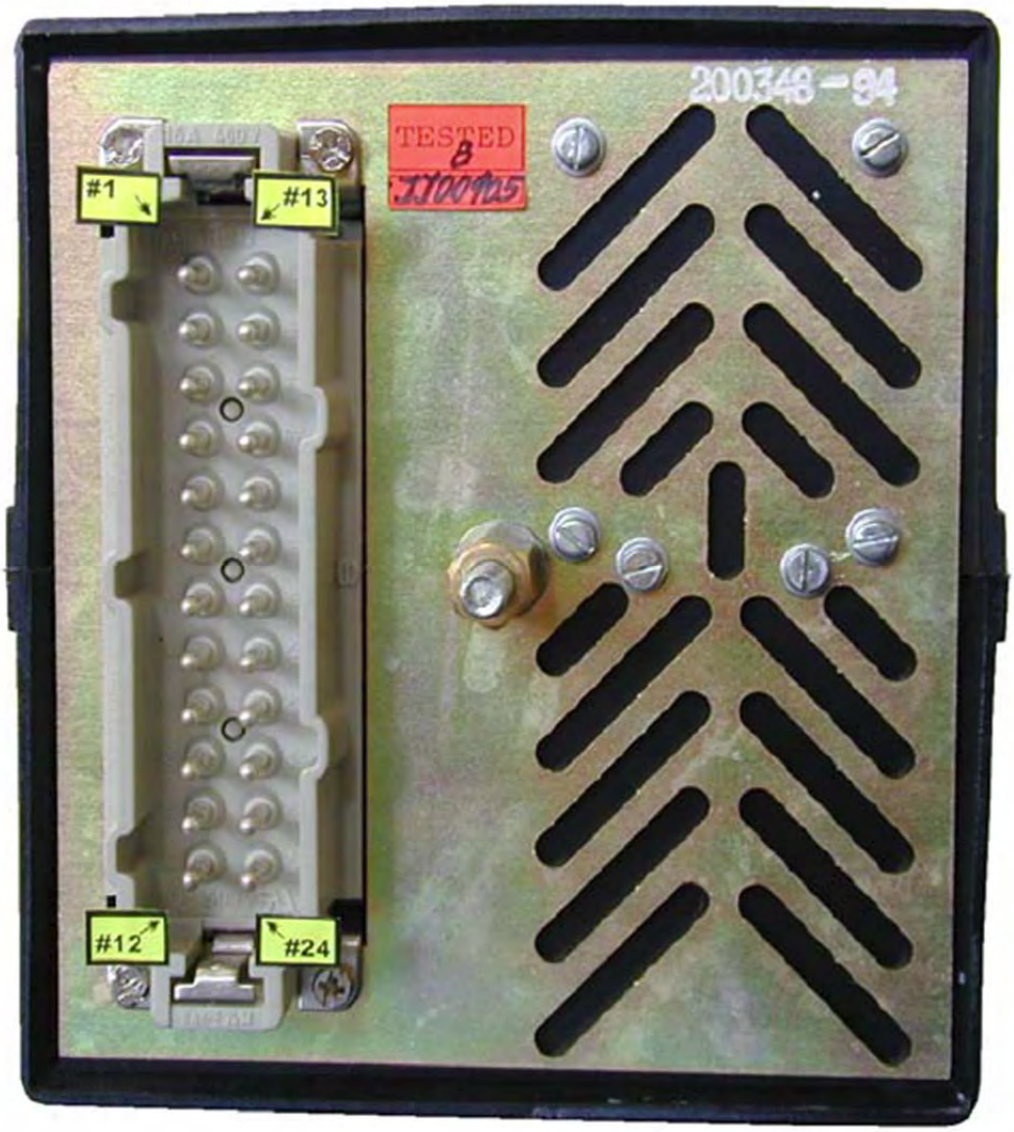


Figure 2: The rear terminal layout of the microLOAD Relay

The tables on the next page provide a quick reference guide and a brief functional description of the microLOAD relay terminals. The terminals are grouped together according to function and are colour-coded to assist with identification of the various functional categories.

6.1. Terminal Descriptions

The microLOAD relay Terminal Description and Application Information

Terminal Block. A	Description	Application note
#1	Power Supply	Live 110 Vac
#13	Power Supply	Neutral 110 Vac
#2	Up push button contact: this increases the value of the parameter being set	Connect to terminal #4to operate
#3	Reset push button contact: resets latched trip conditions	Connect to terminal #4 to operate
#4	Common connection for external interlocks	Terminal #4 provides a common connection for terminals #2 through to #7
#5	Down push button contact: this decreases the value of the parameter being set	Connect to terminal #4 to operate
#6	Set push button contact: this enables the set mode of the relay	Connect to terminal #4 to operate
#7	Decimal point enable: this is used on relays with an overload range of 0.4 to 65 Amps. (It is not used for the 4-600 version)	Link to terminal #4 to operate
#8 #20	Current transformer input Wires 149 and 150 from Dimako CT block (any polarity)	The microLOAD relay is phase sensitive (short circuit protection only)
#9 #21	Current transformer input Wires 147 and 148 from Dimako CT block (any polarity)	and therefore the connection of the current transformer is extremely important
#10 #22	Current transformer input Wires 145 and 146 from Dimako CT block (any polarity)	See the section on connection to the current transformer for this detail.
#11	TX1	RS232 serial port transmit
#23	TX2	terminals

Terminal Block. A	Description	Application note
#12	RX1	RS232 serial port receive
#24	RX2	terminals
#14	Overload Relay : Common of change over contact	The overload relay is de-energised in a an overload or phase imbalance
#15	Overload Relay : Normally open contact	Terminals #14 and #15 are closed when the relay is healthy
#16	Overload Relay : Normally closed contact	Terminals #14 and #16 are closed when the relay is NOT healthy
#17	Short-circuit Relay : Common of change over contact	The short-circuit relay is normally de-energised and will energise with any short-circuit condition
#18	Short-circuit Relay : Normally open contact	Terminals #17 and #18 are closed when the relay is NOT healthy
#19	Short-circuit Relay : Normally closed contact	Terminals #17 and #19 are closed when the relay is healthy

7. Functional Description of Protection Features

7.1. Overload Protection

The relay employs the use of a single purpose made current transformer to provide protection from 4 to 650 Amps with +/- 1% accuracy over the range. To allow for manufacturing tolerances an overall relay accuracy of +/- 3% is claimed over the full range. However in practice better than this is achieved.
Since it may not be desirable to have such a wide range available on the relay, relays with maximum load limits can be ordered.

- One of three overload curves can be selected for overload protection.
- Any curve can be programmed into memory; it has been found that the three curves provided for in the microLOAD VER 4-600 satisfy most motor and cable manufacturer’s specifications for overload protection.

The current on each of the three phases is monitored individually so that overload conditions and trip times are adjudicated on a phase by phase basis.. In other words the relay runs three independent thermal models, one for each phase; the worst case thermal model will result in an overload trip
This avoids the pitfalls of averaging the three phases and assessing overload conditions on a single parameter, particularly under phase imbalance or phase loss conditions. In fact when the relay is used to protect cables and motors this feature almost makes “phase imbalance” protection obsolete.
There are however conditions where is it desirable to have phase imbalance or phase loss protection activated before a thermal overload condition initiates a trip and therefore the feature is still incorporated in the relay. There is however another more fundamental reason for incorporating the imbalance feature. The current imbalance mode when set on not only protects the load from imbalances due to voltage differences, open circuits, and high resistance connections, but also provides protection against faulty current transformers, disconnection of current transformers leads, failure of relay internals, or mathematical current conversion errors.

There are certain circumstances however where the detection of current imbalances may be undesirable. Examples of this are:

a) unbalanced single phase loads
b) where electronically controlled variable speed drives have non-critically damped current or voltage feedback loops which lead to regular current imbalances (particularly under step load conditions or where the drive regenerates into the mains).
c) here complex or very distorted waveforms are present.

Therefore to provide for such cases and other cases the current imbalance feature can be turned “off”.

The overload protection facility is only activated once the current sensed exceeds 105% of the full load setting. As a user interface, a numerical counter is displayed on the relay front panel called “Thermal Capacity”. This counter is capable of counting both up and down. When an up count reaches ‘100’ the relay will trip on “overload”. The thermal capacity displayed corresponds to the phase that has the greatest thermal overload condition. As individual phase loading changes subtle display changes may be noted as the display toggles between the phases.

This display provides the user with feedback of the extent of the overload condition: a reading of “0" means that the relay is not in overload and the load is running below the parameter set on the relay. Any reading greater than zero is an indication of the degree of overload. Dependant on which overload curve has been selected the “Thermal Capacity” counter will count faster for higher overloads thus shortening the overall trip time. Should the overload condition be reduced to between 95% and 105% of the full load setting the counter will remain static and remember the previous overload condition. Only when the load is further reduced below 95% will the counter start counting down. As the load is further reduced the counter will increase its countdown rate unit it reaches zero again.

The counter is very useful in the setup of overload levels for feeders to widely varying load systems, which experience overload as part of their normal duty cycle; such as multi-motored continuous miner machines. Once an overload level has been decided upon and the relay set, the user can assess the degree of overload during the various overload cycles of the machine. This data can be used to decide whether or not the particular overload setting is likely to cause nuisance tripping. It can also be used to assess whether different operators are abusing the machine or it can be used to compare different mining condition from section to section. The lack of any counter reading during a severe load cycle can also be an indication that the overload setting on the relay is too high to protect the load.

7.2. Short circuit protection

The short circuit monitoring circuit has two individual sensors.

- The first setting is purely driven by the magnitude of the current and an instantaneous trip is given at between 11.5 and 12 times the full load setting.
- The second setting is phase sensitive. The trip value is the setting displayed on the short circuit display. This value is the magnitude of current at which the relay trips, when the load is at unity power factor. A short circuit is essentially purely resistive, especially under initial conditions, and therefore runs near to unity power factor. This difference in load characteristic is used to distinguish between motor start-ups and short circuits. Since the two conditions can be differentiated, lower settings can be provided for by the short circuit protection circuitry, but still allow higher inductive loads to pass through without nuisance tripping. The unit applies a formula to the prospective short circuit current which is sampled very quickly and gives a graded trip value once the load power factor starts lagging from unity. The approximate value of trip current will be 12 times at a power factor of 0. This of course is never achieved in practice and start up with power factors lagging by more than 0.6 have the 11.5 to 12 times factor applied to them. Curves are available from the factory which goes some way to making this concept clearer.

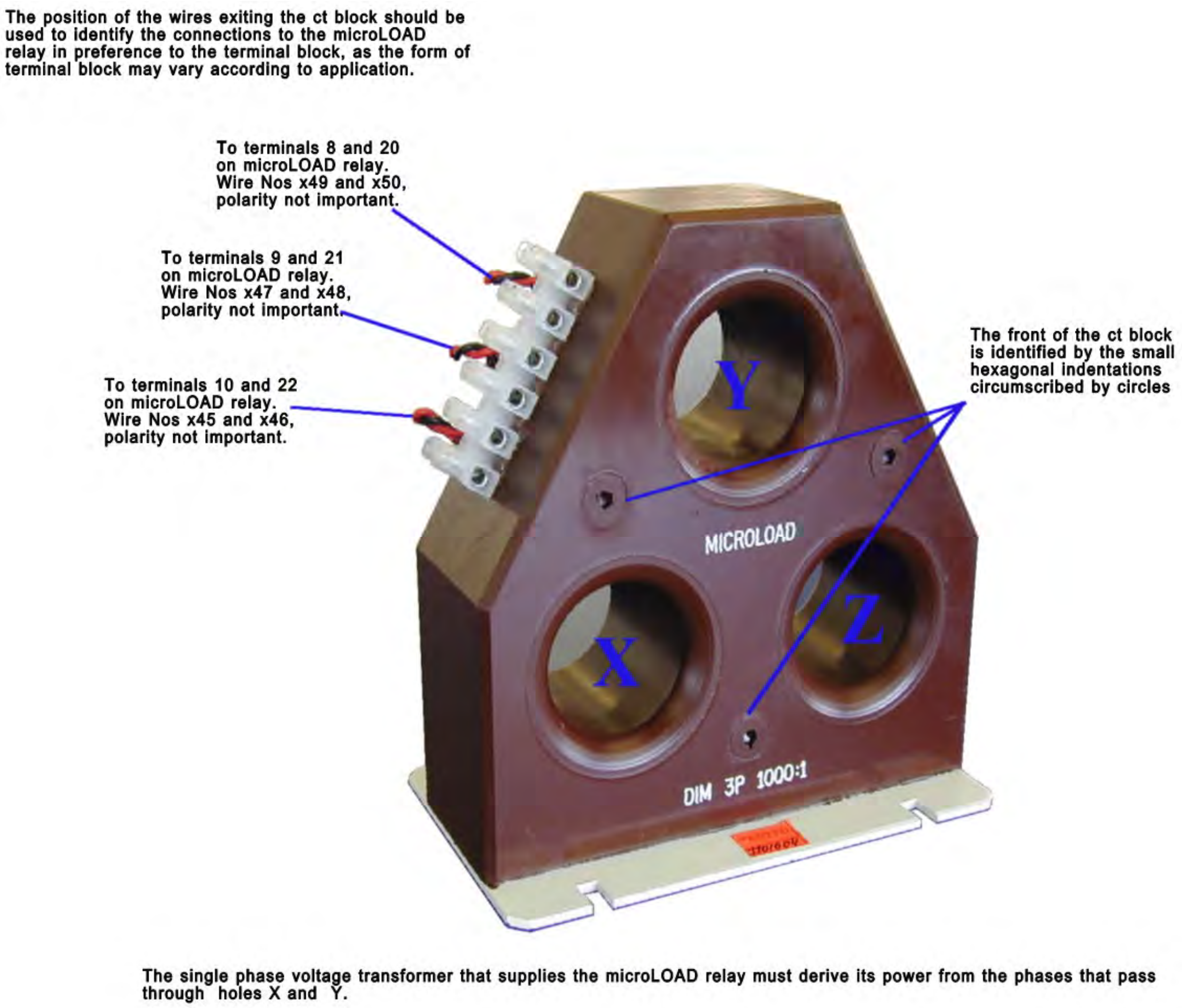
  The internal algorithms of the relay treat two and three phase short circuits differently. In practice a short circuit will generally begin with a two phase fault and develop into a three phase fault as catastrophic failure takes place if the short is allowed to persist. The relay is configured to be most sensitive to two phase faults and the trip level will be the short circuit level programmed by the user. With three phase symmetrical faults however the power factor is different from that of a two phase fault and the relay will correspondingly allow currents up to 3 (1.732) more than the user setting.

  In conditions where the contact metal of the initial short circuit evaporates, an arc can be established, which can sometimes provide wildly fluctuating power factors: the relay has some unique algorithms which can detect such conditions and provides excellent protection. The microLOAD relay however, generally detects and will cause the clearing device to trip before such conditions can take hold and cause extensive damage. There have been a number of well witnessed occasions where the relay has provided outstanding protection performance.

8. Current Transformer Connections

The following section is an extract from “Dimako Industries works Instructions” which is a controlled document. Changes and revisions may take place from time to time which would result in the retrieval of the works document, and the consequent issuing of a revised document. Since this document is not controlled, final reference must always be made to the latest revision of document number “PC 0035".

In general the microLOAD relay is used in conjunction with the CT block depicted in Figure 3 below.



<u>Figure 3: The microLOAD current transformer that provides an overload range of 4 to 650 Amps</u>

The microLOAD relay employs phase sensitive short-circuit protection. The zero crossing of all current waveforms is measured with respect to zero crossing of the relay’s voltage supply. The power factor of the load is then calculated from this data and used to proportion the allowable magnitude of phase current. It is imperative that the relay is provided with the correct phase information otherwise nuisance tripping will occur.

With any incorrect phasing the short circuit level is always reduced to the magnitude of the relay short circuit setting irrespective of the power factor.

To ensure that the microLOAD relay is correctly phased;

- The user must make himself totally familiar with the CT block shown in figure 3. Once the front of the CT block has been identified by locating the three small hexagonal indentations the user must locate CT holes marked “X” and “Y”.
- All the user needs to do now is trace the two wires that pass through these holes and make sure that the single phase voltage transformer that provides power to the microLOAD is fed from these two phases.

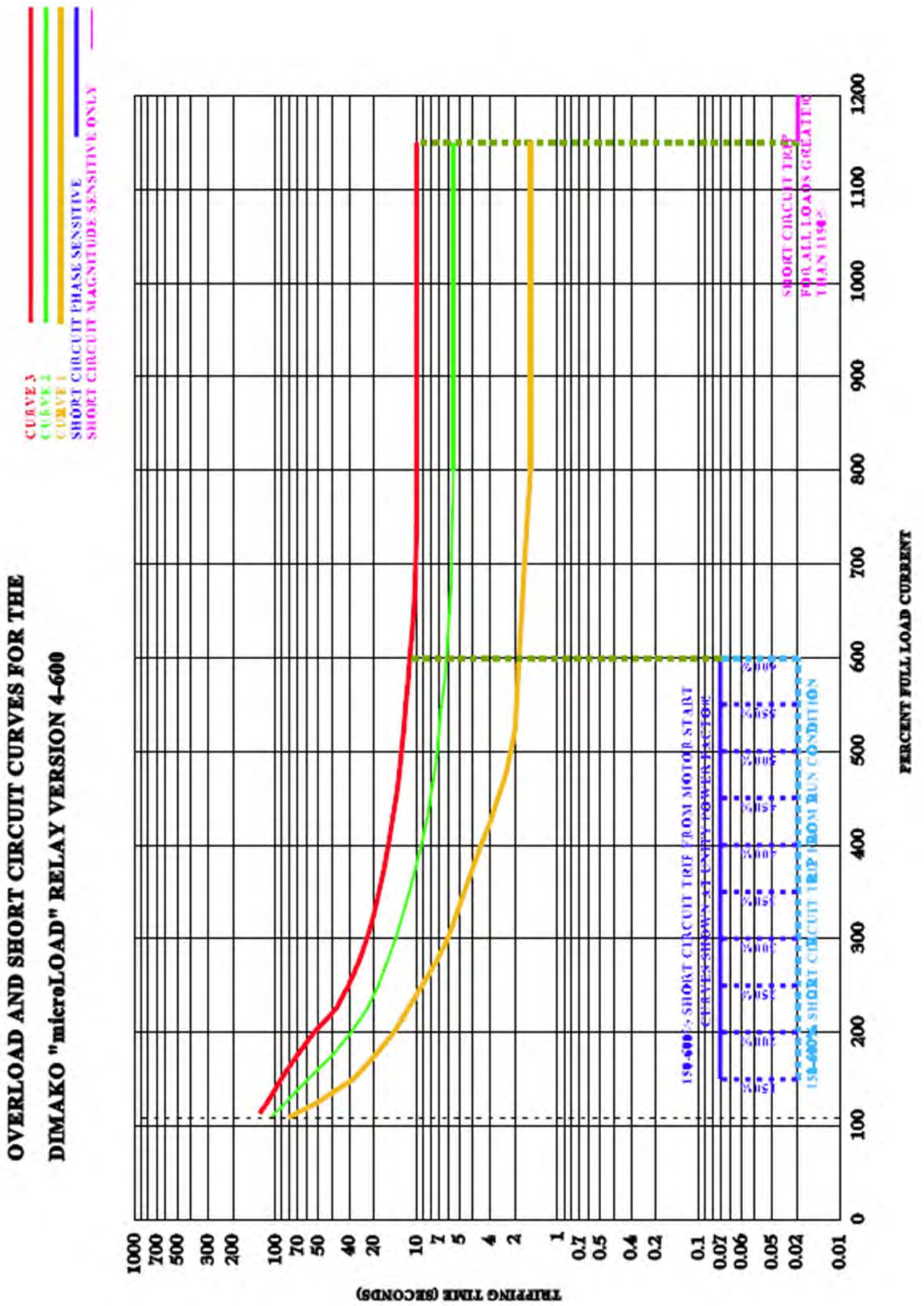
- It is important that this be a single phase transformer, since three phase transformers can introduce an undesired phase shift.
- The user must take great care in correctly orientating himself with the CT block, as the latter may be mounted in a number of different positions.
- He must also not rely on the position or layout of the terminals, as this varies from application to application, and should rather identify the wires by the physical position that they exit the CT block.

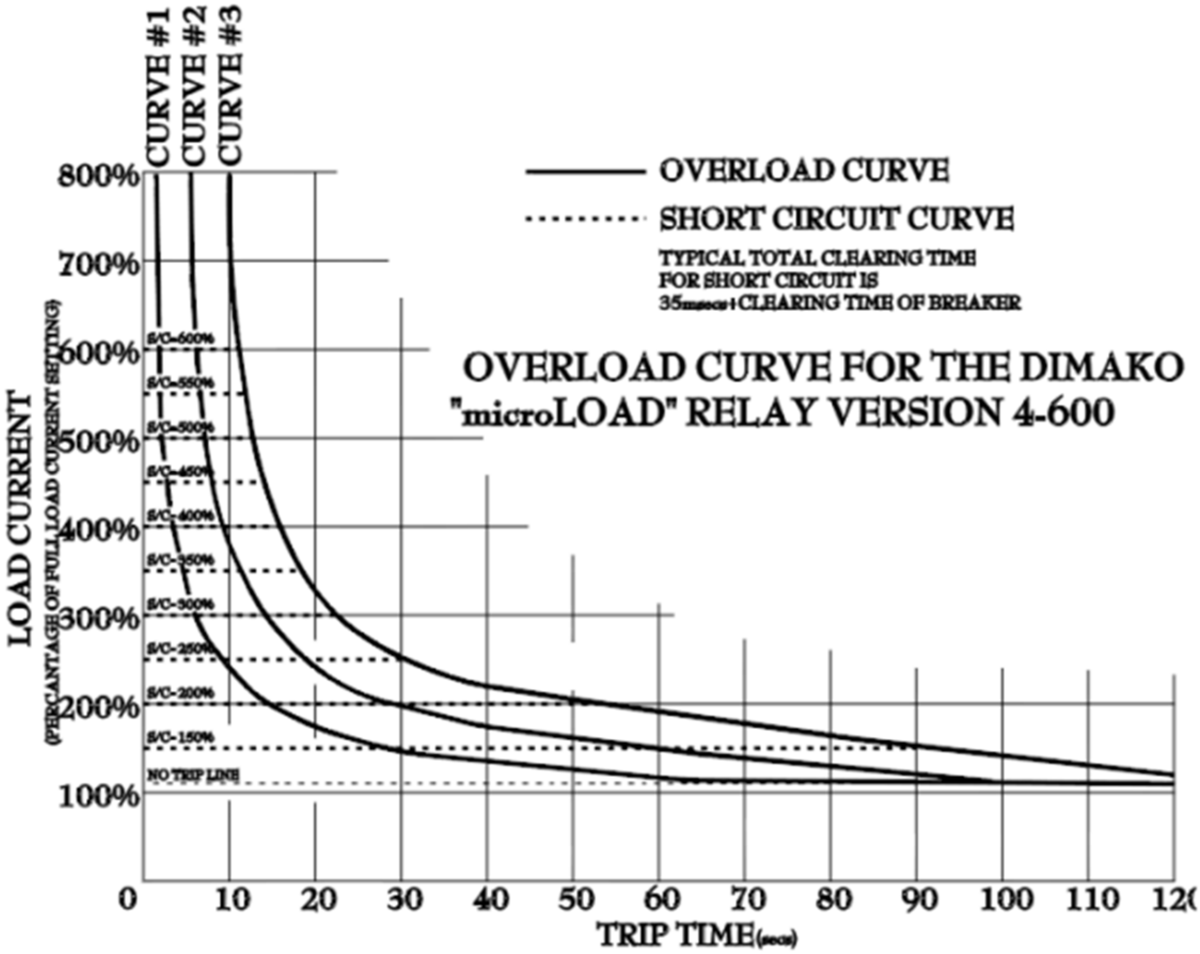
The polarity of the wires supplying the transformer and those supplying the microLOAD is not important. The CT wires for each phase are also polarity independent. It will be noted that in figure 3 that the CT to microLOAD connection wires are numbered ‘x’45, ‘x’46 ... and so on. The ‘x’ stands for the circuit number. It is often found that there are more than one microLOAD circuits in one panel. Consequently circuit 1 will start with wire number 1 and therefor the CT wires will be numbered 145, 146 ... and so on. For circuit 2 they will be numbered 245, 246 ... and so on.

Special consideration must be made when swopping the phase rotation to the load. This should always be done by using the wires that pass through holes “X” and “Y”. Swopping the wire through-hole “Z” with any other wire will lead to nuisance short-circuit trips.

9. Overload and Short Circuit Tripping Curves for the microLOAD ver 4-600

The trip curves of percentage load current are shown below. The first graph is shown with the trip time on a logarithmic scale. The second graph shows tripping time versus load with normal scales. For short circuit tripping times use the first graph below.


OVERLOAD AND SHORT CIRCUIT CURVES FOR THE
DIMAKO "microLOAD" RELAY VERSION 4-600
CURVE 3
CURVE 2
CURVE 1
SHORT CIRCUIT PHASE SENSITIVE
SHORT CIRCUIT MAGNITUDE SENSITIVE ONLY
SHORT CIRCUIT TRIP FOR ALL LOADS GREATER THAN 1150%
150-600% SHORT CIRCUIT TRIP FROM MOTOR START
CURVES SHOWN AT UNITY POWER FACTOR
150-600% SHORT CIRCUIT TRIP FROM RUN CONDITION
PERCENT FULL LOAD CURRENT
TRIPPING TIME (SECONDS)


CURVE #1
CURVE #2
CURVE #3
OVERLOAD CURVE
SHORT CIRCUIT CURVE
TYPICAL TOTAL CLEARING TIME
FOR SHORT CIRCUIT IS
35msecs+CLEARING TIME OF BREAKER
OVERLOAD CURVE FOR THE DIMAKO
"microLOAD" RELAY VERSION 4-600
LOAD CURRENT
(PERCANTAGE OF FULL LOAD CURRENT SETTING)
800%
700%
600%
500%
400%
300%
200%
100%
S/C-600%
S/C-550%
S/C-500%
S/C-450%
S/C-400%
S/C-350%
S/C-300%
S/C-250%
S/C-200%
S/C-150%
NO TRIP LINE
0
10
20
30
40
50
60
70
80
90
100
110
TRIP TIME(secs)

10. Dimako microLOAD Control relay Specification Sheet (19-10-1998)

General data:

Supply voltage	110 Vac
Internal fuse	200 mA
Operating range	80% to 120%
Brown out holding limit	60%
Frequency	50 Hz
Supply current max	130 mA
Duty cycle	continuous
Mounting	Panel mount bracket
Retaining	Single M6 stud with nylock nut
Housing	Glass filled nylon/mild steel backplate

Connection:

Type	Heavy duty self-cleaning captivated male/female
Contact resistance	1 milliohm typical
Rated current	10 A max.
Housing	Glass fibre filled thermoplastic
Insulation group	C
Relay connection	Male plug pin type
Panel connection	Female screw type terminal
Panel wire size	0.5 mm^2 to 2.5 mm^2

Outputs:

Short circuit	1 change over contact
Overload contact	1 change over contact
Voltage	250 Vac / 30 Vdc
Current	10 Amp
Capacity	4 000 VA / 480 W
Contact resistance	30 milliohm
Service life	100 000 severe conditions 5 000 000 light duty

Performance:

Overload protection range	4 to 650 Amps (upper limit factory set)
Trip curve accuracy	+/- 5%
Current detection	+/-3% (4- 650 Amps) with CT3-uLOAD-10000
Bargraph ammeter	+/-5% (0-100%) +/-25% (100-600%)
Digital ammeter	+/-3%
12 x short circuit protection	6 ms (times are measured from fault initiation to contact opening or closure)
Phase sensitive short circuit	55 ms (times are measured from start up to contact opening or closure) 16 ms (from fault occurrence in “run condition “to contact opening or closure)
Power factor display	+/-0.075
Clearing time of relay contacts	60 mSecs max. typical 40 msecs

Insulation:

IEC 255-5
Rated insulation voltage 500 Vdc / 2 kVac
IEC 255-5 Impulse withstand voltage 5 kV

Electrostatic Discharge:

IEC 255-22-2 class 4

Fast Transient:

	IEC 255-22-4 class IV	
Radiated Immunity:	IEC 255-22-3 class III	
Environment:	Temperature range -25ºC IEC 68-2-1 to +70ºC IEC68-2-2	
Humidity	up to 95% 55ºC IEC 68-2-30 severity 6 (4.2b)	
Altitude	2 000 m max	
Storage temperature	-40 c to +70 c	
Shock response	10g / 11 ms	IEC 255-21-2 class 2
Shock withstand	30g / 11 ms	IEC 255-21-2 class 2
Bumping resistance	20g / 16 ms	IEC 255-21-2 class 2
Vibration immunity	0.075mm/1g	IEC 255-21-1 class 2
Dust ingress	IP54	IEC 529 category 2