How to Select and Set Circuit Breakers for Generators

Introduction

Generators differ from other electrical power sources in their ability to withstand electrical overloads and fault currents. These differences should be respected when selecting and setting circuit breakers which protect generators.

This guide explains the parameters of generators and circuit breakers which should be considered when selecting and setting equipment. It contains a five-step selection and setting guide with accompanying graphs and tables.

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Contents

Expertise in Generator Protection

Terasaki supply circuit breakers which protect people and equipment from electrical faults. We provide protection for generators in all industry sectors. For example:

Marine

We supply more switchgear for ships than any other manufacturer. Our **Circuit Breakers** and **GAC 21 Generating Plant Management System** are used to protect and control generators on thousands of ocean-going vessels.

Air Circuit Breaker

Moulded Case Circuit Breakers

Generator Management System

Standby Power

Terasaki circuit breakers are used by:

- **Himoinsa / FG Wilson / Yanmar / Gesan / Aggreko / Ascot / Atlas Copco**

Automatic Changeover for Critical Supplies

Our automatic changeover systems can automatically start the standby generator and activate the switching sequence if the mains power supply in **hospitals, data centres or airports** fails. Circuit breakers are interlocked to prevent parallel voltage supply. We can offer changeover solutions for:

- Systems with one transformer incoming breaker and one generator incoming breaker
- Systems with two transformer incoming breakers

Automatic Changeover System

What is Special about Generator Protection?

Transformers and generators differ in their ability to withstand electrical overloads and fault currents. These differences should be respected when you select and set circuit breakers which protect generators.

Withstand of Short-time Overload Current

Transformers can withstand overloads of short duration and may be intentionally overloaded for pre-defined periods. Generators should never be intentionally overloaded and will be permanently damaged by sustained overload. The calibration method and threshold settings of overload protection elements must ensure that the circuit breaker protecting the generator trips before the windings are damaged.

Withstand of Short-circuit Fault Current

The rotational speed and high reactance of generators mean that they are damaged rapidly when short-circuited. Short-circuit protection must be selected and configured to operate at lower thresholds than for cables or transformers. Compare these examples of the abilities of typical cable, transformers and generators to withstand short-circuit fault current without damage:

	Fault current as a multiple of rated current (%)	Withstand duration before damage
Cable	250%	1000 seconds
Oil-filled Transformer	300%	300 seconds
Generator	300%	5 seconds

Table 1. Comparison of Short-circuit Fault Current Withstand for Various Equipment. Data courtesy of http://www.skm.com/applicationguides16.html. Figures are illustrative and should not be used for design purposes. Always check the manufacturer's data

Magnitude of Short-Circuit Current Output

Circuit breaker protection characteristics have "instantaneous" functions which are dedicated to short-circuit fault protection. These functions can be set to clear high values of short-circuit current without intentional time delay (in less than 30 milliseconds for Terasaki air circuit breakers and less than 20 milliseconds for Terasaki moulded case circuit breakers). The supply source must be capable of delivering a short-circuit current higher than the user-adjustable instantaneous operating threshold.

The maximum short-circuit current of a generator or transformer is determined by the impedance of its winding and its magnetic circuit. Generators under short-circuit have impedance values which vary according to a transient characteristic but which are always higher than those of transformers of equivalent power ratings. This means that the maximum deliverable short-circuit current of a generator is low (typically between 300% and 500% of rated full-load current)* compared with an equivalent transformer. Circuit breakers must be selected and set to ensure that the instantaneous protection element will indeed be activated by a short-circuit.

* Reference: http://electrical-engineering-portal.com/calculating-the-short-circuit-current-synchronous-generator

Five-step Selection and Setting Guide

Follow these steps to select and set a circuit breaker to provide good protection for a generator.

1. The circuit breaker must carry the full-load current of the generator without nuisance tripping. **Table 2** shows circuit breaker types with generator protection characteristics for various values of full-load current. Establish the full-load current of generator, Iflc and select a circuit breaker with a higher rated current:

    - **In (circuit breaker) from Table 2 => Iflc (generator)**

2. The circuit breaker must be capable of interrupting the maximum short-circuit current safely. **Table 2** shows circuit breaker types with generator protection characteristics for various values of maximum short-circuit current. Establish short-circuit capability of generator, Isc max. and select a circuit breaker with a higher breaking capacity:

    - **Icu (circuit breaker) from Table 2 => Isc max. (generator)**

3. The circuit breaker must trip before the generator is damaged by an overload. Establish generator thermal withstand capability from the generator manufacturer's data. Set overload protection function so that it falls to the left of the generator thermal withstand curve. Refer to **Figure 1** for graphical representation.

    - **Circuit breaker overload function < generator thermal withstand**

4. The circuit breaker must trip before the generator is damaged by a short-circuit. Establish the generator damage curve from the generator manufacturer's data. Set the circuit breaker short-time delay function or instantaneous function so that it falls to the left of the generator damage curve. Refer to **Figure 1** for graphical representation.

    - **Circuit breaker short-circuit / instantaneous function < generator damage curve**

5. The circuit breaker must be set to trip instantaneously when the generator delivers maximum short-circuit fault current. Refer to **Figure 1** for graphical representation.

    - **Circuit breaker instantaneous function < generator Isc max.**

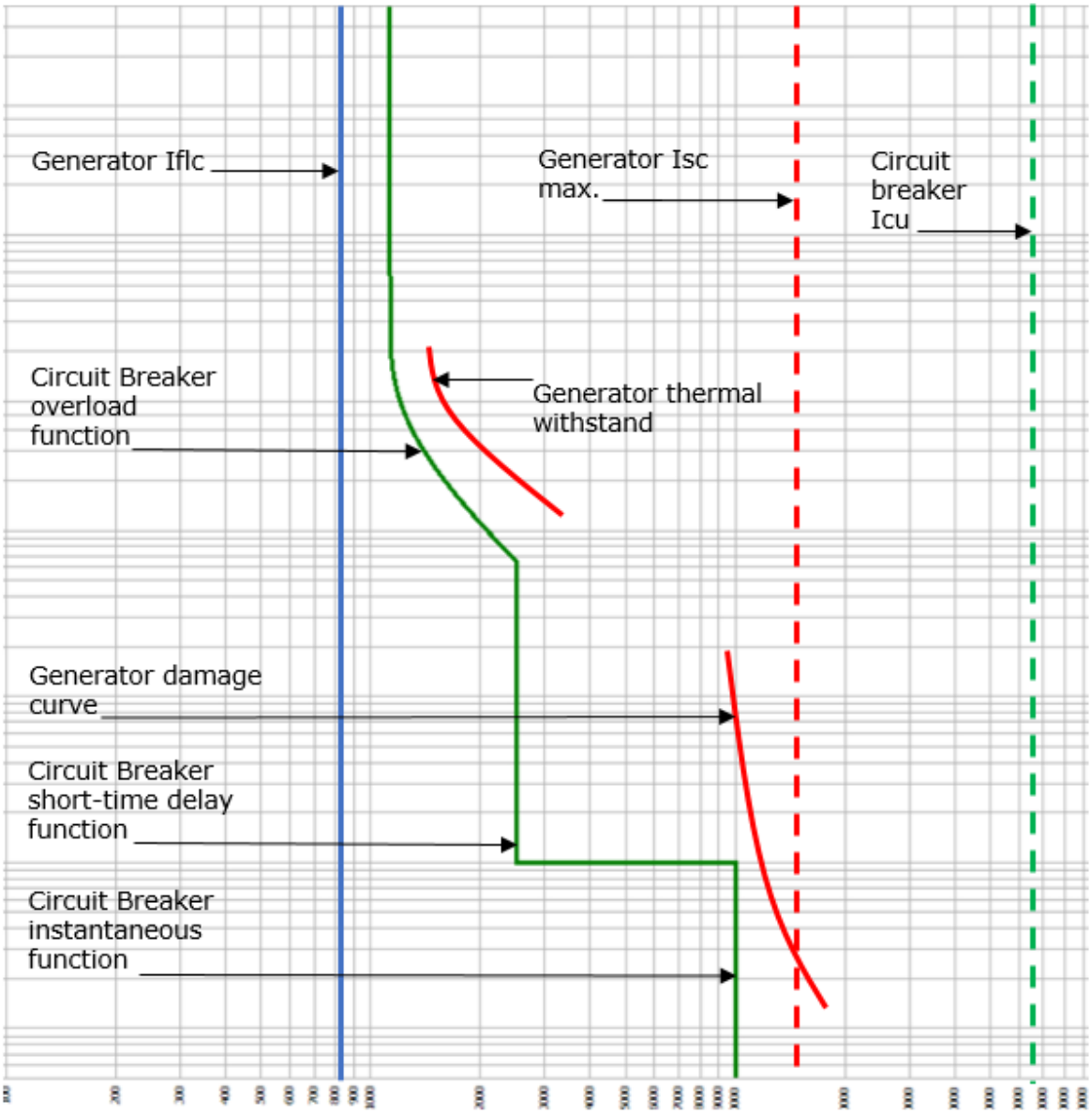


Figure 1. Parameters for Selection and Setting: Graphical

Software for Circuit Breaker Settings

The graphical representation in **Figure 1**. was generated using TemCurve Lite 3.0 software from Terasaki. It can be used to visualise and plan the protection settings for all types of Terasaki circuit breakers. Free to download from http://www.terasaki.co.uk/products/electrical-design-software/

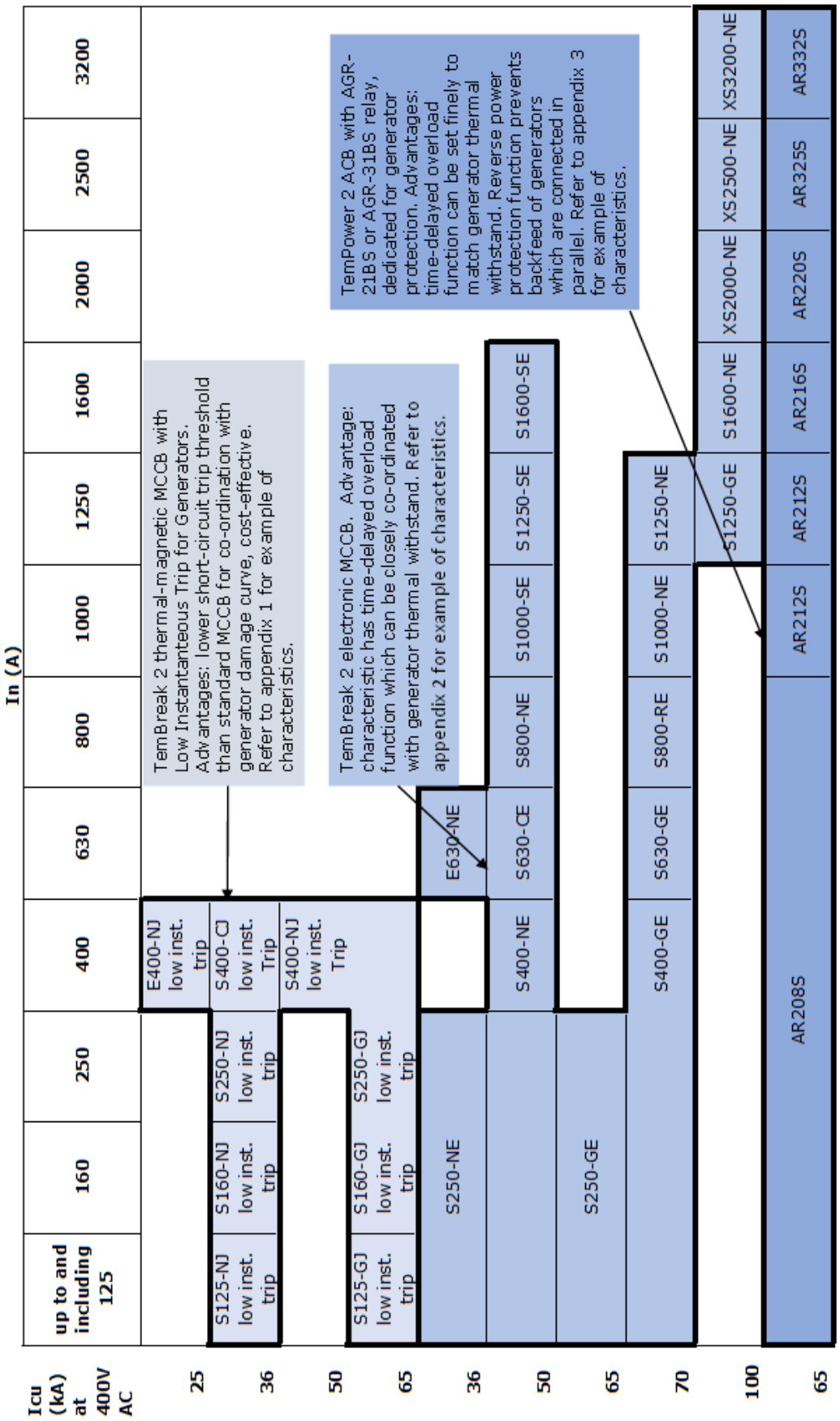


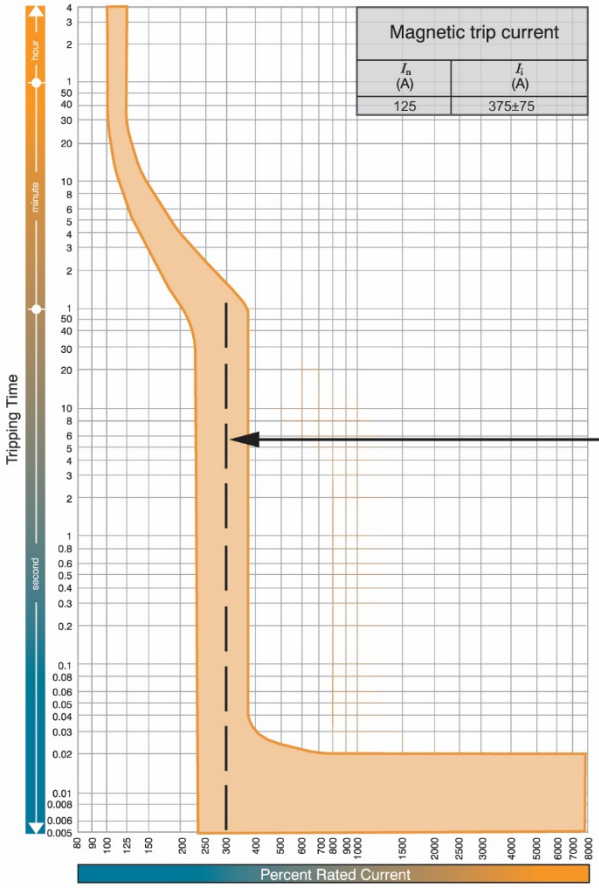
Table 2. Generator Protection Circuit Breaker Models for Various Values of Ifc and Isc Max.

APPENDIX 1

Thermal-magnetic MCCBs with Low Instantaneous Trip for Generators

Time/Current Characteristic Curves

S125-NJ, S125-GJ with Low Instantaneous Trip: for Generator



Instantaneous protection is calibrated at 300% of rated current. Circuit breaker will trip when generator delivers maximum short-circuit current.

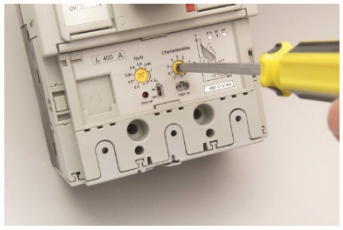
Refer to our catalogue "TemBreak 2 and TemBreak" for details of the full range.

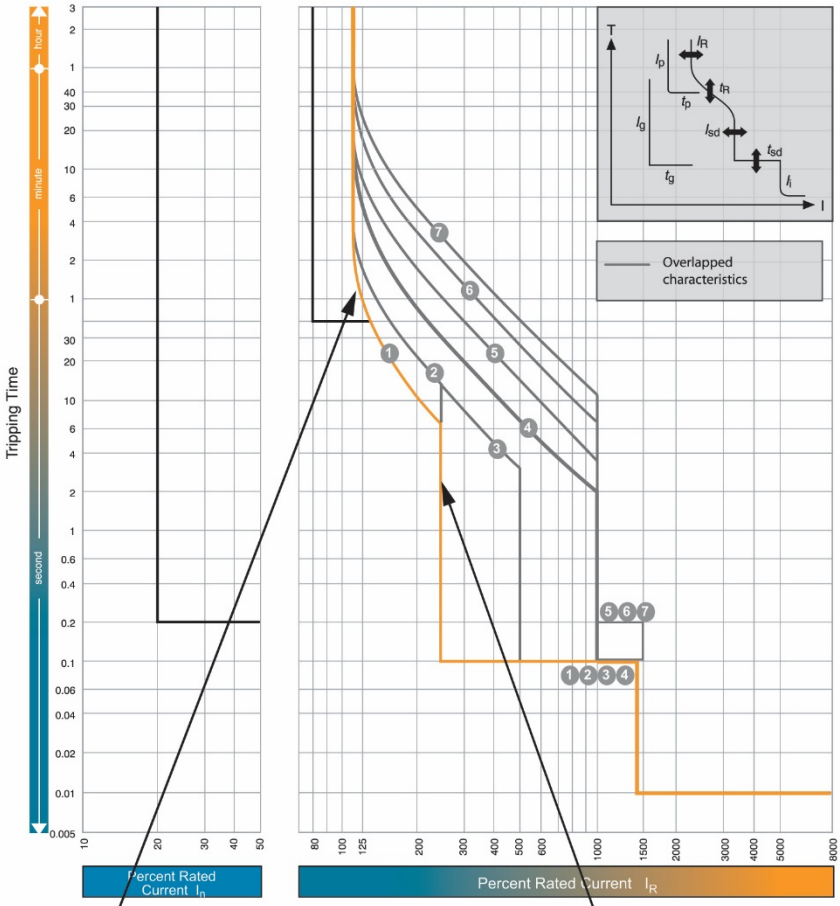
APPENDIX 2

Electronic MCCBs with Selectable Characteristics

Time/Current Characteristic Curves

S400-NE,S400-GE, S400-PE,H400-NE,L400-NE,L400-PE





Preset characteristic number 1 is suited to generator protection. Overload protection function trips in 10s at 200% overload to fall within generator thermal withstand

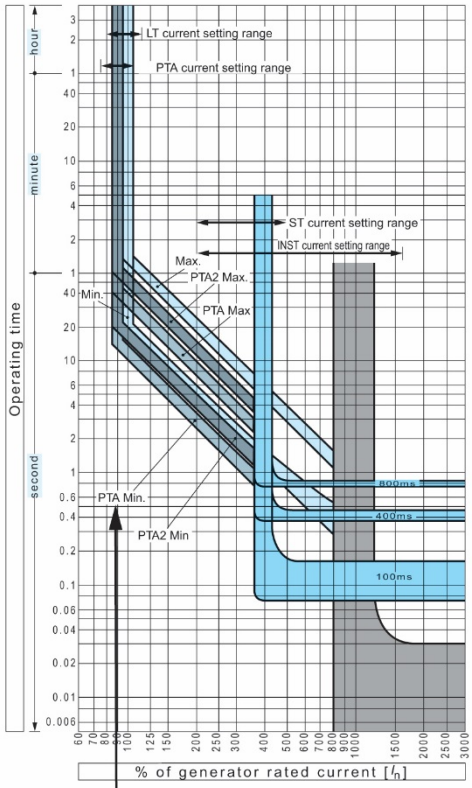
Short-time delay function threshold is 250% of rated current so that it falls below generator damage curve.

Refer to our catalogue "TemBreak 2 and TemBreak" for details of the full range.

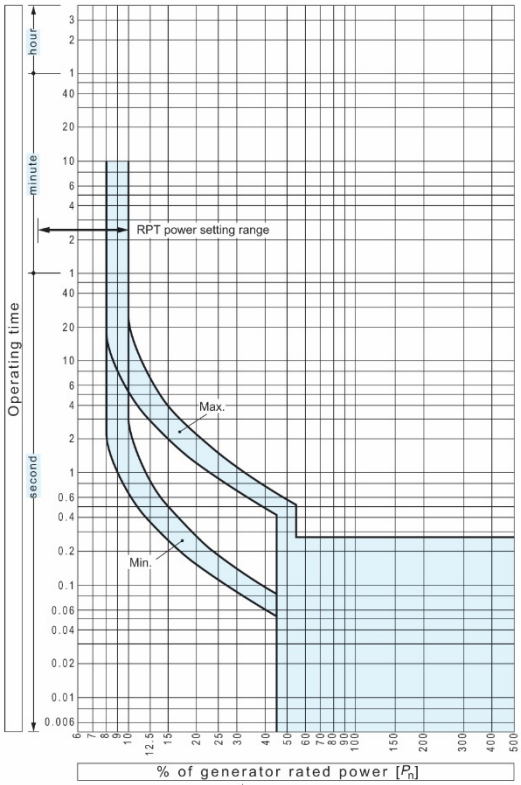
APPENDIX 3

ACBs with AGR-21BS and AGR-31BS dedicated generator protection relays

CHARACTERISTIC CURVES



2- channel pre-trip alarm facilitities load-shedding to prevent generator overload.



Reverse power protection functions prevent back feed of generators which are connected in parallel.