# MULTI-LINE 2

## Option C2
## Generator add-on protection package

- Description of option
- Functional description

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# 1. Delimitation

## 1.1 Scope of option C2

This description of options covers the following products:

| | |
|---|---|
| AGC-3 | SW version 3.4x.x or later |
| AGC-4 | SW version 4.0x.x or later |
| AGC 100 series | SW version 4.0x.x or later |
| AGC 200 series | SW version 3.66.x or later |
| CGC 400 | SW version 1.11.x or later |
| All GPC-3 variants, all GPU-3 variants, PPU-3 | SW version 3.06.0 or later |

**Table 1.1** Functions by product

| Function | AGC-3 | AGC-4 | AGC 100 | AGC 200 | CGC 400 | GPC-3<br>GPU-3<br>PPU-3 |
|---|---|---|---|---|---|---|
| Positive, negative and zero sequence | • | • | | • | | • |
| State state alternator reactive power capability curve (without limiter) | | • | | • | | • |
| Alternator reactive power capability curve with limiting | | • | | | | |
| Inverse time over-current | | • | • | • | • | •* |

*Note: This is a standard feature.

# 2. General information

## 2.1 Warnings, legal information and safety

### 2.1.1 Factory settings

The Multi-line 2 unit is delivered from factory with certain factory settings. These are based on average values and are not necessarily the correct settings for matching the engine/generator set in question. Precautions must be taken to check the settings before running the engine/generator set.

### 2.1.2 Legal information and disclaimer

DEIF takes no responsibility for installation or operation of the generator set. If there is any doubt about how to install or operate the engine/generator controlled by the Multi-line 2 unit, the company responsible for the installation or the operation of the set must be contacted.

**INFO**
The Multi-line 2 unit is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

**Disclaimer**

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

# 3. Description of option

## 3.1 Option C2

Option C2 is a software option and therefore not related to any hardware apart from the standard-installed hardware.

## 3.2 ANSI numbers

| Protection | ANSI no. |
|---|---|
| Negative sequence current | 46 |
| Negative sequence voltage | 47 |
| Zero sequence current | $51I_0$ |
| Zero sequence voltage | $59U_0$ |
| Power-dependent reactive power | 40 |
| Inverse time over-current | 51 |

# 4. Functional description

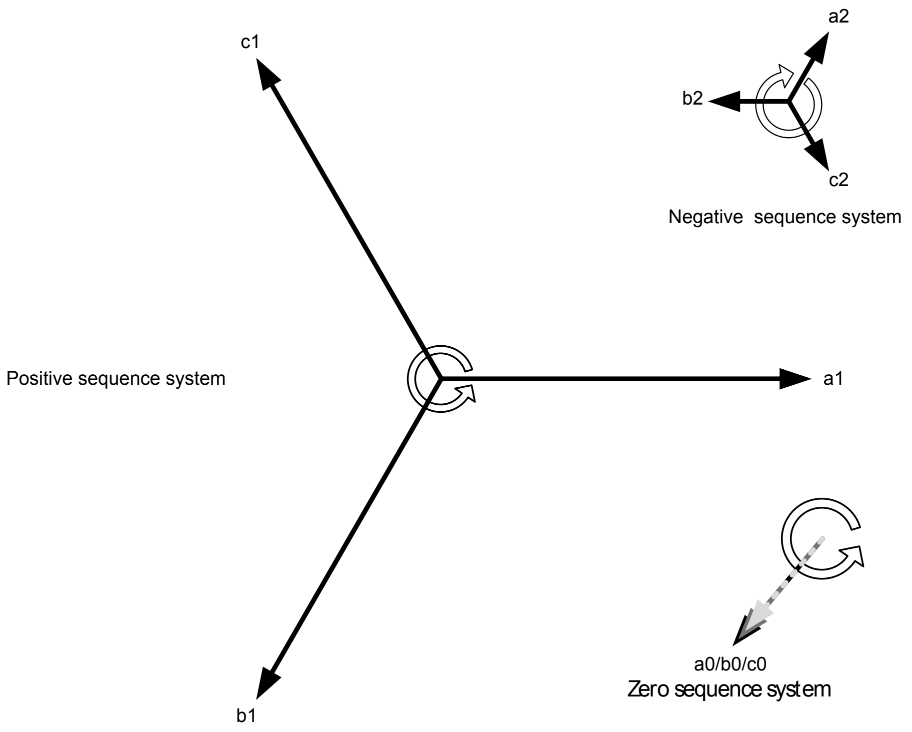
## 4.1 Positive, negative and zero sequences

### 4.1.1 Voltage vector system

The measurements of the generator currents and voltages are split up in three theoretical systems:

- The positive sequence system with a positive direction of rotation.
- The negative sequence system with a negative direction of rotation.
- The zero sequence system with a positive direction of rotation.

As a result of the generator's power production to the consumers, the positive sequence system represents the fault-free part of the voltages and currents. The negative sequence system, which rotates in the opposite direction of the generator, is used by the protections negative sequence current and negative sequence voltage to prevent the generator from overheating. The zero sequence system is used for detection of earth faults.




**Description of the approach**

Positive, negative and zero sequence values are calculated based on estimated phase current/phase voltage phasors. The RMS value of the phase quantity expresses the absolute value of the phasors, and an evaluation of zero crossings delivers expressions for the angles between the phasors.

### 4.1.2 Positive sequence

The voltages and currents in the positive sequence system are desirable, because they can be used by the consumers.

### 4.1.3 Negative sequence

A negative sequence current increases the risk of dangerous overheating in the generator, which could lead to general damage.

The negative sequence currents and voltages can occur for example in the event of single phase loads, unbalanced line short circuits and open conductors, unbalanced phase-phase or phase-neutral loads.

Especially the negative sequence currents can produce harmful overheating inside the generator. The reason is that these currents produce a magnetic field counter-rotating to the rotor. This field crosses the rotor at twice the rotor velocity, inducing double-frequency currents in the field system and in the rotor body.

### 4.1.4 Zero sequence

Zero sequence is used to detect an earth fault (earth current or neutral voltage). It is performed by measuring the vectorial displacement of the zero value (star point) for both current and voltage. The zero sequence measurement can therefore replace the more well-known methods, namely those using zero voltage measurement or summation transformers (zero sequence transformers).

**INFO**
Positive, negative and zero sequence is not available in the AGC 100 series.

## 4.2 Power-dependent reactive power (Capability curve)

### 4.2.1 Alternator capability curve

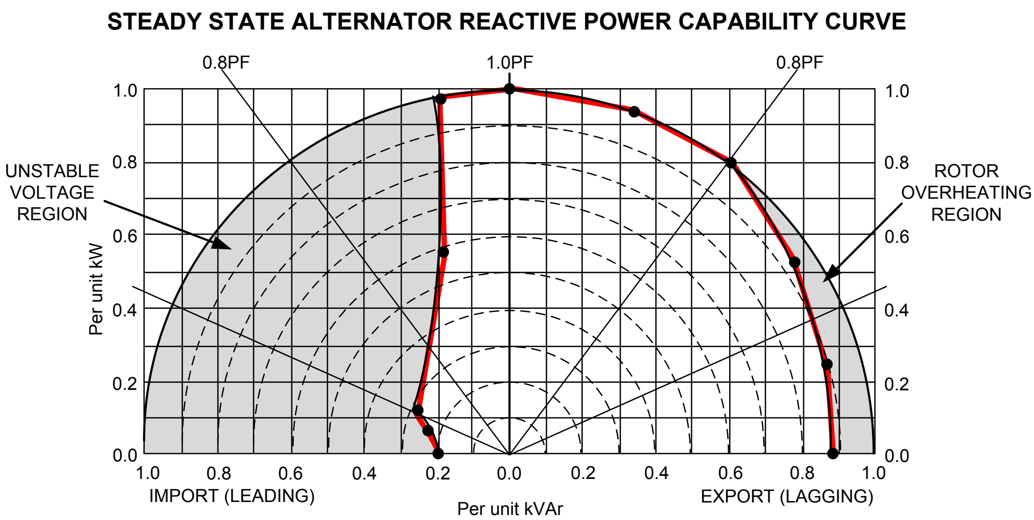
This curve indicates the possible reactive load at any given power load for the generator in question, for exporting and importing reactive power.

As the reactive power varies in a non-linear way with actual (power) load, the setting of trip values is made with a 12-point curve, six for lagging and six for leading reactive power. The unit carries out a linear regression between any two given points in order to find the trip point between the curve point settings.

Each of the 12 points has a setting for real power (P) and a setting for the related reactive power (Q).

The relevant parameters for this protection are 1740-1790. For more detailed parameter information, refer to the respective product parameter list.

### 4.2.2 Setting curves




The settings of points 1-6, leading and lagging, should represent the generator manufacturer's recommended settings for var import (-Q)/export (+Q). Notice that the above curve is just an example, the actual values must be obtained from the generator manufacturer.

INFO
It is imperative that the generator does not enter any of the grey areas. If it does, rotor overheating (export) or loss of synchronism (import) may occur.

INFO
In the above diagram, the positive power/reactive power flow direction is defined as the direction from the generator to the consumer, that is increasing export (lagging) is equal to increasing excitation.

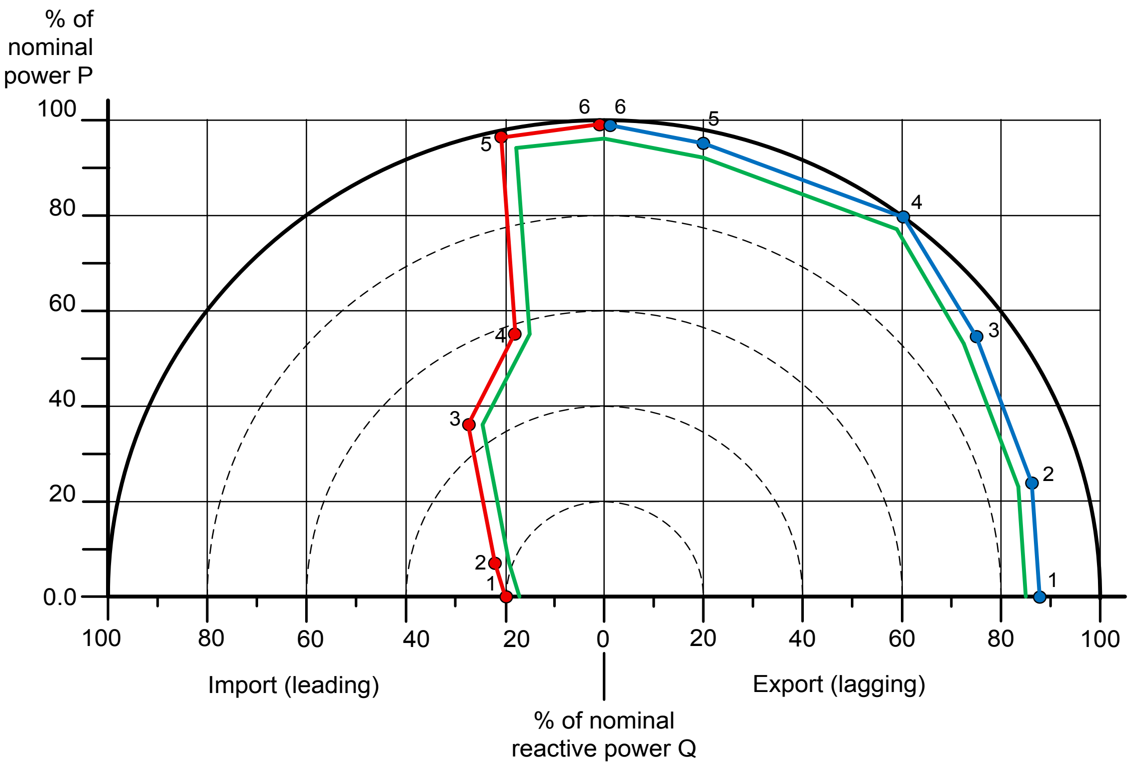
# 4.3 Capability curve in AGC-4

## 4.3.1 Alternator capability curve with limiting

Active power-dependent reactive power limiting is a generator protection feature which is part of option C2. It limits the reactive power production relative to actual power production.

Active power-dependent reactive power limiting can use the generator steady state reactive power capability curve. The actual curve depends on the generator. The curve should be included in the generator's data sheet. Contact the generator manufacturer to get this information.

**Figure 4.1** Example of generator capability curve with limiting




To activate the reactive power limitation based on the capability curve, set *AVR limiting type*, parameter 2811, to *Capability curve Q*.

INFO
Configure the alarms in the parameter list. Use *G P dep. Q*<, parameter 1761, for import, and *G P dep. Q*>, parameter 1791, for export.

The curves are configured under *Advanced Protection*, *Capability curve*. Six active power and reactive power co-ordinates define the curve for import of reactive power. Similarly, six co-ordinates define the curve for export of reactive power. The centre point is fixed at 0 kvar and 100 % of nominal power.

If the set point for reactive power is outside the limiting curve, the controller stops reactive power (or cos phi) regulation. When the reactive power set point moves inside the limiting curve, the controller regulates reactive power (or cos phi).

Protections can also be activated to disconnect the generator from the grid. Menu 1760 configures how to alarm in case of exceeding capability curve under excitation limit. Menu 1790 configures how to alarm in case of exceeding capability curve over excitation limit.

The *AVR lim. setpoint*, parameter 2812, defines when regulation is stopped. If this parameter is *100 %*, the controller regulates all the way to the capability curve. For *95 %*, regulation stops at 5 % away from crossing the limit curve.

*S nominal(import) (1766)* and *S nominal(export) (1796)* under *Advanced Protection*, *Capability curve*, define the limit of the y-axis. It can relate to active power (P/Q diagram) or apparent power (S/Q diagram).

**Example of apparent and active power for the capability curve**

The generator has a 1000 kW nominal power and a 1200 kVA nominal apparent power.

For an S/Q diagram as the capability curve, use 1200 kVA for the *S nominal* settings (under *Advanced Protection*, *Capability curve*). On the capability curve, 100 % of nominal apparent power is then 1200 kVA.

Alternatively, for a P/Q diagram as the capability curve, use 1000 kVA for the *S nominal* settings. On the capability curve, 100 % of nominal power is then 1000 kW.

Most generator manufacturers provide an S/Q diagram. The VDE rules refer to a P/Q diagram. To meet the VDE rules, use the nominal active power (in kW) in the *S nominal* settings.

## 4.3.2 Parameters and settings

These parameters and settings define the active power-dependent reactive power limiting.

The settings are configured under *Advanced Protection*, *Capability curve*.

**Table 4.1** *Set-point for Leading* (under-excited) (red curve)

| Reactive power | Default | Active power | Default |
|---|---|---|---|
| G P dep Q<Q1 (1741) | 20 % | G P dep P<P1 (1742) | 0 % |
| G P dep Q<Q2 (1743) | 22 % | G P dep P<P2 (1744) | 7 % |
| G P dep Q<Q3 (1745) | 27 % | G P dep P<P3 (1746) | 12 % |
| G P dep Q<Q4 (1751) | 18 % | G P dep P<P4 (1752) | 55 % |
| G P dep Q<Q5 (1753) | 21 % | G P dep P<P5 (1754) | 97 % |
| G P dep Q<Q6 (1755) | 1 % | G P dep P<P6 (1756) | 99 % |

**Table 4.2** *Set-point for Lagging* (over-excited) (blue curve)

| Reactive power | Default | Active power | Default |
|---|---|---|---|
| G P dep Q>Q1 (1771) | 88 % | G P dep P>P1 (1772) | 0 % |
| G P dep Q>Q2 (1773) | 86 % | G P dep P>P2 (1774) | 24 % |
| G P dep Q>Q3 (1775) | 77 % | G P dep P>P3 (1776) | 53 % |
| G P dep Q>Q4 (1781) | 60 % | G P dep P>P4 (1782) | 80 % |
| G P dep Q>Q5 (1783) | 33 % | G P dep P>P5 (1784) | 95 % |
| G P dep Q>Q6 (1785) | 1 % | G P dep P>P6 (1786) | 99 % |

**Table 4.3** *AVR limiting type*, parameter 2811

| Set point | Default | Description |
|---|---|---|
| OFF | | The controller does not limit the regulation of cos phi or reactive power. |
| Droop curve | X | Depending on which regulator is active, the controller limits the regulation.<br>For cos phi, the controller uses settings 7171 and 7173 (under *Advanced Protection*, *Droop curve 2*, *Cosphi curve*).<br>For reactive power, the controller uses settings 7161 and 7162 (under *Advanced Protection*, *Droop curve 2*, *Q curve*). |
| Capability curve Q | | The controller limits the regulation using the parameter settings for power-dependent reactive power limiting. |

**Table 4.4** *AVR lim. setpoint*, parameter 2812 (green curve)

| Default | Range | Description |
|---|---|---|
| 95% | 20 to 100% | The cos phi/reactive power regulation stop with respect to the capability curve |

*Scaling*, parameter 9030, determines which *Q curve* the controller uses.

**Table 4.5** *Q curve* for *10-2500V*

| Setting | Default for 10-2500V | Range for 10-2500V | Description |
|---|---|---|---|
| S nominal(import) (1766) | 60 kVA | 1 to 3200 kVA | Limit, apparent power import |
| S nominal(export) (1796) | 60 kVA | 1 to 3200 kVA | Limit, apparent power export |

# 4.4 Inverse time over-current

## 4.4.1 Formula and settings used

The inverse time over-current is based on IEC 60255 part 151.

The function used is **dependent time characteristic,** and the formula used is:

$$t(G) = TMS \left( \frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + C \right)$$

where

| | |
|---|---|
| $t(G)$ | is the theoretical operating time constant value of G in seconds |
| k, c, $\alpha$ | are the constants characterising the selected curve |
| G | is the measured value of the characteristic quantity |
| $G_S$ | is the setting value |
| TMS | is the time multiplier setting |

The constants k and c have a unit of seconds, α has no dimension.

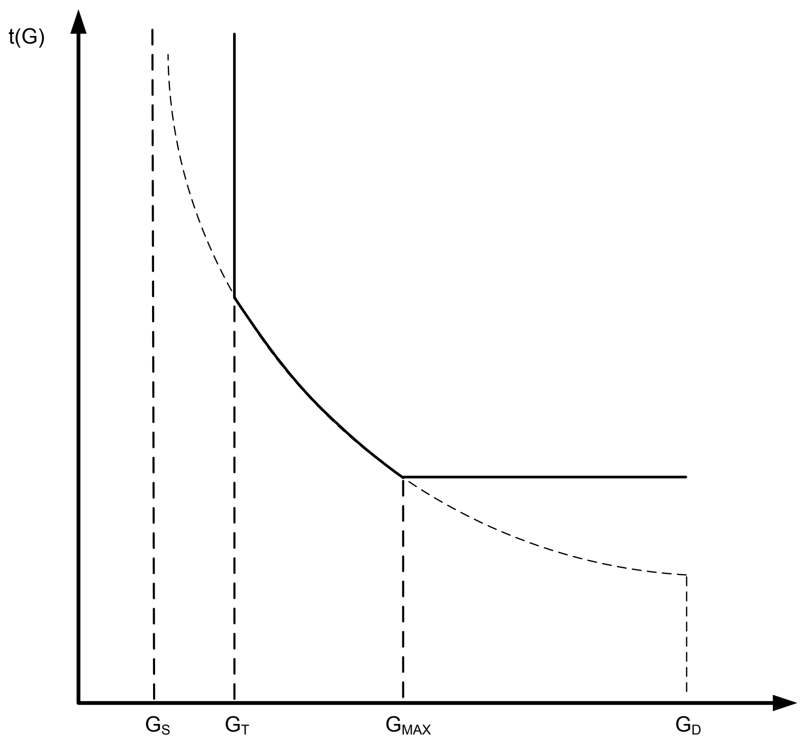
**INFO**
There is no intentional delay on reset. The function will reset when G < $G_s$.

**INFO**
"Inverse time over-current" is NOT supported by AGC-3.

**INFO**
"Inverse time over-current" is a standard feature in GPC-3/GPU-3/GPU-3 Hydro/PPU-3.

## 4.4.2 Curve shapes

Time characteristic:




$G_S = I_{nom}$ x LIM

$G_T = 1.1$ x $G_S$

$G_{MAX}$ = Over-current factor x $CT_P$

$G_D = 20 * G_S$

**Abbreviation explanation**

| | |
|---|---|
| $G_T$ | Minimum trip current |
| $G_{MAX}$ | Maximum trip current |
| $I_{nom}$ | Nominal current setting |
| $CT_P$ | Connected current transformer primary side value |

| | |
|---|---|
| $G_D$ | The point where the alarm shifts from an inverse curve to a definite time characteristic |
| $t_{MIN}$ | Minimum trip time that can be used for protection purpose. Only a calculation can show if this value will interfere with the intended trip curve |

| Product | Over-current factor | $t_{MIN}$ |
|---|---|---|
| AGC-4 | 2.2 | 250 ms |
| AGC 100 | 3.5 | 400 ms |
| AGC 200 | 3.5 | 200 ms |
| CGC 400 | 2.0 | 250 ms |
| GPC/GPU Hydro | 2.2 | 250 ms |
| PPU/GPU Hydro | 2.2 | 250 ms |

There is a choice between seven different curve shapes, of which six are predefined and one is user-definable:

IEC Inverse

IEC Very Inverse

IEC Extremely Inverse

IEEE Moderately Inverse

IEEE Very Inverse

IEEE Extremely Inverse

Custom

Common settings for all types:

| Setting | Parameter no. | Factory setting value | Equals |
|---|---|---|---|
| LIM | 1082 | 110 % | LIM = $G_S$/ $I_{nom}$ |
| TMS | 1083 | 1.0 | Time multiplier setting |

The following constants apply to the predefined curves:

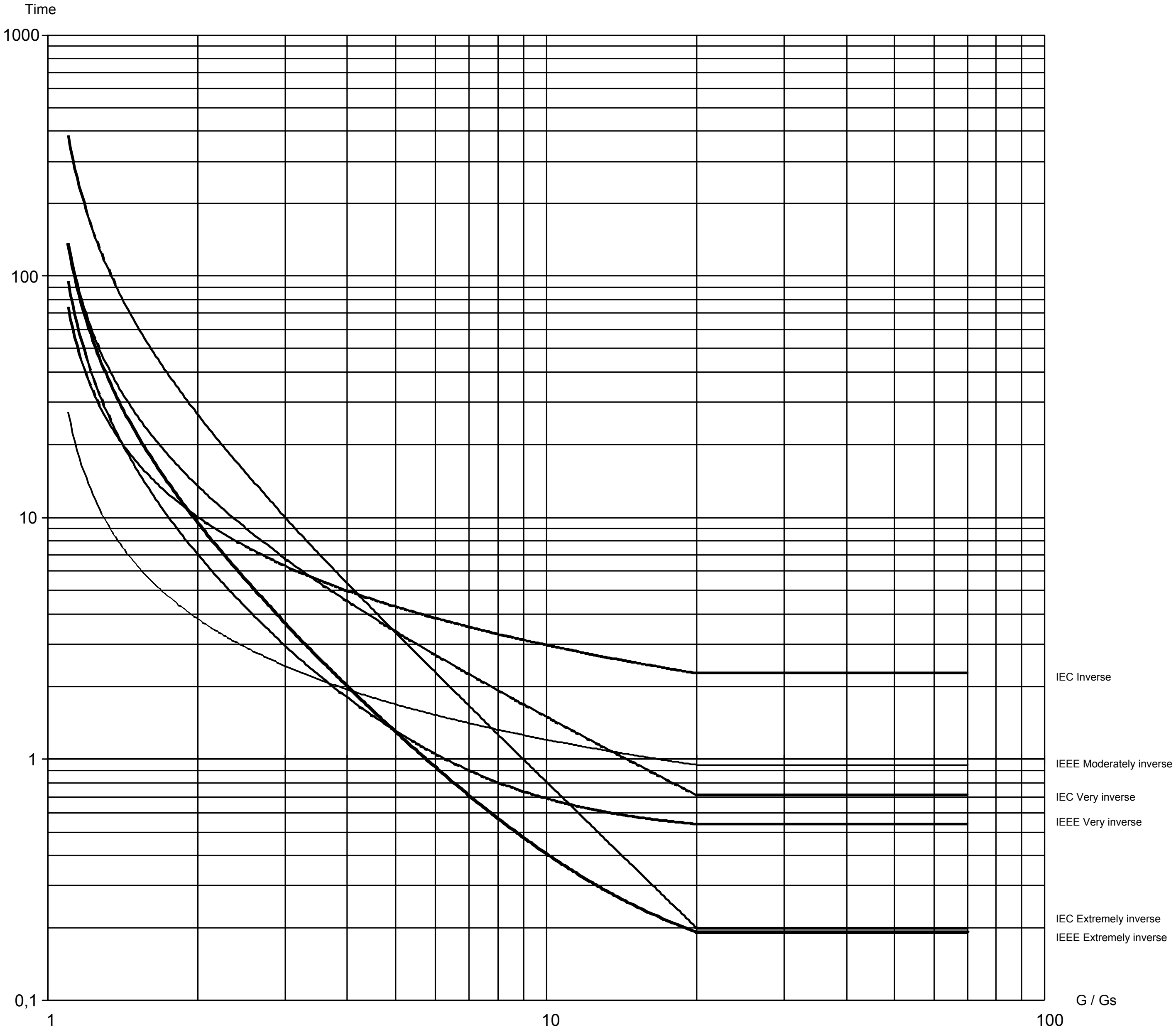
| Curve type | k | c | α |
|---|---|---|---|
| IEC Inverse | 0.14 | 0 | 0.02 |
| IEC Very Inverse | 13.5 | 0 | 1 |
| IEC Extremely Inverse | 80 | 0 | 2 |
| IEEE Moderately Inverse | 0.0515 | 0.1140 | 0.02 |
| IEEE Very Inverse | 19.61 | 0.491 | 2 |
| IEEE Extremely Inverse | 28.2 | 0.1217 | 2 |

For the custom curve, these constants can be defined by the user:

| Setting | Parameter no. | Factory setting value | Equals |
|---|---|---|---|
| k | 1084 | 0.140 s | k |
| c | 1085 | 0.000 s | c |
| α | 1086 | 0.020 | α |

**INFO**
For the actual setting ranges, see the separate parameter list document for the Multi-line unit in question.

### 4.4.3 Standard curves



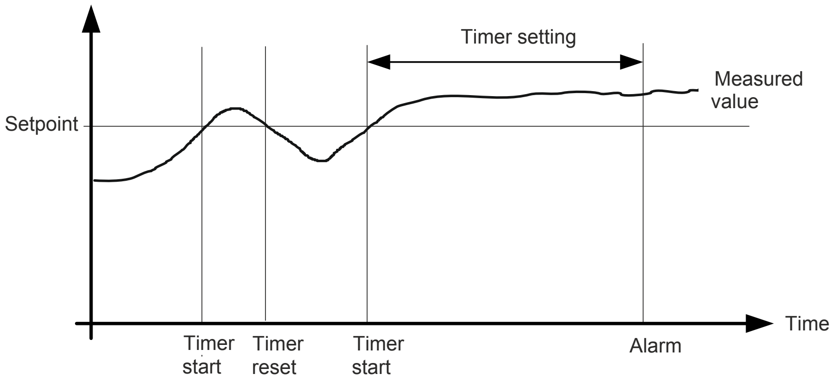

**INFO**
The curves are shown for TMS = 1.

# 5. Alarms

All settings are stated in percent of the nominal generator value.

The delay settings are (with a few exceptions, for example inverse time over-current) of the definite time type, that is a set point and time is selected.

If the function is for example over-voltage, the timer will be activated if the set point is exceeded. If the voltage value falls below the set point value before the timer runs out, the timer will be stopped and reset.




When the timer runs out, the output is activated. The total delay will be the delay setting + the reaction time.

# 6. Parameters

## 6.1 Further information

Option C2 relates to the parameters 1080-1090, 1540-1590 and 1740-1790.

For further information, see the parameter list:

| | |
|---|---|
| AGC-3 | Document number 4189340705 |
| AGC-4 | Document number 4189340688 |
| AGC 100 | Document number 4189340764 |
| AGC 200 | Document number 4189340605 |
| GPC-3, GPC-3 Gas, GPC-3 Hydro, GPU-3 Gas, GPU-3 Hydro | Document number 4189340580 |
| PPU-3, GPU-3 | Document number 4189340581 |