WOODWARD

APPLICATION NOTE
#37638, 08/2016

easYgen-3000XT

Load Shedding via flexible limit

Optional Supplementary Information

General Information

The following alert boxes can be used in this publication:

DANGER **"DANGER" indicates a hazardous situation which, if not avoided, will result in death or serious injury.**

WARNING **"WARNING" indicates a hazardous situation which, if not avoided, could result in death or serious injury.**

CAUTION **"CAUTION", used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.**

NOTICE **"NOTICE" is used to address practices not related to personal injury.**

IMPORTANT **"IMPORTANT" is used to address practices not related to personal injury.**

Personnel

WARNING

WARNING!
Hazards due to insufficiently qualified personnel!

If unqualified personnel perform work on or with the control unit hazards may arise which can cause serious injury and substantial damage to property.

- **Therefore, all work must only be carried out by appropriately qualified personnel.**

For further Product Support Options, Product Service Options, Returning Equipment for Repair, and/or Engineering Services please download application note #37573.

Documentation itself

⚠WARNING

Read this entire application note and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions.
Failure to follow instructions can cause personal injury and/or property damage!

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment.
Any such unauthorized modifications: constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and invalidate product certifications or listings.

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This document provides some examples how simple Load-Shedding can be realized by using the Flexible limits of the easYgen-3000XT.

1.0 Introduction

Load-shedding is part of a Power Management System (PMS) of an island grid. Load-shedding ensures the availability of power for critical loads by disconnecting less critical ones by clear defined rules until sufficient power is established e.g. by starting additional engines or decrease of the remaining load. This makes sure that the generator will not be shutdowned by an overload and the busbar will not be de-energized.

Load-shedding becomes important if

- the consumer load increases faster than generators can be added
- the consumer load increases, but no generator can be added anymore
- a generator failure must be compensated until a new generator has been added

Usually there are different fields with consumer loads which can be shed and one field with base load. Different priorities are assigned to the fields.
The scenarios of the desired Load-Shedding behavior are very different. For this reason the examples of this document can only give you an idea how to realize your requirement.

1.1 General remarks to the configuration

The configuration of Load-Shedding must basically consider the following frame conditions:

1. Rated power of the engine (or rated system power if more engines)
2. Current system power
3. Intended reserve power
4. Expected customer loads of the different load-shedding fields
5. Priorities of the different load-shedding fields

All Load-Shedding examples of this document are working with three Load-Shedding fields (steps) and one field with the base load.
If Load-Shedding becomes active, one or more of the **relays 13, 14, 15** will be energized to shed the corresponding load fields.
These relays are assigned to the Flexible Limits 25, 26, 27 (command variables 15.25, 15.26, 15.27).
The Flexible Limit of every field is defining:

- the limit to shed a field
- the hysteresis
- the delay time
- the fallback time
- the alarm class
- the acknowledge mode
- the enabling condition

  - The **limit** defines the load to shed the field.
  - The **hysteresis** is very important. It defines the ”threshold” for the reconnection of the field if load has decreased or the rated power has increased by an additional engine. To avoid jittering of the load-shedding steps the hysteresis must be a little higher than the maximum load of the field. If load dependent start stop (LDSS) is active additionally the hysteresis must be lower than the reserve power of LDSS.
  - The **delay time** is important to define the priority of load-shedding. The less critical field must be configured with the shortest time the more critical fields with longer times. (The field with the base load should not be shed.)
  - The **fallback time** defines the time to reconnect the field if the load has decreased.
  - The **alarm class** of the examples is configured as Class A to indicate the load-shedding but not cause any additional action.
  - The **acknowledge mode** is always set to “Selfacknowledge”

2 Examples

2.1.0 Single or multiple engine application without load dependent start stop

Generator rated active power (parameter 1752) = 200 kW (System rated active power (parameter 1825) does not care because in multiple engine systems applications with synchronous load share the utilization factor of all engine are almost the same.)
Generator active power (1752) = 200 kW
The system should run with a minimum of 5 % (10 kW) reserve power.
The load is distributed to 4 fields. 3 of these fields are part of the load shedding (Load-Shedding 1, Load-Shedding 2, Load-Shedding 3). Where Load-Shedding 1 is the less, Load-Shedding 3 is the most critical one. Field 4 cannot be shed it carries the base load.
The expected load of each field is max. 20 kW.

2.1.1 Configuration :

Flexible Limits 25 is evaluate Load-Shedding 1, Flexible Limits 26 is evaluate Load-Shedding 2 and Flexible Limits 27 is evaluate Load-Shedding 3.

- Since the system should run with at least 5% reserve power the Real Power must not exceed 100% - 5 % = 95 %. Therefore configure:
  - **Monitoring at:** Overerrun (for all of the three Flexible Limits
  - **Limit** = 95 (for all of the three Flexible Limits
  - Analogmanager
    - **Type =** Pass through (for all of the three Flexible Limits)
    - **A1** (source) = 01.24 Generator active power [%] (for all of the three Flexible Limits)

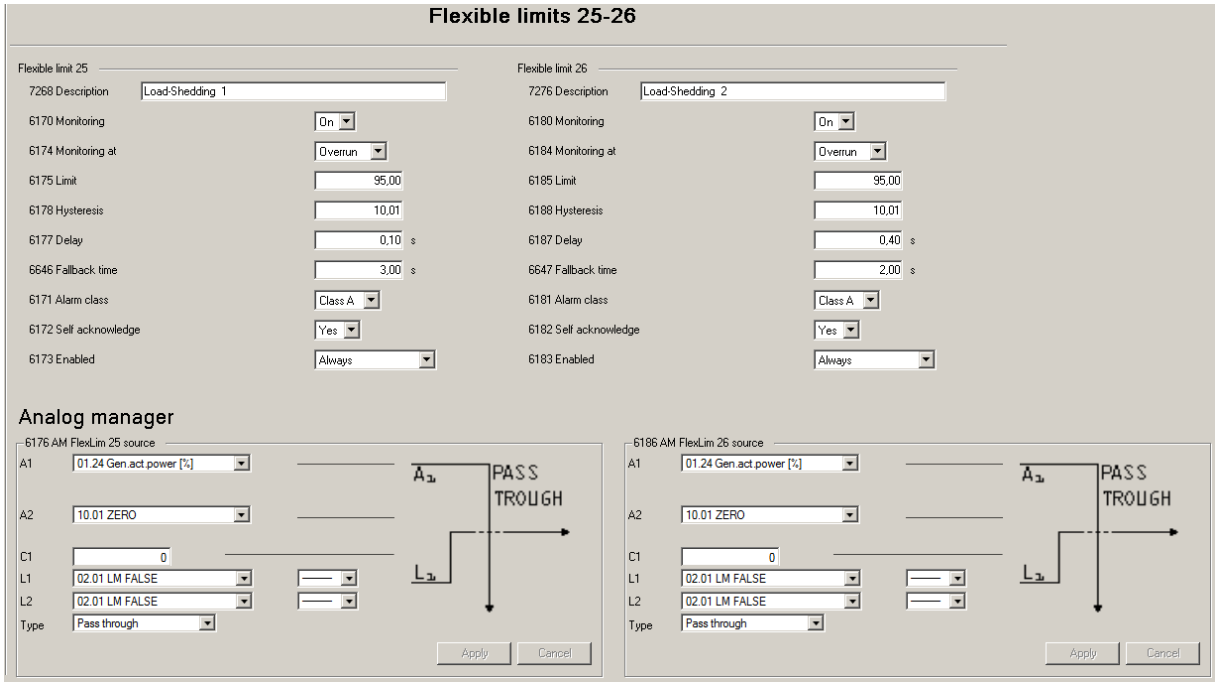
- To avoid jittering the hysteresis must be a little higher than the maximum load of the corresponding field. The maximum load is 20 kW ≙ 10% for field 1 to 3. Therefore configure
  - **Hysteresis** = 10.01 (for all of the three Flexible Limits)

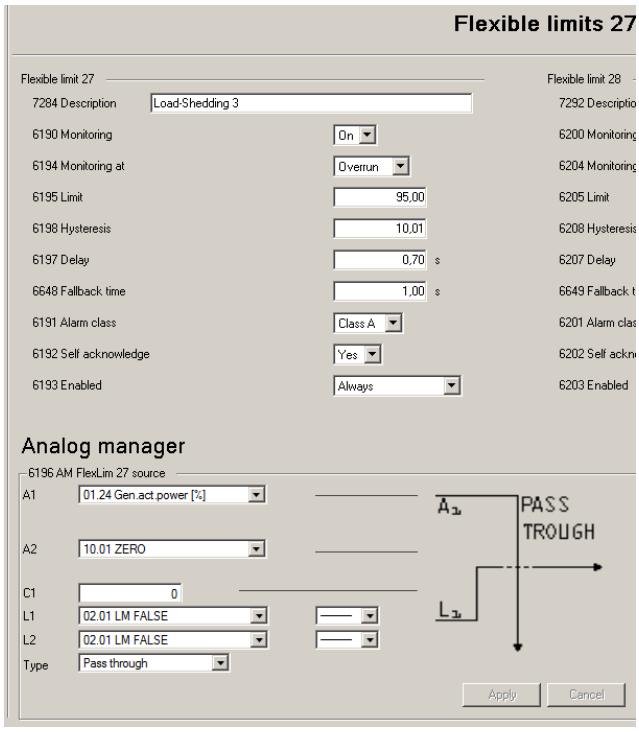
- To stagger (prioritize) the Load-Shedding steps different delay times are configured. Field controlled by Flexible Limit 25 should shed at first configure:
  - **Delay** (Flexible Limit 25) = 0.1 s
  - **Delay** (Flexible Limit 26) = 0.4 s
  - **Delay** (Flexible Limit 27) = 0.7 s

- In case of decreasing power or adding an additional engine after Load-Shedding was active as much fields as possible should be reconnected in a reverse order. Therefore configure
  - **Fallback** (Flexible Limit 25) = 3.0 s
  - **Fallback** (Flexible Limit 26) = 2.0 s
  - **Fallback** (Flexible Limit 27) = 1.0 s

- Load-Shedding **relays:** see “Relay (Discrete Outputs *x.x*) configuration”

2.1.1.1 Toolkit configuration screens for flexible limits 25-27



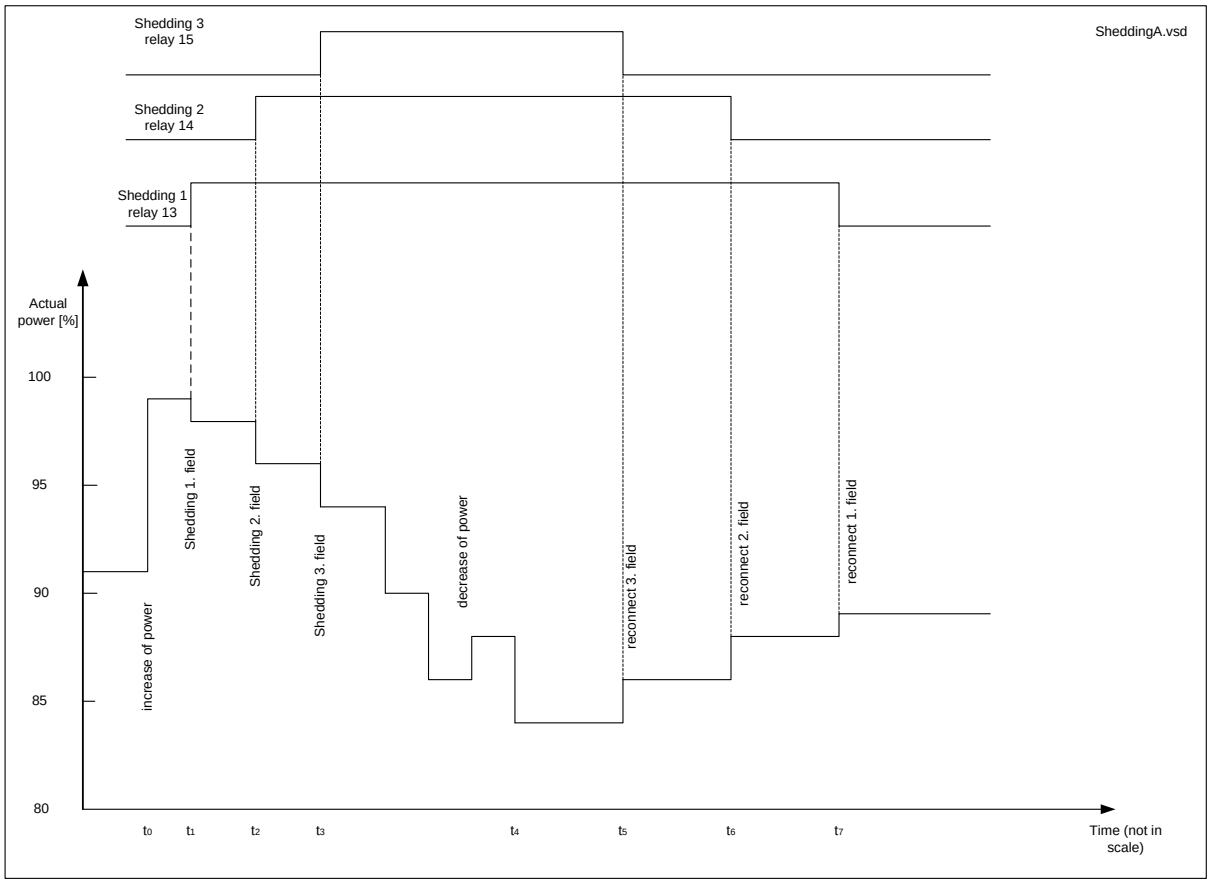


2.2. Timing diagram

The following diagram shows an example how the Load-Shedding is working with these settings.
It is supposed that the load of the fields 1 to 3 is constant with the following loads:

Field 1: 1%,
Field 2: 2%,
Field 3: 2%

and the base load varies:



At the beginning the system is running with 91 % load.
Then(t_0) the load increases to 99 % which is higher than the threshold of 95%
after 100 ms (t_1) field 1 becomes shed, the load decreases to 98 %
after 300 ms (t_2) field 2 becomes shed, the load decreases to 96 %
after 300 ms field 3 becomes shed, the load decreases to 94 % which is lower than the threshold of 95%
after some time (t_4) power decreases by 10 % from 94 % to 84 %. This is 11 % of the threshold and higher than the hysteresis. The fallback timers are starting.
after 1 s (t_4) field 3 becomes reconnected
another second more (t_5) field 2 becomes reconnected
another second more (t_6) field 1 becomes reconnected

2.2.0 Multiple engine application with load dependent start stop (LDSS)

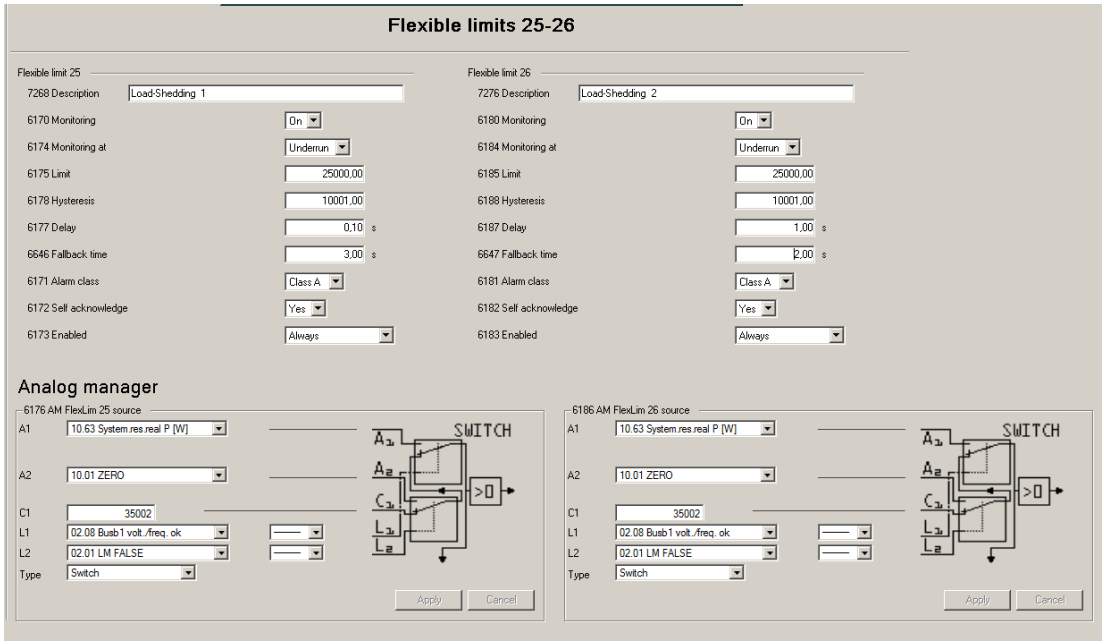
If Load-Shedding is operating with load dependent start stop (LDSS) the settings of Load-Shedding and LDSS must be harmonized very carefully according to the individual requirements.
In this example there are two generators with “Generator rated active power” (parameter 1752) = 100 kW. “Start stop mode” of LDSS (parameter 5752) is set to “Reserve power”. The “IOP Reserve power” (parameter 5760) is 25 kW.
The load is distributed to 4 fields. 3 of these fields are part of the load shedding (Load-Shedding 1, Load-Shedding 2, Load-Shedding 3). Where Load-Shedding 1 is the less, Load-Shedding 3 is the most critical one. Field 4 cannot be shed it carries the base load.
The expected load of each fields 1-3 is max. 10 kW.

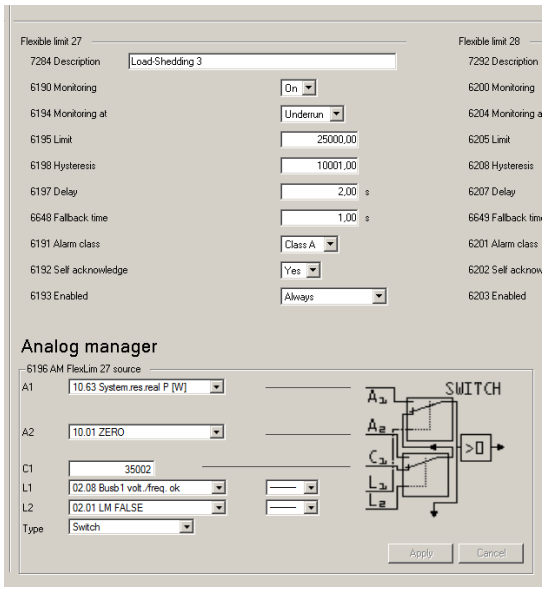
2.2.1 Configuration :

Flexible Limits 25 is evaluate Load-Shedding 1, Flexible Limits 26 is evaluate Load-Shedding 2 and Flexible Limits 27 is evaluate Load-Shedding 3.

- Since the system should run with at least 25 kW reserve power the reserve power should not underrun 25 kW Therefore configure:
  - **Monitoring at:** Underrun (for all of the three Flexible Limits
  - **Limit =** 25000 (for all of the three Flexible Limits
  - **Analogmanager**
    Because the monitoring is configured as underrun and the reserve power is zero if no engine is running, load shedding will be tripped. For this reason the switch takes the value of C1 to avoid tripping in this case.
    - **Type** = Switch (for all of the three Flexible Limits)
    - **A1** (source) = 10.63 System reserve power (for all of the three Flexible Limits)
    - **C1** = 35002 (must be higher than reserve power + hysteresis)
    - **L1** = 02.08 Busb1 volt./freq. ok (enable condition)
  - To avoid jittering the hysteresis must be a little **higher** than the maximum load of the corresponding field. The maximum load is 10 kW for fields 1 to 3. Therefore configure
    - **Hysteresis** = 10001 (for all of the three Flexible Limits)
      (The hysteresis must be lower than the reserve power but a little higher than the expected load at the fields to be shed.)
  - To stagger (prioritize) the Load-Shedding steps different delay times are configured. Field controlled by Flexible Limit 25 should shed at first configure:
    - **Delay** (Flexible Limit 25) = 0.1 s
    - **Delay** (Flexible Limit 26) = 0.4 s
    - **Delay** (Flexible Limit 27) = 0.7 s
  - In case of decreasing power or adding an additional engine after Load-Shedding was active as much fields as possible should be reconnected in a reverse order. Therefore configure
    - **Fallback** (Flexible Limit 25) = 3.0 s
    - **Fallback** (Flexible Limit 26) = 2.0 s
    - **Fallback** (Flexible Limit 27) = 1.0 s
  - Load-Shedding **relays:** see “Relay (Discrete Outputs *x.x*) configuration”

2.2.1.1 Toolkit configuration screens for flexible limits 25-27.

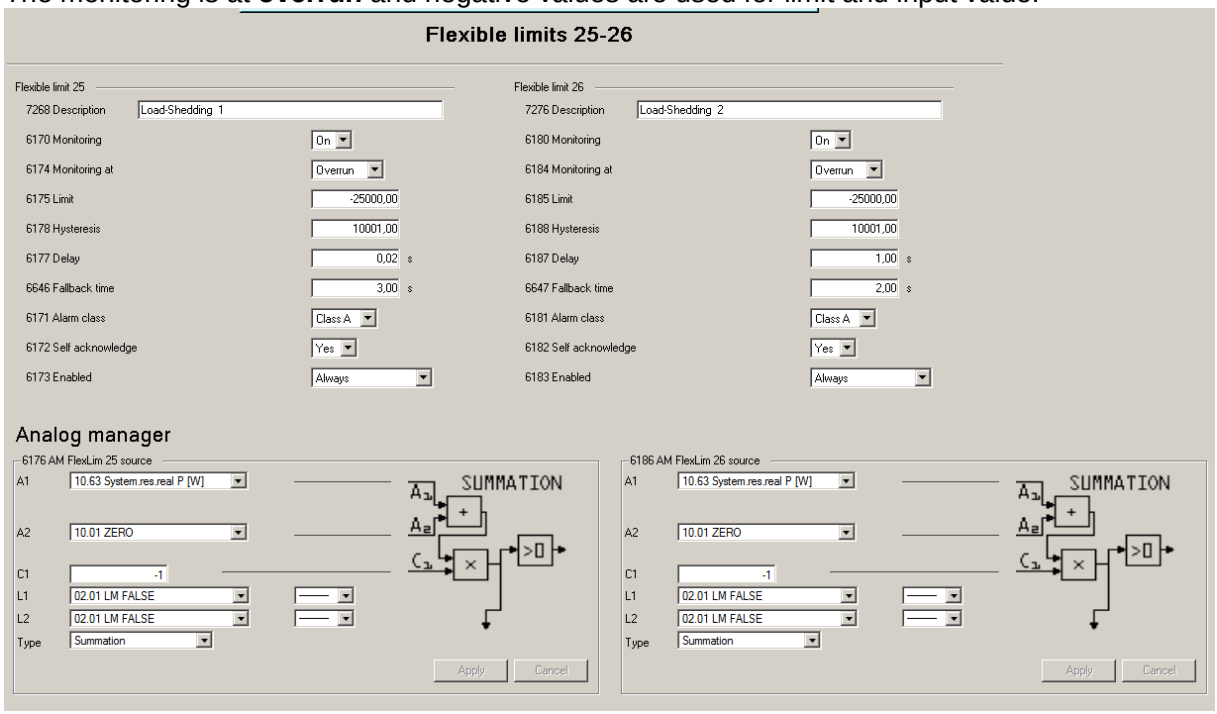


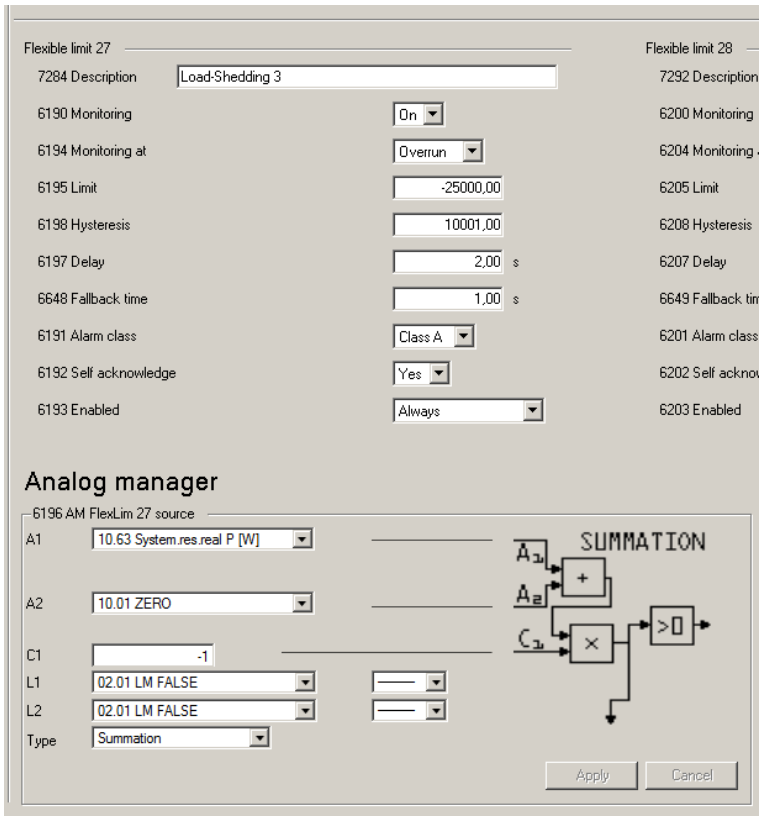


2.2.1.2 An alternative configuration for flexible limits 25 – 27 …

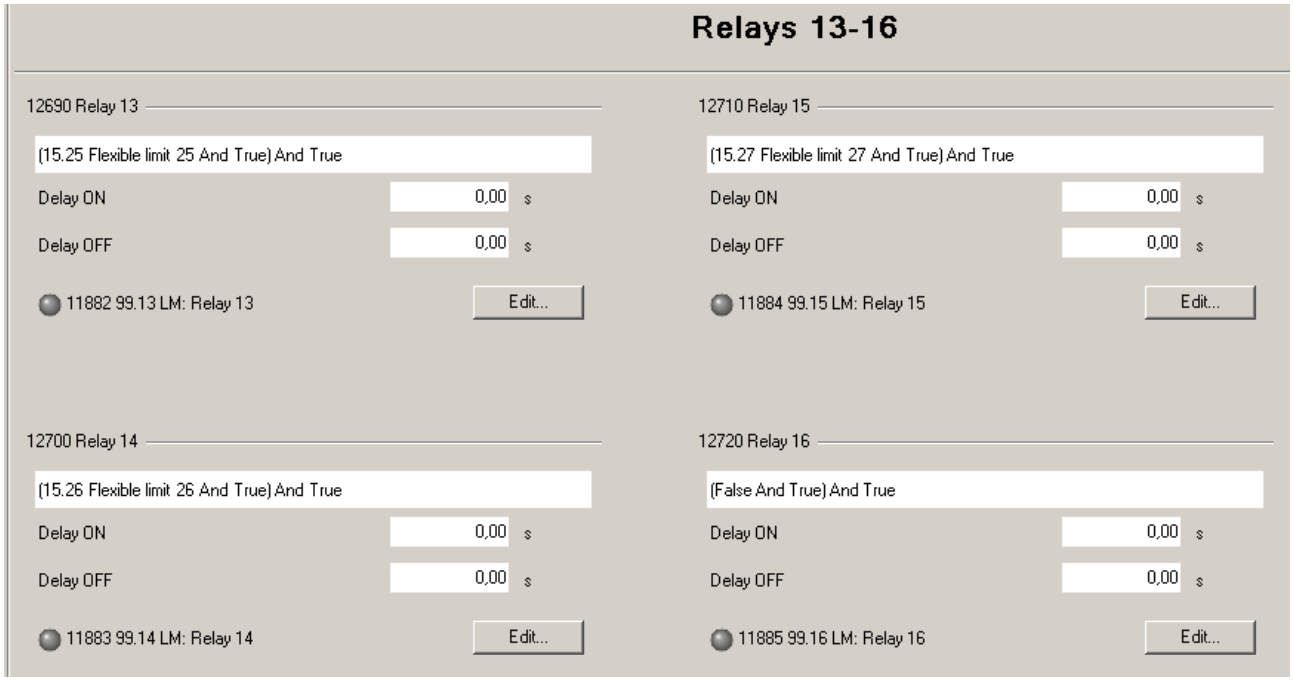
is **without an enable condition** (e.g. 02.08 Busb1 volt./freq.).

The monitoring is at **overrun** and negative values are used for limit and input value:





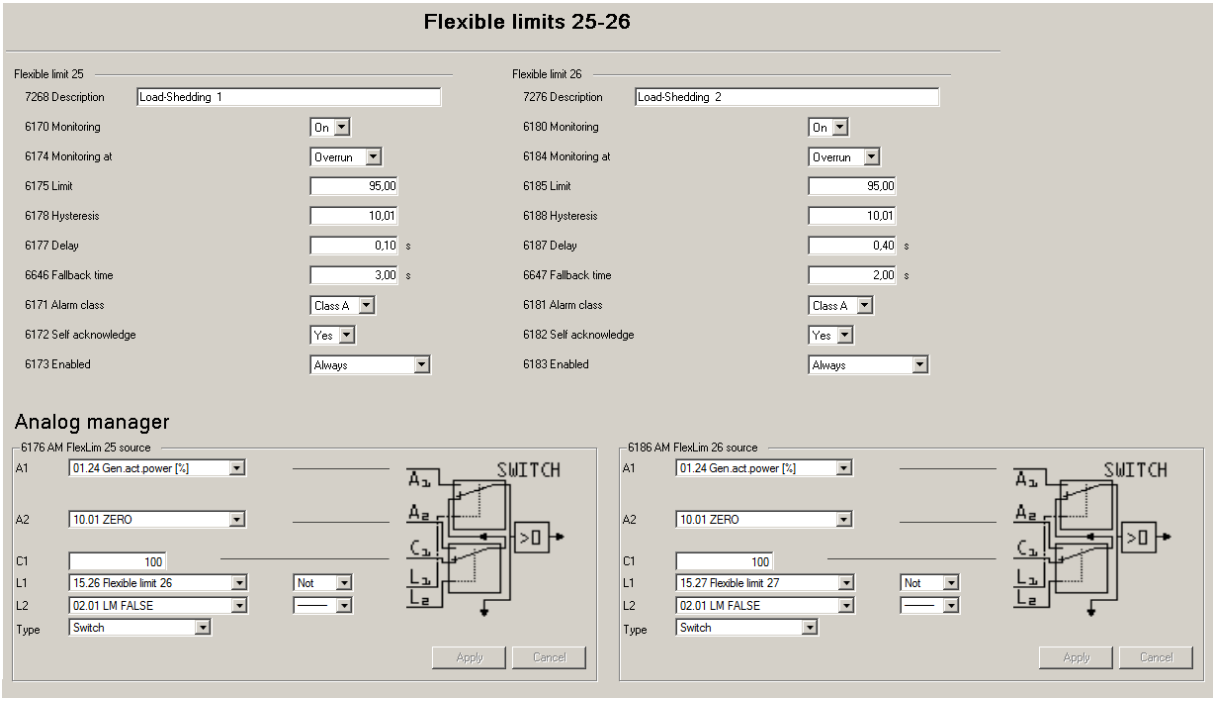
3.0 Relay (Discrete Outputs) configuration:

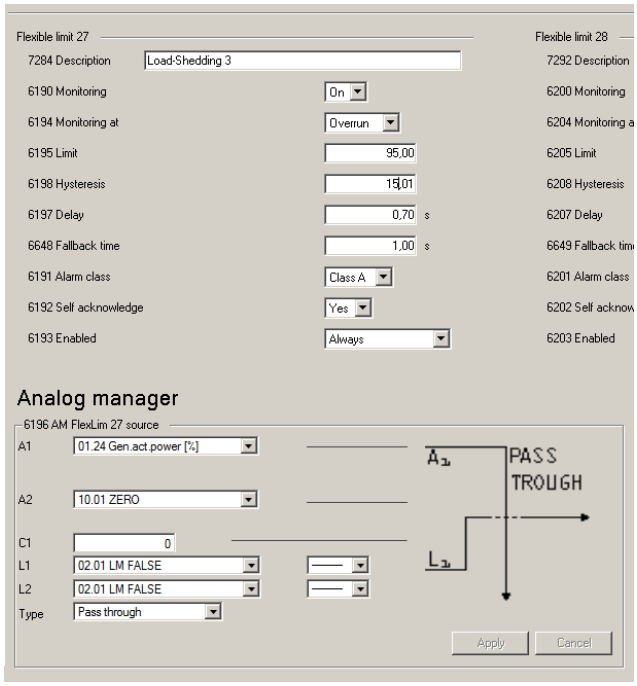


Appendix:

Reconnection order with fields of different loads

If the load fields have different maximum loads with the result of different hysteresis e.g. field 3 is assigned for more load than the other fields it could happen that the order of reconnection is not as expected by the configured fallback times.
Example:
The expected maximum loads at field 1 and 2 are 10 % of rated power and the expected load of field 3 is 15 %. The hysteresis for field 1 and 2 are a little higher than 10 % and for field 3 a little higher than 15 %. Field 4 bears the base load.
Supposed all 3 fields have been shed and the base load at field 4 is 90 %.
Now the load decreases to 82 % was is over the hysteresis of field 1 and 2 **but not over the hysteresis of field 3**. For this reason field 2 will be reconnected after its fallback time even if due to the configuration of fallback times field 3 is expected to be reconnected first.
If this is not desired, a locking mechanism for field 1 and 2 must be configured e.g. by modification of the real power assigned to fields 1 and 2 (Flexible limits 25 and 26).
In the following example the “real power” of field 2 is set to constant 100% via the switch function of the analog manager as long as Load shedding of field 3 is active. Analog to field 2 the “real power” of field 1 is set to constant 100% via the switch function of the analog manager as long as Load shedding of field 2 is active.
The constant must be higher than “limit – hysteresis” then the flexible limits remain tripped as long as the fields with higher number are shed.



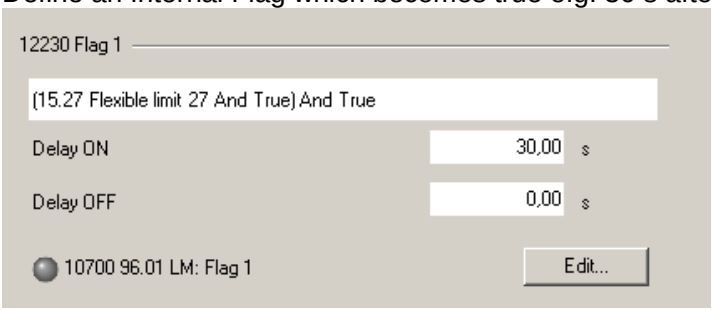


Bypass Hysteresis

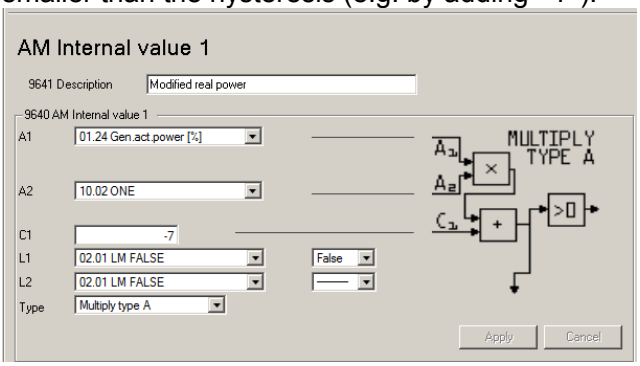
In some cases it could be happen that the fields will not be reconnected anymore. This is the case if the overall load has decreased but is still within the hysteresis.
If it is possible to run the generator with a defined little overload for a short time, it could be tried to reconnect e.g. field 3 even if the conditions for normal reconnection are not met. This could be done e.g. by a modification of the measured Real Power for field 3 under certain conditions.
In this example it is a **time condition**.

Configuration:

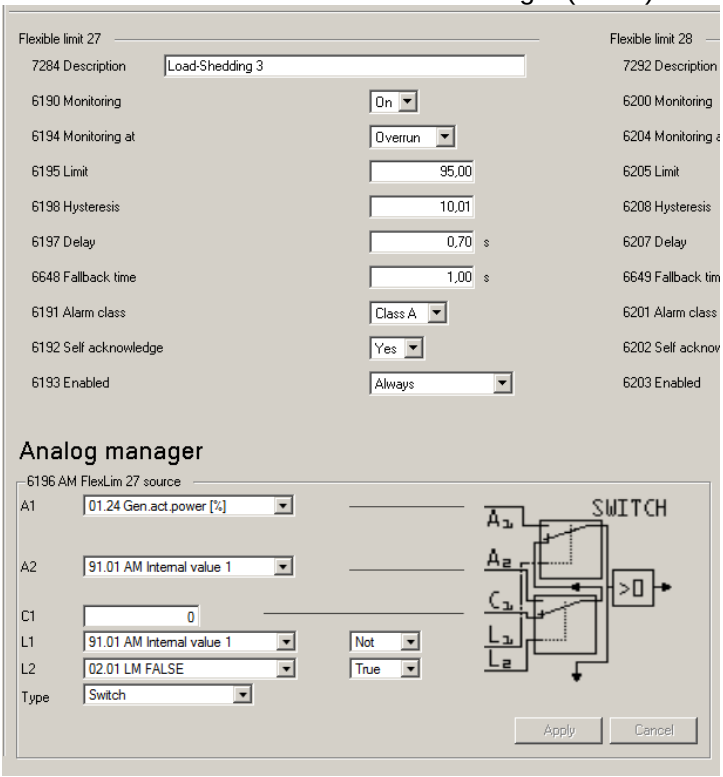
STEP 1 Define an Internal Flag which becomes true e.g. 30 s after field 3 (15.27) was shed:



STEP 2 Define an Internal value with a modified real power e.g. by subtracting a value which is smaller than the hysteresis (e.g. by adding “-7”):

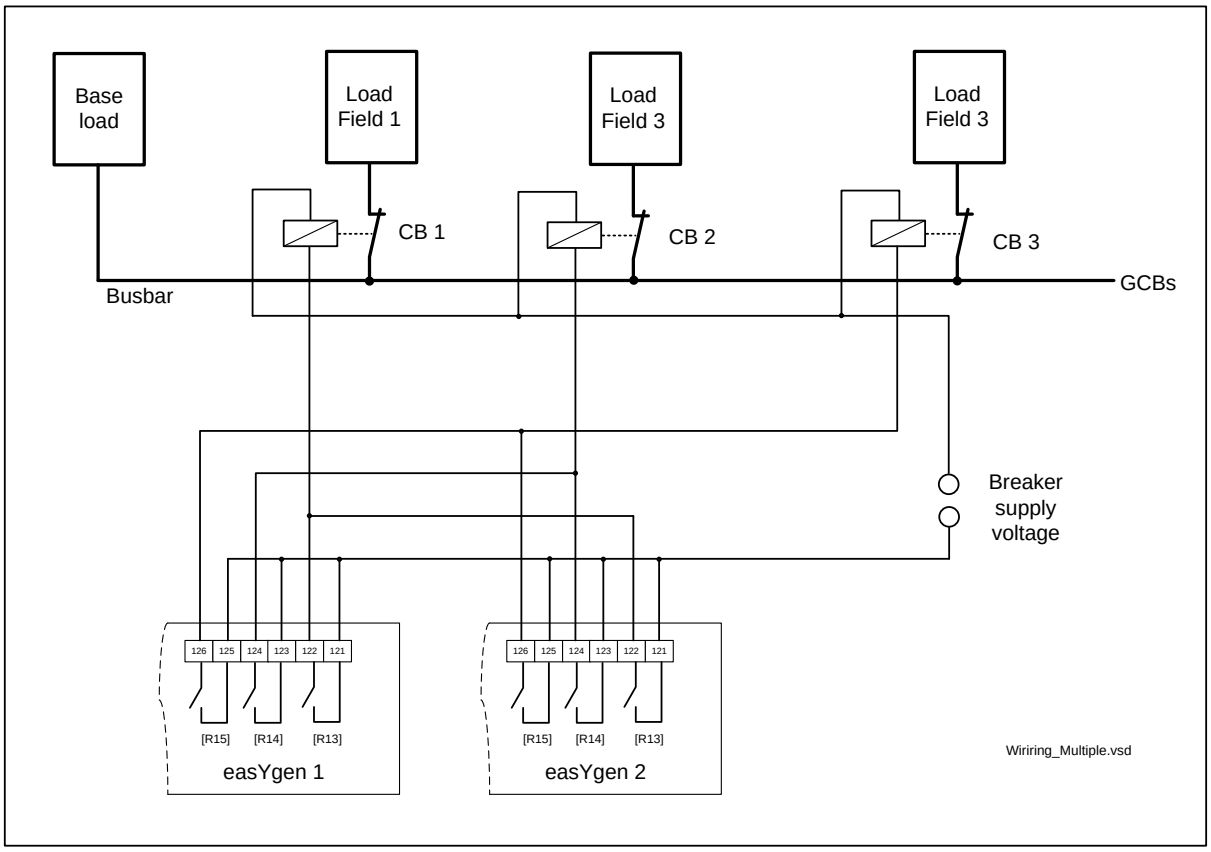


STEP 3 Switch from “System real P” (10.12) to this “Modified system real power” (91.01) if field 3 is shed and the time defined with internal flag 1 (96.01) has exceeded.



Be aware that this makes only sense if the load of has decreased in this time. Otherwise it could happen that the field will be shed again and in worst case the generator is running in **overload with shutdown**

Wiring multiple generators



If there are more easYgens in the system it could be the case that e.g. only one easYgen is running. But the Load-Shedding must available in all constellations. For this reason the Load-Shedding breakers must be “OR – wired” with the easYgens.
This example shows how two easYgens can be connected to the 3 load shedding breakers CB 1, CB 2 and CB 3. If at least one easYgen wants to shed a field the field will be shed. For CB 1, CB 2 and CB 3 normally closed breakers are used to connect/disconnect the different fields.
Like in all examples of this document at the easYgen

relay 13 is assigned to shed field 1,
relay 14 is assigned to shed field 2,
relay 15 is assigned to shed field 3.
These relays are configured as normally open.
(Any necessary suppressor elements are not drawn.)

Please be aware this is only one possibility. In some cases e.g. depending on the power the supply for the circuit breakers (e.g. normally open instead of normally closed) other wiring and relay/breaker setups are to prefer.

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