

## Auto-reclosing function in VAMP protection relays

The modern numerical VAMP protection relays include a sophisticated Auto-reclosing (AR) function. The AR function is normally used in feeder protection relays that are protecting an overhead line. Most of the overhead line faults are temporary in nature. Even 85% can be cleared by using the AR function.

### General

The basic idea is that normal protection functions will detect the fault. Then the protection function will trigger the AR function. After tripping the circuit-breaker (CB), the AR function can reclose the CB. Normally, the first reclose (or shot) is so short in time that consumers cannot notice anything. However, the fault is cleared and the feeder will continue in normal service.

### Terminology

Even though the basic principle of AR is very simple; there are a lot of different timers and parameters that have to be set.

In VAMP relays, there are five shots. A shot consists of open time (so called “dead” time) and close time (so called “burning” time or discrimination time). A high-speed shot means that the dead time is less than 1 s. The time-delayed shot means longer dead times up to 2-3 minutes.

There are four AR lines. A line means an initialization signal for AR. Normally, start or trip signals of protection functions are used to initiate an AR-sequence. Each AR line has a priority. AR1 has the highest and AR4 has the lowest one. This means that if two lines are initiated at the same time, AR will follow only the highest priority line. A very typical configuration of the lines is that the instantaneous overcurrent stage will initiate the AR1 line, time-delayed overcurrent stage the AR2 line and earth-fault protection will use lines AR3 and AR4.

### Circuit-breaker configuration

The status of the circuit breaker must be known by the AR function to operate correctly. The status is taken automatically from the object 1. Therefore, the statuses must be connected to the object 1. Normally, two digital inputs are recommended to be used for the status; one for the open status and one for the close status. However, if two free inputs are not available, then also one input is enough, the close status. Then the open status is left without any inputs (See the screenshot below, submenu “objects”). Please note that using only one input; there is no way to know any intermediate state of the breaker. Please note also that Max ctrl pulse length must be longer than circuit breaker operation time.

| CTRL OBJECT 1           |         |
|-------------------------|---------|
| Obj1 state              | Open    |
| Obj1 final trip by      | -       |
| DI for 'obj open'       | -       |
| DI for 'obj closed'     | DI1     |
| DI for 'obj ready'      | -       |
| Max ctrl pulse length   | 0.20 s  |
| Completion timeout      | 10.00 s |
| Object 1 control        | -       |
| DI for remote open ctr  | -       |
| DI for remote close ctr | -       |
| DI for local open ctr   | -       |
| DI for local close ctr  | -       |

As the status is now known, we need to configure also the opening and re-closing of the breaker. Again, this happens “thru” the object 1. The open and close commands for the object 1 can be linked to any output relays in the submenu “Output matrix” (See the screenshot below).

| OUTPUT MATRIX           |   | T1 | T2 | T3 | T4 | A1 |
|-------------------------|---|----|----|----|----|----|
| ● connected             |   |    |    |    |    |    |
| ⊙ connected and latched |   |    |    |    |    |    |
| AR1 final trip          |   |    |    |    |    | ●  |
| AR2 final trip          |   |    |    |    |    | ●  |
| AR3 final trip          |   |    |    |    |    | ●  |
| AR4 final trip          |   |    |    |    |    | ●  |
| Critical final trip     |   |    |    |    |    | ●  |
| Object1 open            | ● |    |    |    |    |    |
| Object1 close           |   | ●  |    |    |    |    |

When dealing with double bus bar switchgear it's possible to choose from two circuit breakers which should be operated. Circuit breaker that will be operated can be set using automated circuit breaker selection or by using DI signal. When using automated selection relay selects that breaker which has operated last.

|                         |                                     |
|-------------------------|-------------------------------------|
| Breaker object in use   | Obj1                                |
| Breaker 1 object        | Obj1                                |
| Breaker 2 object        | Obj2                                |
| Auto CB selection       | <input checked="" type="checkbox"/> |
| Input for selecting CB2 | -                                   |

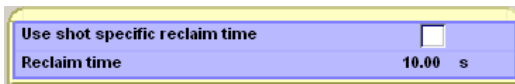
## AR general settings

There are many general settings for AR under the submenu “Auto reclosing”. There it is possible to enable/disable the function, or use an input to enable. Enable AR for 2 grp. means the “Group 2” in protection stages.

|                      |      |
|----------------------|------|
| Enable autoreclosing | ARon |
| DI for ARon/ARoff    | DI1  |
| Enable AR for 2 grp. | ARon |

However, the most important setting here is the “reclaim time”. This time specifies how long the relay waits the fault to happen again.

For example, we had a phase-to-phase fault, so the overcurrent stage opens the CB. Then the AR will reclose the CB after 0.3 seconds. When the CB closes, the reclaim timer starts and waits if the fault happens again. If the overcurrent stage trips again, then the AR will move to the shot 2 with a different settings. If there is no fault during the reclaim time, then the AR will reset and return to the standby stage, waiting for the next fault. This reclaim time can be set as common for all shots or to be shot specific.



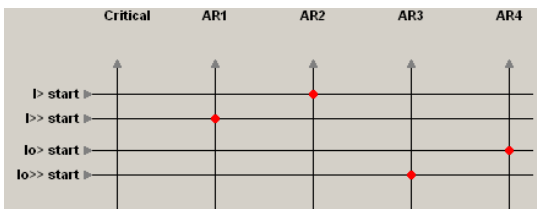
There are also a lot of AR counters that are available in this menu.

### AR matrix setting

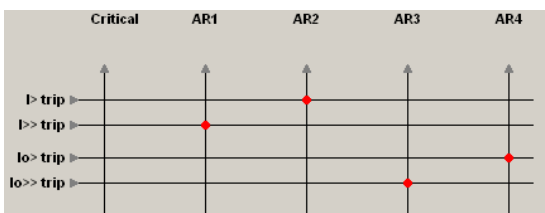
The AR matrix specifies which protection functions will initiate the AR function. Typically, there are two different “schools”. Some prefer using start signals of the protection stages, some use the trip signals.

The benefit using start signals, that the burning times can be different from the time delays of the protection stages and they can also be different for each shot. On the other hand, the using of the trip signals enables easier setting and no coordination problems with the protection stages.

Example of using start signals:



Example of using trip signals:



The critical signal can be used to interrupt the AR sequence.

### AR shots settings (trip signals)

There are 5 shots available for settings. If the trip signals are used, then the start delay and all the discrimination times can be ignored and left to their default values (0.02 s is the minimum setting and it means that there are no additional delays). The most important setting is the dead time settings. Each shot has its own dead time setting. The dead time means, how long the AR keeps the CB open, before the reclosing. Typically, shot 1 has

very short dead time, like 0.3 or 0.4 seconds and then shot2 a longer dead time, like 60 or 120 seconds and then the final trip.

Then one has to determine which AR lines will use shots. This is done easily clicking the text “Off”. Then the clicked line will activate the current shot. For example, if instantaneous overcurrent does not have any shots, do not select any shots ON to the line AR1. If there are two shots for time-delayed overcurrent, select shot 1 and shot 2 to be ON, for the AR2 line. Then if the earth fault has only one shot (shot2), then select the lines AR3 and AR4 to be ON for the shot2. As there are no AR lines ON for the shot 3, it means that the final trip is made after the shot 2.

Please see the example below:

AR Shot settings 79

Use shot specific reclaim time ☐ Reclaim time 10.00 s

| Shot 1 |    |         |             |           |                     |        |
|--------|----|---------|-------------|-----------|---------------------|--------|
| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time |        |
| Off    | 1  | -       | 0.02 s      | 0.02 s    | 0.3 s               | 0.02 s |
| On     | 2  | -       | 0.02 s      | 0.02 s    | 0.3 s               | 0.02 s |
| Off    | 3  | -       | 0.02 s      | 0.02 s    | 0.3 s               | 0.20 s |
| Off    | 4  | -       | 0.02 s      | 0.02 s    | 0.3 s               | 0.20 s |

| Shot 2 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 60 s      | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 2  | -       | 60 s      | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 3  | -       | 60 s      | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 4  | -       | 60 s      | 0.02 s              | 0.02 s       | 10.00 s |

| Shot 3 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 5.00 s    | 0.02 s              | 0.02 s       | 10.00 s |
| Off    | 2  | -       | 5.00 s    | 0.02 s              | 0.02 s       | 10.00 s |
| Off    | 3  | -       | 5.00 s    | 0.02 s              | 0.02 s       | 10.00 s |
| Off    | 4  | -       | 5.00 s    | 0.02 s              | 0.02 s       | 10.00 s |

Another typical setting is to use three shots with the same dead time setting, like 5 seconds for each shot. Please see example below:

AR Shot settings 79

Use shot specific reclaim time ☐ Reclaim time 10.00 s

| Shot 1 |    |         |             |           |                     |        |
|--------|----|---------|-------------|-----------|---------------------|--------|
| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time |        |
| Off    | 1  | -       | 0.02 s      | 5 s       | 0.02 s              | 0.02 s |
| On     | 2  | -       | 0.02 s      | 5 s       | 0.02 s              | 0.02 s |
| On     | 3  | -       | 0.02 s      | 5 s       | 0.02 s              | 0.20 s |
| On     | 4  | -       | 0.02 s      | 5 s       | 0.02 s              | 0.20 s |

| Shot 2 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 2  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 3  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 4  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |

| Shot 3 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 2  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 3  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |
| On     | 4  | -       | 5 s       | 0.02 s              | 0.02 s       | 10.00 s |

## AR shots settings (start signals)

The using of the start signals means, that each reclosing can have a different burning time. This feature is good, when it is needed to burn tree branches, but keeping in mind the cooling of the conductor.

The selection of the used shots and the dead time setting is done as when using trip signals. However, now the start delay and discrimination times define the burning times. Please note that these times should be, at least 100 ms shorter than the delay of any protection stages. For example, if the definite time setting for the overcurrent stage is 0.4 seconds, then the maximum delay for the AR function is 0.3 seconds. If an inverse time characteristic is used, then the minimum tripping time has to be defined to determine the AR delay.

An example using the delays: Firstly, we can have a longer burning time, as the conductor is not heated, yet. Secondly, after the first shot, we already decrease the burning time, not to heat the conductor too much. If also the shot 2 fails, then we use a short burning time. Please see this example next:

AR Shot settings 79

Use shot specific reclaim time ☐

Reclaim time 10.00 s

| Shot 1 |    |         |             |           |                     |        |
|--------|----|---------|-------------|-----------|---------------------|--------|
| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time |        |
| Off    | 1  | -       |             | 0.02 s    | 0.3 s               | 0.02 s |
| On     | 2  | -       |             | 0.3 s     | 0.3 s               | 0.2 s  |
| On     | 3  | -       |             | 0.3 s     | 0.3 s               | 0.2 s  |
| On     | 4  | -       |             | 0.3 s     | 0.3 s               | 0.2 s  |

| Shot 2 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 60 s      |                     | 0.02 s       | 10.00 s |
| On     | 2  | -       | 60 s      |                     | 0.1 s        | 10.00 s |
| On     | 3  | -       | 60 s      |                     | 0.1 s        | 10.00 s |
| On     | 4  | -       | 60 s      |                     | 0.1 s        | 10.00 s |

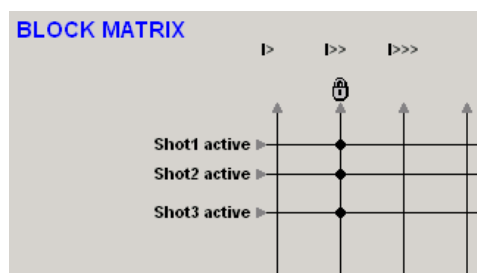
| Shot 3 |    |         |           |                     |              |         |
|--------|----|---------|-----------|---------------------|--------------|---------|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |         |
| Off    | 1  | -       | 5 s       |                     | 0.02 s       | 10.00 s |
| On     | 2  | -       | 5 s       |                     | 0.02 s       | 10.00 s |
| On     | 3  | -       | 5 s       |                     | 0.02 s       | 10.00 s |
| On     | 4  | -       | 5 s       |                     | 0.02 s       | 10.00 s |

Please also make sure that none of the protection functions does a nuisance start. For example, it is very typical that the magnetizing inrush will start the overcurrent stage and then also the AR sequence. Therefore, the overcurrent stage should be blocked, if there is any inrush current. The 2nd harmonic O/C stage can be used for the blocking purposes.

### Blocking of the protection

In some cases, the AR function must be coordinated with downstream protection functions. Fuse protection is a very typical example. If there are fuses in the MV line, this could cause changes in the AR settings.

As an example, if all the branches are protected by fuses, it might be required to block the instantaneous protection after the first shot. Therefore, if the fault is on one of the branch, then the blocking will give time for a fuse to burn. The blocking can be done easily in the blocking matrix using the signal "Shot1 active". This signal activates, when the first shot is started.



The whole AR function can be blocked by DI signal from external synchrocheck but it's also possible to block only a desired shot. Please see examples below:

**Block by external synchrocheck** **DI5**

AR Shot settings 79

Use shot specific reclaim time ☐ Reclaim time 10.00 s

| Shot 1 |    |         |             |           |                     |  |
|--------|----|---------|-------------|-----------|---------------------|--|
| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time |  |
| On     | 1  | DI1     | 0.02 s      | 0.30 s    | 0.02 s              |  |
| On     | 2  | DI1     | 0.02 s      | 0.30 s    | 0.20 s              |  |
| On     | 3  | DI1     | 0.02 s      | 0.30 s    | 0.20 s              |  |
| On     | 4  | DI1     | 0.02 s      | 0.30 s    | 0.20 s              |  |

| Shot 2 |    |         |           |                     |              |  |
|--------|----|---------|-----------|---------------------|--------------|--|
| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |  |
| On     | 1  | DI2     | 0.00 s    | 0.02 s              | 10.00 s      |  |
| On     | 2  | DI2     | 0.00 s    | 0.02 s              | 10.00 s      |  |
| On     | 3  | DI2     | 0.00 s    | 0.02 s              | 10.00 s      |  |
| On     | 4  | DI2     | 0.00 s    | 0.02 s              | 10.00 s      |  |

## Testing of the AR function

The testing is done as with any other stage. A secondary current injection device is needed. The important note is that the current injection must be stopped when the CB opens. Therefore, it is good to use the aux contacts of the CB to stop the current flowing, when the CB is in the open status. The correct operation times can be measured by starting the timer of the testing device, when the current injection starts. Then the timer is stopped when the CB change the status. Then the actual burning time is got. This time is the relay setting + the operation time of the CB.

## Global final trip

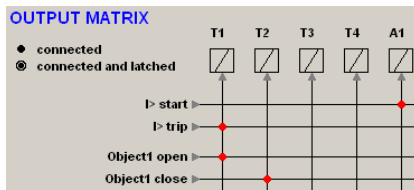
Global final trip is a new event added to VAMP relays. Global final trip events can be enabled from "Event masks for Objects" menu as shown in picture below.

**EVENT MASKS for OBJECTS**

CTRL OBJECT 1

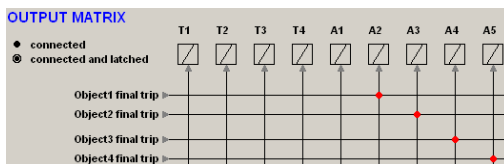
|                        |                                     |
|------------------------|-------------------------------------|
| 'Open' event           | <input type="checkbox"/>            |
| 'Closed' event         | <input type="checkbox"/>            |
| 'Undefined11' event    | <input type="checkbox"/>            |
| 'Undefined00' event    | <input type="checkbox"/>            |
| 'Open request' event   | <input type="checkbox"/>            |
| 'EndOfOpenReq' event   | <input type="checkbox"/>            |
| 'Close request' event  | <input type="checkbox"/>            |
| 'EndOfCloseReq' event  | <input type="checkbox"/>            |
| 'CtrlInhibited' event  | <input type="checkbox"/>            |
| 'Final trip' event     | <input checked="" type="checkbox"/> |
| 'Final trip off' event | <input checked="" type="checkbox"/> |

Protections stage trip signals have to be connected to the same trip relay as the object open signal as shown in picture below.



- A) When auto-reclose is not enabled.
- 1) After protection stage has tripped and object's status has changed to "open"-state global final trip is given.
- B) When autoreclose is enabled.
- 1) When protection stage has tripped and no more auto-reclosures are coming and object's status has changed to "open"-state global final trip is given.
  - 2) When auto-reclosing function has made final trip and object's state has changed to "open"-status global final trip is given.

When global final trip is given: object's final trip signal is activated in matrix and final trip event is generated. After 0,5 seconds or when object state is changed to "close"-state global final trip off is given. When global final trip off is given: object's final trip signal is released and final trip off event is generated.



## AR function availability

The AR function is available in the VAMP feeder managers VAMP 230, VAMP 255, VAMP 257 and VAMP 259. The function is also available in the feeder protection relays VAMP 52 and VAMP 59. Please note that the application setting must be "feeder".

This document applies firmware v.10.99.

Keywords: Auto-reclosing, overload feeder, high and slow speed auto-reclosing

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