ABB Ltd / UK

for

Electricity North West / UK

Proposal for
APPLICATION OF I_S-LIMITER

- Description and Calculation -

DE-PPMV Project No. 01-13Q1896581

PPMV-GBI

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1. Requirements to the I_S-limiter Scheme

Figure 1 below shows the simplified single line diagram of the Heaton Moor / Adswood system of Electricity North West / UK.

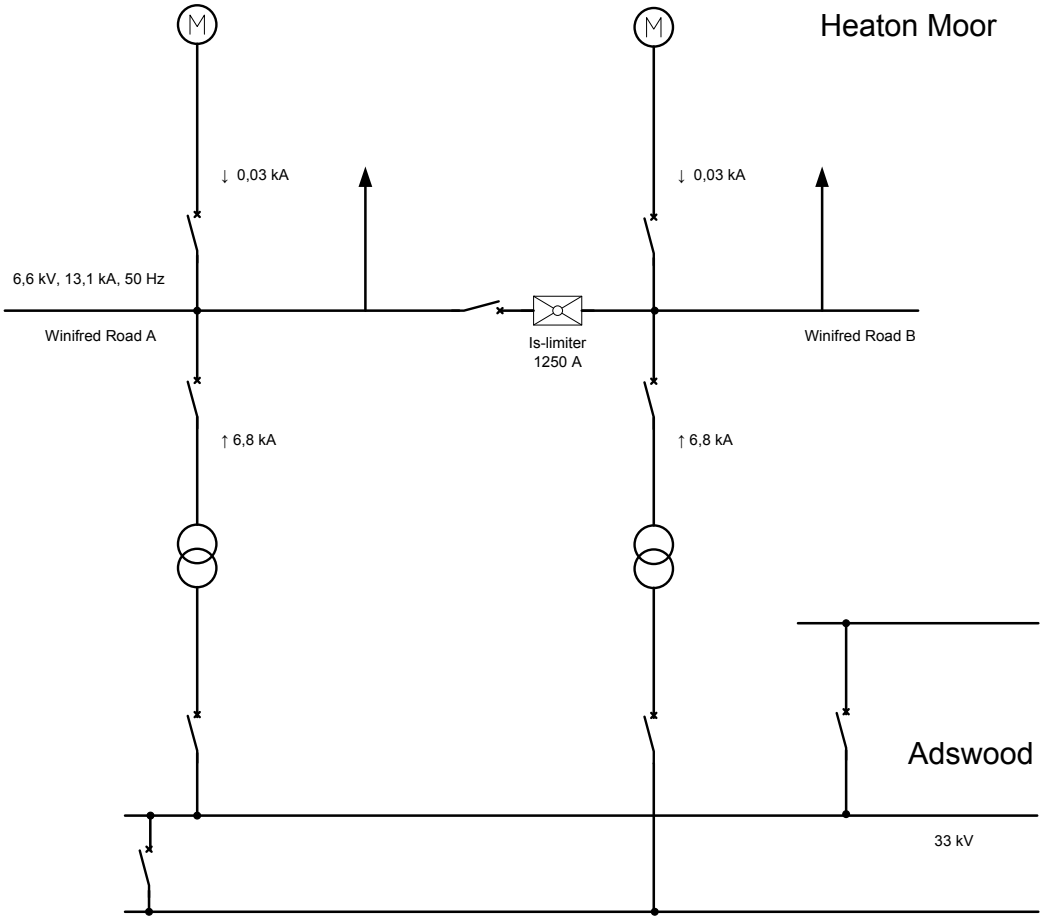


Figure 1: Simplified Single Line Diagram
Heaton Moor / Adswood of Electricity North West / UK

Furthermore in figure 1 above the initial symmetrical short-circuit current I_k'', fed by the incoming transformers as well as the total motor contribution to the system are given.
Rated short-time withstand current of the system is $I_k''_{perm}$ = 13,1 kA.

The total short-circuit contribution to the system was given by Geraldine Bryson / Electricity North West dated 04.03.2013.

The I_S-limiter shall protect the system against too high short-circuit contributions.

2. Tripping Value

For the current over the I_S-limiter used as the tripping criterion, the critical limit value must be found. Should this value be exceeded, the tripping of the I_S-limiter must be released. This limit value is called the `tripping value`, it is always stated in terms of r.m.s. amperes.

For determination of the tripping value, a plant operating condition and a fault location must be assumed such that the current at the fault location just reaches the permissible value of system as 13,1 kA_{rms} or slightly above, while the current used as the tripping criterion is as low as possible. Then this value is the tripping value.
The value of 13,1 kA covers the service condition, when the system is not overloaded in sight of short-circuit currents.

The calculation of the tripping value is done in accordance with the basic method as well as by means of equations shown in the publication "Calculation of the Tripping Value for Applications of I_S-limiters".

For the calculation of the tripping value we assume that on Winifred Road A the incoming transformer as well as all motors are in service.
On Winifred Road B only the incoming transformer is in service, but no motor.
The short-circuit fault occurs on Winifred Road A.

Under these circumstances the tripping value of the I_S-limiter is calculated as follows:

$$I_T = \frac{6{,}8\ kA}{(6{,}8 + 6{,}8 + 0{,}03)\ kA} * 13{,}1\ kA = 6{,}53 kA$$

The tripping value for the I_S-limiter is chosen to I_T = 6,0 kA_{RMS}.

3. Setting Values

The tripping values found out as before mentioned, are r.m.s. values of currents (i.e. symmetrical current values). In order to decide immediately after short circuit initiation, whether tripping must be released or not, the tripping device continuously monitors the momentary current value as well as the rate of rise of the current flowing through the I_S-limiter to detect conditions that will exceed the tripping value.

The I_S-limiter will be set and tripped whenever the rate of current's rise reaches or exceeds predetermined values corresponding to the tripping values as long as the momentary current through the I_S-limiter is between i_1 and i_2. These limit values of the rate of current's rise and the limit values of i_1 and i_2 are called setting values.

The values i_1 and i_2 are dependent on site conditions (i.e. service current, max. possible rate of rise of fault current, tripping value) and on the type of I_S-limiter. Both values are determined by ABB AG / Germany in such a way that a proper function of the I_S-limiter is guaranteed. After i_1 and i_2 have been determined, the setting di/dt can be calculated based on “Calculation of the settings for an I_S-limiter measuring and tripping device“ with a computer program. The setting (di/dt) depends on the values i_1 and i_2 and the tripping value (calculated under Section 2).

Setting values will be calculated in detail in case of an order.
Estimated values for the setting values are:

I_T	=	6,0	kA
$I_{T\,min}$	=	5,08	kA
i_2	=	4,3	kA
$(di/dt)_T$	=	2,255	kA/ms

4. Maximum short-circuit current of the I_S-limiter

The maximum short circuit current, which has to be limited by the I_S-limiter, is 13,1 kA
The I_S-limiter is designed to limit a maximum short-circuit current as:

$I_{k\,max}^{''}$ = 13,1 kA_{RMS}.

IMPORTANT: For the determination of the maximum short-circuit breaking current that can be limited by the I_S-limiter, all further I_S-limiters installed in series have to be seen as a solid connection.

5. Capacitors and or Harmonic Filters

In general the I_S-limiter will not operate based on charging / dis-charging current of the capacitor bank as long as the contribution of this charging / dis-charging current, which is flowing through the I_S-limiter, plus the operating current through the I_S-limiter will not reach the setting values of the I_S-limiter mentioned above.

On the 6,6 kV voltage level no capacitor banks and no harmonic filters are installed on.

6. Inrush Current

In general the I_S-limiter will not operate based on inrush current of transformers, which will be energized from the 6,6 kV voltage level, as long as the contribution of the instantaneous inrush current, which is flowing through the I_S-limiter, plus the instantaneous operating current through the I_S-limiter will not reach the setting value of i_2 = 4,3 kA of the I_S-limiter mentioned above.

As long as the downstream transformers will be energized separately the inrush current of the downstream transformers will not cause tripping of the I_S-limiter.

7. Starting Current

In general the I_S-limiter will not operate based on starting current of motors as long as the contribution of this starting current, which is flowing through the I_S-limiter, plus the operating current through the I_S-limiter will not reach the tripping value $I_{trip\ min}$ = 5,08 kA_{rms} of the I_S-limiter mentioned above.

As long as the motors will be started separately the starting current of these motors will not cause tripping of the I_S-limiter.

8. Blocking of the I_S-limiter

As long as the permissible value of the system as I_k" = 13,1 kA_{rms} is not exceeded the I_S-limiter should resp. must be blocked.

That means whenever one incoming transformer is not in service, the I_S-limiter has to be blocked.

Blocking of the I_S-limiter will be realised by energizing the blocking relay K202 / K203.

9. Circuit breaker installed in series to I_S-limiter

A circuit breaker, which will be immediately triggered (without delay) when the I_S-limiter operates, is required in series with the I_S-limiter. The associated auxiliary activating relay is included in the I_S-limiter tripping device (i.e. operation of the I_S-limiter in one phase causes the operation of the circuit breaker to open all three phases).

10. Operational safety

In order to guarantee the proper, long term operation of both, the I_S-limiter and the electrical system to be protected, the inspection- and testing-periods must be kept (Please see our Instruction Manuals BA 396/04E resp. BA 323/04E).
Furthermore the tripping and setting values must be checked in case the electrical system constellation changes or in case the short circuit currents of the system will be affected.

11. Other current limiting switching devices

The I_S-limiter will operate in case the instantaneous current and the di/dt of the current will reach at the same time pre-calculated setting values.

Operation of the I_S-limiter means that the main current path of the I_S-limiter insert will be opened and the current commutates to the parallel fuse element.

From the beginning of the short-circuit current (t = 0 s, i = 0 kA) up to the limitation of the short-circuit current by the fuse element of the I_S-limiter it takes a specific time.

We have to point out that in case additional current limiting switching devices (i.e. current-limiting fuses, other I_S-limiters) are connected on the same voltage level where the I_S-limiter is installed on further, these additional current limiting devices will start to operate within the first fault current's rise when the current flowing over this device is higher than its threshold value.

For this reason it is very important that all current-limiting switching devices connected to the same voltage level where the I_S-limiter is installed on, are designed to limit the total existing short-circuit current of the complete system. For the determination of the maximum short-circuit breaking current that has to be limited by these devices, all I_S-limiters installed in the system have to be seen as a solid connection.

12. Approval of this document

Before start of production we need from the customer's side an approval for the design of the I_S-limiter (calculated tripping and setting values, design of the I_S-limiter measuring and tripping device etc.)

In case after start of production the design of the I_S-limiter has to be modified on customer's request by:

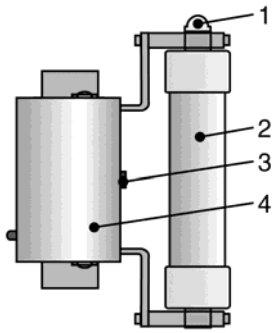
- revised short-circuit data become valid
- new or additional service conditions
- modification of the cable / busbar connection of the I_S-limiter cubicle
- new protection requirements for the system

the re-design-work of the I_S-limiter has to be back-charged to the customer as actual for:

- re-calculation of the tripping and setting values
- modification of the documents (application of I_S-limiter, schematic diagrams etc.)
- replacing of components in the I_S-limiter measuring and tripping device
- re-construction of the I_S-limiter cubicle

[redacted]

13. Disposal of I_S-limiter inserts



The figure beside shows the I_S-limiter insert. The opening of the main current path of the I_S-limiter insert will be done by triggering a charge. The charge is surrounded by a flameproof tube element (item 4 of our figure beside).

For safety reason it is strongly forbidden to open this I_S-limiter insert or to take out the charge itself.

Tripped I_S-limiter inserts can be refurbished in our works in Ratingen. In case in the future the customer want to dispose “old” I_S-limiter inserts, these inserts must be send to our works in Ratingen:

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