Application note: DC overcurrent protection using shunt converter and MIM input

1. Background:

The need of such protection comes from its applicability for detection of ground faults in the DC/DC section of the start-up converter of gas turbine/generator or for monitoring the excitation voltage /current of synchronous machines.

Such functionality is typically required to be included into the generator protection system for the gas turbine/generator sets equipped with static startup converter or pump storage schemes with converter starting.

In case of a ground fault in the start-up converter DC/DC circuit, a DC current will flow through all earthed equipments which are galvanically connected with the startup converter. As earthing transformers or neutral grounding transformers have a lower ohmic rezistance compared to the voltage transformers connected at the terminals of the generetors, the most of the DC current will be taken by it with the danger of thermal overload.

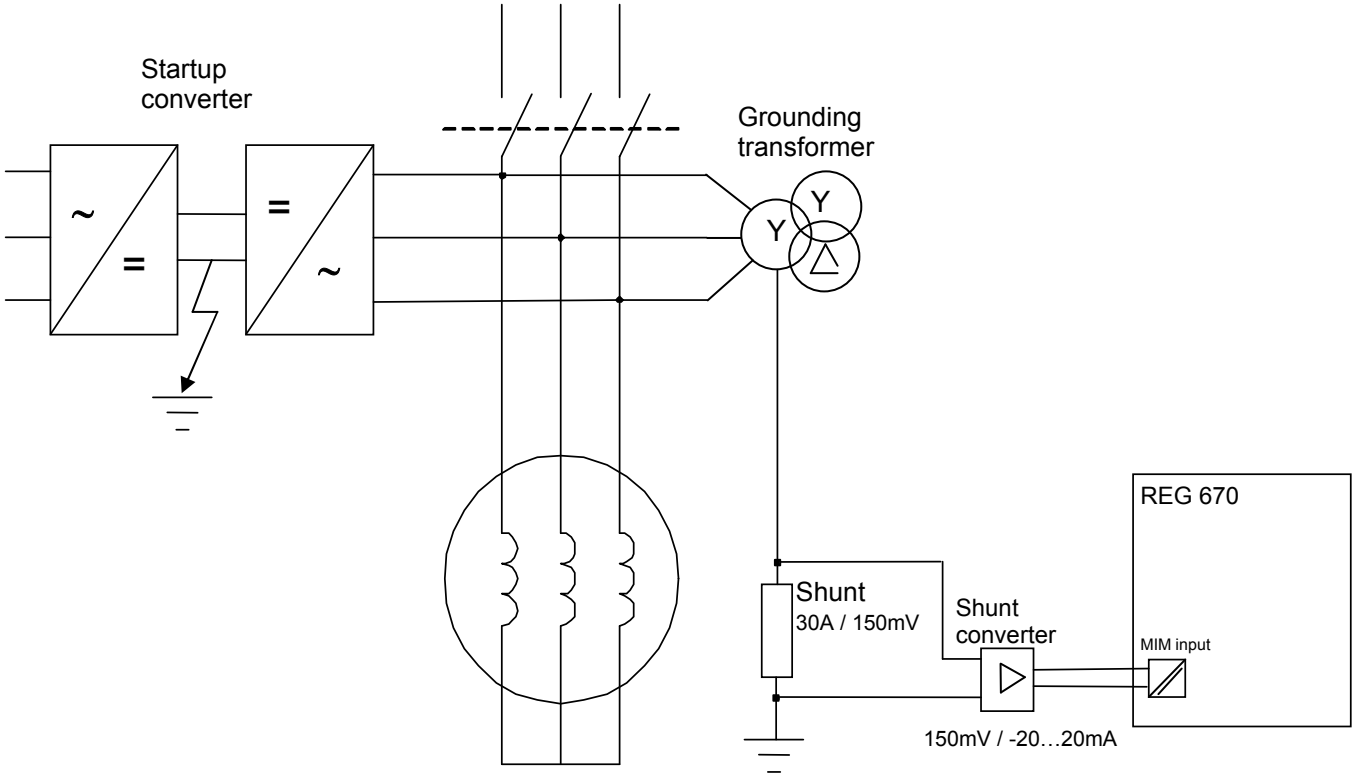

Figure 1: Typical connections (grounding transformer at the terminals shown)

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The only possibilitie to detect such ground fault is to measure the DC current flowing through the grounding path of the respective equipment via a DC/DC converter, which in return can feed a protection relay with a measuring element adjustable in the range of ±20mA and a threshold element for implementing the protection. Additional time delay element typically set to 2-5s for tripping is implemented in the protection relay (REG670) configuration.

Note that similar solutions can be implemented in installation where supervision of excitation current / voltage (with tripping elements) is required for a synchronous machine.

2. Hardware configuration layout:

The following components have been tested for such protection scheme in lab environment and it can be used as reference. Similar equipments are available on the market, so it is a matter of selecting a device with similar capabilities:

1. Shunt resistor Knick
   Characteristics:
   Type F-M30S-0011
   30A/150mV
   class 0.5
   Shunt isolation base type ZU0910

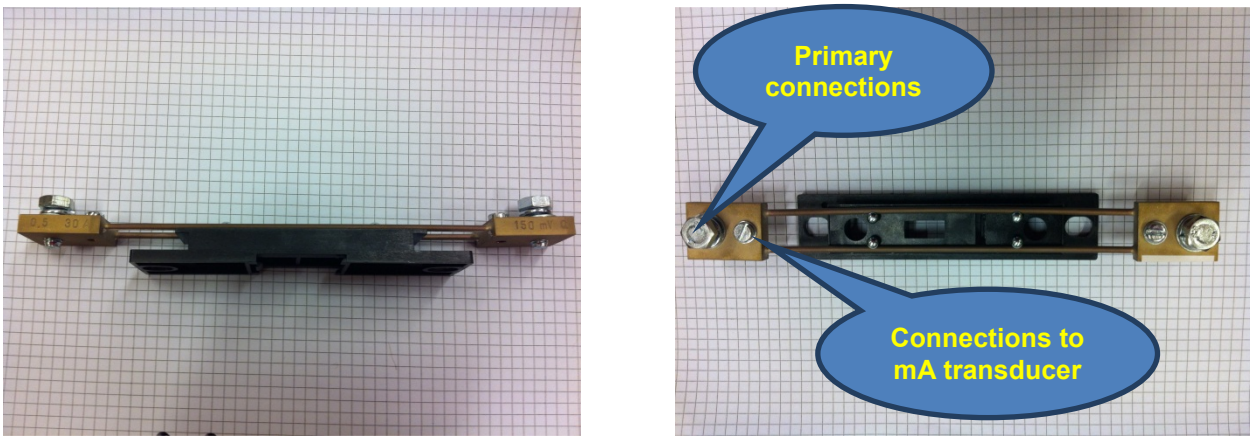

Figure 2: Shunt resistor with isolation base

2. DC-Isolation Amplifier VariTrans Knick
   Charateristics
   Type P 41166 D1
   Input: ±150mV
   Output: ±20mA
   Response time: T90 0.15ms
   Power: 22..230V AC/DC

   Test Voltage: Input – Output/Suppy 15kV ~

   Output – Supply 4kV ~

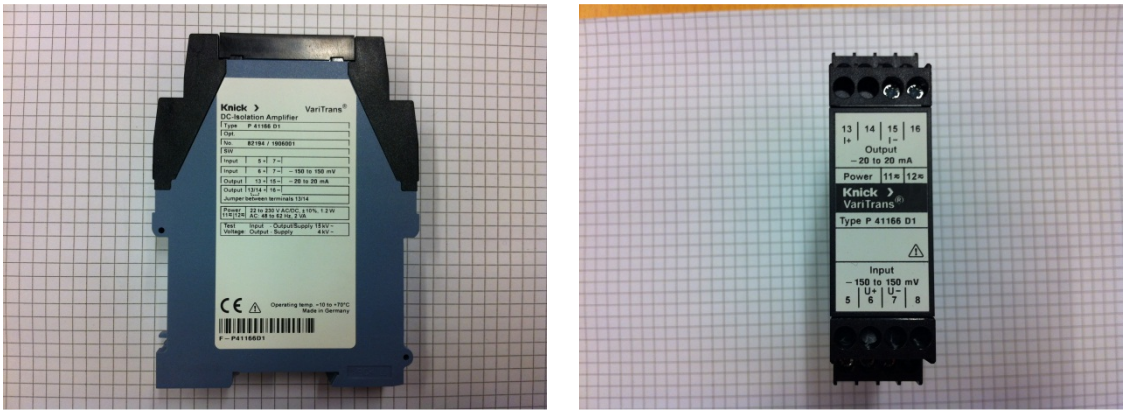

Figure 3: DC-Isolation Amplifier

3.REG670 with MIM card

3. REG670 configuration and settings:

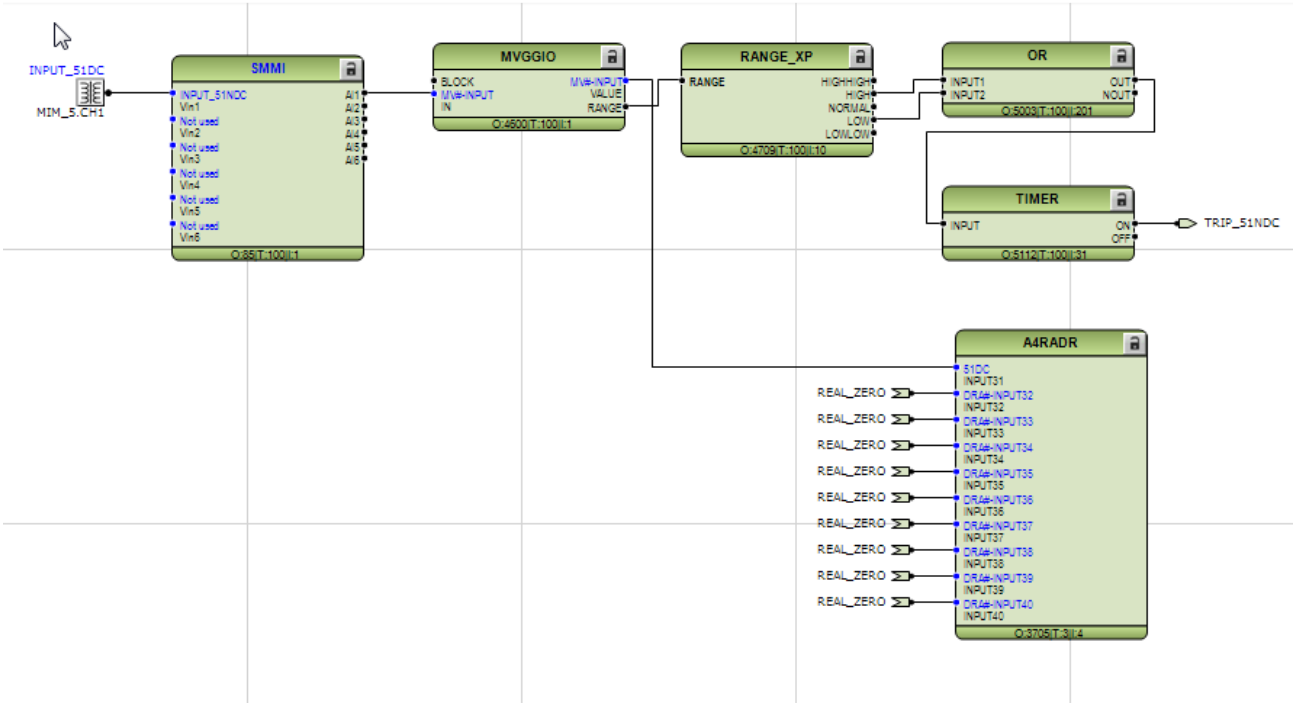

Figure 4: ACT configuration

Settings for the MIM card channel:

REG670 - Parameter Setting

Group / Parameter Name	IED Value [SG1/Common]	PC Value [SG1/Common]	Unit	Min	Max
MIM_5					
General					
Operation		On			
MaxReportT		0	s	0	3600
mA channel 1					
NAMECH1		CH1			13 character(s
EnDeadBandCh1		On			
DeadBandCh1		0,00	mA	0,00	20,00
IMinCh1		-20,00	mA	-25,00	25,00
IMaxCh1		20,00	mA	-25,00	25,00
ValueMinCh1		-30,000		-10000000000,	10000000000,(
ValueMaxCh1		30,000		-10000000000,	10000000000,(

Figure 5: MIM settings (transducer scaling)

The settings *IMinCh1, IMaxCh1* are given by the converter (DC Isolation Amplifier) output characteristics which for our reference device is ±20mA.
The settings *ValueMinCh1, ValueMaxCh1* are given by the input shunt characteristics , which for our reference device is 30A.

Settings for the MVGGIO function block used to implement the protection:

REG670 - Parameter Setting

Group / Parameter Name	IED Value [SG1/Common]	PC Value [SG1/Common]	Unit	Min	Max
MVGGIO: 1					
NAME		MV#-INPUT			13 character(s
MV db		1	Type	1	300
MV zeroDb		500	m%	0	100000
MV hhLim		90,000		-10000000000,	10000000000,(
MV hLim		2,000		-10000000000,	10000000000,(
MV lLim		-2,000		-10000000000,	10000000000,(
MV llLim		-20,000		-10000000000,	10000000000,(
MV min		-15,000		-10000000000,	10000000000,(
MV max		15,000		-10000000000,	10000000000,(
MV dbType		Int deadband			
MV limHys		5,000	%	0,000	100,000

Figure 6: MVGGIO settings (i.e. pickup level)

The settings for parameters *MV hLim* and *MV lLim* has to be set up with the corresponding value resulted from the calculations for the respective instalation. An calculation example is given in the next paragraph.

4. Application example

The envisaged application is the earth fault protection for the startup converter of gas turbine – generator set.
In the situation of a ground fault on the DC part of the startup converter, circa half of the DC voltage will appear in the star-points of the transformers connected on the AC side of the converter.
As the starpoints of the transformers are connected to ground, this potential will create a current flow which value is determined by the feeding voltage and the equivalent ohmic resistance of all transformers that are galvanic connected together with the startup converter and grounded.

For a startup converter with a startup transformer having the rated ph-to-ph voltage of U_{NSTUP}=1kV and a 6-pulse bridge rectifier, it will generate a DC voltage of U_{DC}≈1.35·U_{NSTUP}=1.35kV.
In case of a ground fault in the DC intermediate circuit, the voltage displacement will be half of the DC voltage U_{DCFLT}=0.5 U_{DC}=675V.
Assuming that the grounding transformer has winding ohmic resistance of R_{GTRF}≈150Ω, a DC current of I_{DCFLT}=675V/150Ω=4.5A will flow through its star-point to ground.

Note: The ohmic winding resistance of earthing and neutral transformers to be used for calculation has to be checked against the specifications of the manufacturer of the transformer.

For a reliable pickup of the protection in this case a setting value of less than half of the fault current is recommended, leading in our case to a value of 2A. This value has to be set for the parameters *MV hLim* and *MV lLim.*

A common tripping delay of cca. 2s is to be applied to the corresponding ON delay timer function block.

5. Mounting recommendations

The general practice for such shunt-converter assemblies requires mounting of these two devices as close as possible to each other in order to diminish the influences on the connecting cabling.

The connection cable from the converter to the REG670 panel shall be 1,5mm^2, shielded, twisted pair cable.

REVISION

Rev. ind.	Page (P) Chapt. (C)	Description	Date Dept./Init.