PowerFactory

Short-Circuit Method IEC 61363

Technical Reference

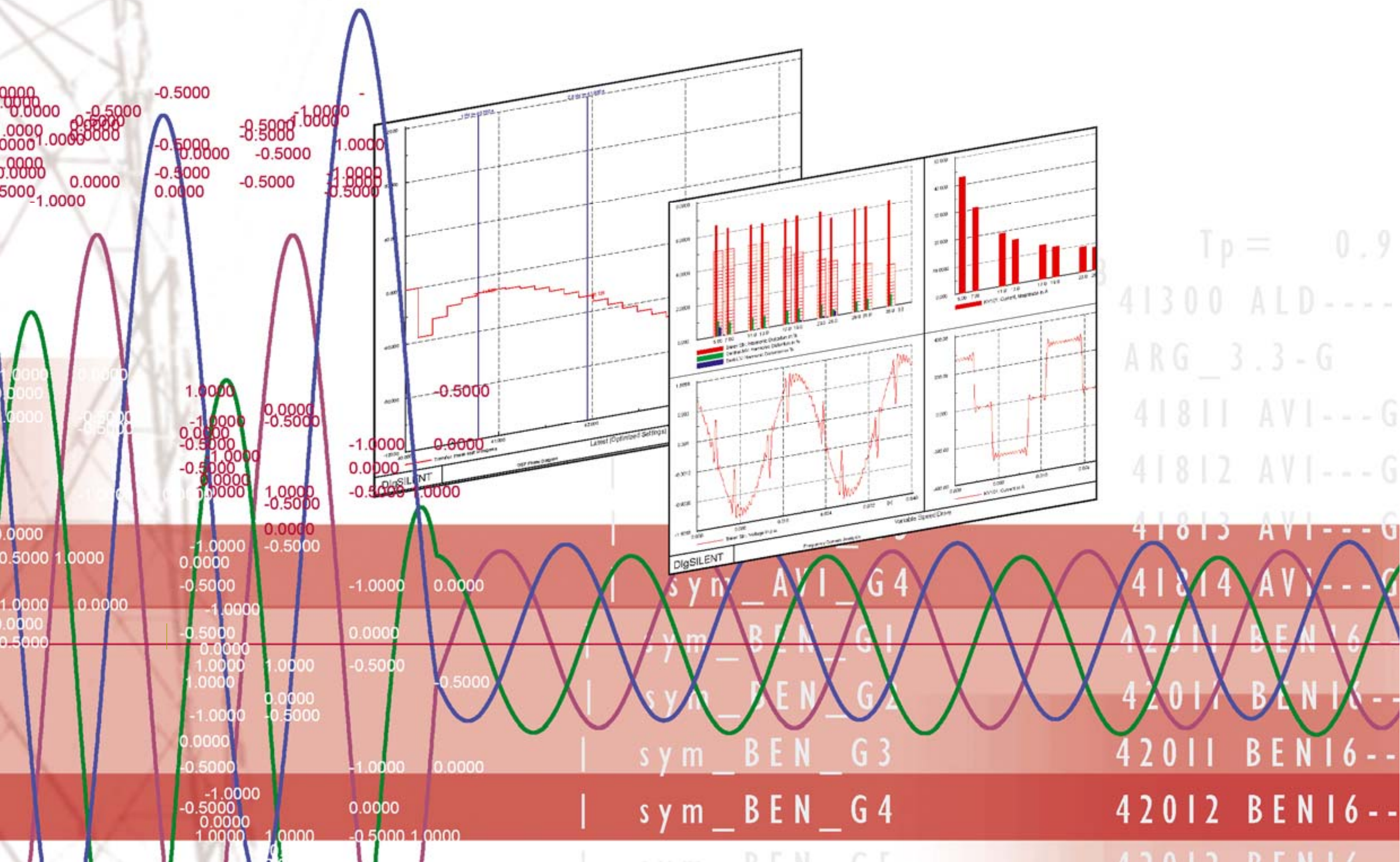

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Table of Contents

User-Interface and Handling

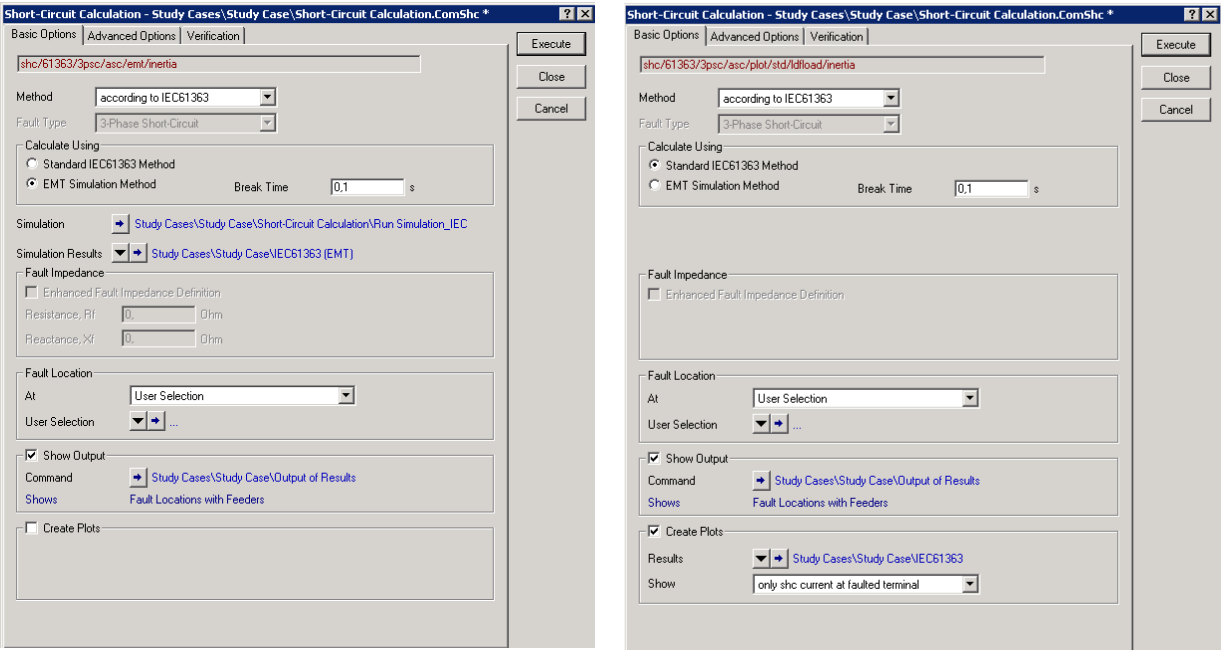
1.1 Introduction

The IEC 61363 standard describes procedures for calculating short-circuits currents in three-phase ac radial electrical installations on ships and on mobile and fixed offshore units.

In PowerFactory, access to the implementation of this standard is via the 'Basic Options' page of the Short-Circuit Calculation (ComShc) object. Here, the 'Method' can be set to the IEC 61363 standard by selecting it in the drop-down list.

1.2 Input Parameters

With the 'Method' set to 'according to IEC 61363', the Short-Circuit Calculation command dialog will automatically display the selection 'Calculate using', which allows the user to select between either the 'Standard IEC61363 Method' or the 'EMT Simulation Method', as illustrated in Fig. 1.



(a) (b)

Fig. 1 Short-Circuit Calculation command

1.2.1 Input Parameters for EMT Simulation Method

If the 'EMT Simulation Method' is selected in the 'Calculate Using' field (as shown in Fig. 1.a), the following options are available in the Short-Circuit Calculation dialog:

1. 'Fault Type': read-only as the IEC 61363 always considers 3-phase short-circuits.
2. 'Break Time': represents the contact separation time for circuit-breakers. Default setting is 100 ms.
3. 'Simulation': reference to the Simulation command (ComSim) to be used.

   This Simulation object is automatically created, configured and stored inside the Short-Circuit Command. Therefore, no prior knowledge regarding the configuration of the Simulation command in order to perform a short-circuit calculation is required.

   Fig. 2. shows the Simulation parameters and their default settings:

   - Absolute stop time: 0.1 s.
   - Display result variables in output window
   - Display internal DSL-events in output window

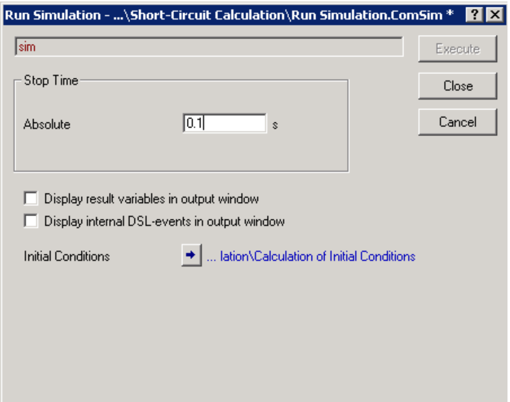


Fig. 2: Simulation command (ComSim) used for EMT in the IEC61363 calculation

   - 'Initial conditions': automatically creates a Calculation of Initial Conditions command (ComInc), and stores it inside the Short-Circuit Command. The parameters are explained below and are set as shown in Fig. 3.

     'Basic Options' page:
     - Simulation Method**:** = Instantaneous Values (Electromagnetic Transients);
     - Verify initial conditions: = 1;
     - Automatic Step Size Adaptation: 0;
     - Result Variables: This result file is automatically set in accordance with that set by the 'Simulation Results' parameter in the Short-Circuit Calculation dialog. The user should not specify a result file here.
     - Events: An event object (IntEvt) is automatically created and stored inside the Short-Circuit Command.
     - Load flow: set to the Load Flow Calculation command (ComLdf) object defined inside the 'Study Case'.

     'Step Sizes' page:
     - Integration Step Sizes:

o Electromagnetic Transients: 0,0001

- Start time: 0 s.

The remaining Calculation of Initial Conditions command parameters are left set to their default values.

The commands used for the EMT simulation within IEC 61363 (ComSim, ComInc), and the defined events (IntEvt), are stored inside the Short-Circuit Command so that they will not be confused with the default ones used for user simulations (which are stored inside the Study Case).

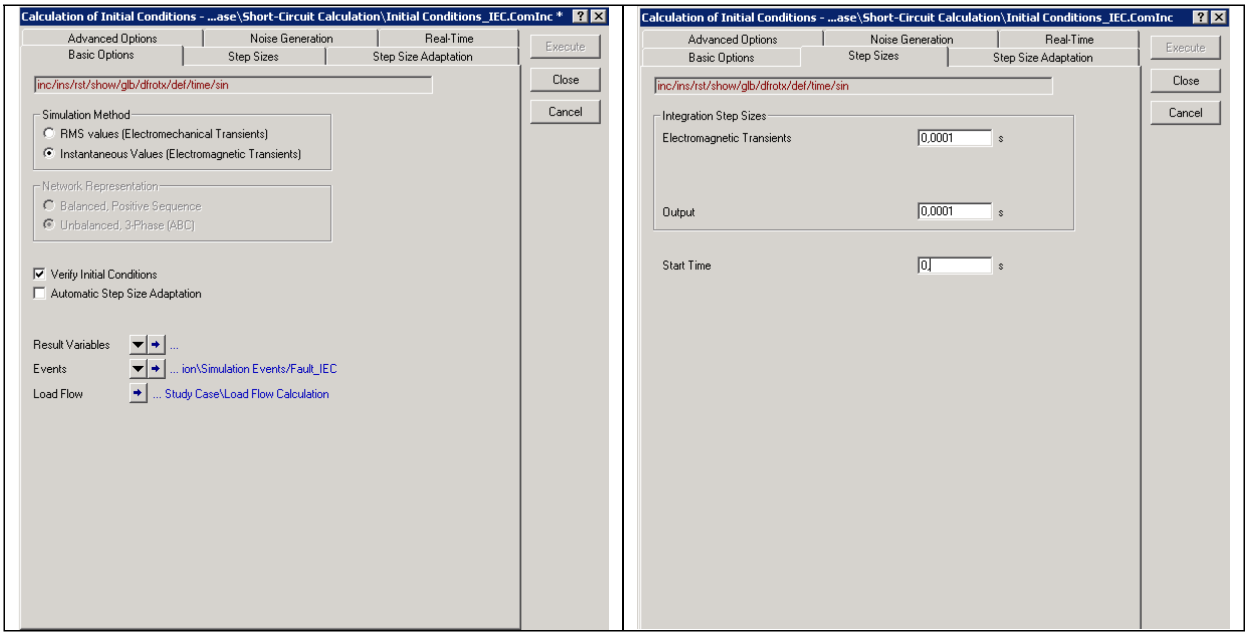


Fig. 3: ComInc used for EMT in IEC61363 calculation

4. 'Fault Impedance': read-only. Fault impedance is set to zero.

5. 'Fault Location': selection of terminal/s to simulate.

6. 'Show Output': show reports in output window.

7. 'Create Plots': automatically create plots for short-circuit currents.

On the 'Advanced Options' page of the Short-Circuit Command, the flag 'Assume Inertia as infinite' must be selected so that the acceleration time constants of rotating machines are set to 9999 s. This is illustrated in Fig. 4.

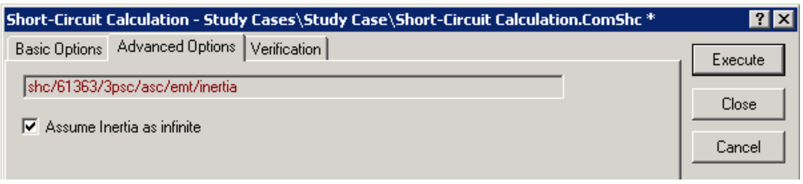


Fig. 4: Advanced Options of ComShc for EMT in IEC61363 calculation.

1.2.2 Input Parameters for Standard IEC 61363 Method

When selecting the 'Standard IEC61363 Method' in the 'Calculate Using' box, the Short-Circuit Calculation dialog will display the options as illustrated in Fig. 1.b.

In this case only a subset of the parameters described in the previous sections will be used.

Algorithms

1.3 Procedure for Standard IEC 61363 Method

PowerFactory internally uses a virtual representation of the active component of a short-circuit (synchronous and asynchronous machines, external grid, static generator or voltage source) and the non-active component (line, transformer, switch, common impedance or series reactance) that connects, transmits or transforms the short-circuit current from the source to the fault point.

This virtual representation serves the following purposes:

- Stores data relating to the IEC 61363 synchronous machine (Standard IEC 61363-1, item 5.1.1, page 29);
- Stores data relating to the IEC 61363 asynchronous machine (Standard IEC 61363-1, item 5.1.2, page 37);
- Calculates short-circuit currents according to the IEC 61363 standard, considering the effects of non-active components;
- Performs actions for aggregating machines; i.e. equivalent generator and motor representations.

The variables used in this virtual representation are described in Table 1 and Table 2, and in the following sections.

Virtual Representation	Description	Unit
f	Network frequency	Hz
U_0	Operating line-line voltage	p.u.
I_0	Operating current	p.u.
ϕ_0	Delta angle $\lvert\Phi_{U0} - \Phi_{I0}\rvert$	
I_{kd}	Steady-state short-circuit current	p.u.
R_a	Stator resistance	p.u.
X_d''	Subtransient reactance	p.u.
X_d'	Transient reactance	p.u.
T_d''	Subtransient time constant	s
T_d'	Transient time constant	s
T_{dc}	Direct current time constant	s

Table 1 – Parameters for modelling an IEC 61363 Synchronous machine.

Virtual Representation	Description	Unit
f	Network frequency	Hz
U_0	Operating line-line voltage	p.u.
I_0	Operating current	p.u.
ϕ_0	Delta angle $\|\Phi_{U0} - \Phi_{I0}\|$	
R_R	Rotor resistance	p.u.
R_S	Stator resistance	p.u.
X_R	Rotor reactance	p.u.
X_S	Stator reactance	p.u.
$T_M^{"}$	Subtransient time constant	See note 1
T_{dc_M}	Direct current time constant	See note 2

Table 2 – Parameters for modelling an IEC 61363 Asynchronous machine.

Notes:

1. Subtransient time constant Standard IEC 61363-1, item 5.1.2.5, page 39 (related to the decay of ac component) $T_M^{"} = \frac{(X_R + X_S)}{2*\pi*f*R_R}$ Eq. (13)
2. DC time constant (related to decay of the aperiodic component): Standard IEC 61363-1, item 5.1.2.5, page 39: $T_{dc_M} = \frac{(X_R + X_S)}{2*\pi*f*R_S}$ Eq. (14)
3. p.u. at system base (1 MVA).

1.3.1 Active Components

For all active components, the active voltages E", E' are dependent upon the pre-load current. The algorithm considers the preload condition according to the settings on the 'Advanced Options' page of the Short-Circuit Calculation command. These settings are shown in Fig. 5. Three options are available for the preload condition: 'use load flow initialization', 'use rated currents/power factors', or 'neglect preload condition'.

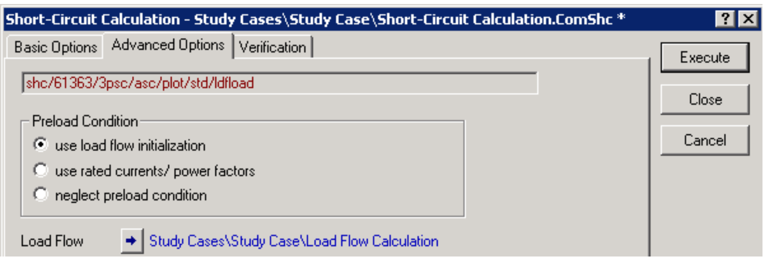


Fig. 5 – Advanced Options tab of Short-Circuit Calculation Command.

For all active components, the operational line-line voltage and current are set according to Table 3.

Virtual Representation	Variable name
Preload condition from load flow initialization:	
U_0	u (complex value)
I_0	cur (complex value)
Preload condition as rated values:	
U_0	$1\angle 0$
I_0	rated current$\angle$rated power factor angle
Neglect preload condition:	
U_0	$1\angle 0$
I_0	$0\angle 0$

Table 3 – Preload condition parameters for active components

1.3.1.1 Synchronous Machine – ElmSym

For the synchronous machine, the input parameters required for the IEC 61363 calculation are shown in Fig. 6. The mapping of these parameters to the virtual representation is given in Table 4.

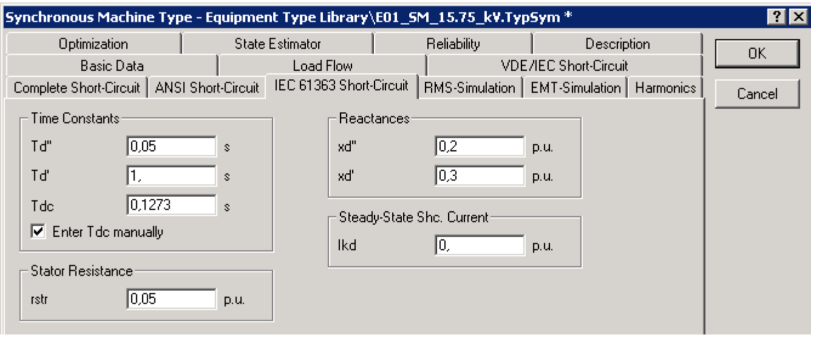


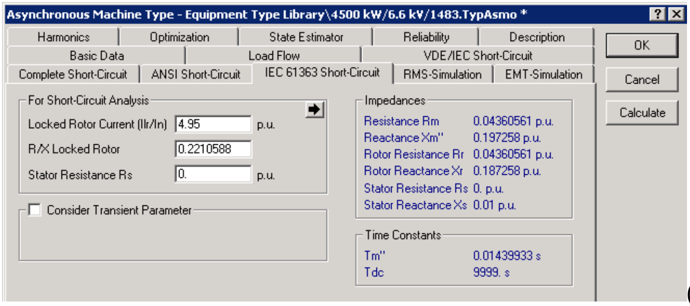
Fig. 6 – Synchronous machine input parameters for IEC 61363 calculation.

Virtual Representation	Variable name
f	r:cpGrid:frnom
I_{kd}	t:Ik
R_a	t:rstr
X_d''	t:xdss
X_d'	t:xds
T_d''	t:tdss
T_d'	t:tds
T_{dc}	t:tdc

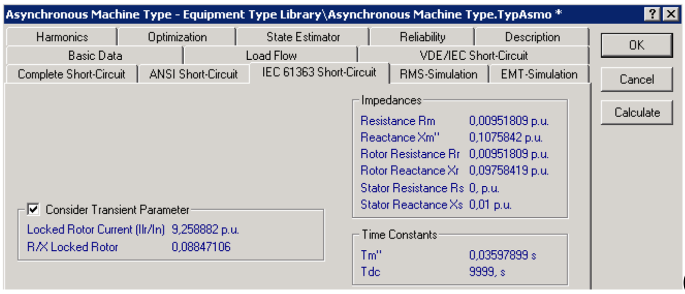
Table 4 – Parameter mapping for Synchronous Machine

1.3.1.2 Asynchronous Machine – ElmAsm

For the asynchronous machine, the input parameters required for the IEC 61363 calculation are shown in Fig. 7. The mapping of these parameters to the virtual representation is given in Table 5



(a)



(b)

Fig. 7 – Asynchronous machine input parameters for IEC 61363 calculation.

Virtual Representation	Variable name
f	r:cpGrid:frnom
X_S	t:xstr
R_S	t:rstr or t:rstrshc
X_R	$X_R = X''_M - X_S$ See note[1]
R_R	$R_R = R_M - R_S$ See note[2]

Table 5 – Parameter mapping for Asynchronous Machine

<u>Notes:</u>

1. X''_M is input by the user (xdssshc), or is calculated from the parameters 'Locked Rotor Impedance' (t:aiaznshc) and 'R/X Locked Rotor' (t:rtoxshc). $X''_M = \dfrac{1}{aiaznshc * \sqrt{1 + rtoxshc^2}}$

   If option 'Consider Transient Parameter' is selected, then the values considered are taken from the Load Flow page (t:aiazn and t:rtox): $X''_M = \dfrac{1}{aiazn * \sqrt{1 + rtox^2}}$

2. R_M is calculated using 'R/X Locked Rotor' (t:rtoxshc or t:rtox) $R_M = X''_M * rtoxshc$

1.3.1.3 External Grid – ElmXnet

For the external grid, the input parameters required for the IEC 61363 calculation are shown in Fig. 8. The mapping of these parameters to the virtual representation is given in Table 6.

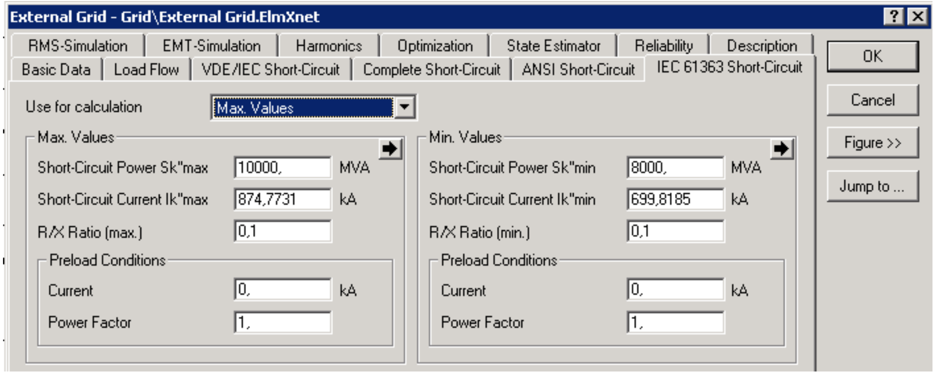


Fig. 8 – External Grid input parameters for IEC 61363 calculation.

Virtual Representation	Variable name
f	r:cpGrid:frnom
I_{kd}	I_k''
R_a	r1 See note 1
X_d''	x1 See note 1
X_d'	x1
T_{dc}	See note 2

Table 6 – Parameter mapping for External Grid

Notes:

1. If consider maximum values (parameter 'Use for calculation' is selected on the IEC 61363 Short-Circuit page in ElmXnet. (**e:cused** = 0)):

   x1 = e:cmax / [e:snss * sqrt(1 + e:rntxn * e:rntxn)]

   r1 = e:rntxn * x1

Else (consider minimum values):

   x1 = e:cmin / [e:snssmin / sqrt(1 + e:rntxnmin * e:rntxnmin)]

   r1 = e:rntxnmin * x1

Since $S_k'' = \sqrt{3} * I_k'' * V$ the user can enter the maximum and minimum values for 'Short-circuit power' or 'Short-circuit current' on the External Grid IEC 61363 Short-Circuit page.

2. If consider maximum values: $T_{dc} = \text{xntrn}/(2 * \pi * f)$

Else (consider minimum values):

$$T_{dc} = \text{xntrnmin}/(2 * \pi * f)$$

3. T_d'' and T_d' time constants are not necessary because subtransient, transient and steady-state reactances are equal.

1.3.1.4 Voltage Source – ElmVac

For the voltage source, the input parameters required for the IEC 61363 calculation are shown in Fig. 9. The mapping of these parameters to the virtual representation is given in Table 7.

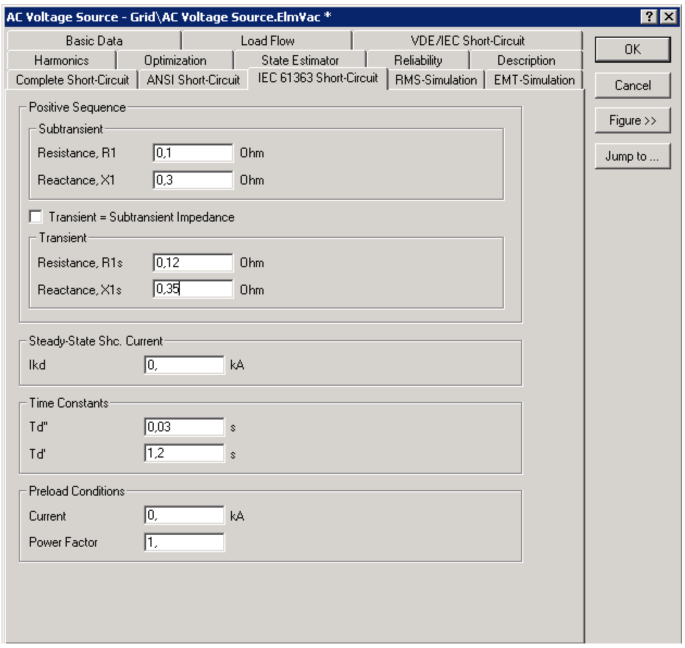


Fig. 9 – Voltage source input parameters for IEC 61363 calculation.

Virtual Representation	Variable name
f	r:cpGrid:frnom
I_{kd}	e:Ik
R_a	e:R1
X_d''	e:X1
X_d'	e:X1 or e:X1s See note 1
T_d''	e:tdss
T_d'	e:tds
T_{dc}	See note 2

Table 7 – Parameter mapping for Voltage Source

<u>Notes:</u>

1. If Transient is equal to Subtransient (e:iztreqz = 1):

   $X_d' = e:X1$

   T_d'' is not necessary because subtransient and transient reactances are equal.

   Else:

$X_d^{'} = e:X1s$

2. $T_{dc} = X_d^{''} / (2 * \pi * f_r * R_a)$. If Ra = 0 then T_{dc} = 9999 s.

1.3.1.5 Static Generator – ElmGenstat

For the static generator, the input parameters required for the IEC 61363 calculation are shown in Fig. 10. The mapping of these parameters to the virtual representation is given in Table 8.

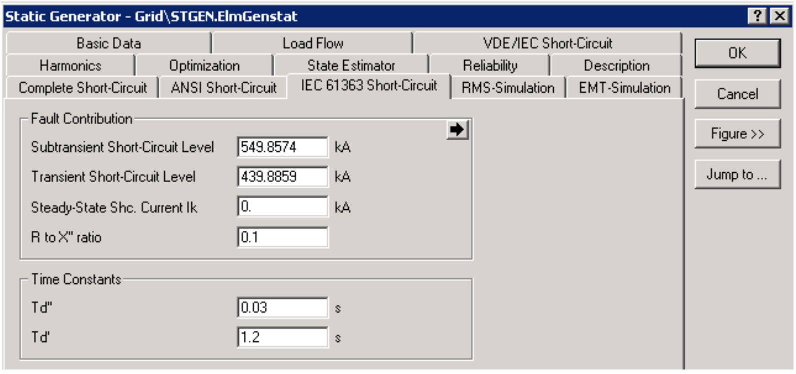


Fig. 10 – Static generator input parameters for IEC 61363 calculation

Virtual Representation	Variable name
f	r:cpGrid:frnom
I_{kd}	e:Ik
R_a	*Ra* See note 1
$X_d^{''}$	*Xdss* See note 1
$X_d^{'}$	*Xds* See note 1
$T_d^{''}$	e:tdss
$T_d^{'}$	e:tds
T_{dc}	See note 2

Table 8 – Parameter mapping for Static Generator

Notes:

1. Subtransient: calculation of impedances from subtransient short-circuit power/current

   Ikss = e:Skss / ($\sqrt{3}$ * unom) kA

   Zdss = (unom / $\sqrt{3}$) / Ikss ohms

   Xdss = Zdss / $\sqrt{1 + e:rtox^2}$ ohms

   Ra = e:rtox * Xdss; ohms

Transient: calculation of impedances from transient short-circuit power/current

   Iks = e:Sks / ($\sqrt{3}$ * unom) kA

Zds = (unom / $\sqrt{3}$) / Iks ohms

Xds = Zds / $\sqrt{1+e:rtox^2}$ ohms

2. $T_{dc} = X_d'' / (2 * \pi * f_r * R_a)$. If Ra = 0 then T_{dc} = 9999 s.

1.3.2 Non-active components

The impacts of non-active components connected in series with active components are as follows: a reduction in the magnitude of the short-circuit current; an increase in the subtransient and transient time constants; and a decrease in the dc time constant.

This section defines how the impedance of the connected non-active component is mapped. The changes in impedance and time constants are calculated inside the virtual representation of the active component using equations (89 -100) in Standard IEC 61363-1, item 8.2, pages 65-67.

1.3.2.1 Line – ElmLne

For the line, the input parameters required for the IEC 61363 calculation are shown in Fig. 11. The mapping of these parameters to the virtual representation is given in Table 9.

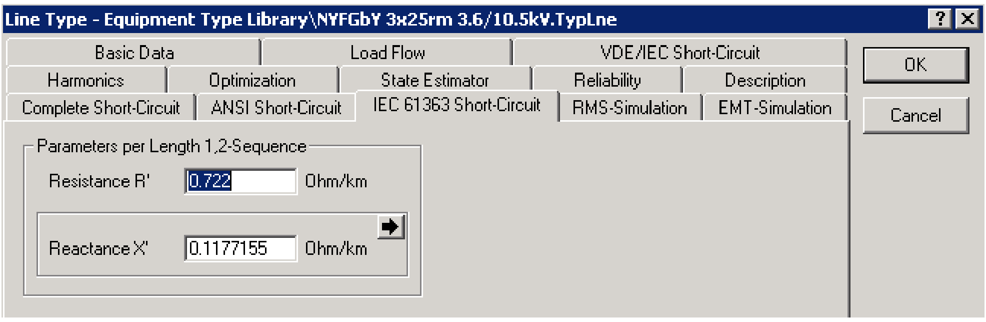


Fig. 11 – Line input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
Z = R + jX	zline	Impedance of the connecting branch	p.u.

Table 9 – Parameter mapping for Line

1.3.2.2 Switch – ElmSwitch

For the switch, the input parameters required for the IEC 61363 calculation are shown in Fig. 12. The mapping of these parameters to the virtual representation is given in Table 10.

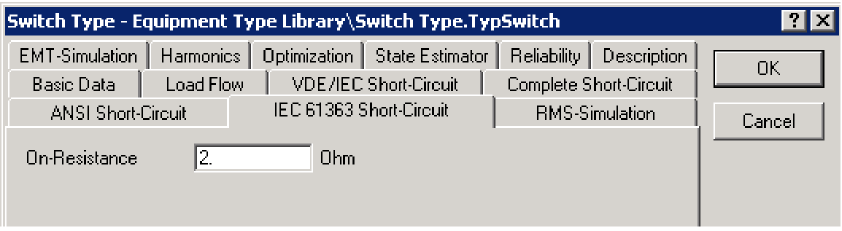


Fig. 12 – Switch input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
R (X=0)	t:R_on	Impedance of the connecting branch	p.u.

Table 10 – Parameter mapping for Switch

1.3.2.3 Common Impedance – ElmZpu

For the common impedance, the input parameters required for the IEC 61363 calculation are shown in Fig. 13. The mapping of these parameters to the virtual representation is given in Table 11.

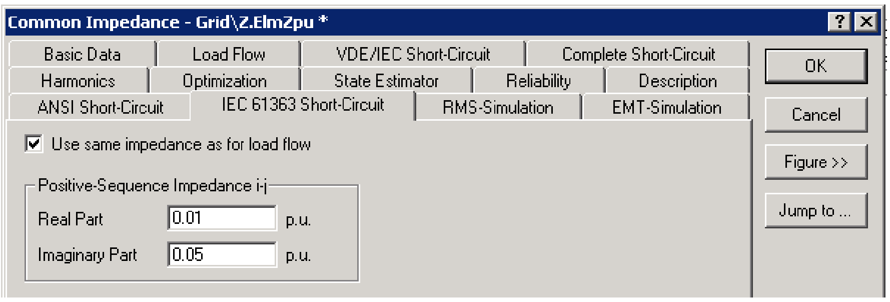


Fig. 13 – Common impedance input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
Z = R + jX	e:z1_ij	Impedance of the connecting branch	p.u.

Table 11 – Parameter mapping for Common Impedance

1.3.2.4 Series Reactor – ElmSind

For the common impedance, the input parameters required for the IEC 61363 calculation are shown in Fig. 14. The mapping of these parameters to the virtual representation is given in Table 12.

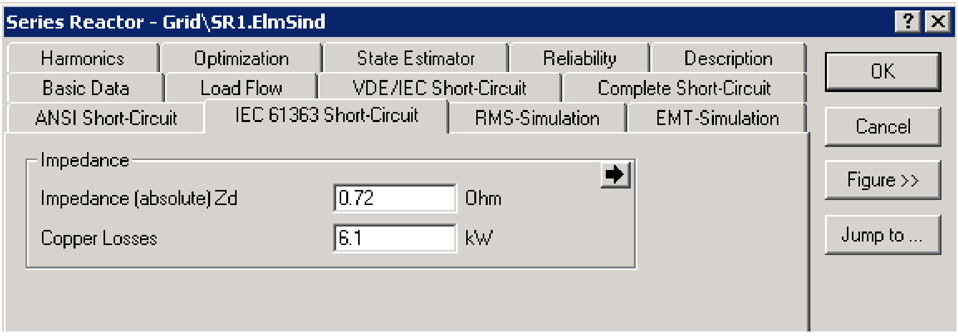


Fig. 14 – Series reactor input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
Z = R + jX	Zind_1	Impedance of the connecting branch	p.u.

Table 12 – Parameter mapping for Series Reactor

1.3.2.5 Series Capacitor – ElmScap

The series capacitor impedance is always neglected and is not considered in the IEC61363 short-circuit calculation.

1.3.2.6 2-Winding Transformer – ElmTr2

For the 2-winding transformer, the input parameters required for the IEC 61363 calculation are shown in Fig. 15. The mapping of these parameters to the virtual representation is given in Table 13.

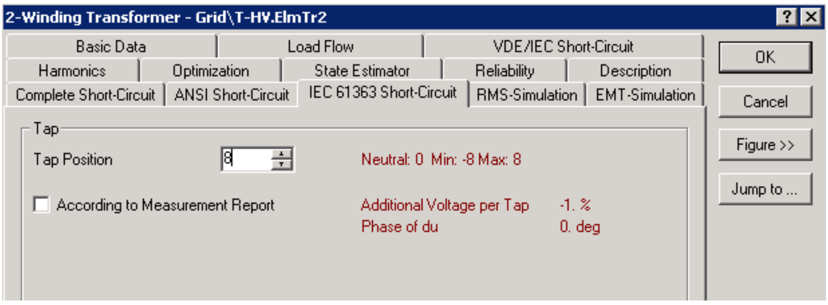


Fig. 15 – 2-Winding transformer input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
Z = R + jX	zshv + zslv (See note 1)	Impedance of the connecting branch	p.u.
tratio (See note 2)	t (See note 3)	Tap ratio	p.u.

Table 13 – Parameter mapping for 2-Winding Transformer

The algorithm considers the current tap position when option 'Consider Transformer Taps' is selected on the 'Advanced Options' tab of the Short-Circuit Calculation command, as illustrated in Fig. 16.

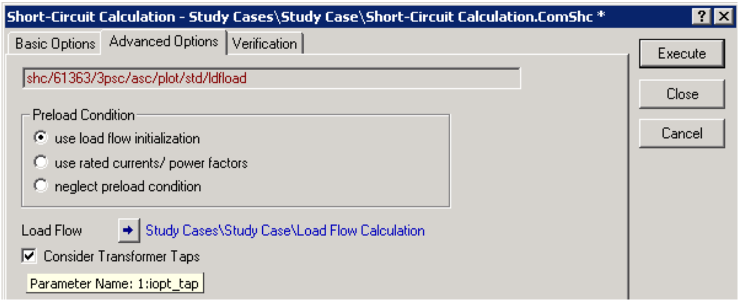


Fig. 16 – Basic Options for IEC 61363 calculation

<u>Notes:</u>

1. The impedances are in p.u. at system base referred to the short-circuit side (HV or LV).
2. The tap ratio is used to refer the virtual representation impedances, currents and voltages to the correct side where the short-circuit is applied.

   If the short-circuit is at the HV side of the transformer:

   ImpedanceReferFactor = tratio * tratio

   VoltageReferFactor = tratio

   CurrentReferFactor = 1.0 / tratio

   If the short-circuit is at the LV side of the transformer:

   ImpedanceReferFactor = 1 / tratio * tratio

   VoltageReferFactor = 1 / tratio

   CurrentReferFactor = tratio
3. If there is not a 'Measurement Report' specified (Fig. 15), the tap ratio is calculated considering the tap side (HV or LV). Else the tap ratio is calculated according to the 'Measurement Report' parameters.

1.3.2.7 3-Winding Transformer – ElmTr3

For the 3-winding transformer, the input parameters required for the IEC 61363 calculation are shown in Fig. 17. The mapping of these parameters to the virtual representation is given in Table 14.

3-winding transformers are handled as three 2-Winding transformers with a star connection. The equivalent machines are summated to the referred short-circuit side.

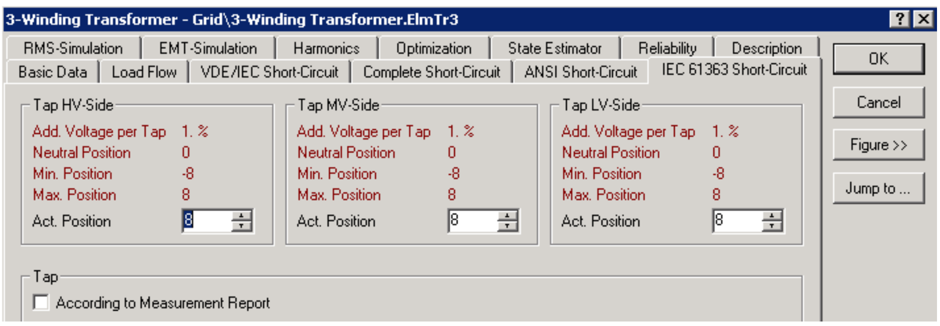


Fig. 17 – 3-Winding transformer input parameters for IEC 61363 calculation

Virtual Representation	Variable name	Description	Input Unit
Z = R + jX	zs_h, zs_m, zs_l (Note 1)	Impedance of the connecting branch	p.u.
tratio (See note 2)	t_h, t_m, t_l (See note 3)	Tap ratio	p.u.

Table 14 – Parameter mapping for 3-Winding Transformer

The algorithm considers the current tap position when option 'Consider Transformer Taps' is selected on the 'Basic Options tab' of the Short-Circuit Calculation command, as illustrated in Fig. 16.

Notes:

1. zs_h: short-circuit impedance (HV). zs_m: short-circuit impedance (MV). zs_l: short-circuit impedance (LV). The impedances are in p.u. at system base referred to the short-circuit side.
2. The tap ratio is used to refer the virtual representation impedances, currents and voltages to the correct side where the short-circuit is applied.
3. If there is no 'Measurement Report' specified (*Fig. 17*), the tap ratios are calculated considering the tap side (HV, MV or LV). Otherwise the tap ratios are calculated according to the 'Measurement Report' parameters.

1.3.3 Calculation of Short-Circuit Currents

1.3.3.1 IEC-61363 Synchronous Machine

Internal voltages considering terminal voltage and pre-load conditions are calculated using equations (5 - 6) in Standard 61363-1, item 5.1.1.5, page 35:

$$Z_d'' = R_a + jX_d''$$
$$Z_d' = R_a + jX_d'$$

$$E_{q0}'' = U_0 + I_0 * Z_d''$$
$$E_{q0}' = U_0 + I_0 * Z_d'$$

The subtransient and transient and steady-state currents are calculated using equations (3 -4) in Standard 61363-1, item 5.1.1.5, page 35:

$$\left|I_{kd}''\right| = \left|E_{q0}'' / Z_d''\right|$$
$$\left|I_{kd}'\right| = \left|E_{q0}' / Z_d'\right|$$

Now the ac component of the short-circuit is calculated according to equations (2); the dc component is calculated according to (9) and the upper envelope according to (1) in Standard IEC 61363-1, item 5.1.1.5, pages 33-35.

1.3.3.2 IEC-61363 Asynchronous Machine

Internal voltage considering terminal voltage and pre-load conditions are calculated using equations (18) in Standard 61363-1, item 5.1.2.5, page 41:

$$Z_M^{"} = R_M + jX_M^{"}$$

$$E_M^{"} = U_0 - I_0 * Z_M^{"}$$

The subtransient current is evaluated using equation (17) in Standard IEC 61363-1, item 5.1.2.5, page 41:

$$\left|I_M^{"}\right| = \left|E_M^{"} / Z_M^{"}\right|$$

Now the ac component of the short-circuit is calculated according to equation (16); the dc component is calculated according to (20) and the upper envelope according to (15) in Standard IEC 61363-1, item 5.1.2.5, pages 39-41.

1.3.4 Algorithm Overview

The following procedure is followed when a user executes the Short-Circuit Calculation command:

Loop: for each terminal '*k*' specified in the Short-Circuit Calculation command's 'Fault Location' field :

1. Check if the system is radial. Parallel lines are allowed and handled as a special case.
   - If the radiality check fails, the calculation procedure is aborted and a message is printed in the output window.

2. A loop over all terminals is performed to create virtual representations of the active component of the short-circuit (synchronous and asynchronous machines, external grid, static generator or voltage source). If there is more than one active object connected to the same terminal, an equivalent machine representation is made as described in Standard IEC 61363-1, pages 57-63. This is illustrated in Fig. 18.

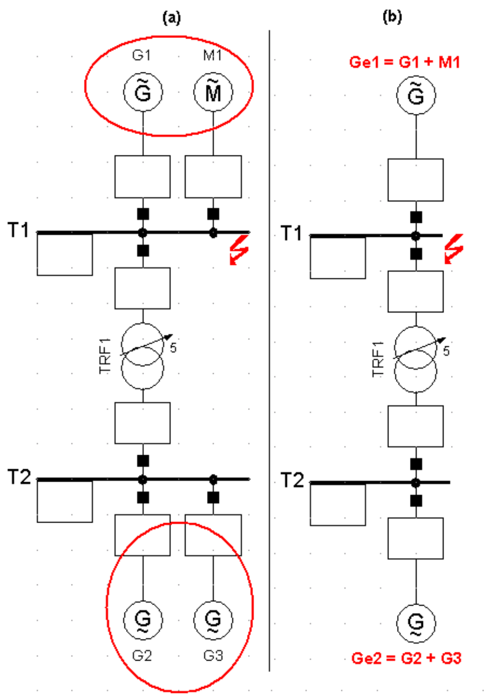


Fig. 18 – Equivalent machine representation

3. Short-circuit currents for the virtual representations are calculated according to formulae (1) – (21) described in Standard IEC 61363-1 pages 29-41 and in section 1.3.3 of this document.
4. From longest to shortest distance to the short-circuited Terminal '*k*', the non-active components are considered as described in Standard IEC 61363-1, pages 65-67, in the equivalent machine representation. At the end of the procedure, only one equivalent machine representing all contributions will be attached to the short-circuited node '*k*', as illustrated in Fig. 19.

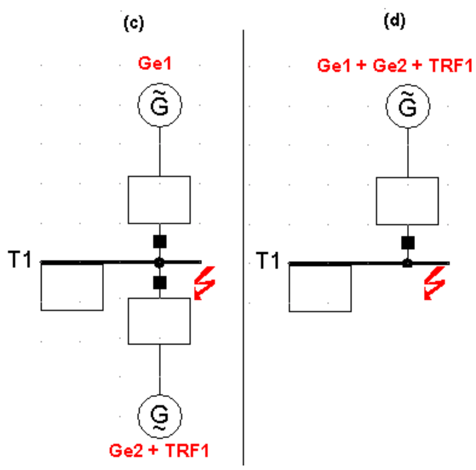


Fig. 19 – Equivalent machine representation at single terminal

5. Plots are calculated for the following variables considering the interval $0 \le t \le 100ms$

Variable	Description
i_t	Instantaneous value of Short-Circuit Current in kA
ik_t	Upper Envelope of Short-Circuit Current in kA
ikl_t	Lower Envelope of Short-Circuit Current in kA
idc_t	D.C. Component of Short-Circuit Current in kA
Iac_t	A.C. Component of Short-Circuit Current in kA

Variable	Name	Calculation
ik_t	$Upper$	Eq. (1). See Standard IEC61363-1 page 33.
ikl_t	$Lower$	$ikl(t) = -\sqrt{2}\, Iac(t) + idc(t)$
idc_t	DC	Eq. (9). See Standard IEC61363-1 page 35.
Iac_t	AC	Eq. (2). See Standard IEC61363-1 page 35.
i_t		$i(t) = \sqrt{2}\, Iac(t) * \sin\left(2\pi f * t - \frac{\pi}{2}\right) + idc(t)$

The $Upper$, $Lower$, DC and AC naming convention is used to facilitate readability of the formulae.

6. Calculation of monitored variables:

Variable	Description	Calculation
Ikss	Initial Short-Circuit Current in kA	$I_{kss} = \max\left[\left\|\frac{Upper(t) - DC(t)}{\sqrt{2}}\right\|, \left\|\frac{Lower(t) - DC(t)}{\sqrt{2}}\right\|\right]$ $t =$ short - circuit time
Skss	Initial Short-Circuit Power in kA	$S_{kss} = \sqrt{3}.V.I_{kss}$
ip	Peak Short-Circuit Current in kA	$ip = \|ik(t_{peak})\|$ $t_{peak} = \frac{1}{2f}$ $for\ 50Hz \Rightarrow t_{peak} = 0.01$
Ib	Short-Circuit Breaking Current in kA	$Ib = \|Iac(t_b)\|$ $t_b =$ circuit - breaker time
ib_dc	D.C. Component of Short-Circuit Current (breaker time) in kA	$i_{b\_dc} = \|idc(t)\|$ $t_b =$ circuit - breaker time

7. If the option 'Create Plots' has been selected in the Short-Circuit Calculation command dialog, the virtual instrument page displays plots of the short-circuit current using the following variables:

   i_t
   ik_t
   idc_t

End Loop

1.4 Procedure for EMT Simulation Method

The following procedure is followed whenever the user executes the Short-Circuit Calculation command:

Loop: for each busbar specified in the Short-Circuit Calculation's 'Fault Location' field:

1. Define a short-circuit event that will be applied as soon as the instantaneous value of the voltage at phase 'A' of the faulted busbar is zero.
   Short-circuit settings:
   - A 3-phase short-circuit is calculated, as specified by the Short-Circuit Calculation's 'Fault Type' parameter. See Section 1.2.1, item 1.

2. Define the set of monitor variables for the short-circuited busbar:
   - To be calculated during EMT simulation:

Variable	Description
m:Ishc:A for Terminals **m:I:_LOCALBUS:A** for Edge elements	Short-Circuit Current in kA (instantaneous value)

   - To be calculated as post-processing:

Variable	Description
ik_t	Upper Envelope of Short-Circuit Current in kA
ikl_t	Lower Envelope of Short-Circuit Current in kA
idc_t	D.C. Component of Short-Circuit Current in kA
Iac_t	A.C. Component of Short-Circuit Current in kA

3. Run the Calculation of Initial Conditions command to calculate initial conditions.

4. Start the transient simulation using the defined Run Simulation command.

5. Post-process the result file. Use the short-circuit current obtained from the EMT simulation to calculate the Upper Envelope, D.C. Component, A.C. Component and Instantaneous value from the Short-Circuit Current curve. All curves are calculated considering the interval: $0 \le t \le 100\,ms$

Variable	Name	Calculation
ik_t	$Upper$	Calculated using a linear function for interpolating the maximum (peak) values of the short-circuit current.
ikl_t	$Lower$	Calculated using a linear function for interpolating the minimum (valley) values of the short-circuit current.
idc_t	DC	$DC(t) = Lower(t) + \frac{\lvert Upper(t) - Lower(t) \rvert}{2}$
Iac_t	AC	$AC(t) = \frac{\lvert Upper(t) - DC(t) \rvert}{\sqrt{2}}$

   The $Upper$, $Lower$, DC and AC naming convention is used to facilitate readability of the formulae.

6. Calculation of monitored variables:

Variable	Description	Calculation
Ikss	Initial Short-Circuit Current in kA	$I_{kss} = \max\left[\left\lvert \frac{Upper(t) - DC(t)}{\sqrt{2}} \right\rvert, \left\lvert \frac{Lower(t) - DC(t)}{\sqrt{2}} \right\rvert\right]$ $t =$ short-circuit time

Skss	Initial Short-Circuit Power in kA	$S_{kss} = \sqrt{3}.V.I_{kss}$
ip	Peak Short-Circuit Current in kA	$\max\lvert Ishc\rvert$ for Terminals $\max\lvert I\rvert$ for Edge elements
Ib	Short-Circuit Breaking Current in kA	$I_b = \max\left[\left\lvert\frac{Upper(t_b) - DC(t_b)}{\sqrt{2}}\right\rvert, \left\lvert\frac{Lower(t_b) - DC(t_b)}{\sqrt{2}}\right\rvert\right]$ $t_b =$ circuit - breaker time
ib_dc	D.C. Component of Short-Circuit Current (breaker time) in kA	$i_{b\_dc} = DC(t_b)$ $t_b =$ circuit - breaker time

7. If the option 'Create Plots' has been selected in the Short-Circuit Calculation command dialog, the virtual instrument page displays plots of the short-circuit current using the following variables:

   m:Ishc:A for Terminals
   m:I:_LOCALBUS:A for Edge elements
   ik_t
   idc_t

End Loop

Output

Following an IEC 61363 calculation, the results are available in the following formats:

- in the single line diagram;
- in formatted text reports;
- as graphical plots.

The following sections describe the configuration of these output formats.

1.5 Output in the Single Line Diagram

By default, the values of the initial short-circuit power (Skss), initial short-circuit current (Ikss), and peak short-circuit current (ip) are displayed for each selected short-circuited node and for the directly-connected components, as illustrated in Fig. 20.

In order to see other calculated values, e.g., short-circuit breaking current (Ib) or dc component of the short-circuit current at breaker time (ib_dc), the user needs to change the definition of the variables that are to be displayed. This can be done by right-clicking in the element of interest's result box on the single line graphic and selecting 'Edit Format for Short-Circuit Nodes' or 'Edit Format for Edge Elements'.

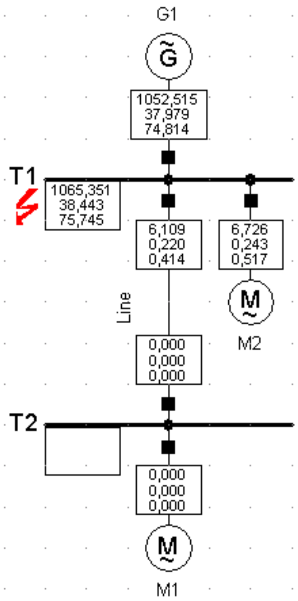


Fig. 20 – Example: output of results in single line diagram

1.6 Output in Formatted Text Reports

To view the results as formatted text reports, select option 'Show Output' in the Short-Circuit Calculation command dialog. Two reports are available for the IEC 61363 calculation:

- Fault Locations with Feeders (default): this reports the short-circuit power/currents at the faulted terminals and also the contributions of the directly-connected components. This is illustrated in Fig. 21.

- Fault Locations: this is a shorter form of the previous report, containing only the short-circuit power/currents at the faulted terminals. This is illustrated in Fig. 22.

```
-----------------------------------------------------------------------------------------------------------------
| Fault Locations with Feeders                                                                                  |
| Short-Circuit Calculation according to IEC61363                          3-Phase Short-Circuit    /            |
-----------------------------------------------------------------------------------------------------------------
|                                          | Fault Impedance                          |                         |
|    Break Time                     0,10 s |                                          |                         |
|                                          |                                          |                         |
-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid            |                                  | Annex:        / 1  |
-----------------------------------------------------------------------------------------------------------------
|                      rtd.V.                    Sk"             Ik"              ip              Ib           |
|                      [kV]                  [MVA/MVA]        [kA/kA]          [kA/kA]           [kA]          |
-----------------------------------------------------------------------------------------------------------------
|                                                                                                               |
|T1                    16,00              1065,35 MVA        38,44 kA         75,75 kA          25,75          |
|    Line            T2                      6,11 MVA         0,22 kA          0,41 kA                         |
|    G1                                   1052,52 MVA        37,98 kA         74,81 kA                         |
|    M2                                      6,73 MVA         0,24 kA          0,52 kA                         |
-----------------------------------------------------------------------------------------------------------------
```

Fig. 21 – Example: fault locations with feeders report

```
-----------------------------------------------------------------------------------------------------------------
| Fault Locations                                                                                               |
| Short-Circuit Calculation according to IEC61363                          3-Phase Short-Circuit    /            |
-----------------------------------------------------------------------------------------------------------------
|                                          | Fault Impedance                          |                         |
|    Break Time                     0,10 s |                                          |                         |
|                                          |                                          |                         |
-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid            |                                  | Annex:        / 1  |
-----------------------------------------------------------------------------------------------------------------
|                 rtd. V              Sk"               Ik"               ip                  Ib               |
|                  [kV]              [MVA]             [kA]              [kA ]               [kA]              |
-----------------------------------------------------------------------------------------------------------------
|                                                                                                               |
|T1               16,00             1065,35            38,44             75,75               25,75             |
-----------------------------------------------------------------------------------------------------------------
```

Fig. 22 – Example: fault locations report

1.7 Output in Graphical Form

To view the results in plotted graphic form, the option 'Create Plots' must be selected in the Short-Circuit Calculation command dialog. Following the execution of the calculation, a graphic board is created for each faulted terminal, depending on which of the following 'Create Plots' options is selected:

- 'only short-circuit current at faulted terminal': creates a plot containing the curves for the upper envelope, dc component and instantaneous value of the short-circuit at the faulted terminal. This is illustrated in Fig. 23.
- 'all short-circuit current contributions': creates a plot containing the curves for the upper envelope, dc component and instantaneous value of the short-circuit at the faulted terminal and for each of the directly-connected components. This is illustrated in Fig. 24.

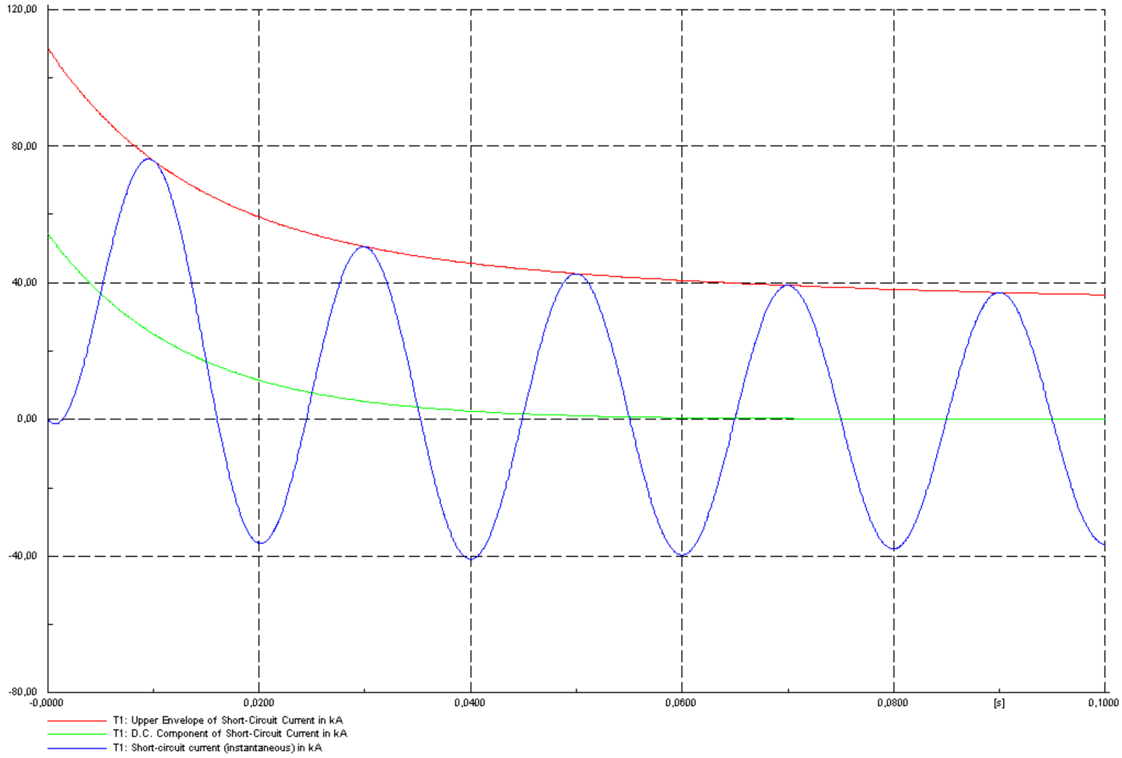


Fig. 23 – Example: short-circuit currents at faulted terminal

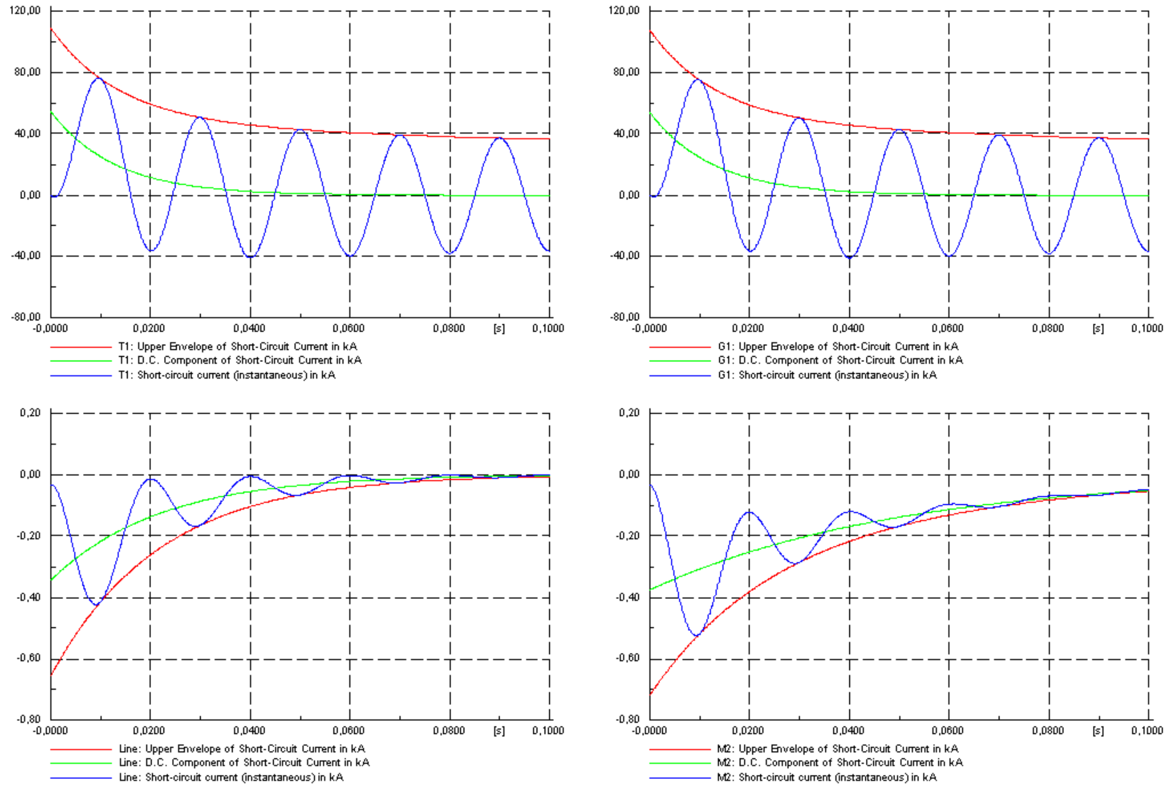


Fig. 24 – Example: short-circuit currents at faulted terminal and contributions from connected components