POWERFACTORY

PowerFactory 2021

Technical Reference

DC Load

ElmLoddc, ElmLoddcbi, TypLod

PF2021

POWER SYSTEM SOLUTIONS
MADE IN GERMANY

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Contents

1 General Description

This document describes the models of the Load *ElmLod* with DC Load Type *TypLoddc*, the DC Load *ElmLoddc*, and the DC Load with two terminals *ElmLoddcbi*.

2 DC Load

DC loads are always single-phase, as shown in Figure 2.1. For load flow analysis, the DC load is characterized by the active power flow P. Inductive effects are only considered in transient simulations.

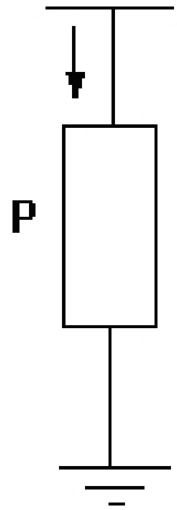

Figure 2.1: 1-phase DC load model

2.1 Load Flow

In *Load-Flow Analysis* the *DC Load* element supports AC balanced and unbalanced calculations. The model is not considered for DC Load Flow calculations.

2.1.1 Model Equations

For AC balanced and unbalanced *Load Flow Analysis* the reactive power of the load model is ignored, therefore only the active power P is considered.

The model is described in the equations below:

$$I_{DC} = \frac{P}{U_{DC}} \tag{1}$$

2.1.2 Voltage dependency

The voltage dependency of loads in *PowerFactory* (since v14.0) is modelled using three polynomial terms as shown in (2) and (3), instead of only one polynomial term. In (2) and (3), the subscript '0' indicates the *Operating Point* values as defined on the Load Flow page of the load element dialogue.

$$P = P_0 \left(aP \cdot \left(\frac{v}{v_0}\right)^{e\_aP} + bP \cdot \left(\frac{v}{v_0}\right)^{e\_bP} + (1 - aP - bP) \cdot \left(\frac{v}{v_0}\right)^{e\_cP} \right) \tag{2}$$

where
$[1 - aP - bP = cP]$, and v is the busbar voltage (p.u.).

$$Q = Q_0 \left(aQ \cdot \left(\frac{v}{v_0}\right)^{e\_aQ} + bQ \cdot \left(\frac{v}{v_0}\right)^{e\_bQ} + (1 - aQ - bQ) \cdot \left(\frac{v}{v_0}\right)^{e\_cQ} \right) \tag{3}$$

where
$[1 - aQ - bQ = cQ]$, and v is the busbar voltage (p.u.).

By specifying the respective exponents (*e_aP/e_bP/e_cP* and *e_aQ/e_bQ/e_cQ*) on the Load Flow page in the dialogue of the general load type, the load behaviour can be modelled. Table 2.1 shows the values required for the exponents in order to model constant power, constant current and constant impedance. The relative proportion of each coefficient can be freely defined using the coefficients aP, bP, cP and aQ, bQ, cQ.

Table 2.1: Selection of exponent value for different load model behaviour

Exponent	**Constant**
0	power
1	current
2	impedance

Note: These factors are only considered if the parameter *Consider Voltage Dependency of Loads* is checked in the *Load Flow Calculation* command dialogue.

The exponents *e_aP, e_bP, e_cP* are effectively equivalent to *kpu0, kpu1, kpu* when considering the earlier *PowerFactory* load model which used only one exponent, *kpu*, which can be expressed in terms of the variables as *kpu=aP*e_aP*. The same can be said regarding variables *e_aQ, e_bQ, e_cQ* and *kqu*. Equivalence with the earlier *PowerFactory* single exponent load model can be obtained by setting $aP = bP = 0$ and $aQ = bQ = 0$.

2.1.3 Reference Voltage

The reference voltage v_0 in (2) and (3) is the busbar voltage at which $P = P_0$ and $Q = Q_0$, and is therefore referred to as the nominal voltage of the load model. However, in *contingency analysis*, v_0 may be selected to be the busbar voltage in the base case. When executing a *contingency analysis*, this option can be enabled as follows:

- In the *contingency analysis* command dialogue: select option Allow different settings on the Multiple Time Phases tab; and

- access the *Contingency Load Flow* on the same page, in order to select Consider Voltage Dependency of Loads in the *Load Flow Calculation* dialogue; and
- on the Advanced Options page of the *Load Flow Calculation* dialogue: select the option Use Base Case voltage as reference.

2.1.4 Load Scaling Factors

Loads can be scaled individually by setting the Scaling Factor on the Load Flow page in the load element.

Considering the scaling factor, the load is calculated as follows:

$$P = scale \cdot P_0 \tag{4}$$

$$Q = scale \cdot Q_0 \tag{5}$$

If the voltage dependency of loads is considered, then ((4)) and ((5)) become:

$$P = scale \cdot P_0 \left(aP \cdot \left(\frac{v}{v_0}\right)^{e\_aP} + bP \cdot \left(\frac{v}{v_0}\right)^{e\_bP} + (1 - aP - bP) \cdot \left(\frac{v}{v_0}\right)^{e\_cP} \right) \tag{6}$$

$$Q = scale \cdot Q_0 \left(aQ \cdot \left(\frac{v}{v_0}\right)^{e\_aQ} + bQ \cdot \left(\frac{v}{v_0}\right)^{e\_bQ} + (1 - aQ - bQ) \cdot \left(\frac{v}{v_0}\right)^{e\_cQ} \right) \tag{7}$$

As an alternative to explicitly specifying the scaling factors, loads in radial feeders can be scaled based on the total inflow into the feeder, as illustrated in Figure 2.2.

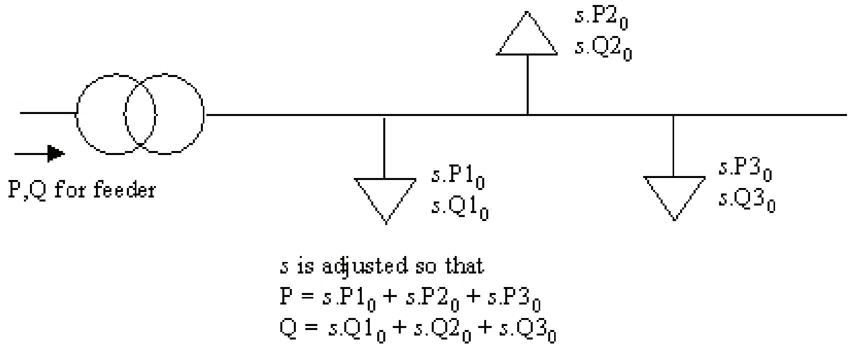

Figure 2.2: Load scaling to maintain feeder settings specified in the feeder definition

In order for a load in the feeder to be considered by the load scaling process, the option in the relevant load elements' dialogues *Adjusted by Load Scaling* must be enabled. In this case, the individual load element's Scaling Factor is not considered and the feeder scaling factor is used instead.

The feeder load scaling function can be enabled or disabled globally using the corresponding load flow option Feeder Load Scaling.

2.2 Short Circuit Analysis

The DC Load element is ignored for short circuit calculation.

2.3 Harmonics/Power Quality

The DC Load element is ignored for harmonic load flow and frequency sweep calculations.

2.4 RMS-Simulation

The initialization for this model is:

$$glod = \frac{I_{DC,ldf}}{U_{DC,ldf}} \tag{8}$$

An the equation for this model is:

$$U_{DC} \cdot glod = I_{DC} \tag{9}$$

2.5 EMT-Simulation

For *EMT-Simulation* the same model is used as in Section 2.4.

3 DC Load with Two Terminals

Figure 3.1 depicts the equivalent circuit of the model with two terminals.

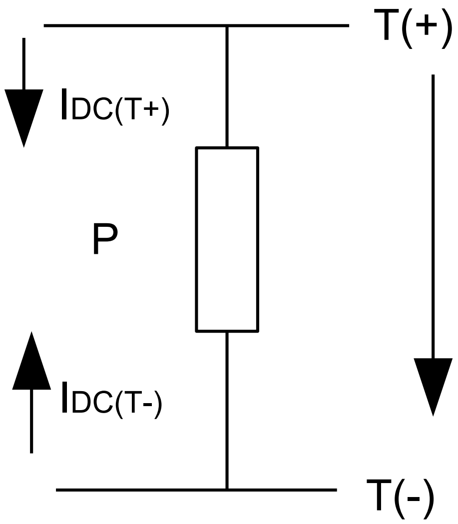

Figure 3.1: DC load model with two terminals

3.1 Load Flow

In *Load-Flow Analysis* the *DC Load* element supports AC balanced and unbalanced calculations. The model is not considered for DC Load Flow calculations.

3.1.1 Model Equations

For AC balanced and unbalanced *Load Flow Analysis* the reactive power of the load model is ignored, therefore only the active power P is considered.

The model is described in the equations below:

$$I_{DC} = \frac{P}{U_{DC}} \tag{10}$$

where:

$$U_{DC} = U_{T(+)} - U_{T(-)} \tag{11}$$
$$I_{DC} = I_{T(+)} + I_{T(-)} \tag{12}$$

3.1.2 Voltage dependency

The voltage dependency for this model is as described in Section 2.1.2.

3.1.3 Load Scaling Factors

The load scaling factors for this model is as described in Section 2.1.4.

3.2 Short Circuit Analysis

The DC load with two terminals is ignored for the short circuit calculation.

3.3 RMS-Simulation

The models described in Section 2.4 are also valid for the two terminals model.

3.4 EMT-Simulation

The models described in Section 2.5 are also valid for the two terminals model.

3.5 Harmonics/Power Quality

The DC load with two terminals is ignored for the harmonics calculation.

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