4.2.8. Type 175: Power Conditioning Unit

Type 165 is a mathematical model for a power conditioning unit. The model is based on empirical efficiency curves for electrical converters (DC/DC) or inverters (DC/AC or AC/DC). The empirical relationship used in Type 175 was first proposed by [1] and further improved by [2]. The model is in agreement with related literature [3].

4.2.8.1. Nomenclature

P_{in}	[W]	Power entering the conditioner
P_{out}	[W]	Power leaving the conditioner
P_{loss}	[W]	Power losses of the conditioner
P_0	[W]	Idling power
P_n	[W]	Nominal (rated) power
U_s	[V]	Setpoint voltage
U_{out}	[V]	Output voltage
R_i	[Ω]	Internal resistance
R_{ipn}	[V²]	Internal resistance constant = R_i P_n
η	[-]	Electric efficiency
I_{out}	[A]	Output current

4.2.8.2. Electrical model

The power conditioner can have either output or Input power as Input for the calculations (output if the system is connected to a load, or Input if the system is connected to an electric power source). MODE=1 indicates that the power source is known, while MODE=2 indicates it is an output.

Power conditioners are devices that can invert DC power to AC power, and/or vice versa, or they function as DC/DCconverters. In a Stand Alone Power Systems (SAPS) consisting of both DC power producing and DC power consuming components, DC/DCconverters are sometimes needed to transfer DC power from one voltage to another. This is particularly true if there is a large mismatch between the I-U characteristics of the various components.

In a SAPS based on a natural energy source, such as solar or wind energy, the system Input power varies continuously with time. The output characteristics of a PV array, wind turbine, or hydro turbine (run off river) have peak power points that depend on solar insolation and cell temperature, wind speeds, and water flow rates, respectively. Therefore, it may be advantageous to use a maximum power point tracker (MPPT) to utilize the Input power source to its fullest capability [3].

The power loss (P_{loss}) for a power conditioner is mainly dependent on the electrical current running through it. Laukamp, [1], proposed a three-parameter expression to describe the power loss for a power conditioner:

$$P_{loss} = P_{in} - P_{out} \qquad \text{Eq 4.2.8-1}$$

$$P_{in} - P_{out} = P_0 + (U_S / U_{out}) P_{out} + (R_{ipn} / U_{out}^2) P_{out}^2 \qquad \text{Eq 4.2.8-2}$$

A convenient relationship between the Input power P_{in} and output power P_{out} can be derived by normalizing Eq 4.2.8-2 with respect to the nominal (maximum) power P_n of the power conditioner:

$$\frac{P_{in}}{P_{nom}} = \frac{P_0}{P_{nom}} + \left[1 + \frac{U_s}{U_{out}}\right] \cdot \frac{P_{out}}{P_{nom}} + \frac{R_{ipn}}{U_{out}^{\ 2}} \cdot P_{nom} \cdot \left[\frac{P_{out}}{P_{nom}}\right]^2 \qquad \text{Eq 4.2.8-3}$$

In Type 175, either the Input power P_{in} or the output power P_{out} can be specified as Inputs. If P_{out} is Input, then Eq 4.2.8-3 is used directly. However, if P_{in} is Input, then an expression analytically derived from Eqn.3 is used. This makes the model numerically very robust. The efficiency of the power conditioner is simply:

Electric efficiency:

$$\eta = \frac{P_{out}}{P_{in}} \qquad \text{Eq 4.2.8-4}$$

Current ouput:

$$I_{out} = \frac{P_{out}}{U_{out}} \qquad \text{Eq 4.2.8-5}$$

4.2.8.3. Additional information

Type 175 is also described in an EES-based executable program distributed with TRNSYS 17: %TRNSYS17%\Documentation\HydrogenSystemsDocumentation.exe

4.2.8.4. References

1. Laukamp H. (1988) Inverter for photovoltaic systems (in German). User-written TRNSYS source code., FraunhoferInstitute für Solare Energiesysteme, Freiburg im Breisgau, Germany.
2. Ulleberg Ø. (1998) Stand-Alone Power Systems for the Future: Optimal Design, Operation & Control of Solar-Hydrogen Energy Systems. PhD thesis, Norwegian University of Science and Technology, Trondheim.
3. Snyman D. B. and Enslin J. H. R. (1993) An experimental evaluation of MPPT converter topologies for PV installations. Renewable Energy 3 (8), 841-848.