# TYPE 672: N-STAGE DIFFERENTIAL CONTROLLER IN COOLING

## General Description

An N-stage differential controller is modeled to output N ON/OFF control functions that can be used to control a cooling system having a N-stage cooling source.

The controller commands a first stage control signal at high input values, a second stage control signal at higher input values, a third stage control signal at even higher input values etc. through the $n^{th}$ defined level.

The user has the option to enable or disable the output control functions for levels lower than the critical control function. For example if the model decides that the third stage signal should be ON, the user has the option of then deciding whether stage 1 and stage 2 should be ON or OFF.

## Nomenclature

| | | |
|---|---|---|
| $SetPt\|_t$ | [ºC] [1] | The set controller set point at the current time step. |
| $SetPt\|_{t-1}$ | [ºC] [1] | The controller set point at the previous time step. |
| $\gamma$ | [0..1] | The controller state (1 if the controller is ON, 0 if the controller is OFF |
| $\Delta T_{db}$ | [ºC] [1] | The controller dead band. |
| $\gamma_{SetUp}$ | [0..1] | The control signal for the controller set up option. |
| $\Delta T_{SetUp}$ | [ºC] [1] | The temperature difference the that the controller will be set up when the setup function is enabled. |

[1.] While "temperature" notation is used throughout this model and documentation, any consistent set of variables may be used in model to simulate different types of ON/OFF controllers.

## Detailed Description

While "temperature" notation is used throughout this model and documentation, any consistent set of variables may be used in model to simulate different types of ON/OFF controllers.

*Set Up Controls*

In many applications, the desired set point condition may depend on the time of day or the day of the week. This variation of the set points are modeled in Type672 using an optional set up control function (INPUT 2) and set up difference (PARAMETER 4).

*Hysteresis*

Hysteresis effects can be included in the model by supplying the dead band difference $\Delta T_{db}$ (PARAMETER 5). A single value of $\Delta T_{db}$, is applied to all N output control functions.

PARAMETER 2, NSTK, sets the number of oscillations permitted within a time step before the output state of the controller is stuck. It is recommended that NSTK be chosen carefully. An odd value of NSTK may cause the controller to oscillate during successive time steps while an even value of NSTK may cause the output control function to stay ON or OFF longer than it should. For a discussion of controller stability problems, see Section 4.4 of Volume 1 (the red binder) of the TRNSYS documentation set.

The ON/OFF set points for any given stage are determined as shown in equation 672.1.

$$SetPt\big|_t = SetPt\big|_{t-1} + (1-\gamma)\frac{\Delta T_{db}}{2} - \gamma\frac{\Delta T_{db}}{2} + \gamma_{SetBack} * \Delta T_{SetBack} \qquad \text{(Eq. 672.1)}$$

If hysteresis effects are not desired, $\Delta T_{db}$ is set to zero. If set back option is not desired then both $\gamma_{SetUp}$ and $\Delta T_{SetUpk}$ are set to zero.

Care should be taken when choosing deadbands and set points. Deadbands that are greater than the temperature difference between the set points will cause controller convergence problems.

**Example**

Type672 is used in an example that can be found in:
" ..\trnsys16\TESS Models\Studio Projects\Controllers Library\Lots of Controllers.tpf"