AN001

Output Current Limitation Methods

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1 Introduction

Switch mode power supplies use various methods to limit the output current/power in case of output short circuit or overload conditions. The purpose of this document is to explain the two different method normally used by other vendors and Nextys switch mode power supplies. The methods used by Nextys are slightly different from the ones used as industry standard.

2 Method 1: Standard constant current limitation

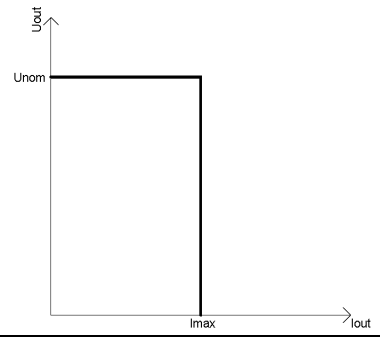
This is probably the most widely used limitation method. The output current is electronically limited at a maximum value (I_{max}) and it is not possible to exceed the I_{max} value whatever happens to the load. The power supply never switches off but behaves like a constant voltage source (CV_mode) or as a constant current source (CC_mode) depending on the load resistance. It is exactly the same method used on laboratory power supplies with independent voltage and current regulation knobs.

2.1 Operation in overload

Overload condition does not exist by itself in a constant current limited power supply; the current can never exceed I_{max}. If the load resistance becomes < U_{out}/I_{max} the output voltage starts to decrease keeping $I_{out}=I_{max}$.

2.2 Operation in short circuit

A short circuit condition is exactly the same as an overload condition for a constant current limited power supply; the current is still limited at I_{max} . Given that in short circuit $U_{out}\approx 0V$ the output power ($U_{out}.I_{out}$) is very low and thus the power supply operates at very relaxed conditions (low power) generating less heat compared to its normal rating behaviour.



Constant current limitation output characteristic

Current evolution over time in short circuit conditions

3 Method 2: Standard hiccup mode current limitation

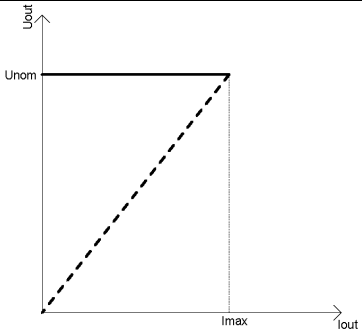
This protection method is the easiest to implement and most present on the market. It provides adequate protection for the power supply and the load in case of failures, but it can create problems with large capacitive loads or loads with high inrush current in general. It can generate very high currents for short time, useful in blowing the fuses of the loads thus separating the problems in multiple branched circuits.

3.1 Operation in overload

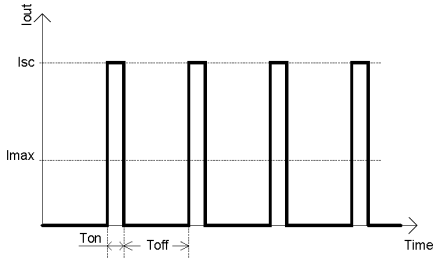
If the output current exceeds I_{max} the output is switched OFF after a given amount of time (T_{ON}, normally some tens of milliseconds). The output remains OFF for a defined amount of time (T_{OFF}) and then the cycle restarts and continues until the output load is reduced below I_{max}. Generally I_{max} is set at 1.2…1.5 times the power supply rated output current.

3.2 Operation in short circuit

In short circuit condition the output current increases up to I_{SC}, normally 2…5 times the rated output current for a time of some tens of milliseconds (T_{ON}), then the current becomes 0A during the OFF time (T_{OFF}). Since T_{ON}<<T_{OFF} the duty cycle is very low and the average output current is however much smaller than the power supply rated output current. Given that in short circuit U_{out}≈0V the output power (U_{out}.I_{out}) is very low and thus the power supply operates at very relaxed conditions (low power) generating less heat compared to its normal rating behaviour.



Hiccup limitation output characteristic



Current evolution over time in short circuit conditions

4 Method 3: Nextys constant current limitation

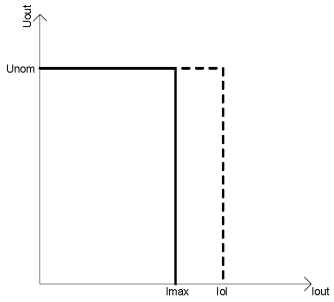
This method is an evolution of the standard constant current limitation that provided the same safety of operation in overload or short circuit conditions, but provides also a short term power boost to better handle high inrush current loads.
Basically there are 2 thresholds for the output current: I_{max} and I_{OL}; usually I_{OL} is set at around 1.2…1.5 times I_{MAX}.
A power supply using this method can provide higher output current for a limited time (T_2 usually 3…5 seconds) keeping the maximum output current at safe levels and very well controlled.
Constant current limitation is vital when using more than one unit in parallel for increasing the total output power.

4.1 Operation in overload

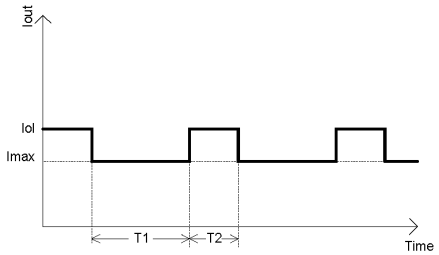
If the output current exceeds I_{max} a timer is started and the “overload” red LED is turned ON. If the output current decreases below I_{max} before the maximum allowable time (T_2) the normal operation is restored and the “overload” LED is turned OFF.
If the output current does not decrease below I_{max} before T_2 the current is automatically limited to I_{max} for a time equal to T_1 (normally around 2.T_1). Whatever happens to the load the output current can never exceed I_{OL}.

4.2 Operation in short circuit

In short circuit condition the output current increases up to I_{OL}, normally 1.2…1.5 times the rated output current for the time T_2 then the current is reduced to I_{max} during the time T_1. The cycle continues until the short circuit at the output is removed.
The maximum current is kept limited at maximum I_{OL}. Given that in short circuit U_{out}≈0V the output power (U_{out}.I_{out}) is very low and thus the power supply operates at very relaxed conditions generating less heat compared to its normal behaviour.



Nextys constant current limitation output characteristic



Current evolution over time in short circuit conditions

5 Method 4: Nextys hiccup mode current limitation

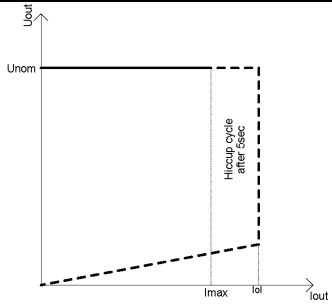
This method is an evolution of the standard hiccup model limitation that provided the same safety of operation in overload or short circuit conditions, but provides also a short term power boost to better handle high inrush current loads.
Basically there are 2 thresholds for the output current: I_{max} and I_{OL}; usually I_{OL} is set at around 1.2…1.5 times I_{MAX}.
A power supply using this method can provide higher output current for a limited time (T_2 - usually 3…5 seconds) keeping the maximum output current at safe levels and very well controlled.

5.1 Operation in overload

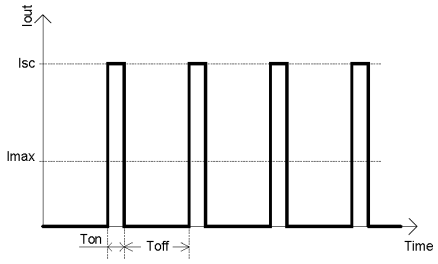
If the output current exceeds I_{max} a timer is started and the “overload” red LED is turned ON. If the output current decreases below I_{max} before the maximum allowable time (T_2) the normal operation is restored and the “overload” LED is turned OFF.
If the output current does not decrease below I_{max} before T_2 the output is turned off for a time equal to T_1 (normally around 2.T_1).

5.2 Operation in short circuit

In short circuit condition the output current increases up to I_{SC}, normally 2…5 times the rated output current for the time T_{ON} then the output is switched off during the time T_{OFF}. The cycle continues until the short circuit at the output is removed.
T_{ON} is in the range of tens of milliseconds.
On some product I_{SC} limited to I_{OL} and the T_{ON}, T_{OFF} are equal to T_1 and T_2 in §5.1
Given that in short circuit U_{out}≈0V the output power (U_{out}.I_{out}) is very low and thus the power supply operates at very relaxed conditions generating less heat compared to its normal behaviour.



Nextys hiccup mode limitation output characteristic



Current evolution over time in short circuit conditions

6 Nextys power supplies limitation methods

Nextys offers various type of output limitation depending on the product. In the following tables the relevant data are reported for the 24V models. The reported data are typical and can vary according to load/line/temperature conditions.

6.1 Products with standard hiccup mode only

Model	T_{ON} [ms]	T_{OFF} [ms]	I_{MAX} [A]	I_{OL} [A]	I_{SC} [A]
NPSM20-24	40	900	0.85	1.5	4
NPSM40-24	50	2000	2	3.5	7
NPSM80-24	50	1500	3.3	4	25
NPSM85-24	50	1500	3.5	5	30
NPSM120-24	50	1500	5	7	30
NPSM240-24	150	700	10	13.5	35

6.2 Products with Nextys hiccup mode only

Model	T_{ON} [ms]	T_{OFF} [ms]	T_1 [ms]	T_2 [ms]	I_{MAX} [A]	I_{OL} [A]	I_{SC} [A]
NPSW120-24	300	1400	>30000	>30000	5	7.5	14
NPSW240-24	250	1200	6000	1200	10	15	38
NPSM480-24	200	2000	5000	2000	20	28	50
NPST480-24	200	2000	5000	2000	20	28	50
NPSW480-24	200	2000	5000	2000	20	28	50

6.3 Products with programmable limitation mode

Set in “hiccup mode”

Model	T_{ON} [ms]	T_{OFF} [ms]	T_1 [ms]	T_2 [ms]	I_{MAX} [A]	I_{OL} [A]	I_{SC} [A]
NPSM121-24	70	6000	5000	12000	5	7.5	15
NPSM241-24	5000	8000	5000	8000	10	15	18
NPSM481-24	5000	8000	5000	8000	20	30	32
NPSM501-24	5000	10000	5000	10000	20	30	30
NPST501-24	5000	10000	5000	10000	20	30	30
NPST721-24	5000	10000	5000	10000	30	45	45
NPST961-24	5000	10000	5000	10000	40	60	60
NPS2400	100	10000	5000	10000	100	150	160

Set in “CC-mode”

Model	T_1 [ms]	T_2 [ms]	I_{MAX} [A]	I_{OL} [A]	I_{SC} [A]
NPSM121-24	5000	12000	5	7.5	7.5
NPSM241-24	Continuous	N/A	10	10	11
NPSM481-24	Continuous	N/A	20	20	22
NPSM501-24	5000	10000	20	30	30
NPST501-24	5000	10000	20	30	30
NPST721-24	5000	10000	30	45	45
NPST961-24	5000	10000	40	60	60
NPS2400	5000	10000	100	100	100