Advel Application Note – AAN2008.3

Importance of CROWBAR protection on V_{out} of power supplies

Eng. Alessio Spinosi

1. Introduction

In switching power supplies, the stabilization function of V_{out} is usually achieved by the feedback error signal on the oscillator block (PWM).
Now do not care to study the internal circuit in detail, but it's sufficient to say that is used the concept of **feedback**, which can be schematized of using block diagrams, as in Figure 1:
essentially V_{out} is the stabilized voltage. To keep the output V_{out} stable it is, through the block **B**, compared with a reference voltage V_{ref}.
For example, if V_{in} drops, through block **A** also V_{out} decreases, but after the difference with the reference voltage, there is a positive signal in the input of block **A**, which offset the decrease in V_{in}.
The reverse occurs if the input voltage tends to increase. As you can see, the system works even if the output voltage changes as a result of the input voltage or due to load variations.

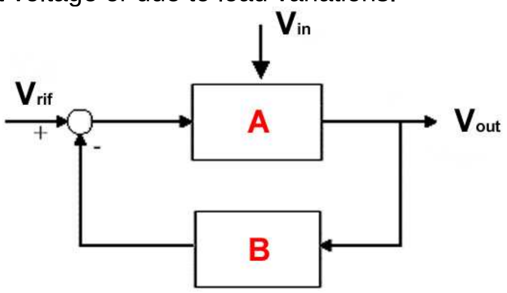

Figure1 *– Block diagram for a feedback system, which can be applied to the control of Vout in a stabilized power supply*

The control of V_{out} is maintained by one or more integrated circuits which perform the "calculations" necessary for stabilization. What you need to ask is:
what happens if one or more parts of the control circuitry of V_{out} goes in fault?
In case of failure in one or more parts of the control circuitry of V_{out}, the power supply may behave in different ways, depending on the type of failure or the presence or absence of the protections in the power supply.

2. Failure in the control of V_{out}

In any system, the worst event that can happen is that a failure in the power supply can damage the loads that it's powering (which often cost much more than the power supply itself).
In any power supply, some failures cause input overload, and the input fuse opens, therefore do not cause any damage to the load because the power is shut off.
However if the fault occurs on the control of output voltage (**B** block in the block diagram of Figure 1), basically two events can happen:

1. V_{out} drops than its nominal value;
2. V_{out} increases compared to its nominal value.

While the first of the two cases is not serious, the second is the absolute worst case: the output voltage rises (typically can reach twice the nominal voltage) and consequently the loads connected to it are damaged.

3. Failure in the control of V_{out} in a redundant system

Given a system of power supplies in parallel, what happens if one of them has a fault in the control that causes its V_{out} to rise?

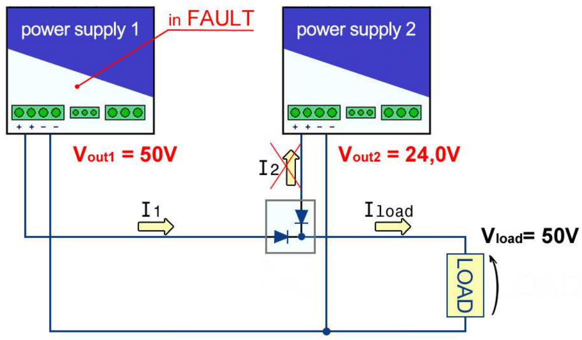

Figure2 *– System of 2 redundant power supplies: one of them was in failure in the Vout control, and Vout rises*

Figure 2 shows a system of two power supplies ($V_{out,nom}$ = 24V), the first of which was a failure in the control of V_{out}, that reaches 50V. Well: the load "sees" the 50V, which is the highest voltage between the two voltages in parallel (this is a natural rule, which applies to every type of power supply).
Therefore neither the redundancy can help in case of failure of the control of V_{out}.

4. Protection of V_{out}

Many power supplies on the market provide an output overvoltage protection: this is typically a second control circuitry involved in the case of failure of the first control circuitry.

For example, given a power supply, $V_{out,nom}$ = 24V: in case of failure on the first control of output voltage, the second control intervenes to stabilize Vout at about 26 ÷ 27V, which is a voltage which certainly does not damage the load.
In this case, continuing the example in Figure 2, if the power supply that goes in fault in the control of Vout, is equipped with the aforesaid overvoltage protection, the situation that would occur is shown in Figure 3.

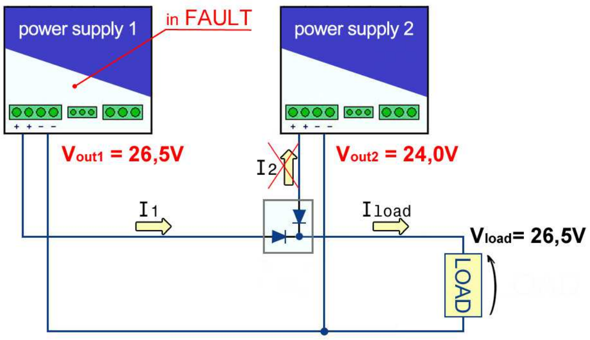

Figure3 *– System of 2 power supplies in redundancy: one has a fault in the control of Vout that cause che increase of Vout, but the power supply is equipped with overvoltage protection on the output.*

Well described by the example in Figure 3, we understand how important is the presence of an overvoltage protection on the output, however, present in 70% of industrial power supplies on the market.
Now, there is still a risk that the second control circuit goes in fault or that the failure in the power supply is at the stage of driving the mosfet (block **A** in the block diagram of Figure 1): how you can protect yourself from this possibility, remote but still always possible? It's important prevent this event, especially if the loads they cost a lot.

5. CROWBAR protection of Vout

Advel proposes, as an available option for all range of power supplies (SPS modules for rack or DIN series), in addition to the ever-present standard overvoltage protection, a second protection of Vout, which gives an extra safety that Vout does not exceed a certain value limit: it is a **CROWBAR** protection of output.

This protection is very simple (and so effective): **CROWBAR** the circuitry (<u>which is completely independent of the control circuitry</u>, block **A** and **B** in Figure 1) reads the output voltage Vout, and if it exceeds a certain threshold, a net short circuit in the output is generated (before the parallel-diode, of course).

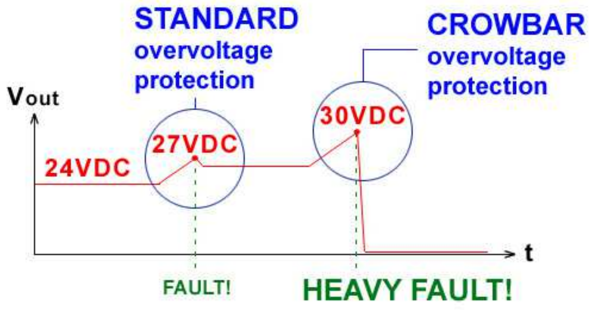

Figure4 *– Example of a standard overvoltage protection intervention, and CROWBAR intervention in an Advel SPS series power supply, output rated 24VDC*

Figure 4 outlines the evolution of output voltage ($V_{out,nom}$ = 24VDC) for an Advel power supply: in case of failure in the control of Vout, the standard overvoltage protection intervenes, which blocks the output voltage value at 26÷27V. In the event of a disaster, in which the first protection is ineffective, the output voltage tends to rise, but once it reaches 30V, the CROWBAR put in short-circuit the output voltage.

6. Conclusions

It have been shown the risks involved when there is a fault on the control of Vout of a power supply: the risk is the damage of the load of the power supply.
Many power supplies on the market incorporate a default protection for Vout, commonly known as overvoltage-protection (OP).
It has been shown the CROWBAR protection of Vout proposed by Advel, which intervenes in case of failure or malfunction of the OP itself, and which provides greater protection to the load.
The protection of CROWBAR, optional, is suggested when the cost of the loads is very high.

»ADVEL«
ELETTRONICA INDUSTRIALE
HEADQUARTER: Via Miglioli 13, Segrate 20090 MI (Italy)
Technical DPT: Eng. A.Spinosi, tec@advel.it