Local Over Voltage Protection for fLVPS DC-DC converters (Bricks), Production and Test Report

Bohuslav Palan, Alexander Solin, Anton Tikhonov

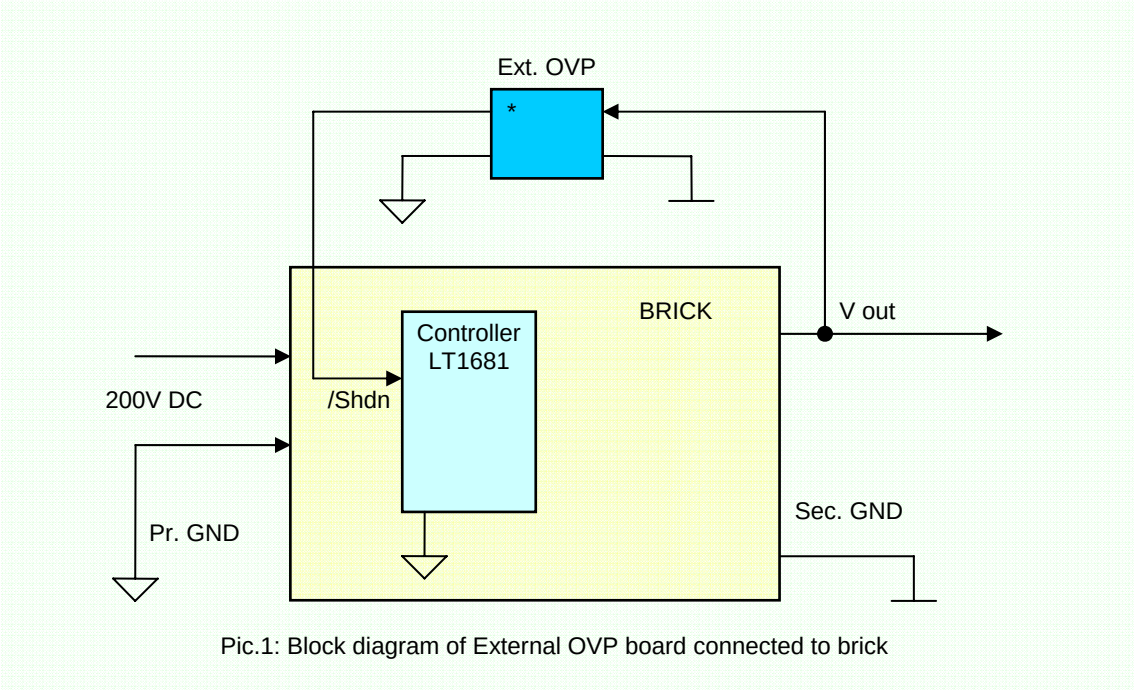
September 18, 2006 **CERN/ATLAS/TileCal/LVPS**

This report outlines a system for providing local Over Voltage Protection (OVP) on each brick of the Tilecal finger low voltage power supplies (fLVPS). It senses the actual output voltage of the brick and operates by providing a signal to the shutdown pin of the LT1681 controller chip. Two versions are presented. The first utilizes a small satellite printed circuit board for the components, connected to the brick PCB by two input and two output wires. The second OVP circuit is made of a comparator and opto-coupler already available and unused on the brick.

A. Local OVP using satellite PCB

1. General idea and Functionality

In this version, OVP is implemented by an additive board (External OVP). The small PCB board (~3 cm^2) is mounted on a brick via one screw and connected to the brick via four soldered wires. It takes V_{out} from the Brick and compares to an internal threshold set by a resistive divider, producing a Shutdown signal for the Brick's controller (LT1681).

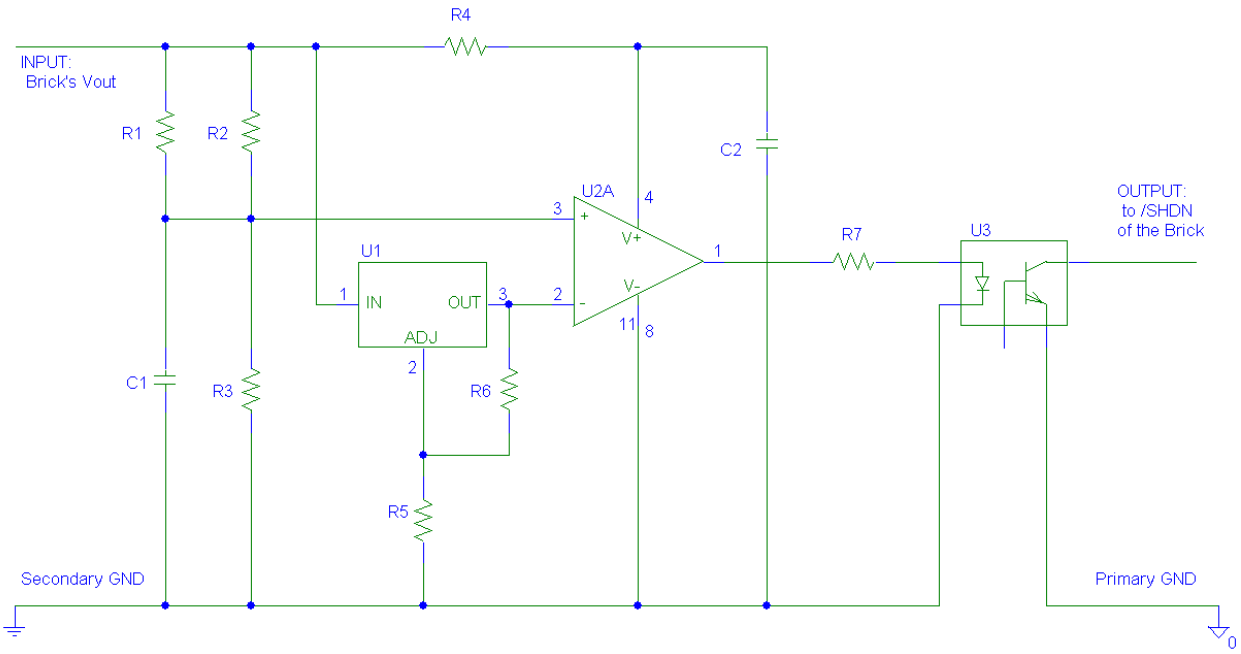


Pic.1: Block diagram of External OVP board connected to brick

2. Data for production

The external OVP will be produced in three versions, as follows:

Type	V thresh
3.3V	4.0V
5.0V	6.0V
15.0V	16.0V



The same circuit (drawing above) will be uses for the three versions, except for the values of resistors. The following tables specify the components:

Passive components:

Capacitors:
SMD 0805
C1-10n
C2-100n

Resistors:
SMD 0805

Type	R1	R2	R3	R4	R5*	R6	R7*
3.3v	7.5k	560	240	51	0	240	0
5.0v	n/used	330	240	100	240	240	0
15v	68k	2.4k	1k	680	680	240	0

*- R5 and R7 have shortcut in PCB.

Active components:

1. U1 - Reference: 3-Terminal Adjustable Regulator National Semiconductor LM317
   Case: 4-Lead SOT-223 (EMP)

NS Package Number: MP04A LM317EMP
Package marking: N01A

2. U2 - Comparator (O.Amp): National Semiconductor LM6142
Case: 8-Pin Small Outline
Ordering number: LM6142AIM

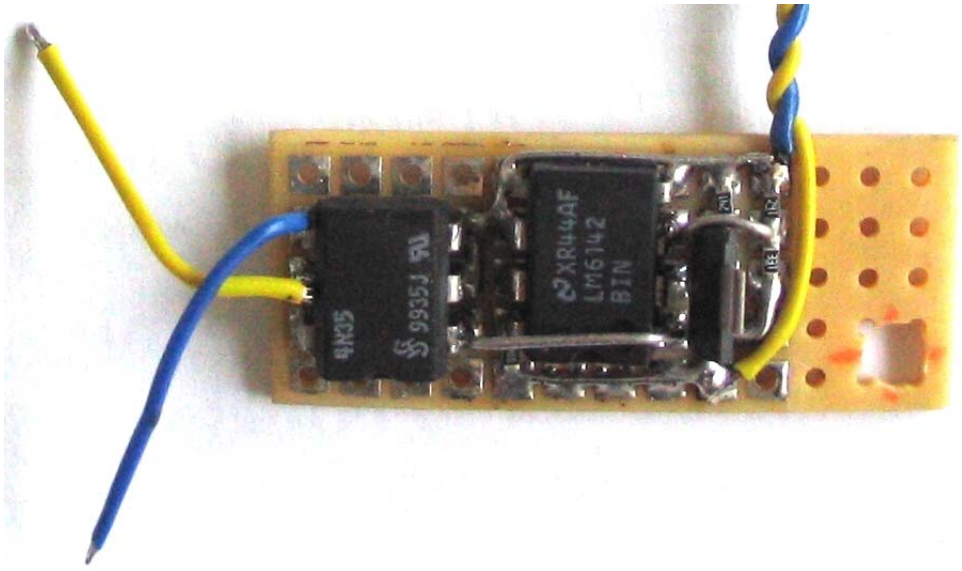
3. U3 - Opt-isolator: GENERAL PURPOSE 6-PIN PHOTOTRANSISTOR OPTOCOUPLER 4N35
Ex.: Fairchild Semiconductor
Case: 6-DIP

Radiation tolerance

All components except U3 were taken from the fLVPS design. We expect that the 4N35 chosen for component U3 has similar behavior. This point needs extra study, and it is likely that an appropriate opto-coupler can be identified whose radiation tolerance has been tested by some ATLAS subdetector. In any case, because of the effects of radiation, all currents were chosen to be as large as reasonably possible.

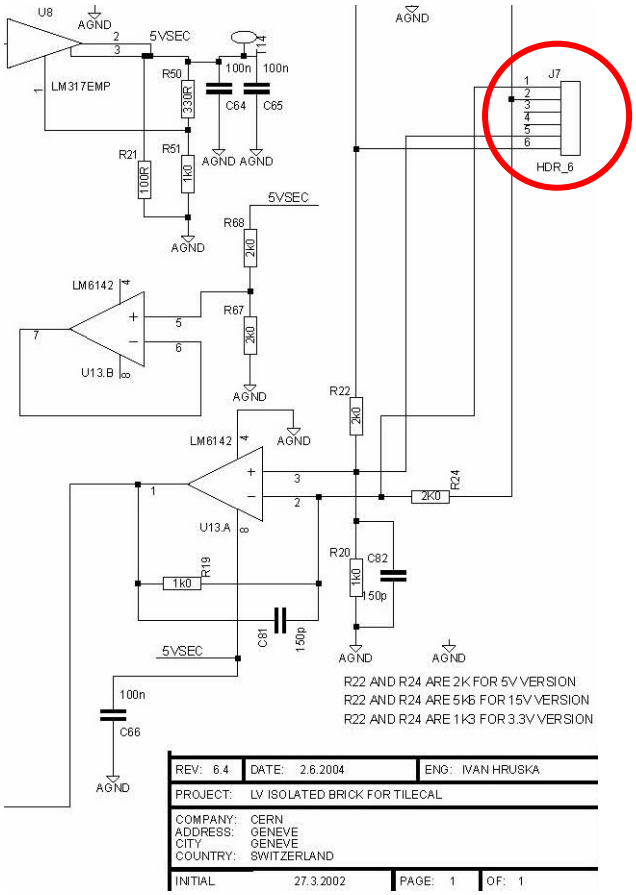
3. Realization and mounting

A complete set of eight satellite boards have been built and installed in the eight bricks on one fLVPS. A photograph of one prototype satellite board is below.

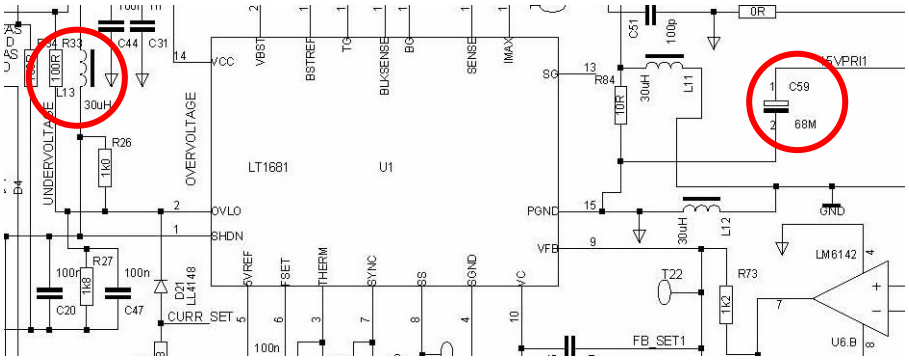


Points of connection to the Brick:

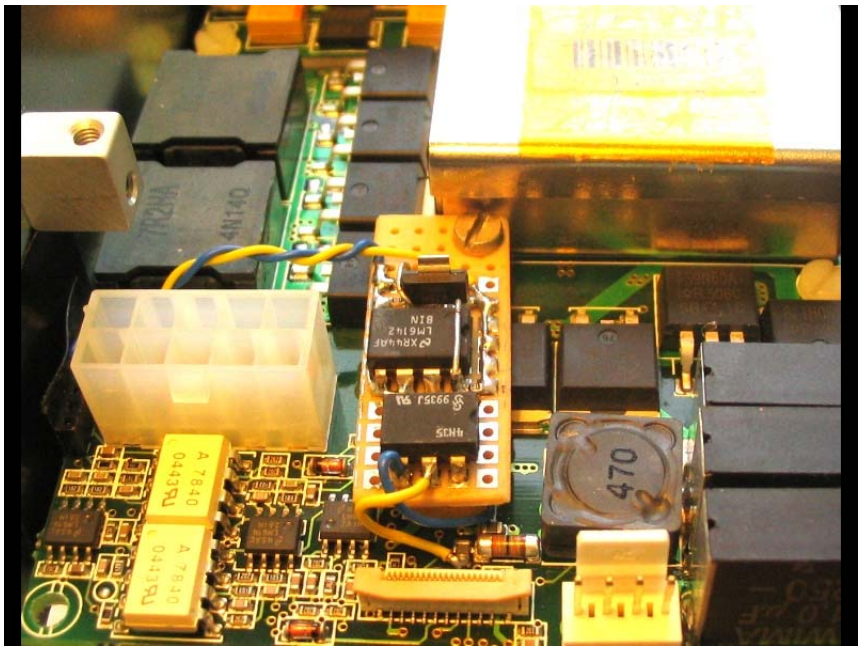
Input wires of the Ext OVP are soldered to pins of the connector J7 (in circle in the partial brick schematic below). GND connection is to pin 2, Vout is taken from pin 6.



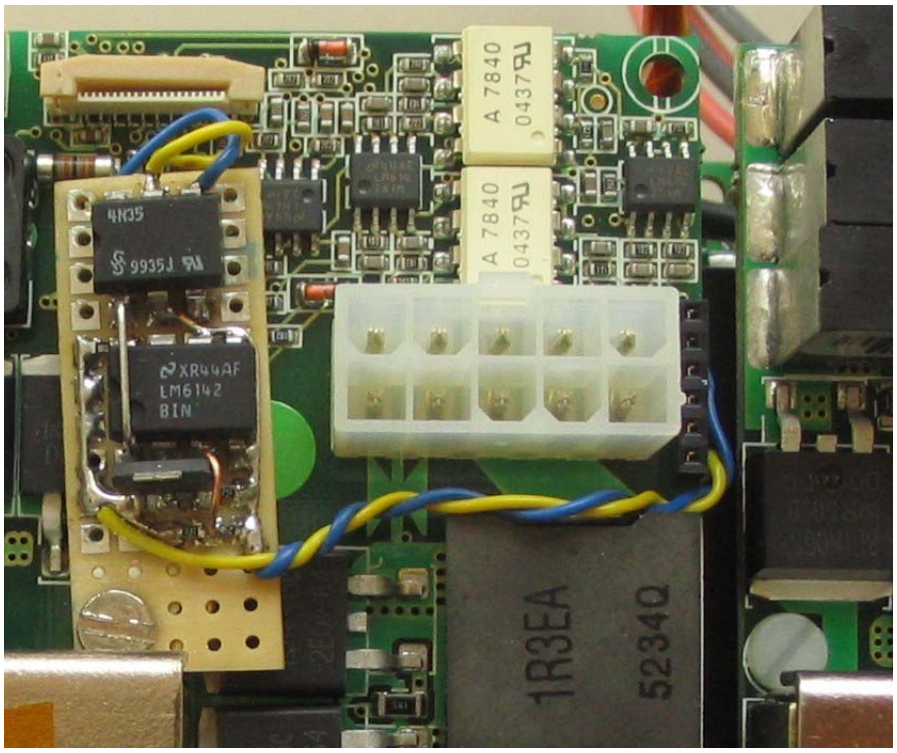
The output wires Of the Ext.OVP are soldered, with the negative going to the minus pin of the capacitor C59, and the positive going to inductance L13 (in circles in the partial brick schematic below).



The external OVP board is mounted to the brick by central screw and additional plastic cylinder.



The main problem of connection of the external OVP to the Brick is that there is no reliable point of connection to V_{out} on the top side of the Brick. We have to solder input wires to the pins (2, 6) of the J7 connector. But this point is very close to the input switchers of the other Brick or to the Box's case. So this connection must be done very carefully without damaging the wire insulation. (It is better to put extra insulation).



4. Measurements and testing

All Ext.OVP boards (before installation at the Brick) were tested by simple procedure. The input of the Ext. OVP was connected to the regulated DC power supply and the output to the 5V DC P.S. in series with a 1kOhm resistor and light diode. Then the V_{min} was measured by noting when the light diode turned on.

Measured figures:

Type	V thresh
3v	3.95v
5v	4.9v
15v	16.05v

After mounting the Ext.OVP to the Brick a Dynamic test was done. The Brick was started with minimum load; then V_{out} was trimmed to 50mV less than V threshold. The feedback was then shortcut and the Brick was forced to over voltage. The over voltage pulse was then measured by oscilloscope.

The picture below was typical of all 8 Bricks;

100mV/div, 500uS/div

Over voltage pulse: Amplitude = 160mV (pulse) – 50mV (to V thresh) = 110mV,
Time = 150uS at base.

After the first test, the Brick was left operating for a while so as to come to operating temperature. Repeating the test showed the same result.

5. Cost estimate

The cost of the satellite board in quantity is estimated at 12 CHF per brick. 2500 satellite boards would be produced. See the detailed estimate in the Appendix.

B. Local OVP using existing components in brick

The scheme and report are described in detail elsewhere

C. Summary and comparison of the two OVP systems

Both circuits (ext. OVP PCB board as well as modified brick v.6.5.) can be equivalent with the same performance. Bricks modifications can be done faster without new components (opamps and a PCB board) delivery delay.

D. Appendix

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Cost estimation of external OVP components + PCB
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B.Palan 18/09/2006

for 2500 bricks
-------------------------------------------------------------------------------
9494561 AMPLIFICATEUR OP CMS DOUBLE 17MHZ; Type d'amplificateur:Opérationnel;
        Nombre d'amplificateurs:2; Tension, alimentation + nom:5V; Bande
passante:17MHz;
        Tension, offset d'entrée max.:2.2mV; Slew rate:15; Température de fo
LM6142AIM
2500pcs Partiellement en stock(596)
      5,49 €  13 725,00 €
-------------------------------------------------------------------------------
1021173 OPTOCOUPLEUR SORTIE TRANSISTOR; Nombre de pattes:6; Optocoupler type:
      Transistor Output; Type de sortie:Transistor; Nombre de voies:1;
Tension,
      sortie max.:30V; Tension, isolation:5300V; Approuvé:UL, VDE;
2500pcs     Type de boîtier:  4N35.300   Partiellement en stock(1464)
            0,23 €  575,00 €
-------------------------------------------------------------------------------
3327164 REGULATEUR DE TENSION AJUST. CMS; Type de régulation de tension:
      Positive Adjustable; Tension, sortie:39.7V; Courant, sortie max.:1.5A;
      Tension, entrée max.:40V; Température de fonctionnement min.:0°C;
2500pcs     Température de fonc  LM317EMP   Disponible
      0,37 €  925,00 €
-------------------------------------------------------------------------------
722236      CONDENSATEUR 10000PF 50V; Capacité:10NF; Tension c.c.:50V;
      Type du diélectrique:Ceramic Multi-layer; Tolérance +:10%; Tolérance -
:5%;
      Température de fonctionnement max.:125°C;
2500pcs     Température de fonctionnement min.:-55°C;  2238 586 15636
Disponible        0,022 €  55,00 €
-------------------------------------------------------------------------------
1086793     CONDENSATEUR 0805 X7R 100NF 50V 10%; Capacité:100nF; Tension
c.c.:50V;
      Type du diélectrique:Ceramic Multi-layer; Tolérance +:10%; Tolérance -
:10%;
      Température de fonctionnement max.:125°C;
2500pcs     Température de fonctionnement m  B37941X5104K062   Disponible
            0,045 €  112,50 €
-------------------------------------------------------------------------------
(771260)  RESISTANCE CMS 240R; Type de résistance:Couche épaisse;
        Résistance:240Ohm; Type de boîtier:0805; Puissance:0.1W;
        Tolérance +:5%; Tolérance -:5%; Température de fonctionnement
max.:125°C;
7x2500pcs   Température de fonctionnement min  MC 0.1W 0805 5% 240R.
Disponible        0,023 € = 402.50 €
-------------------------------------------------------------------------------
Total cost of components 15 795.00 €


PCB fabrication
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PRINTED, CZ
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3x2cm^2

40pcs prototype 1.11euro/pc
2500pcs final 0.36euro/pc Total 905.00 € + assembly cost CZ (1euro/pcb?)

Brick OVP external board
Total price = components + PCB cost + assembly cost + mounting cost (LVPS group/CERN) = 15795 + 905 + 2500 = 19200€

~30kCHF /2500 brick pcs = 12CHF/brick
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