Voltage Clamp IC for Protection, Regulation and Mitigation of Failure Propagation

AMICSA 2021

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• Foundation of **SPACE IC** in 2014 by experts from the TELEFUNKEN IC product development
• **SPACE IC** exclusively takes over development and manufacturing of **rad-hard IC products** from TELEFUNKEN
Overview

Technical and Application Focus

• Space-Grade Analog and Mixed-Signal Integrated Circuits for **Power Management** and **Robust Data Interfaces**

IC Product Development

**Chip Development:**
- IC Spec
- IC Design
- Package Design
- Prototyping

**Testing:**
- Screening
- Evaluation
- Qualification

Manufacturing:

• Chip Foundry
• Wafer Test
• Dicing
• Assembly
• Screening
• Qualification Testing

Service:

• Mixed-Signal ASIC Service
• Manufacturing Service
Power Management Products

Modular Secondary Power Distribution

- PWM
- DC/DC Controller
- 12V DC/DC
- 12V DC/DC
- 12V DC/DC
- Module
- Module
- Module
- 1.5V Module
- 3.3V Module
- 1.1V Module
- Voltage Clamp
- Hi-POL
- POL
Power Management Products

Modular Secondary Power Distribution

- 12V DC/DC
- 12V DC/DC
- 12V DC/DC

- POL
- Voltage Clamp
- Hi-POL
- DC/DC Controller
- PWM

- 5V Module
- 3.3V Module
- 1.1V Module
- Module

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Redundancy DOES NOT necessarily "resolve" propagating failures!

Voltage clamping protection component is desired

- Discharges actively the node
- Faster reaction, than linear regulator
- No function interruption at OV events
- Can be used in combination with LCL
Voltage Clamp IC

Monolithic adjustable shunt voltage regulator:
- 10A shunt regulator, > 10V adjustable clamp voltage
- > 18W power dissipation capability (10ms)
- Stand-by current consumption < 200µA
- OT, OC and OV detection
- Configurable ALERT output
- Radiation-hardened by design

Voltage clamp:

POL protection:

Voltage regulator:
### ALERT Logic

<table>
<thead>
<tr>
<th>Detection Mode</th>
<th>MODE Input</th>
<th>ALERT Output</th>
<th>Latched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latch mode</td>
<td>HIGH</td>
<td>push-pull</td>
<td>YES</td>
</tr>
<tr>
<td>Flag mode</td>
<td>LOW</td>
<td>open-drain</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Modes:** MODE, ACT*, fault, fault register, ALERT, ALERT high-side, ALERT low-side
- **Signals:** VIN, POL, VCC, ALERT, GND, VOUT, VCL

**Logic Diagram:**

- **Diode:** Connected to VIN and POL
- **Resistor:** Connected to POL and GND
- **Capacitor:** Connected to VCC and ALERT
- **Diode and Resistor:** Connected to ALERT and GND

**Timing Diagram:**

- **Signals Timing:**
  - MODE: Active high
  - ACT*: Active high
  - fault: Active low
  - fault register: Active high
  - ALERT: Active high
  - ALERT high-side: Active high
  - ALERT low-side: Active low
- **Reset:** Indicated by a vertical line.
Electrical Characteristics

Overvoltage Event

Voltage Clamp:
• Fast reaction 1μs to 10μs
• Precise clamping

Load Regulation

Voltage Regulator:
• Corners simulation
• Load regulation < 0.1%/A
Thermal Design

**Dynamic Event**

Voltage Clamp:
- Short-time power absorption
- 18W power @ 10ms
- Power completely absorbed in chip die

![Diagram of Voltage Clamp](image)

\[ \Delta T = +32^\circ C \]

at die surface hotspot

**Static Regulation**

Voltage Regulator:
- Continuous power absorption
- 2W power steady-state
- Thermal flow via heat sink glued to pcb

![Diagram of Voltage Regulator](image)

\[ \Delta T = +32^\circ C \]

at die surface hotspot
Dynamic Thermal Analysis

Thermal Characteristics:

- Thermal Impedance [K/W]
  - Internal thermal capacitance
  - External heat flow
  - Die thermal resistance

Power Absorption [W] (@ 3V / 125°C Operation)

Alert Functions and SOA:

- Safe Operating Area
  - Over-current alert
  - 250°C damage threshold
  - Over-temperature alert
  - 165°C

- Power Absorption [W]
  - Shunt capability

Event Duration [ms]

0.01 0.1 1 10 100 1000 10000 100000

0.01 0.1 1 10 100 1000 10000 100000
Conclusion

Voltage Clamp IC component is designed:

• Easy applicable and versatile
• Fast and precise clamping and regulation
• Careful thermal design
• Radiation-hardened
• Test results will follow
Special thanks to ESA, the co-authors and other contributors to

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Thank you for your attention!

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