Protecting DUTs at Hardware Speed: Inside the Tektronix MP5000 PSU Platform

TECHNICAL BRIEF

Overview

Modern validation and production test environments demand fast, deterministic power supply behavior and robust protection schemes to safeguard both devices under test (DUTs) and test hardware. The Tektronix MP5000 Series platform delivers on these needs by combining high-density modular power supply units (PSUs) with hardware-based protection features.

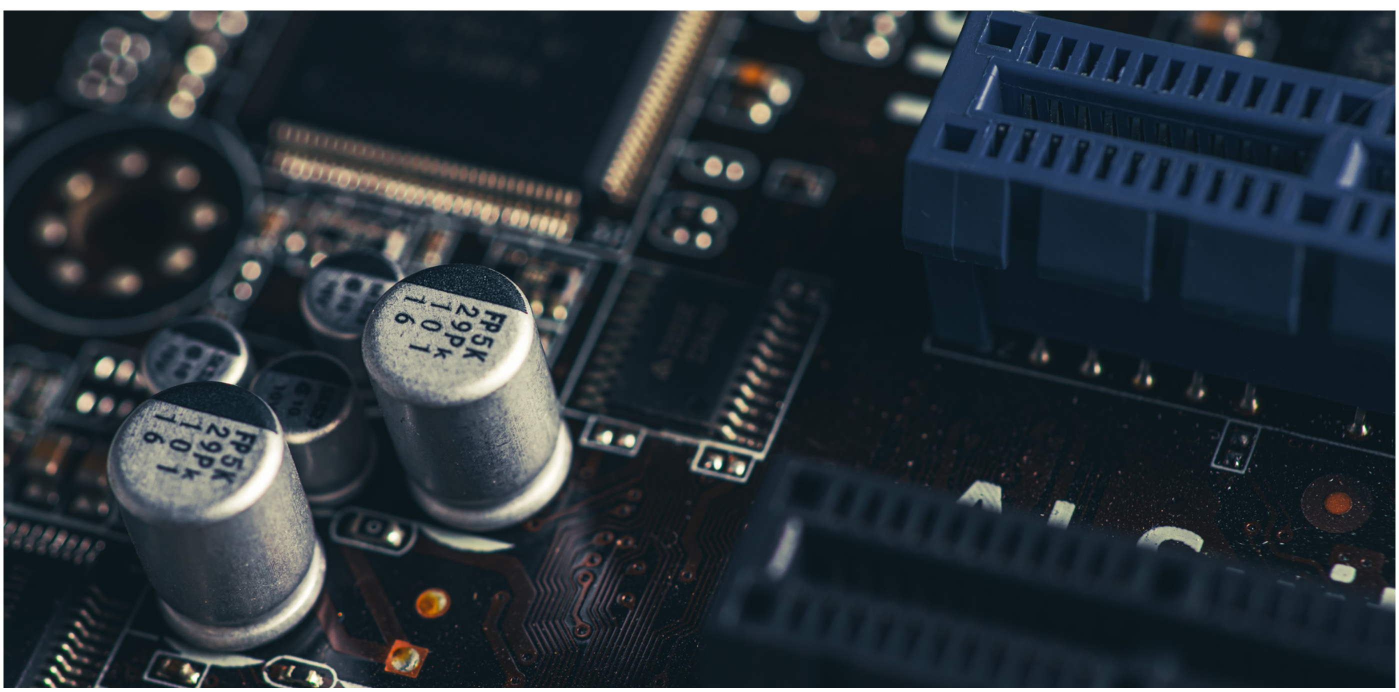
Each MP5000 Series PSU module embeds per-channel output disconnect relays and autonomous Overvoltage (OVP), Overcurrent (OCP) and Overtemperature (OTP) protection. These fast-acting protections operate at hardware speed (trip times under 50 µs) and instantly isolate the DUT via solid-state relays. In practice, this means that if a voltage spike or current surge occurs, the PSU opens its output relays within microseconds, preventing damaging power from reaching the DUT. The result is repeatable, fail-safe power sequencing that minimizes downtime and prevents costly DUT failures.

Output Disconnect Relay (solid-state):

A key hardware feature is the output disconnect relay on each PSU channel. This solid-state relay physically opens the output terminals whenever the supply is turned off or a fault occurs. In practice, if an overcurrent or overvoltage event is detected, the relay opens within 50 µs, immediately isolating the DUT from the power supply. Importantly, the relay disconnects all terminals (force and sense), providing complete isolation. Users should ensure safety ground references to the DUT and fixture are maintained as needed (the relays are on the current paths). In normal operation, the relays remain closed to pass power to the load until the supply is turned off. Users should note that once the relays open (for example, after a fault), the DUT and leads may still hold charge, so safe handling procedures (discharging capacitive loads, verifying power off) are recommended before reconnecting the DUT. Combined with its flexible trigger and digital I/O capabilities, the MP5000's hardware features enable test systems that are both high-throughput and inherently safe.

In automation, scripts or handlers might use the relay status: for example, once output is set to ON, the script can monitor *`source.output` or related status bits to confirm the relay is closed. If a protection trip occurs, the script can also wait on or detect *`source.output = psu.OFF` or the protection flag using the *`source.protect.trippedi and *source.protect.trippedv` commands.

Because the relays are solid-state, they require no replacement or mechanical maintenance. However, engineers should always treat the outputs as potentially energized (due to charge on the DUT) until they are fully discharged.



Close-up of a representative circuit board, illustrating the type of DUT environment where the MP5000's fast, hardware-based protection mechanisms (OVP, OCP, and OTP) ensure safe and reliable operation

Understanding PSU Protection on MP5000: Technical Deep Dive

The MP5000's PSU modules implement four primary protection mechanisms: Overvoltage Protection (OVP), Overcurrent Protection (OCP), Overtemperature Protection (OTP) and an Overpower Voltage Limit. All protections are per-channel (i.e., each channel can have independent settings) and operate primarily in hardware without requiring host intervention. Below are details on how each mode works, including spec values and user considerations.

Overvoltage Protection

OVP continuously monitors the channel's output voltage at its output terminals. If the actual voltage exceeds the user-set OVP threshold, the hardware trips and opens the output disconnect relay. In effect, OVP enforces a maximum voltage limit beyond the normal regulated output. For example, if a DUT shorts or enters an unintended high-voltage state, OVP will prevent the PSU from exceeding the safe limit. Tektronix specifies that the OVP trip occurs in under 50 µs, thanks to fast internal comparators and the solid-state relays.

The OVP setpoint range is from 0.1 V up to 55 V for the MPSU50-2ST module. Notably, OVP is not coupled to the current limit; even if the channel is already in current limit (CC mode), exceeding the OVP threshold will still cause a hardware shutdown. In practice, engineers set the OVP slightly above the DUT's expected normal operating voltage. In remote sense mode, this practice prevents unintended OVP trips caused by voltage drops in the source leads. These drops can raise the voltage at the output terminals above the set point, as the supply compensates to deliver the programmed voltage to the DUT. If the DUT's voltage rating is unknown, a common strategy is to set OVP about 10% above the intended source voltage, then observe behavior and adjust as needed. Because the MP5000 provides direct control (via TSP, web UI, or front panel) to enable/disable OVP, set the level and read the OVP trip flag, one can dynamically adapt OVP for different phases of a test.

Overcurrent Protection

OCP similarly monitors the output current. If the current draw exceeds the programmed OCP limit, the relay opens to isolate the load. OCP is a hard limit, independent of the normal current limit regulation. While the standard current limit function (constant-current or CC mode) throttles the output to maintain a set current value without shutting off, the OCP function triggers a hardware shutdown above the OCP threshold. Tektronix specifies an OCP response time of under 50 µs as well. The OCP setpoint range is from 0.25 A to 5.5 A per channel for the MPSU50-2ST.

In short, OCP protects the DUT from fast transients or shorts that the normal CV/CC loop might not catch quickly enough. For example, a capacitive load that suddenly changes voltage could briefly draw a large surge; if that surge exceeds the OCP, the supply immediately opens the disconnect relays. Best practices to avoid nuisance tripping OCP include using the slowest practical slew rate when driving heavy capacitive loads, which helps smooth out inrush current, and placing capacitors or filters on the DUT side to prevent rapid changes that could drive the PSU into an overcurrent state. Like OVP, each channel's OCP can be enabled/disabled, set and monitored separately via software and the UI.

Overtemperature Protection (OTP) & Thermal Behavior

To protect the PSU hardware itself, each module monitors its internal temperature. If an overtemperature condition is reached, the PSU shuts off all outputs. OTP is not user-configurable: it is always enabled and cannot be disabled. When OTP trips, the relays open as in other faults. In practice, OTP is most relevant in high-density racks or heavy-duty conditions; in typical lab or fab use, it is rare.

Engineers should ensure adequate airflow and cooling per the MP5103 Airflow guidelines (ventilation and fan cooling in rack mounting) in the MP5103 User Manual to avoid reaching thermal limits. If an OTP event does occur, the recommended action is to let the mainframe fans run with outputs off to cool the module for 30 minutes before turning the outputs back on. Outputs are blocked from turning on until the internal temperature falls back into safe range. The front panel will indicate an overtemperature fault if this happens. Because OTP is so rare in normal use, the easiest approach is prevention: avoid blocking vents, place heat-generating equipment higher in the rack away from sensitive measurement equipment and operate below maximum load.

Overpower Voltage Limit Protection

The MPSU50-2ST also includes a unique overpower limit to cap the maximum power delivered, addressing cases where high source lead resistance causes large voltage drops on the source leads. This feature ensures the PSU never supplies more than a fixed power limit (75 W on the MPSU50-2ST). During normal operation, the PSU does not allow the programmed voltage multiplied by the current limit to exceed 50W, but due to possible large source lead drops, the PSU-supplied voltage can exceed the programmed voltage. The PSU will not allow the voltage output from the terminals to be greater than 75W based on the programmed current limit. For example, if the current limit is set to 5 A, the PSU will not allow the voltage to rise above about 15 V (since 15 V × 5 A = 75 W).

In practice, an overpower event looks very much like OVP: the relay opens and an OVP trip is reported. This feature cannot be disabled by the user. To avoid spurious overpower trips, designers should minimize lead resistance (use heavier gauge or shorter leads) so that the voltage doesn't climb to compensate for drops. Because this protection is internal to the PSU, a user observing an unexpected overvoltage trip might check whether they inadvertently asked for more voltage than the module's power budget allows. In all, the overpower limit is a safeguard against runaway conditions when driving high power.

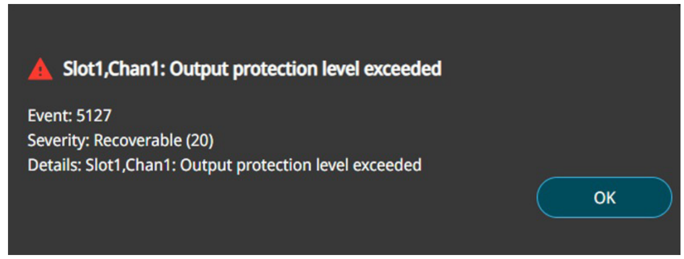
Diagnostics & Status Registers

The MP5000 provides clear indicators and status bits for each protection mode. The measurement event registers (accessible via TSP) include a Protection Summary bit that signals a trip has occurred on any protection. In TSP, users can also query each channel's protect status individually via commands like:

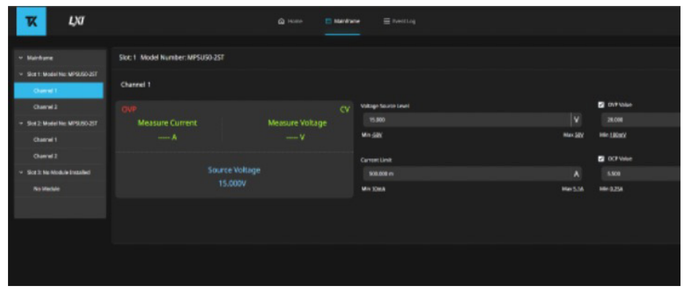
```
slot[z].psu[x].source.protect.trippedi  -- returns 1 if OCP tripped

slot[z].psu[x].source.protect.trippedv  -- returns 1 if OVP tripped
```

(These commands report whether an overcurrent or overvoltage event has occurred since the last clear.)

The front panel display and the Web UI also show clear LED/status indicators for OVP, OCP, or OTP on each channel. For example, if an OVP trip occurs, a red icon labeled OVP appears on the channel's UI panel, and the error log will note Protection Tripped (OVP). Because the protection shutdown is an isolation event, a subsequent clear or restart is not required to resume. Once the condition is corrected, the user can simply turn the output back on (the relay will close again) without needing to explicitly clear the fault.



Error Message Protection Tripped



OVP Indicator on webpage. Users do not need to clear a protection trip to resume operation.

To sum up, the MP5000 supports test automation from no-code to full code. On the instrument side, TSP scripting and trigger models handle fast, local logic. From the host, Python or other drivers can orchestrate higher-level test sequences and collect telemetry. The web UI provides a quick readout, and the front panel display is handy for bench use. In every case, the OVP/OCP/OTP mechanisms work the same, and their statuses can be observed and controlled through all these interfaces. This multi-path integration ensures that whether you're debugging on a bench or running a factory line, the MP5000's protection features can be woven into your toolchain.

This approach ensures that even in a high-voltage ramp test, a single transient only pauses that specific channel. The rest of the multi-channel test array continues uninterrupted, saving time and avoiding a full system reset.

Example Workflow: Protecting DUTs in High-Throughput Production

In a production test line, speed and determinism are paramount. A single device failure (such as a shorted DUT) should not bring the entire line down. The MP5000's channel-level protections shine in this context by isolating problems without halting other DUTs.

Scenario

Imagine a wafer-probing station with multiple DUTs powered by several MP5000 PSU channels. If one DUT suddenly short-circuits (for example, due to a process defect), its PSU channel's OCP will trip. Because each channel acts independently, one lane shuts off while neighboring lanes remain powered and testing. This parallel protection strategy ensures that the rest of the system continues to run.

Implementation

In a TSP or host script, you can treat each channel as self-monitoring. The script configures all channels with appropriate OVP/OCP levels, then enters the main test loop. Concurrently, it monitors **`slot[Z].psu[X].source.protect.trippedi`** for each channel. If it detects a tripped status, it immediately takes action on that specific channel. For example, the script might log the failure, alert the handler, and turn off or reset that channel. Crucially, the script may also drive a digital output line connected to the handler mechanism. For instance, if channel 3 trips, the script can pulse a Channel 3 Fault output pin. The handler or robotic system sees the pin and can remove the defective DUT for sorting, then load the next one.

Performance Impact

Because the MP5000's protection trip is so fast (<50 μs) and handled in hardware, the channel shutoff is deterministic. The only overhead in software is a few microseconds to detect the flag and send a trigger signal. In practice, this latency is negligible compared to process times. The benefit is large: only one DUT/test collapses instead of an entire multi-site line. Testing throughput remains high, since the other channels continue uninterrupted. The key is that the MP5000 does not require a system-wide reset on a PSU trip; only the affected channel is taken down, as described in the Parallel protection strategy above.

Engineers often tie the MP5000's event flags to factory automation. For example, many integrators connect one of the mainframe's digital output pins to an external GPIO module. When protect.trippedi goes high, a TSP script immediately sets that pin, which triggers the test handler hardware. This kind of integration requires only a few lines of TSP code but leverages the hardware-level response for maximum efficiency.

TPS Code Examples

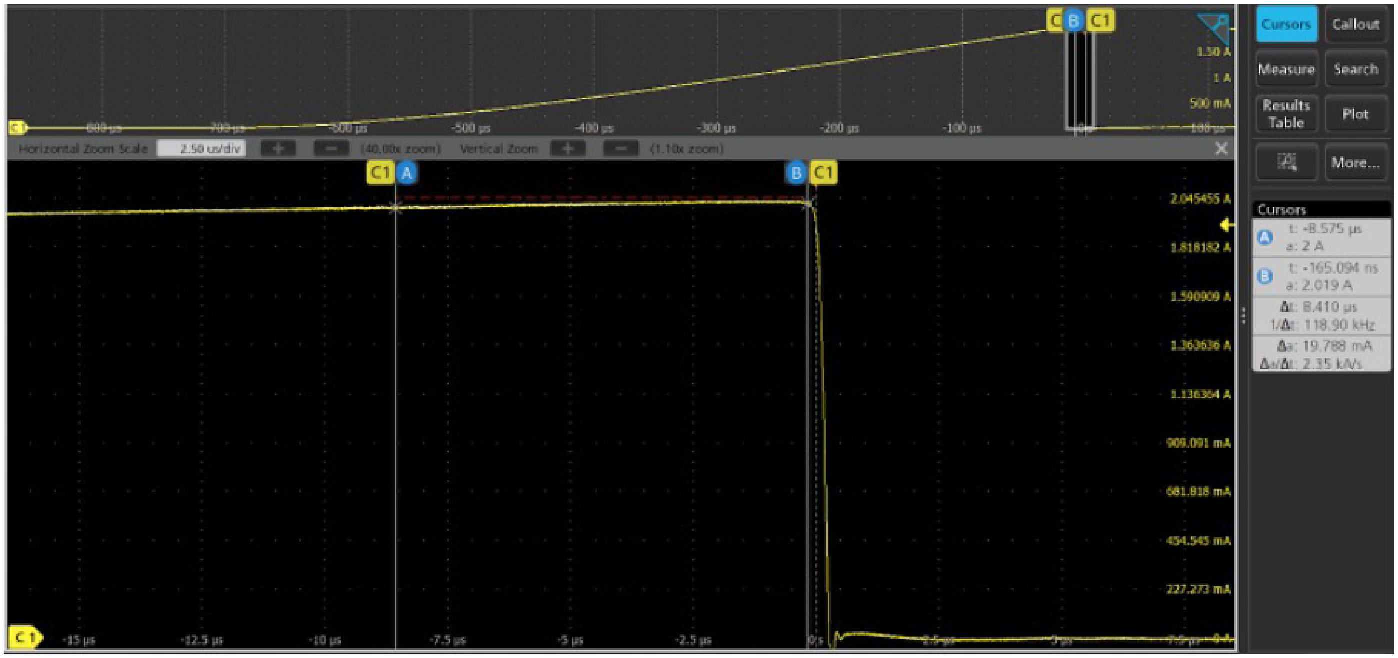
While full code will depend on the application, a typical TSP sequence might look like this:

```
-- Alias the PSU
local slot_no = 2
local chan_no = 1
local psu = slot[slot_no].psu[chan_no]

-- Reset to power-on defaults
psu.reset()
digio.trigger[1].reset()

-- Set sourcing levels
psu.source.levelv = 5
psu.source.limiti = 100e-3

-- Configure protect settings
psu.source.protect.enablev = psu.ENABLE
psu.source.protect.enablei = psu.ENABLE
psu.source.protect.levelv = 10
psu.source.protect.leveli = 250e-3

-- Initialize digio for a trigger on OVP/OCP
digio.trigger[1].mode = digio.MODE_TRIGGER_OUT
digio.trigger[1].logic = digio.LOGIC_NEGATIVE

-- Turn output on
psu.source.output = 1

-- Every 10ms check for an OCP/OVP event
while bit.bitand(slot[slot_no].status.measurement
protection.condition, slot[slot_no].status
measurement.protection.PSU1) == 0 do
delay(10e-3)
end

-- Assert a trigger on the first digio line
digio.trigger[1].assert()
print("TRIPPED")
```

This snippet demonstrates how to programmatically set limits and poll the trip flags. In practice, you could expand the logic to log the exact time or condition of the fault, or to immediately switch to a contingency flow.

Logging and Waveforms

When tuning protection limits, it can help to capture the event waveforms. The MP5000's fast measure rate mode (~400 readings per second) is insufficient to catch a 50 μs event in detail. Instead, Tektronix recommends using an oscilloscope to probe the output. For example, hook a high-speed scope to the PSU output terminals while intentionally provoking an OCP trip. You should see the current spike and then fall off as the relay opens (with ≈50 μs delay). Such a capture confirms that the hardware acted correctly and shows any ringing or overshoot you might need to address. Keep an eye on the scope's time base and use a trigger if needed to isolate the event.



Scope capture of OCP trip opening output

Status Registers

The protection event is recorded in the module's status registers. One can read **`slot[Z].status.measurement.condition`** which has a protection summary bit as bit 3 in the register. For debugging, reading these bits immediately after an event is helpful.

Key Advantages

The MP5000's integrated protection features offer several benefits over traditional power supplies or external protection schemes:

Integrated Automation and Safety

The MP5000 marries protection with advanced automation. TSP scripting and TSP-Link ensure protection is part of the test program, not an afterthought. The platform also includes user interlock circuits (for operator safety) and software lockouts, but crucially, the DUT protection features described here operate regardless of user intervention. This layered safety allows engineers to focus on test recipes, confident that the hardware will intervene instantaneously if something goes wrong.

Seamless Instrument Ecosystem

Whether you control the system via Python, IVI, or the web GUI, you see and set the same protection parameters. This consistency reduces errors. For example, setting OCP on channel 2 can be done by sending a single TSP command through TSP Toolkit, calling it via the drivers, or using the language of your choice, and the channel's fault status is visible in the UI and in code. It all works together to speed development and deployment of safe test routines.

Competitive benefits of the MP5000

Feature	MP5000	Competition
Per-channel hardware protection	Independent OVP, OCP, OTP, per channel. Hardware trips open the output disconnect relay	May rely on regular shutdown or require add-on protection modules for full physical isolation
Protection response time	Relay opens in less than 50 μs when a hardware trip occurs. This is faster than any software response and comparable or better than discrete crowbar circuits.	Slower response time; energy continues to reach the DUT during the delay.
Modularity and Serviceability	Swap modules without powering down the mainframe	Competitors require a power-down to service the module
Multi-chassis synchronization	TSP-LINK™ for sub-microsecond sync across nodes	An equivalent high-speed synchronization bus is often unavailable
Physical Isolation	When tripped, the MP5000 physically opens the output circuit via solid-state disconnect relays, fully isolating the DUT.	Many power supplies only shut down the output regulator; the DUT remains electrically connected.
Channel Density	Up to 6 independent PSU channels in a single 1U chassis (three dual-channel modules), each with its own OVP/OCP/OTP settings.	Competing solutions often require more rack space or external protection boxes to achieve equivalent per-channel granularity.

The Tektronix MP5000 Series platform combines hardware-enforced OVP, OCP, OTP, and power limiting, all at per-channel granularity with the compact efficiency of a 1U rack unit. The platform gives test integrators fail-safe protection without sacrificing throughput. In the rare event of a fault, the MP5000 confines the problem to the affected channel, signals it clearly, and enables rapid recovery with no system-wide reset required. Proper configuration of protection limits based on DUT specifications, good wiring practice, and adequate cooling ensure smooth operation, empowering engineers to push testing performance with confidence.

Engineers can use DUT validation in real-world lab environments to ensure reliable testing and system performance.

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Rev. 02.2022

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