

DS1110A / DS1111A / DS1112A Multimode Fault Injection Lasers



Why We Developed Them

Observations

Many labs use laser cutters. However, some of our users also needed additional features and capabilities including:

1. The ability to inject multiple faults at the target within a short interval. Laser cutters need to charge the laser crystal for the laser effect to initialize. Charging is relatively slow, taking hundreds of microseconds.
2. Accurate timing of laser pulse with a short response time. The laser cutter charging phase introduced a delay in the response to trigger. The nature of the charging effect introduces jitter in the delay and makes laser pulse timing inaccurate.
3. The ability to repeat a laser fault injection. Repeating a fault injection requires accurate timing and power control. Laser cutters show energy instability between pulses and over time.
4. A laser cutter setup that's easy to run all the time. Typically, a laser cutter's flashlight must be replaced regularly.

To meet user needs, we developed lasers based on a diode laser. Diode lasers are typically low power. We selected diode lasers with the highest power in its range to create multimode fault injection lasers.



Improvements to the multimode fault injection lasers include:

1. Multi-pulse functionality to inject multiple faults at the target within a short interval.
2. Accurate timing of laser pulses with short response times. Diode lasers react at least 1,000 times faster than laser cutters.
3. Highly stable pulse power. Diode lasers show greater stability between pulses and greater stability over time.
4. A diode laser's long life translates into much greater reliability.

Challenges Multimode Lasers Solve

1. Supporting multiple countermeasures

Generating multiple faults at the target makes it possible to pass multiple defensive countermeasures at the target.

2. Reacting quickly to observed process steps

By measuring side channels as power and electromagnetic signals, testers can recognize patterns of process steps running on the target. Shortly after pattern recognition, they need to be able to quickly generate a laser pulse.

3. Having lasers available 24/7

Searching for fault injection vulnerabilities is often a time-consuming activity. Testers need to have their laser fault injection system running around the clock.

4. Ensuring laser power stability

Thermo-electric cooling inside the lasers provide accurate temperature control for laser power stability and low trigger jitter. A sealed laser container with protective gas minimizes contamination and aging compared to laser cutters.



Figure 1. The 445 nm DS1110A Multimode Fault Injection Laser’s blue light can penetrate apertures in metal layers (front side), which are smaller than 1 micron

Unique Features

1. High-power fault injection lasers

Multimode laser diodes with a high-power rating are selected. This allows coarse chip surface scanning with a large spot size and sufficient intensity within that spot.

2. High pulse frequency, a short delay, and minimal jitter

High pulse frequency allows multi-pulse fault injection attacks. A short delay between the trigger pulse and actual light pulse in combination with minimal jitter allows for accurate laser pulse timing.

3. A large spot size

By applying objectives and the Spot Size Reducer, a spot size with a 100:1 range makes it possible to choose from coarse to detailed chip surface scanning.

4. Laser diodes with a long life

Laser diode aging is minimal.

5. Integration with Keysight products

Multimode fault injection lasers are compatible with the Fault Injection Laser System, Dual Laser Fault Injection System, and older Diode Laser Station. Optical power and laser timing are controlled by the Smartcard Voltage and Clock Glitcher or Glitch Pattern Generator.



Figure 2. A free laser beam exits from this side (pictured above). Connectors for the interlock switch, power control, triggering, and fault injection laser current monitor are on the other side

Use Case: Near-Infrared Laser

Multimode fault injection lasers comprise three versions: the 445 nm DS1110A Multimode Fault Injection Laser, 808 nm DS1111A Multimode Fault Injection Laser, and 1064 nm DS1112A Multimode Fault Injection Laser. This use case covers the 1064 nm or near-infrared (NIR) laser. Use cases for the 445 nm (blue) and 808 nm (red) multimode lasers are very similar, including only the front (metal side) instead of the back (substrate side).

The test scenario

6. Select your objective. To determine spot diameter, use the Spot Size Reducer.
7. Mount the Spot Size Reducer onto the Fault Injection Laser Station (if you're using it), then position the 1064 nm DS1112A Multimode Fault Injection Laser on top. If you don't use the Spot Size Reducer, mount the laser directly on the Fault Injection Laser Station.
8. Decap the chip and fix the target underneath the microscope.
9. Identify the relevant part of the chip with the AV Goldeye G-008 InGaAs Camera.
10. Set up communication to the target.
11. Define test parameters to check for laser fault sensitivity.
12. Evaluate results.



Figure 3. The 1064 nm DS1112A Multimode Fault injection Laser mounts directly on the Fault Injection Laser Station or onto the Spot Size Reducer to reduce spot diameter by a factor of 10x


Technical Specifications

Connectors

- Pulse amplitude: SMB, 1 k Ω . Analog input 0.0 – 3.3 V corresponding to 0% – 100% laser power
- Digital glitch: SMB, 50 Ω . TTL level, laser active high
- Diode current: negative analog voltage proportional to laser diode current
- Interlock: 12 V DC connected to Safety Box PSU
- Lifetime: > 3,500 hours continuous operation

	Blue	Red	NIR
Wavelength	445 nm	808 nm	1064 nm
Laser pulse power	3 W	20 W	30 W
Trigger to laser pulse delay	40 ns		
Laser pulse duration	2 ns - 100 μ s		
Pause time between laser pulses	10 ns - ∞		
Spot size 5x / 20x / 50x objective, no SSR	400 x 140 / 100 x 35 / 40 x 14 μ m	600 x 150 μ m / 150 x 38 μ m / 60 x 15 μ m	
Spot size 5x / 20x / 50x objective, with SSR	40 x 14 / 10 x 3.5 / 4 x 1.4 μ m	60 x 15 μ m / 15 x 3.8 μ m / 6 x 1.5 μ m	

Package

Quantity	Description	Photo
1	Multimode laser head 445 nm (blue), 808 nm (red), or 1064 nm (NIR)	

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