CURRENT LIMITING DIODES

abstract

The explosive growth of emergent end-markets such as Solid State Lighting (SSL), test & measurement, and low voltage power management is driving the need for current regulation methodologies.

To satisfy the need for lower cost current regulation solutions, a cost-effective discrete semiconductor device can be utilized for a wide range of emerging low current applications.

basics of current limiting:

What is a Current Limiting Diode?

A current limiting diode (CLD) or current regulating diode (CRD) is a diode that regulates and limits current over a specified voltage range. These devices allow the passage of current, rise to a certain value, and then level off at a specific value. Contrary to Zener diodes, which keep voltage constant, CLDs keep the current constant. A CLD can also be considered a current source as it is an electronic circuit that delivers or absorbs an electric current, independent of the voltage across it. The CLD or current source is considered the dual of a voltage source.

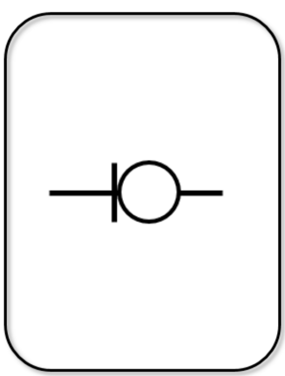


Figure 1: CLD symbol

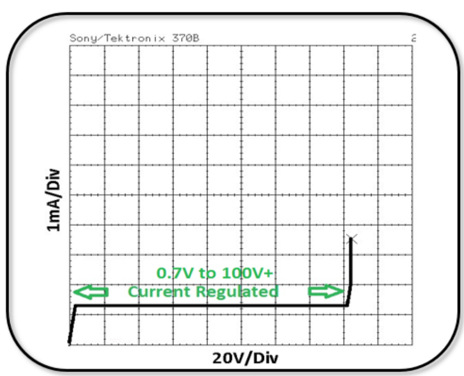


Figure 2: I/V curve tracer measured

How are CLDs specified?

Forward characteristics are very insignificant when selecting a CLD and are typically not specified. Below is a datasheet for the CMJ0130-CMJ2700.

When selecting a CLD, one should:
(in order of importance)

(1a) Select the desired level of current regulation.

(1b) Select a peak operating voltage that is larger than the maximum operating range.

(2) Select a maximum limiting voltage at or below the minimum regulating voltage requirement

(3) Select a package with adequate power dissipation

MAXIMUM RATINGS: (T_A=60°C)	SYMBOL		UNITS
Peak Operating Voltage (CMJ0130 THRU CMJ5750)	(1b) P_{OV}	100	V
Peak Operating Voltage (CMJH080 THRU CMJH220)	P_{OV}	50	V
Power Dissipation	(3) P_D	500	mW
Operating and Storage Junction Temperature	T_J, T_{stg}	-65 to +150	°C
Thermal Resistance	Θ_{JA}	180	°C/W

ELECTRICAL CHARACTERISTICS: (T_A=25°C unless otherwise noted)

Type	(1a) Regulator Current (Note 1) I_P @ V_T=25V			(4) Minimum Dynamic Impedance Z_T @ V_T=25V	Minimum Knee Impedance Z_K @ V_K=6.0V	(2) Maximum Limiting Voltage V_L @ I_L=0.8 x I_P MIN	Temperature Coefficient (Note 2) TC	Marking Code
	MIN mA	NOM mA	MAX mA	MΩ	kΩ	V	%/°C	
CMJ0130	0.05	0.13	0.21	6.0	2,000	0.6	+2.10 to +0.10	101
CMJ0300	0.20	0.31	0.42	4.0	1,000	0.8	+0.40 to -0.20	301
CMJ0500	0.40	0.515	0.63	2.0	500	1.1	+0.15 to -0.25	501
CMJ0750	0.60	0.76	0.92	1.0	200	1.4	0.0 to -0.32	701
CMJ1000	0.88	1.1	1.32	0.65	100	1.7	-0.10 to -0.37	102
CMJ1500	1.28	1.5	1.72	0.45	70	2.0	-0.13 to -0.40	152
CMJ2000	1.68	2.0	2.32	0.35	50	2.3	-0.15 to -0.42	202
CMJ2700	2.28	2.69	3.1	0.30	30	2.7	-0.18 to -0.45	272

How are CLDs developed?

CLDs start with a JFET process where the gate and source are connected. This interconnect is part of the diffusion process. Additionally, the diffusion process for each type is carefully controlled in order to provide the specific regulation current required.

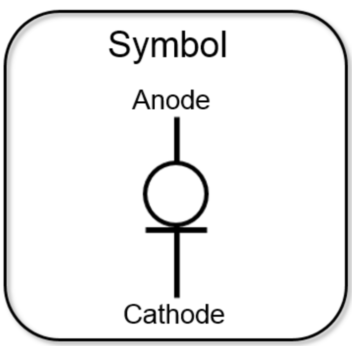


Figure 3a: Device symbol

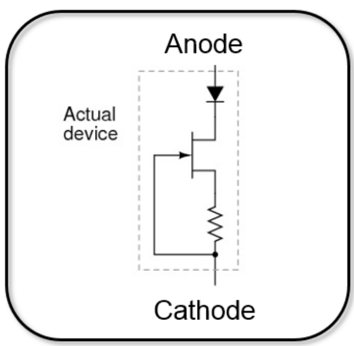


Figure 3b: JFET current limiter

advantages of CLDs:

Why are CLDs a better solution for low current applications?

Only one Central Semiconductor CLD is required in order to accomplish the function; other options are typically more costly and much more complex. Management ICs often require a 5V voltage source that will also add to overall power/current consumption, complexity and cost of the circuit.

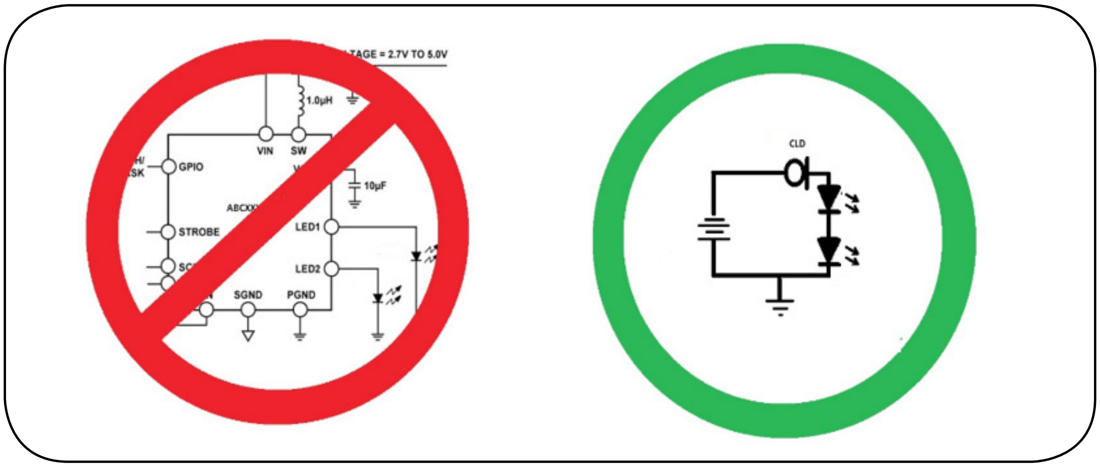


Figure 4: Management IC with 5V source versus CLD alternative solution

What other types of current limiting devices are there?

The practice of limiting current in a circuit can also be accomplished with both active and passive components:

Current Management ICs
(Power Management ICs) are integrated chips used for managing the power requirements of a system. PMIC refers to a wide range of chips on the market, however most include some form of electronic power conversion and power control function. These often require several components.

Fuses
Resettable fuses can provide on-battery over-current protection. They have a similar function to thermal fuses, but after opening, will reset once the fault conditions have been removed and must be cooled down again before limiting current.

Resistors
Current limiting resistors are designed to limit the flow of current to a calculated value limit that may be delivered to a load to keep current within certain range.

These are not ideal solutions, however: active components add cost and complexity, while passive components provide little or no regulation and are energy inefficient. **CLDs are the superior choice.**

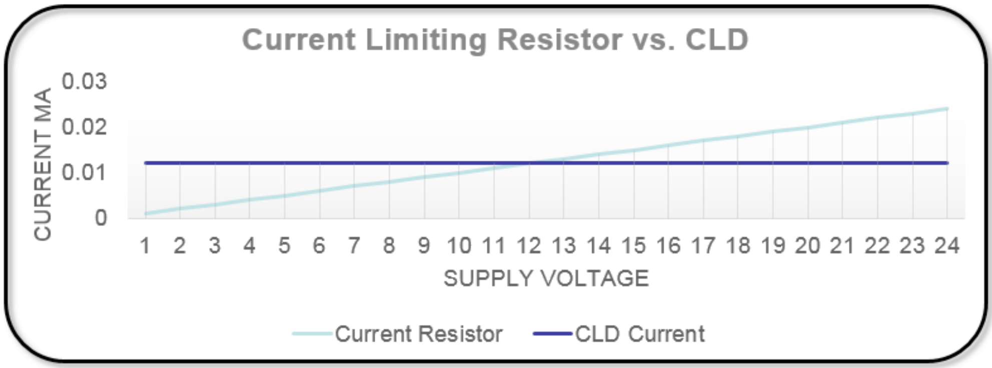


Figure 5: Resistor versus CLD solution

CLD performance:

Why are CLDs superior?

Besides being a simple and cost effective solution, another benefit of using CLDs is the wide operating voltage range.

Wide operating voltage range

Beginning at its specified voltage, a CLD can regulate current to voltages of 100V and beyond. Figure 4 shows a CLD with a current rating of 1.5mA regulating current up to 100V.

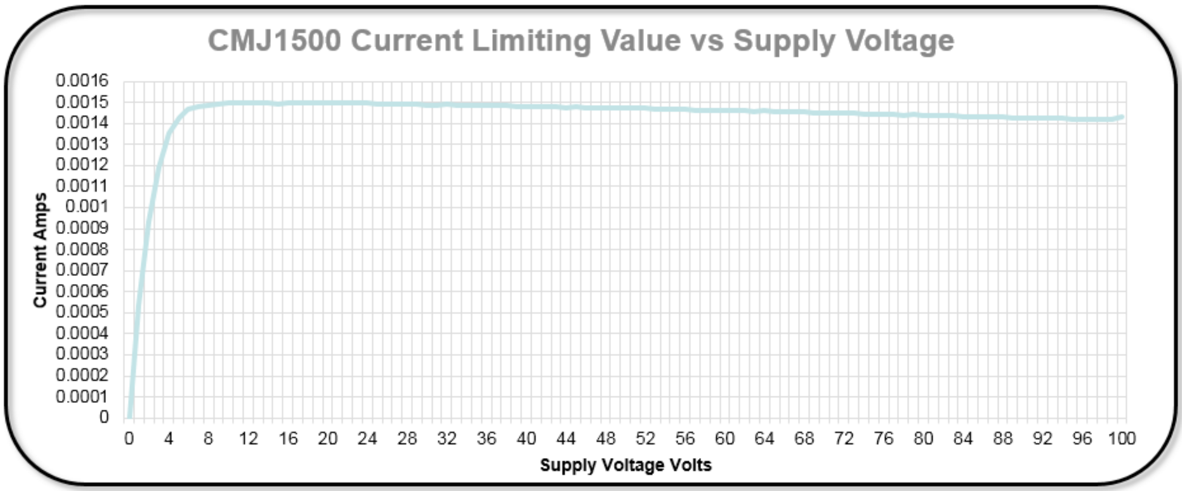


Figure 6: 1.5mA regulation from 2V to 100V

Inherent voltage surge suppression

The voltage range of the CLD combined with current limiting ability results in excellent voltage surge suppression. Shown below is a relay closing connecting a CLD to a 100V, 2A supply.

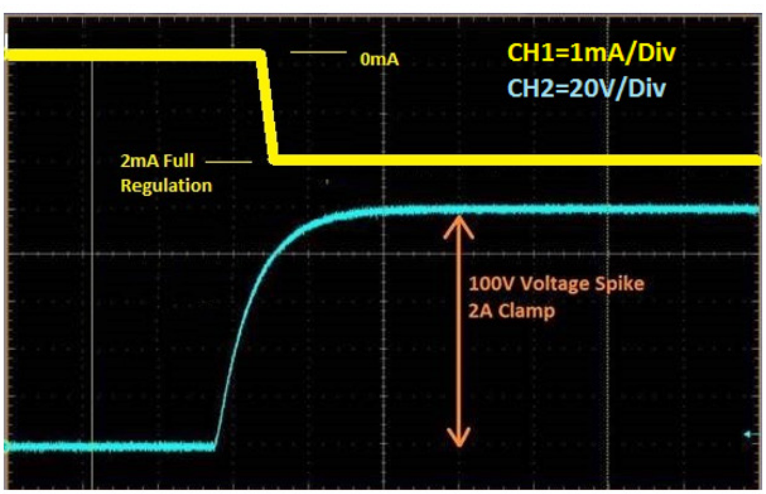


Figure 7a: Response of CLD to 100V, 2A spike

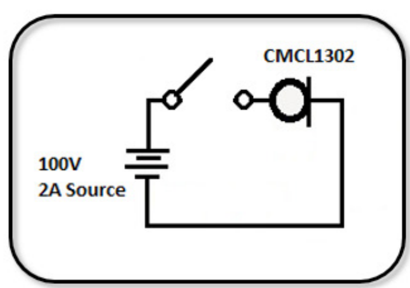


Figure 7b: Test circuit

Flickering and buffer noise in LED applications

One of the more common issues with LED light is flickering; any source voltage variation or noise can be visually detectable and very unwanted in LEDs. While there are many reasons an LED lamp can flicker, the most common are:

- **AC line frequency related light fluctuation**
  Linear power supplies generate high frequency switching noise.
- **Noise**
  This phenomenon may be due to several things: internal clocking transients, high speed turn-on and turn-off of output switches, and others that are inherently difficult to reduce or eliminate.
- **Random light intensity fluctuation**
  Often caused by incompatibility between lamp and peripheral lighting components.

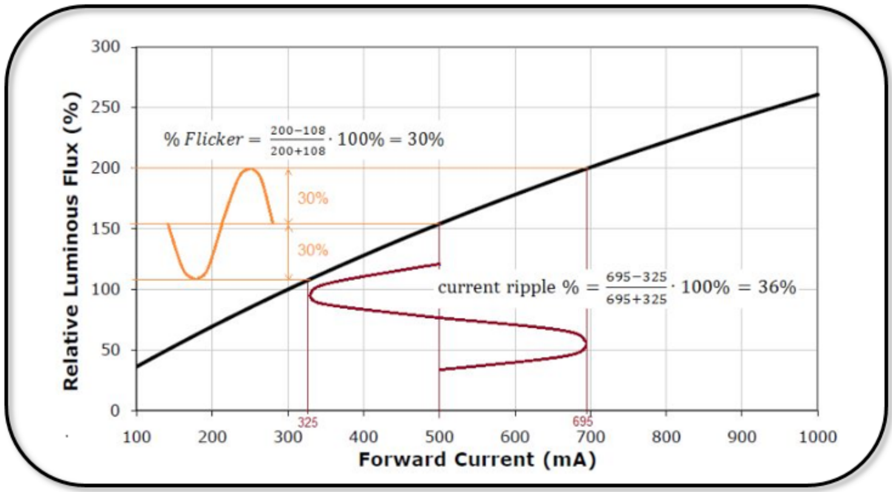


Figure 8: Flicker as a result of power supply noise

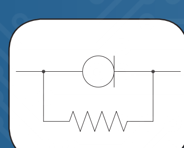
adjustable current limiting diodes

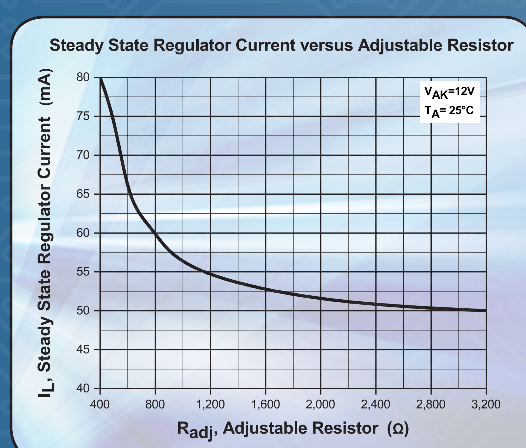
Central Semiconductor has recently released an adjustable current limiting diode, the 50V, 50-80mA CMJA5050. This adjustable CLD allows for current regulation to be varied via an external resistor, allowing for optimization to higher currents. Placing a resistor in parallel with a CLD can correct any current decrease when the applied voltage increases. If no adjustment is required, adjustable CLDs can be used alone as standard current regulating devices. Adding a resistor in parallel will increase the current output if higher current is a design requirement.

REGULATOR CURRENT PER RESISTANCE:

Steady State Regulator Current I_L @ V_T=12V			Resistor (1/4W)
MIN mA	NOM mA	MAX mA	Ω
45	50	55	none*
49.5	55	60.5	1000
54	60	66	800
58.5	65	71.5	600
67.5	75	82.5	500
72	80	88	400

*A 3000Ω resistor may be added to achieve more linear regulator current characteristics.





ideal applications for CLDs:

LED driver:

Despite the fact that an LED uses very little power in its steady "on" state, an LED when powered will cause a brief but significant transient current. According to Central's measurements , this transient current draw can be as much as 250 times the LED's rating.

The LED channel current is set by the CLD itself and is compatible with high voltage up to 50V supporting many LED applications.

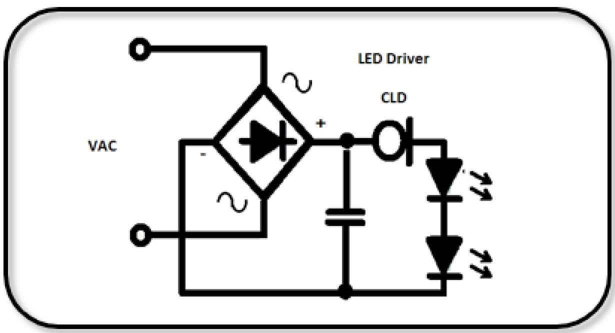


Figure 9: LED driver

Battery charging protector:

Electronic protection circuits themselves draw current from the battery, reducing the effective capacity of the battery to supply the desired load. By limiting the current consumed and device "spikes," longer battery life and protection against current surges can be attained.

CLDs protect against power source noise, excessive drive current or incorrect connections to source.

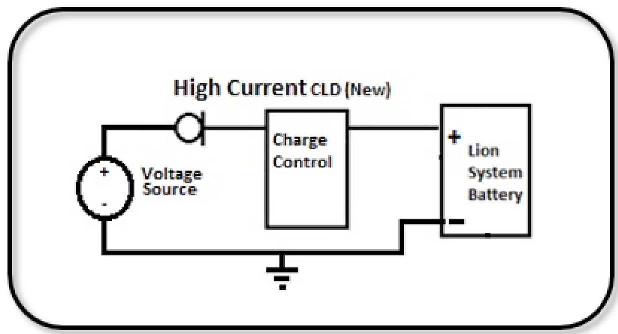
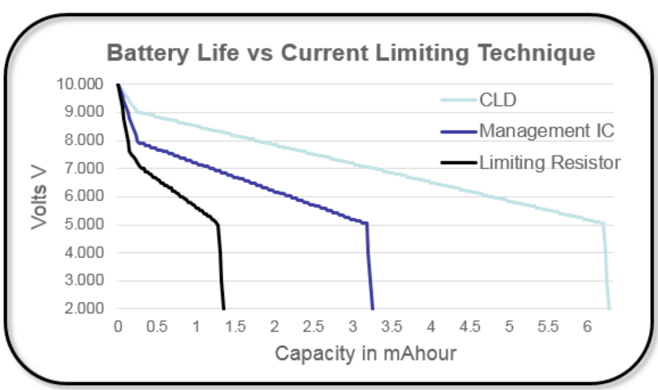


Figure 10: Charging circuit protector

Battery life extender:

The performance of a battery is characterized by energy storage (capacity) "mAh" and power per hour. Shown below is battery life vs load currents of 1mA, 10mA, 50mA, and 100mA.



Power per hour = ImAh /Volts

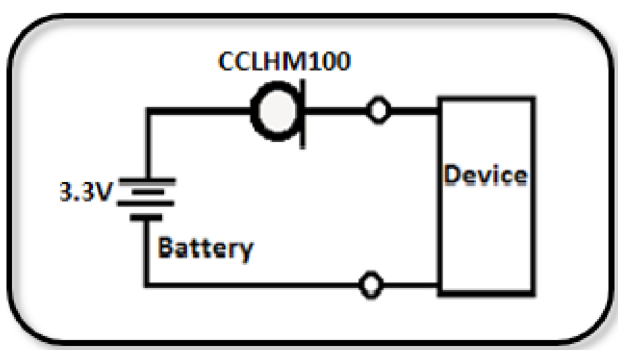


Figure 11: Battery saver

"Surge Stopper":

With nanotechnology advancing and the continued reduction in transistor size, the need for surge protection is becoming more and more important.

A surge stopper implements over-current and transient voltage suppression (TVS) on any device input to enable ESD over-voltage protection and provide over-current latch-up immunity.

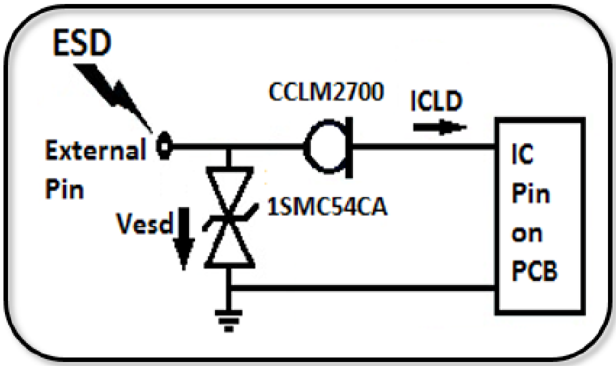


Figure 13a: Surge stopper circuit

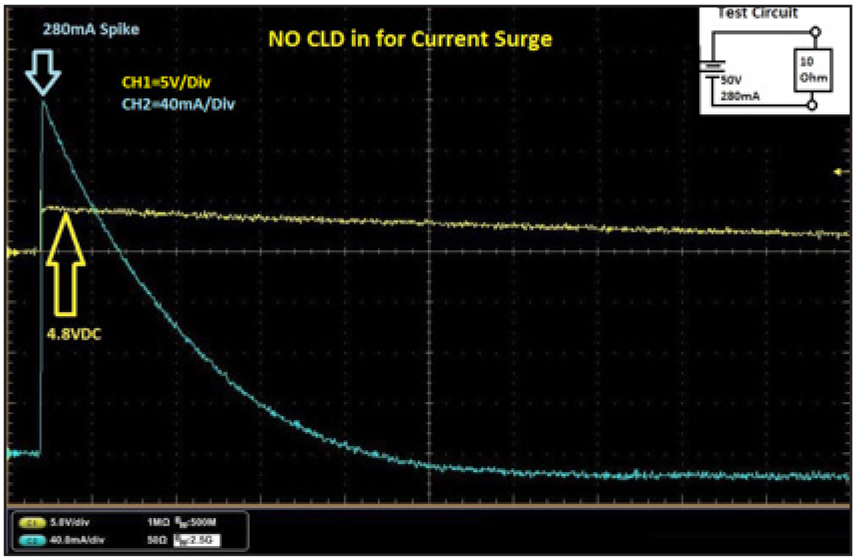


Figure 13b: Circuit without surge stopper

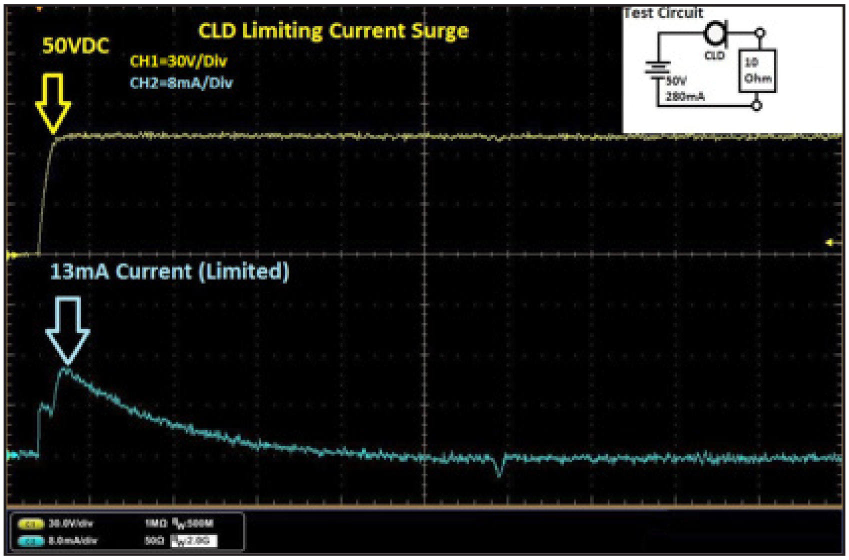


Figure 13c: Circuit with surge stopper

conclusions:

- Emerging applications will continue to drive the need for sources of regulated current.
- For low current needs, CLDs provide the most cost effective, energy efficient and simple solution.
- CLDs manufactured by Central Semiconductor provide a single package solution with a small footprint.
- Throughout 2019 and beyond, Central Semiconductor will continue to add CLDs with higher current regulation and higher peak operating voltages to its portfolio.

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