HIGH VOLTAGE OPTOCOUPLER

HV801

Control element for high voltage power supplies

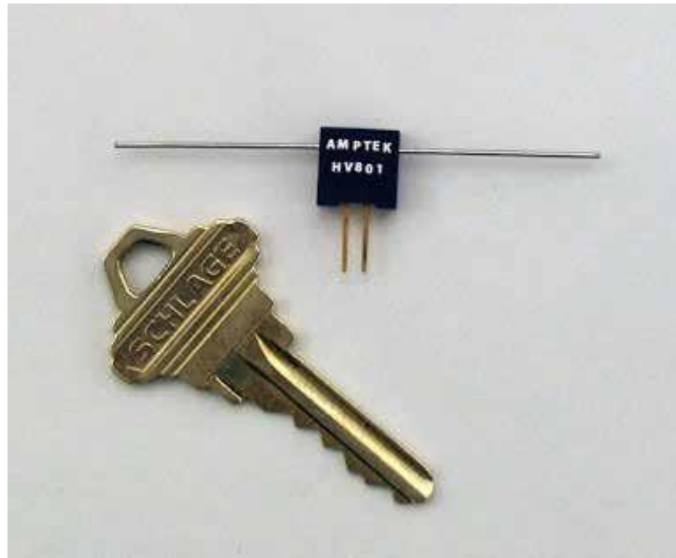
(Rev D8 Dated 11/19/2020)

Applications

- Photoelectron Microscopy
- Electrostatic Deflection Plates
- Space instrumentation
- Electrostatic analyzers
- High voltage power supplies
- Regulated current source
- High Voltage relay
- High Voltage bipolar amplifier

Features

- 5 V Control
- 8 kV Bias Voltage
- Current Transfer Ratio ≥0.6%
- Low Leakage Current
- 12 kV Isolation Voltage
- Radiation Tolerant to 10^5 rad(Si)
- Up to 100 V/µs slew rate (10 pF load)
- Small footprint
- Backward compatible to HV601B



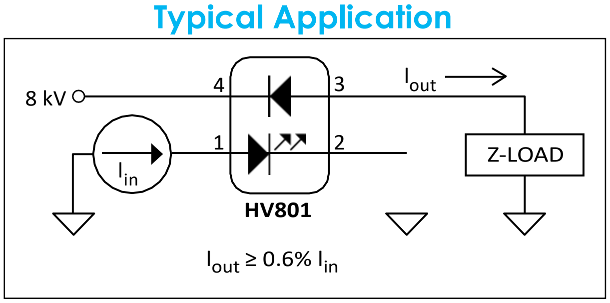
Shown in actual size

General Description

The HV801 is a high voltage optocoupler developed as a control element for High Voltage Power Supplies. It consists of a multiple junction high voltage diode, optically coupled to three infrared emitting LEDs in series. The photocurrent in the output diodes is proportional to the light produced by the LEDs. The ratio of the output photocurrent to the LED input current is the current transfer ratio (CTR) of the device.

The HV801 provides high breakdown voltage, low leakage current, and a fast slew rate, making it ideal for use in a wide range of high voltage power supply applications. It provides linear control of voltages up to 8 kV and is current controlled from a convenient 5 V source. It is supplied in a small size, high dielectric strength, space rated epoxy package.

Typical Application



Amptek Inc. 14 DeAngelo Drive, Bedford, MA 01730-2204 USA
+1 781 275-2242 Amptek.sales@ametek.com amptek.com

AMETEK MATERIALS ANALYSIS DIVISION

SPECIFICATIONS

Input Characteristics

The input (Pins 1 and 2) behaves as a diode with a nominal threshold voltage of 3.1 volts. Output current (Pins 3 and 4) is controlled by varying the input current in the range of 0 to 100 mA. Input current should be limited such that the total power dissipated in the device is less than 0.5 watt at ambient conditions. Consideration should be given to the input circuit such that the input reverse bias does not exceed 5 volts.

Output Characteristics

In the normal mode of operation, the output cathode (Pin 4) is more positive than the output anode (Pin 3). In this mode the output current is proportional to the input current. The current transfer ratio is guaranteed to be >0.6% at zero bias and 20 mA input current, at 25 °C. The CTR generally increases with bias voltage and input current, to a typical maximum of 2% to 4%. Output slew rate is typically 100 V/µs into a 10 pF load. If Pin 3 is made more positive than Pin 4, the output will act like a forward biased diode with a nominal threshold voltage of 3.5 volts.

Amptek offers an HV801RH, or rad-hard, option. The light output of LEDs is well known to decrease with displacement damage, i.e., due to penetrating protons in space. The RH option uses an alternate LED, which has a lower initial light output but which decreases more slowly with proton fluence. The HV801RH CTR is >0.2%. The two parts are otherwise identical.

Absolute Maximum Ratings (T=21°C)

Input Current: Continuous Pulse (10 µs, 100 Hz)	 100 mA 1 A
Input Reverse Voltage	5 V
Junction Temperature	100 °C
Output Bias Voltage	8 kV
Operating Temperature (See Thermal Considerations next page)	-35 °C to +100 °C
Storage Temperature	-35 °C to +100 °C

Stress above those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

Electrical Characteristics (T=21°C)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Reverse Breakdown Voltage	V_{BR}	$I_D = 1$ µA		>10.0		kV
Current Transfer Ratio	CTR					
HV801		$I_{in} = 20$ mA, $V_{bias} = 0$ V	0.6			%
HV801		$I_{in} = 20$ mA, $V_{bias} = 6$ kV		1.6		%
HV801RH		$I_{in} = 20$ mA, $V_{bias} = 0$ V	0.2			%
HV801RH		$I_{in} = 20$ mA, $V_{bias} = 6$ kV		0.8		%
Dark Current	I_D	$V_B = 8$ kV		10.0	250	nA
Output Capacitance	C_O	$V_J = 0$ V		8.0		pF
Input Voltage	V_{in}	$I_{IN} = 20$ mA		4.0		V
Isolation Capacitance	C_{ISO}			0.6		pF
Isolation Voltage	V_{ISO}		12.0			kV

HV801 and HV801RH OPTION A+ SCREENING

1.	Nondestructive Bond Pull (100%)	MIL-STD-883K, Method 2023
2.	Visual Inspection	MIL-STD-883K, Method 2017
3.	Encapsulation	Low outgassing epoxy package
4.	Marking	Serial Number, Date Code, ID
5.	Electrical Test	At +25 °C
6.	Temperature Cycling	MIL-STD-883K, Method 1010, (modified) T = -35 °C to 100 °C, 15 cycles, 4 min. each extreme, 5 °C /min. ramp time
7.	Electrical Test	At +25 °C
8.	Radiographic	MIL-STD-883K, Method 2012
9.	Burn-in	MIL-STD-883K, Method 1015, 320 hrs @ 90 °C
10.	Final Electrical Test	At +80 °C, +25 °C and -35 °C
Optional		
11.	Life Test of Sample Devices	1000 hours (total) Burn-In at +90 °C with additional interim and Final Electrical Tests at +80 °C, +25 °C and -35 °C

Engineering, non-flight units (no screening) may be available. Please contact Amptek for more information.

TYPICAL PERFORMANCE

Current Transfer Ratio

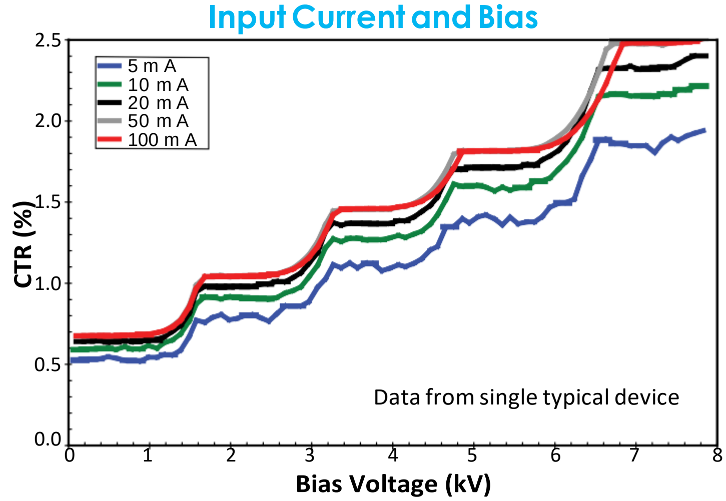
As these plots show, the Current Transfer Ratio (CTR) increases as a function of input current and bias voltage and decreases with increasing temperature. The CTR of each HV801 is measured by Amptek to be >0.6% at I_{LED} = 20 mA, no bias voltage, and at 25 °C.

The CTR is not a linear or even a smooth function of bias or current. Because the HV801 is in the feedback loop, this is not important. Nonlinear devices, such as transistors, are commonly used for feedback. The circuit designer must insure that the loop has enough gain, under the worst case conditions, to meet the accuracy requirements. The detailed variation of the CTR with the various parameters is generally not critical because of its location in the feedback loop of the control circuit.

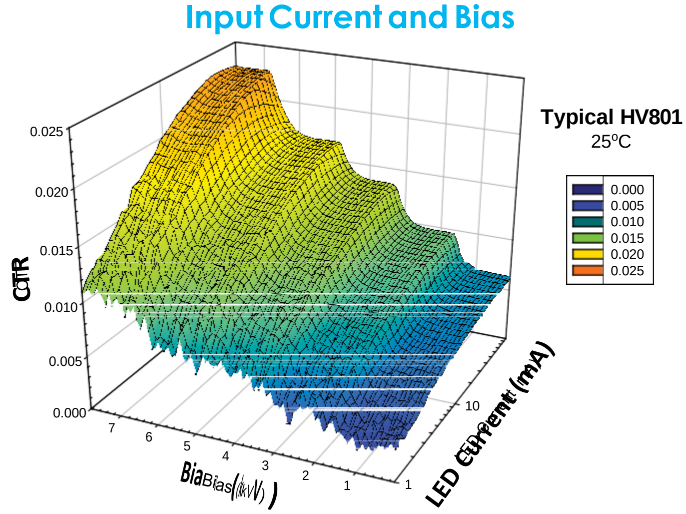
The plots above show that, if the LED current is fixed and the bias voltage increased, the CTR increases as a series of steps. The steps occur when one of the junctions in the output diode stack begins to avalanche. The avalanche voltage is a function of LED current (increasing with I_{LED}) and of temperature (increasing with temperature). The avalanche voltages will vary from one device to the next, as will the magnitude of the CTR increase and the sharpness of the avalanche onset. If the bias is fixed and the current increased, the CTR will increase fairly smoothly, unless the bias voltage is near one of the steps.

The detailed shape of the CTR curve is not important to use the HV801: the circuit should be designed to provide sufficient loop gain at the lowest CTR, which will occur at the lowest LED current, lowest bias voltage, highest temperature, and with end of life displacement damage.

Current Transfer Ratio (CTR) vs Input Current and Bias

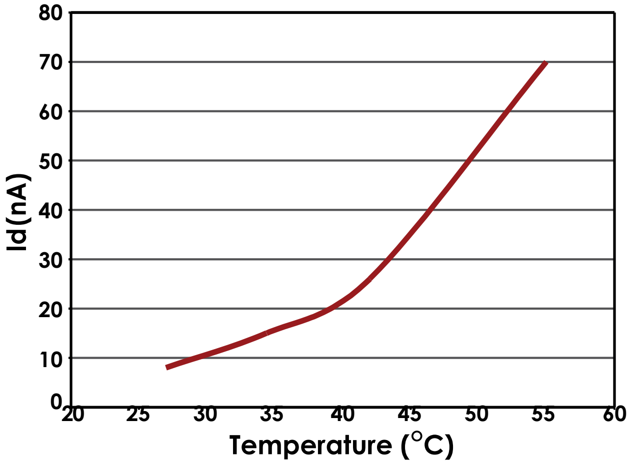


Current Transfer Ratio (CTR) vs Input Current and Bias

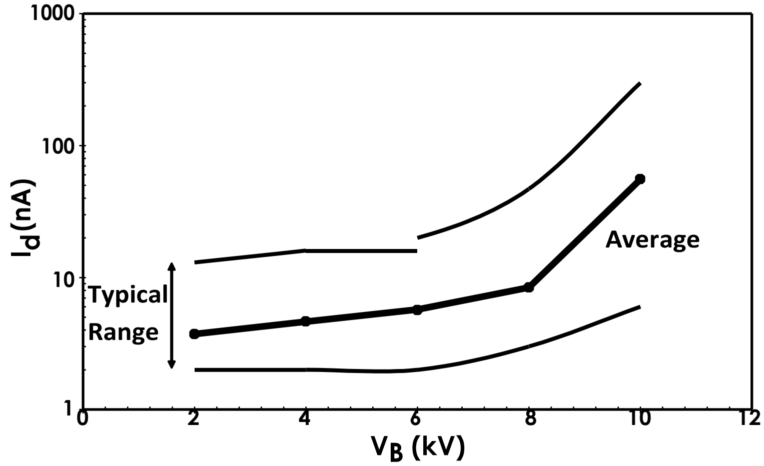


TYPICAL PERFORMANCE (con't)

Dark Current vs Temperature



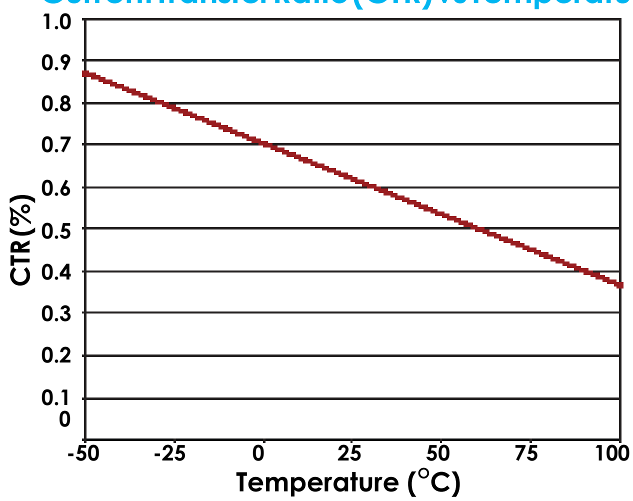
Dark Current vs Bias Voltage



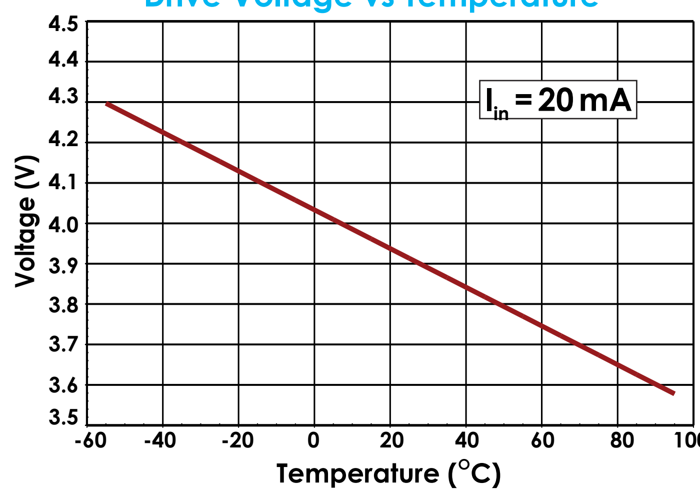
Dark Current

The HV801 is rated for a maximum of 8 kV bias. The maximum dark current at 8 kV is 250 nA but the average is under 10 nA at 25 °C. The dark current approximately doubles for every 10 °C increase in temperature. Each HV801 is tested at 10 kV, beyond its rated voltage, to verify that breakdown voltage is >10 kV. As seen in the plot, the dark current is nearly independent of bias at 8 kV and below, but increases to a typically value of 70 nA at 10 kV.

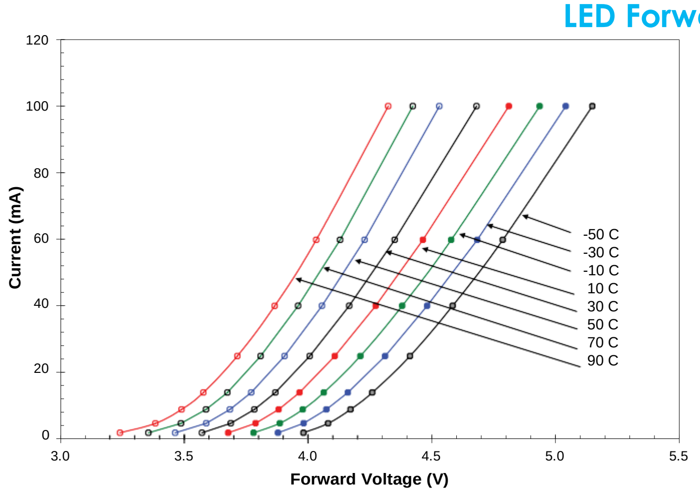
Current Transfer Ratio (CTR) vs Temperature



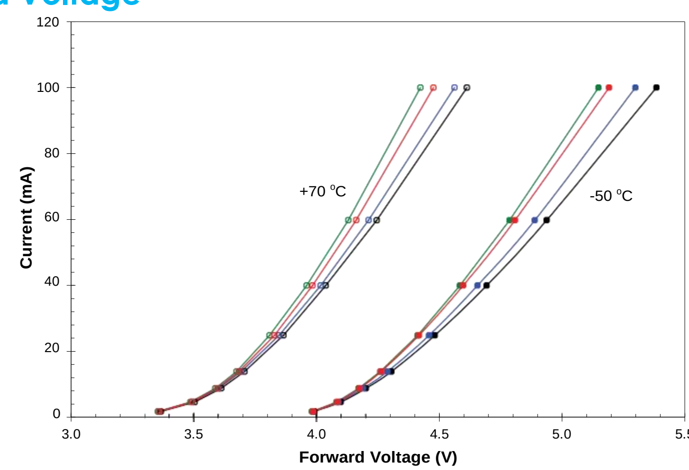
Drive Voltage vs Temperature



LED Forward Voltage



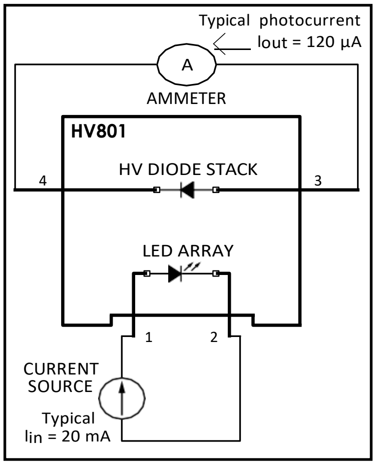
Plot showing the diode curve, the forward voltage across the LED stack in a typical HV801, as a function of current, at temperatures from -50 to +90 °C.



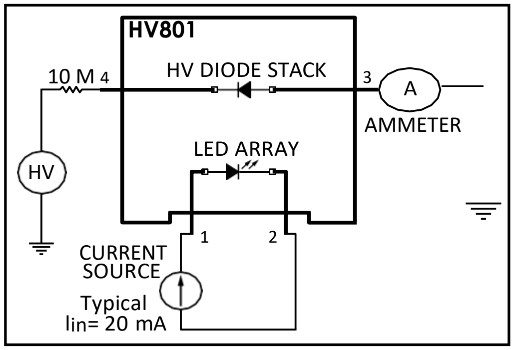
Plot showing variation in forward voltage versus current, for four HV801s from different lots, at -50 °C and at +70 °C.

TYPICAL PERFORMANCE (con't)

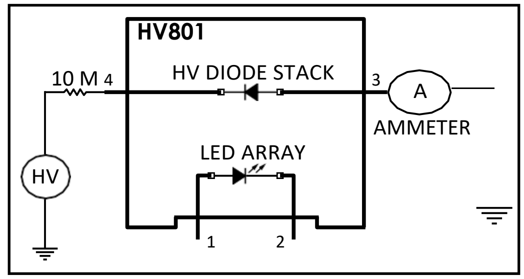
CTR Test Circuit at Unbiased Conditions



CTR Test Circuit at Biased Conditions



Dark Current Test Circuit



Thermal Resistance

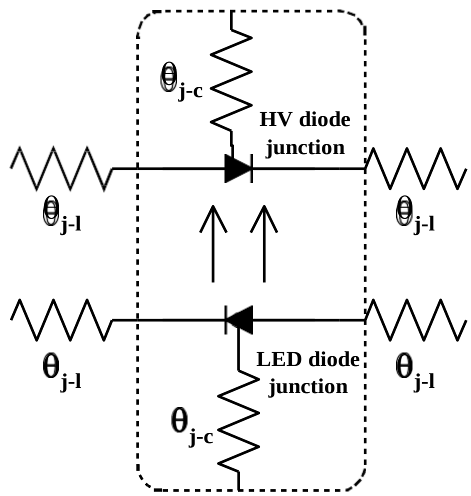
$\theta_{j\text{-}l}$ is the thermal resistance from the junction to a single lead.

Note: If both leads are connected to the PCB, the total thermal resistance is ½ $\theta_{j\text{-}l}$

$\theta_{j\text{-}c}$ is the thermal resistance from the junction to the case

	$\theta_{j\text{-}l}$ °C/W	$\theta_{j\text{-}c}$ °C/W
HV diode	31	38
LED	74	44

For assembly and soldering recommendations, refer to:
IPC-A-610
IPC-HDBK-001



Thermal Considerations

The maximum power dissipation and derating considerations must be specified so that the T_J, the junctions of the diodes, do not exceed 100 °C.

Application Example

Consider an example where the four leads provide the thermal path to the PCB, assumed to be at ambient. This gives θ_{JA} = 15 °C/W for the HV stack and 37 °C/W for the LEDs. Assume I_{in} = 10 mA, with V_F = 4 V, V_{bias} = 5 kV, and CTR = 2%, so I_{out} = 200 µA. The power dissipations will be 40 mW in the LEDs and 1 W in the HV diode stack. This yields a ΔT of 15 °C for the HV diode stack and 1.5 °C for the LEDs. This unit can be operated at an ambient temperature of 82 °C (printed circuit board temperature).

Note that the CTR is a function of bias voltage, current, temperature, and exhibits manufacturing variability. The user must examine all these parameters closely if operation near the maximum junction temperature is anticipated.

This calculation, though simple, does not represent the typical usage of an HV801. An HV801 is most often used to control rapidly a stepped voltage, i.e., biasing the deflection electrodes in an electrostatic analyzer. The current only flows for a brief period at the beginning of each step, i.e., there is a very low duty cycle. The total power dissipation is reduced greatly. Typical applications exhibit tens of mW of total power.

TYPICAL PERFORMANCE (con't)

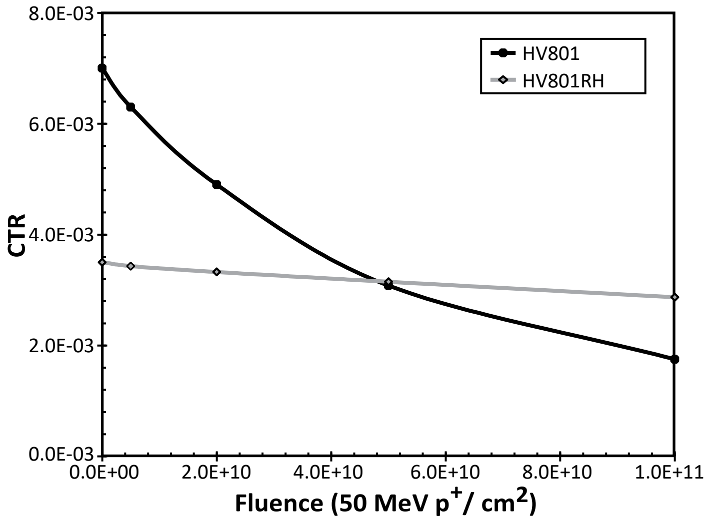
Radiation Damage

Total Ionizing Dose: 100 krad (Si).

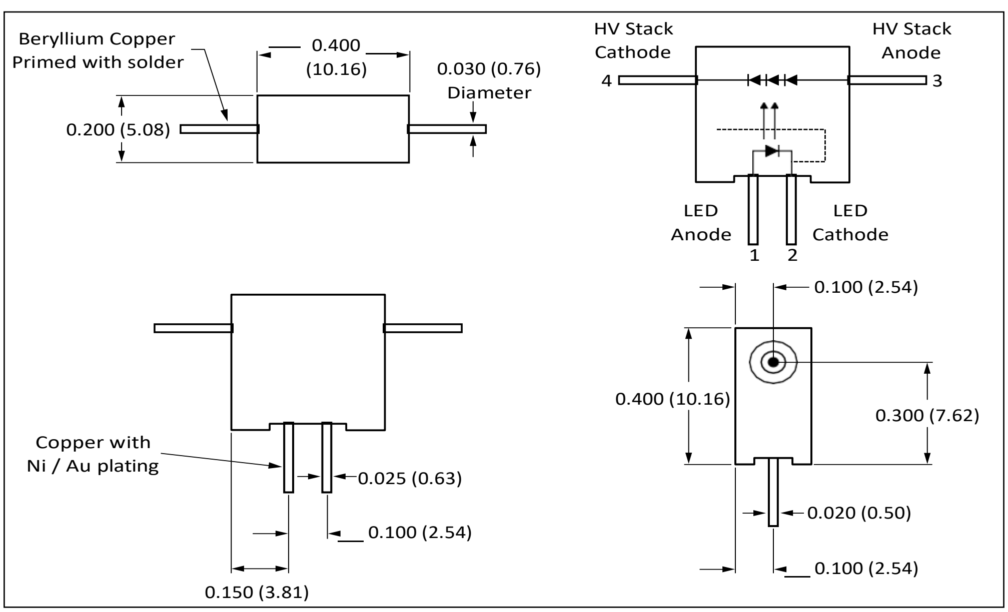
The HV801 and HV801RH were tested to 100 krads (Si), using ^{60}Co gamma-rays. The CTR for the HV801 decreased by 7.6%. The CTR for the HV801RH was unchanged. No measurable change was found for the other parameters.

Displacement Damage

As is well known, the LEDs are generally susceptible to displacement damage. The plot below shows typical results which are expected for the HV801 and the HV801RH when tested with 50 MeV protons. These results here are typical of the both the packaged devices and the LEDs used in the two parts. The HV diode stack is not susceptible to displacement damage at these levels.

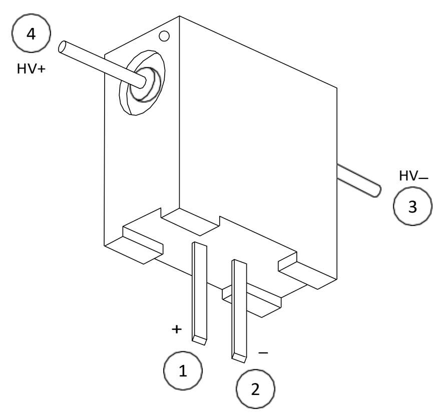


PACKAGE DIMENSIONS



In inches (millimeters)

PACKAGE DIAGRAM

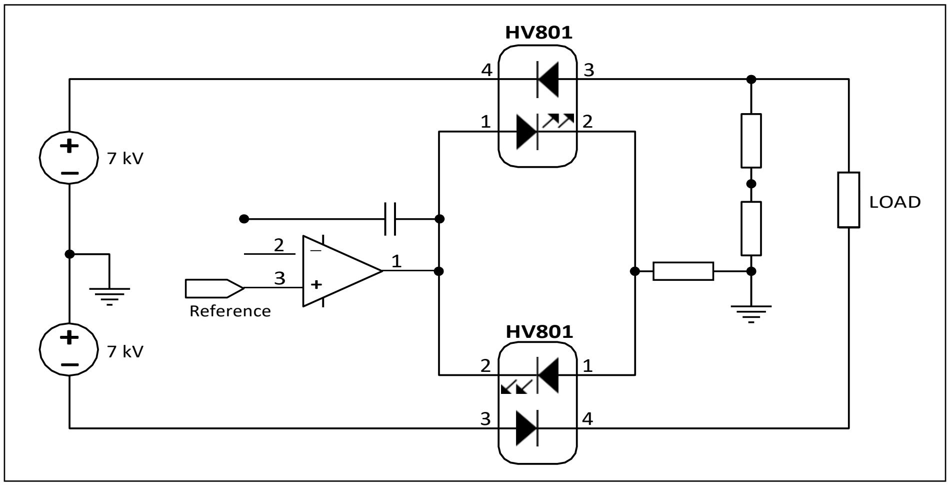


PIN 1: Input, positive
PIN 2: Input, negative
PIN 3: Output, negative
PIN 4: Output, positive

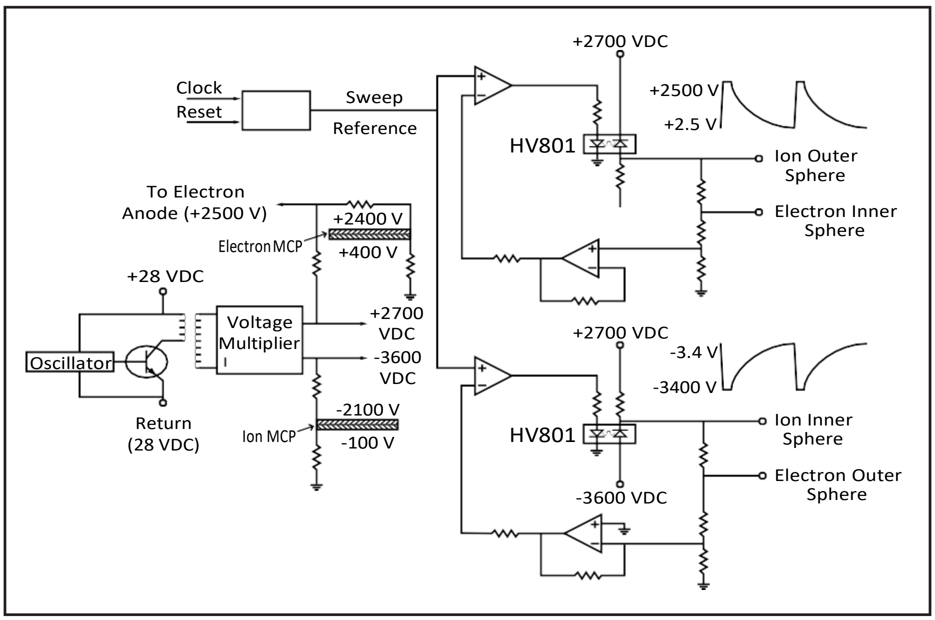
Weight: 1.53 grams

APPLICATIONS for HV801

Simplified Bipolar Power Supply



Simplified Schematic of a Low Power High Voltage Circuit Using the HV801



Burn-in Circuit