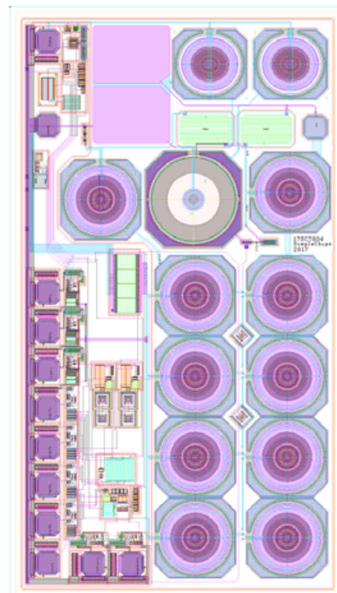
17SCT004A
1200V CURRENT LIMITER WITH ENABLE AND OVER-TEMPERATURE PROTECTION

17SCT004A - PRELIMINARY SPECIFICATION - REVISION March 31, 2020

- Maximum Voltage. . . 1200 V
- 4 Programmable Current (4.6, 8, 15 and 21mA)
- No External Components
- Simple 3 Terminals Operation
- Temperature-Limited Current
- Low Off-State Current
- Available as wire-bondable or Flip-Chip (Bumped)

DIE
(TOP VIEW)



Description

The 17SCT004A is a high-voltage current limiter with over-temperature protection. When the enable signal is applied, the high-voltage (HV) terminal sinks a constant current that is temperature-limited. Upon removing the enable signal, the 17SCT004A presents a very-high resistance to the HV terminal. The sink current can be user-programmed to 4 target values for maximum system flexibility. In all case the maximum junction temperature is internally limited to about 150C. This allows the 17SCT004A to very efficiently discharge high-voltage capacitors when needed while protecting itself and surrounding circuitry.

Absolute Maximum Ratings

PARAMETER	MIN	MAX	UNIT
Input High-Voltage (HV_{dd} - LV_{ss})	-1	1200	V
Enable Voltage	-1	20	V
Storage Temperature	-65	150	C

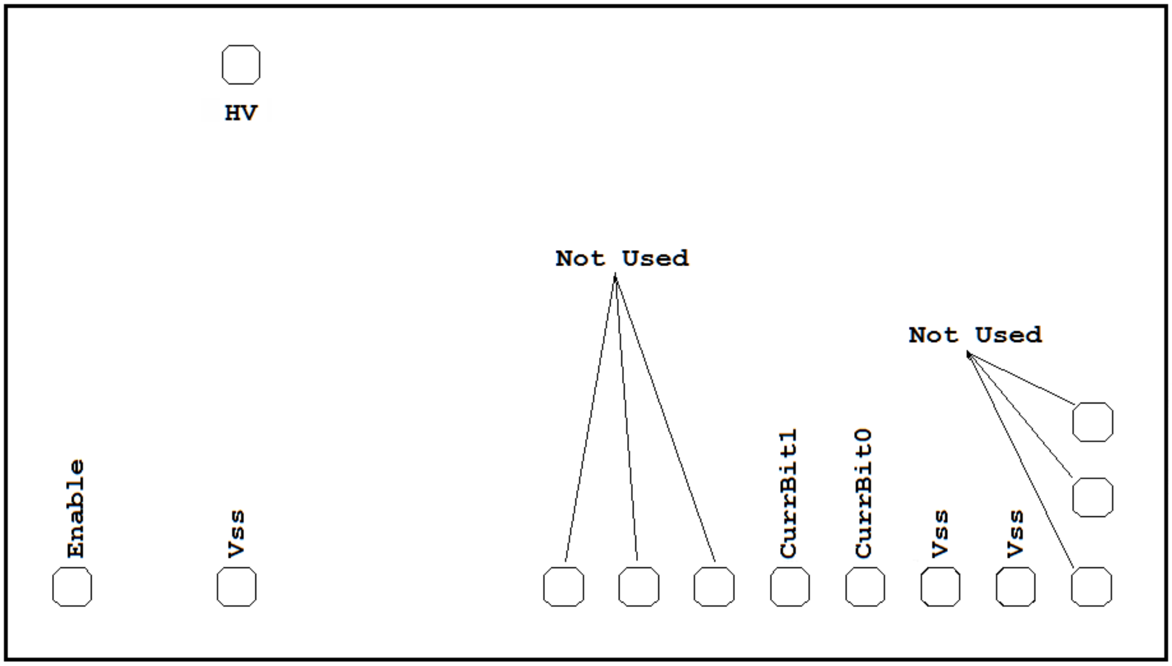
Maximum Operating Conditions

PARAMETER	MIN	MAX	UNIT
Operating Voltage (HV_{dd} - LV_{ss})		1000	V
Operating Voltage (Enable)	5	16	V
Operating Junction Temperature	-40	150	C

Pin Definitions

SYMBOL	DESCRIPTION
HV	High-Voltage Terminal
V_{SS}	Common Terminal
Enable	Enable
CurrBit1	Current Select Bit 1
CurrBit0	Current Select Bit 0

Pin Positions (wire bondable version shown)



“Not Used” Pads should be left open and should not be connected to Vss or to one another.

CurrBit1 and CurrBit0 should either be tied to Vss, Enable or to a voltage <=16V for proper operation.

All Vss terminals must be connected.

Later in this document we use Range=XY where “XY” is either 00, 01, 10, 11 to refer to the state of CurrBit1 as “X” and CurrBit0 as “Y”. CurrBitx is set to 1 when CurrBitx pin voltage is greater than $V_{ThCurrBitx}$.

Static Electrical Characteristics(25C ± 5°C) All Ranges, V(Enable)=8V unless specified

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
HV_{max}	Maximum High Voltage	i_{HV}=100μA, Enable=0V	1200	1250	N/A	V
I_{HV1k}	Maximum off-state HV Current	HV=1000V, Enable=0V	10	25	50	μA
TCI_{HV}	Maximum off-state HV Current Temperature Coefficient			4400		ppm/C
I_{HV100}	100V Off-state Current	HV=100V, Enable=0V	0.8	2.5	5	μA
IE_{LHV05}	5V Enable Current Low HV	HV=0V, Enable=5V	30	50	160	μA
IE_{LHV16}	16V Enable Current Low HV	HV=0V, Enable=16V	40	85	160	μA
IE_{MHV05}	5V Enable Current Medium HV	HV=25V, Enable=5V	-1	0	1	μA
IE_{MHV16}	16V Enable Current Medium HV	HV=25V, Enable=16V	-1	0	1	μA
IE_{HHV05}	5V Enable Current High HV	HV=1000V, Enable=5V	-1	0	1	μA
IE_{HHV16}	16V Enable Current High HV	HV=1000V, Enable=16V	-1	0	1	μA
$V_{ThCurrBit1}$	CurrBit1 Transition Voltage	Sweep $V_{CurrBit1}$ until I(HV) >12mA while $V_{CurrBit0}$ = 0V	0.90	1.20	1.50	V
$V_{ThCurrBit0}$	CurrBit0 Transition Voltage	Sweep $V_{CurrBit0}$ until I(HV) >12mA while $V_{CurrBit1}$ = 0V	0.90	1.20	1.50	V
$I_{CurrBitx}$	Maximum CurrBitx Current	$V_{CurrBitx}$=16V, Enable=0V, HV=1000V	-1	0	1	μA
VE_{max}	Maximum Enable Voltage	HV=0V, I_{Enable}=1mA	20	23	25	V
I_{RefHV0}	Internal Current Reference	HV=0V	0.50	1.5	3.0	μA
$I_{RefHV30}$	Internal Current Reference	HV=30V	0.50	1.6	3.5	μA
I_{SenseT}	Temperature Sensor Current	HV=0V	6	15	30	μA
V_{SenseT}	Internal Temperature Sensor	HV=0V	1.26	1.30	1.34	V
$V_{SenseRef2}$	Internal Temperature Reference	HV=0V	0.468	0.480	0.492	V
V_{ref}	Internal Voltage Reference	HV=0V	6.15	6.35	6.55	V
DV_{ref}	Sensor to Reference Difference	V_{SenseT} - $V_{SenseRef2}$	0.780	0.840	0.900	V
$I(HV)_{T06}$	Current at SenseT=0.6V	V_{SenseT}=0.6V	0.00	0.08	1.00	mA

Static Electrical Characteristics (25C ± 5C) Range=00 (10mA)

This range is used for trimming

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{HV3005_00}	Current Limit V_{Enable} min	HV_{dd}=30V, Enable=5V	8.5	10.2	13.0	mA
I_{HV3016_00}	Current Limit V_{Enable} max	HV_{dd}=30V, Enable=16V	8.5	10.2	13.0	mA
R_{HV_00}	Effective HV terminal resistance at HV=1V	HV_{dd}=1V, Enable=5V	200	450	1000	Ω
DI_{HV05_00}	Maximum I_{HV} Variation at V_E=5V	I(HV=1000V) @ Enable=5V - I_{HV3006_00}) /I_{HV3005_00}	-3.0	0	3.0	%
DI_{HV16_00}	Maximum I_{HV} Variation at V_E=16V	I(HV=1000V) @ Enable=16V - I_{HV3016_00}) /I_{HV3016_00}	-3.0	0	3.0	%

Static Electrical Characteristics (25C ± 5C) Range=01 (19mA)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{HV3005_01}	Current Limit V_{Enable} min	HV_{dd}=30V, Enable=5V	16.0	18.8	23	mA
I_{HV3016_01}	Current Limit V_{Enable} max	HV_{dd}=30V, Enable=16V	16.0	18.8	23	mA
R_{HV_01}	Effective HV terminal resistance at HV=1V	HV_{dd}=1V, Enable=5V	200	450	900	Ω
DI_{HV05_01}	Maximum I_{HV} Variation at V_E=5V	I(HV=1000V) @ Enable=5V - I_{HV3006_01}) /I_{HV3005_01}	-3.0	0	3.0	%
DI_{HV16_01}	Maximum I_{HV} Variation at V_E=16V	I(HV=1000V) @ Enable=16V - I_{HV3016_01}) /I_{HV3016_01}	-3.0	0	3.0	%

Static Electrical Characteristics (25C ± 5C) Range=10 (24mA)

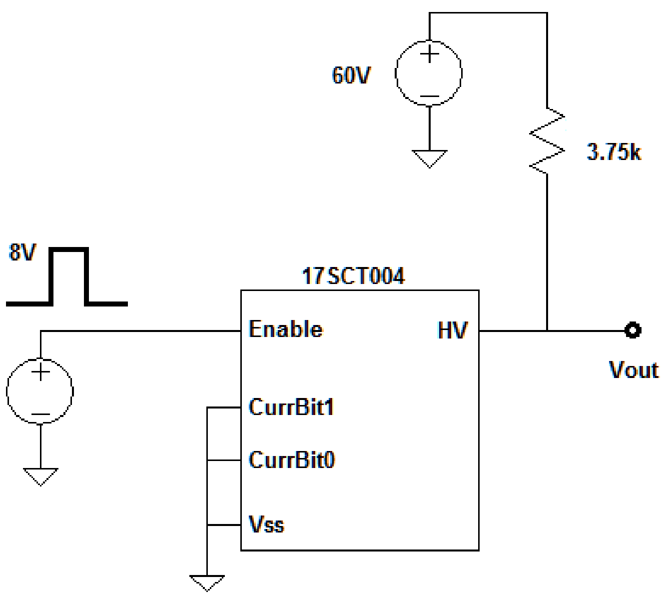
SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{HV3005_10}	Current Limit V_{Enable} min	HV_{dd}=30V, Enable=5V	20.0	23.6	29.0	mA
I_{HV3016_10}	Current Limit V_{Enable} max	HV_{dd}=30V, Enable=16V	20.0	23.6	29.0	mA
R_{HV_10}	Effective HV terminal resistance at HV=1V	HV_{dd}=1V, Enable=5V	200	450	900	Ω
DI_{HV05_10}	Maximum I_{HV} Variation at V_E=5V	I(HV=1000V) @ Enable=5V - I_{HV3006_10}) /I_{HV3005_10}	-5.0	0	5.0	%
DI_{HV16_10}	Maximum I_{HV} Variation at V_E=16V	I(HV=1000V) @ Enable=16V - I_{HV3016_10}) /I_{HV3016_10}	-5.0	0	5.0	%

Static Electrical Characteristics (25C ± 5C) Range=11 (6.0mA)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{HV3005_11}	Current Limit V_{Enable} min	HV_{dd}=30V, Enable=5V	4.5	5.9	7.5	mA
I_{HV3016_11}	Current Limit V_{Enable} max	HV_{dd}=30V, Enable=16V	4.5	5.9	7.5	mA
R_{HV_11}	Effective HV terminal resistance at HV=1V	HV_{dd}=1V, Enable=5V	200	500	1100	Ω
DI_{HV05_11}	Maximum I_{HV} Variation at V_E=5V	I(HV=1000V) @ Enable=5V - I_{HV3006_11}) /I_{HV3005_11}	-3.0	0	3.0	%
DI_{HV16_11}	Maximum I_{HV} Variation at V_E=16V	I(HV=1000V) @ Enable=16V - I_{HV3016_11}) /I_{HV3016_11}	-3.0	0	3.0	%

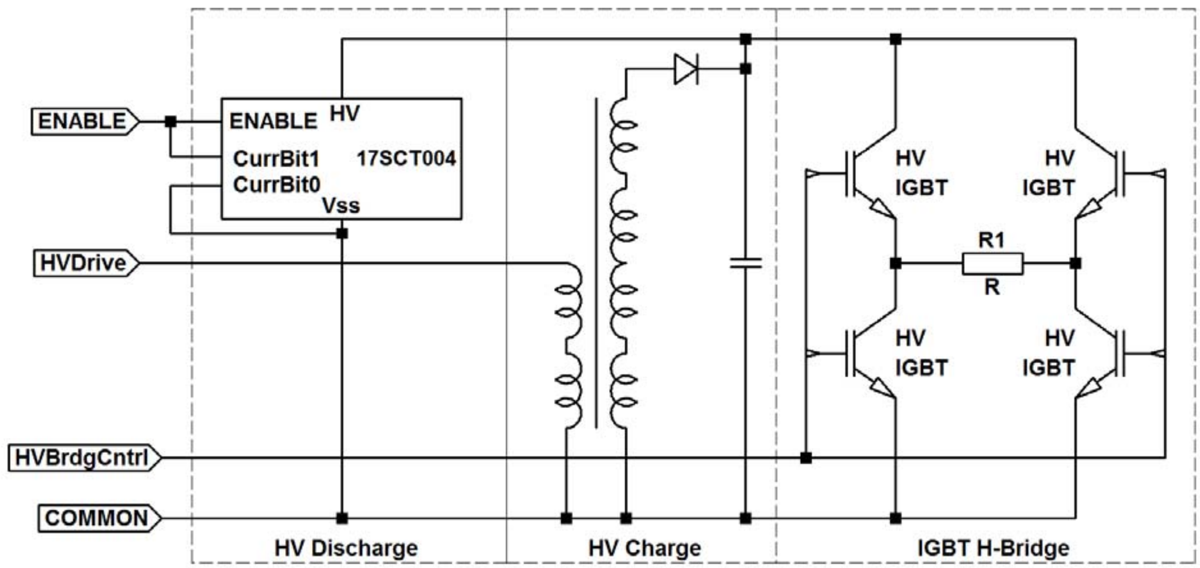
Dynamic electrical characteristics (25C ± 5C) Range=00 (10mA)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ond}	Turn-on Delay to 1mA	HV_{dd}=30V, Enable=0 to 8V	0.15	0.8	3	µS
t_r	Rise time from 1mA to 7mA	HV_{dd}=30V, Enable=0 to 8V	0	0.1	2.0	µS
t_{offd}	Turn-off delay to 7mA	HV_{dd}=30V, Enable=8 to 0V	0	0.1	2.0	µS
t_f	Fall time from 7mA to 1mA	HV_{dd}=30V, Enable=8 to 0V	2	4	10	µS
t_{Er}	Enable 10%-90% rise time	Enable=0 to 8V	0		100	nS
C_{NU}	Maximum capacitance on “Not-Used” pads		0		10	pF



This is the circuit used for transient measurements.

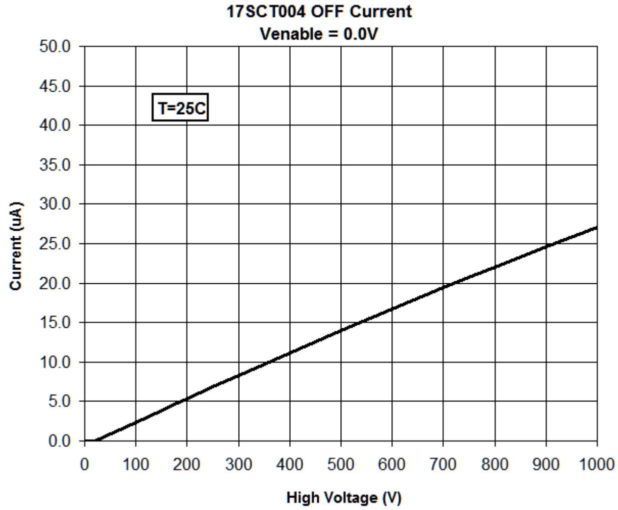
Typical application

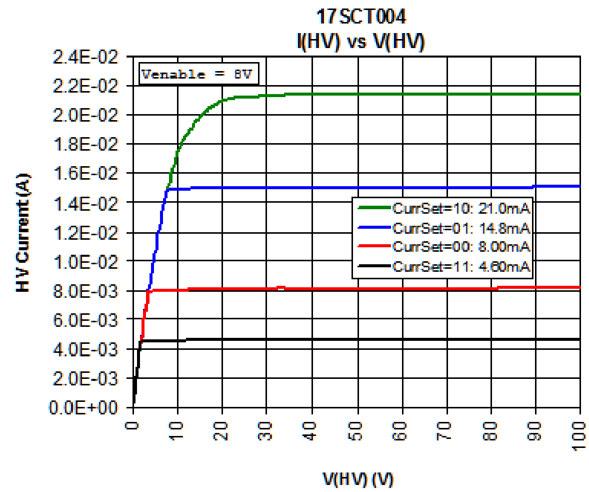


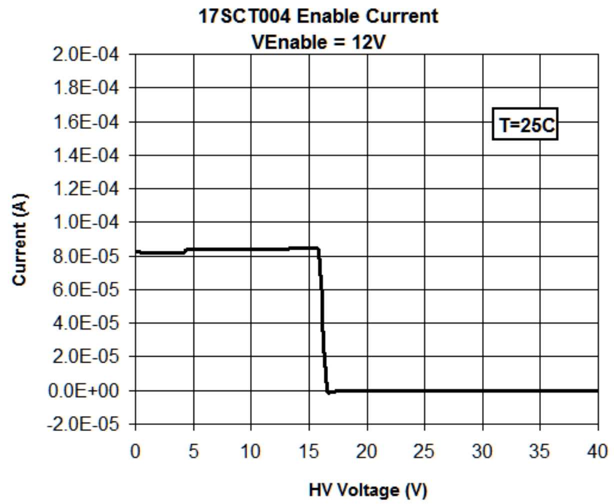
Truth Table for Current Selection

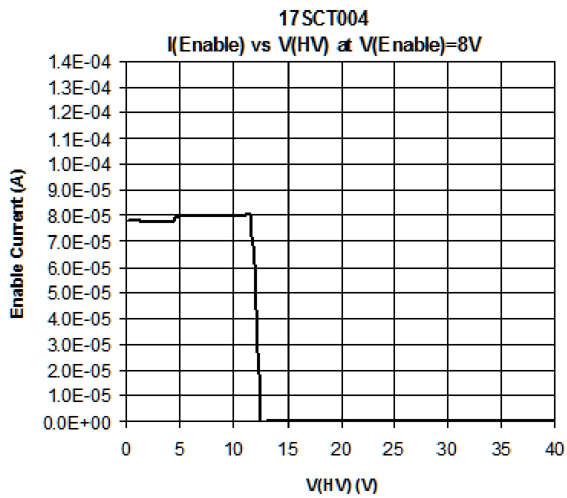
Nominal Current	CurrBit1	CurrBit0
10.0	0	0
19.0	0	1
24.0	1	0
6.0	1	1

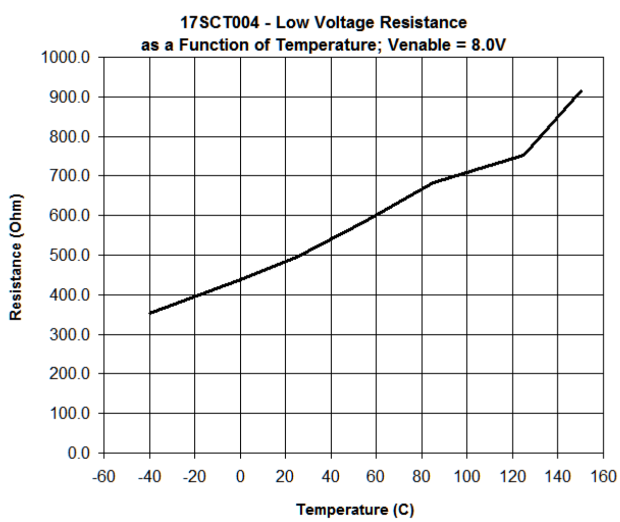
TYPICAL CHARACTERISTICS

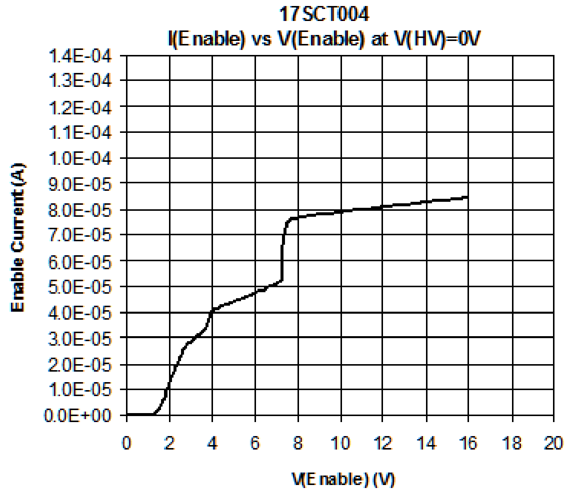


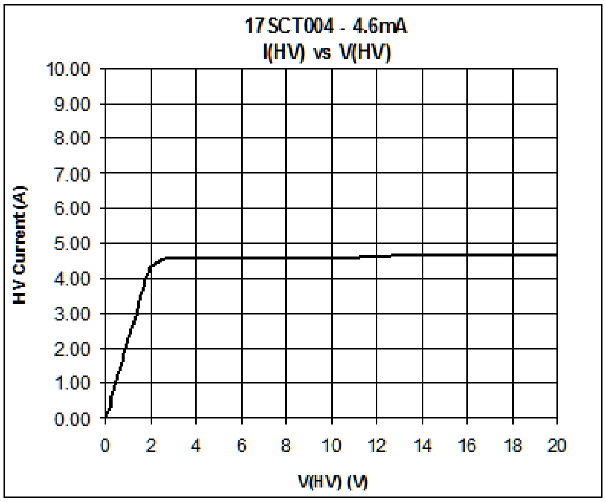


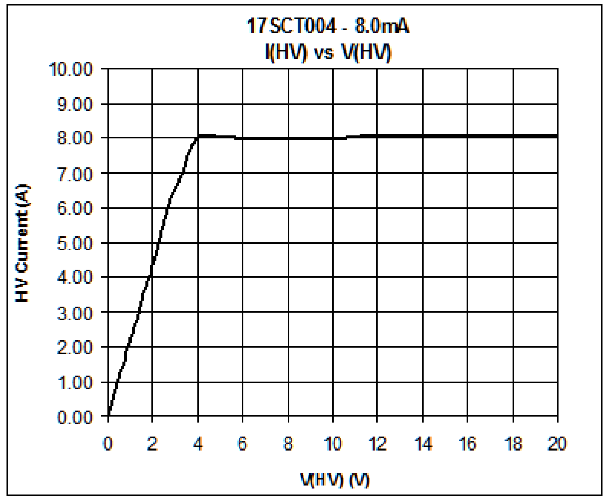


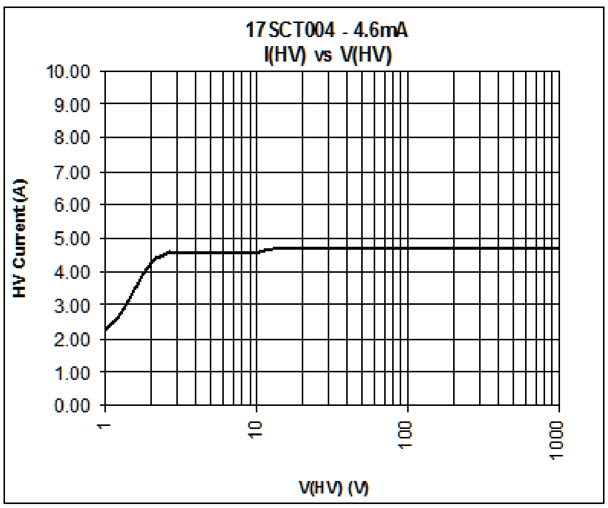


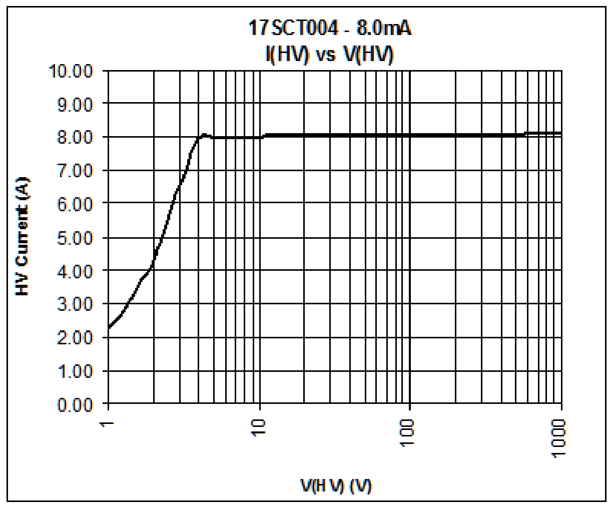


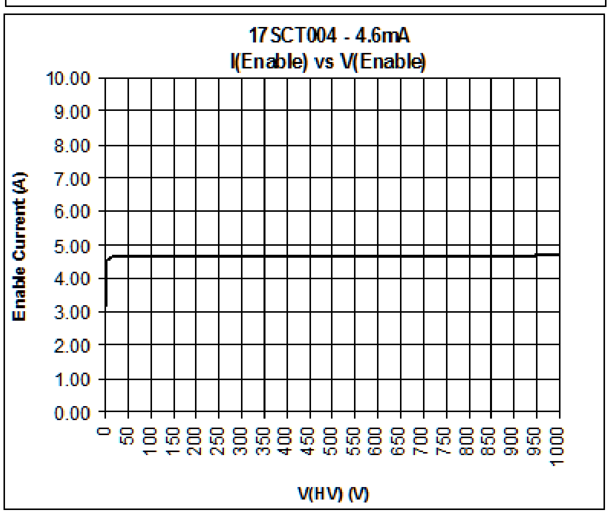


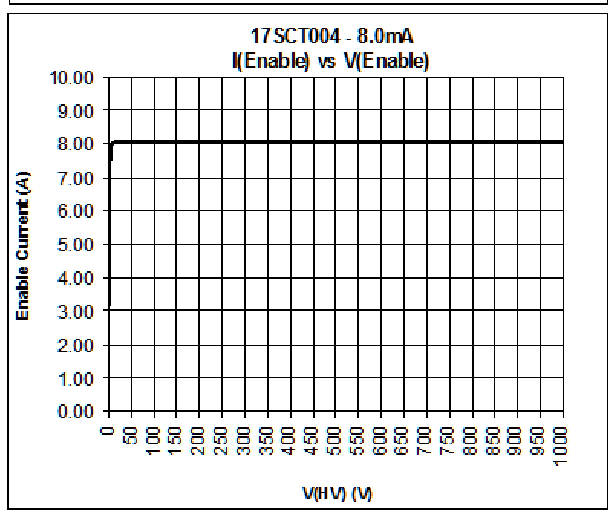

17SCT004 - 4.6mA
I(HV) vs V(HV)
HV Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 2 4 6 8 10 12 14 16 18 20
V(HV) (V)


17SCT004 - 8.0mA
I(HV) vs V(HV)
HV Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 2 4 6 8 10 12 14 16 18 20
V(HV) (V)


17SCT004 - 4.6mA
I(HV) vs V(HV)
HV Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1 10 100 1000
V(HV) (V)


17SCT004 - 8.0mA
I(HV) vs V(HV)
HV Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1 10 100 1000
V(HV) (V)


17SCT004 - 4.6mA
I(Enable) vs V(Enable)
Enable Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
V(HV) (V)


17SCT004 - 8.0mA
I(Enable) vs V(Enable)
Enable Current (A)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
V(HV) (V)

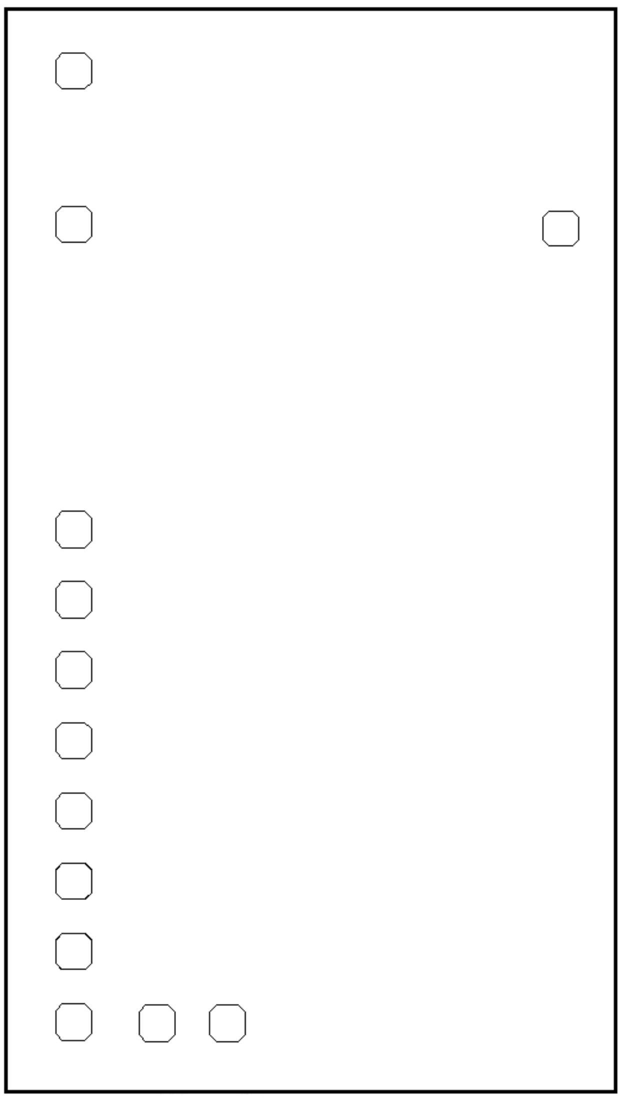
Wire Bondable Die Dimensions

	PARAMETER	MIN	TYP	MAX	UNIT
Y_{SIZE}	Long Side Dimensions	2700	2750	2800	µm
X_{SIZE}	Short Side Dimensions	1500	1550	1600	µm
Z_{SIZE}	Die Thickness	260	285	310	µm

DXF file available for exact pad locations.

Die Thickness 285um +/- 25um

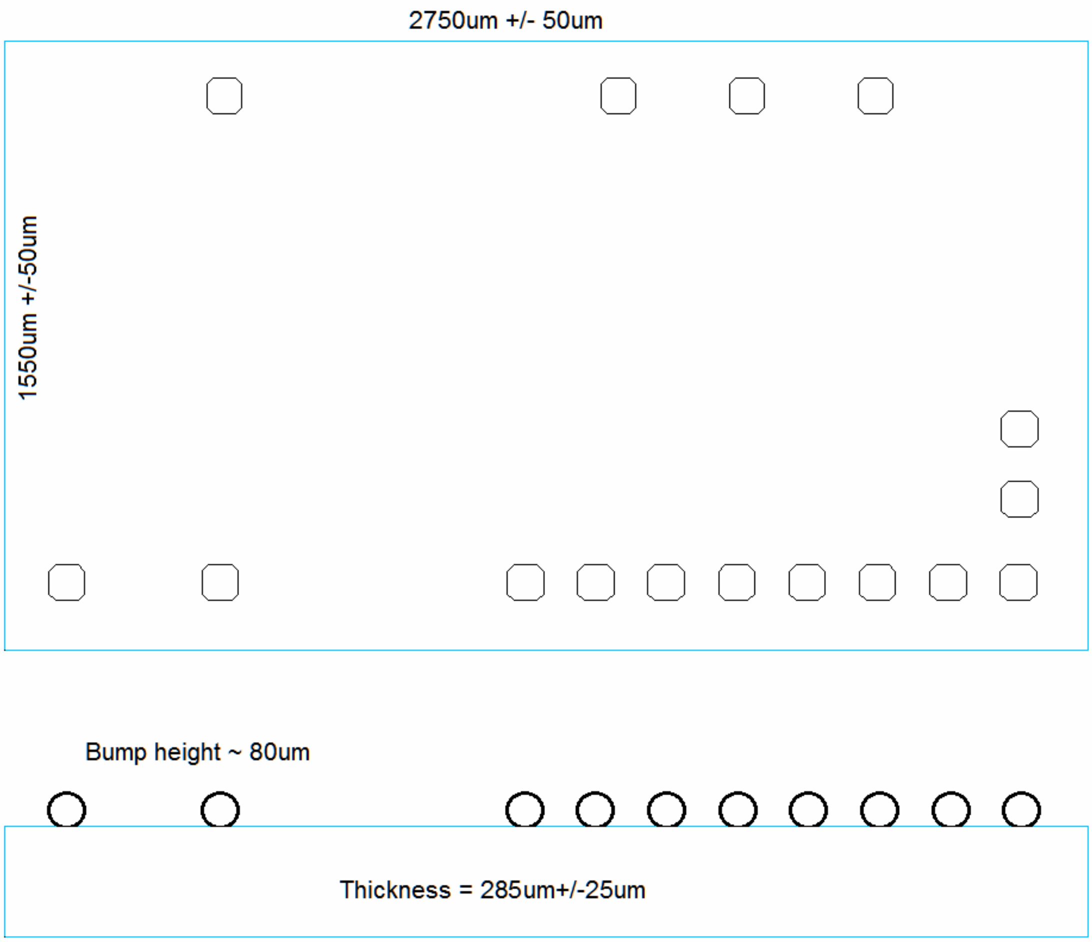
1550um +/- 25um



2750um +/- 25um

Bumped Die Dimensions

	PARAMETER	MIN	TYP	MAX	UNIT
Y_{SIZE}	Long Side Dimensions	2700	2750	2800	µm
X_{SIZE}	Short Side Dimensions	1500	1550	1600	µm
Z_{SIZE}	Die Thickness	260	285	310	µm
B_{SIZE}	Bump Thickness	65	80	100	µm



Visual Inspection

PARAMETER	Lot Sampled	Sample Size	Fails Allowed	UNIT
100% Visual Inspection per MIL STD 883H Method 2010 Condition B.	ALL	100%	n/a	n/a

Product Qualification Tests

PARAMETER	Lot Sampled	Sample Size	Fails Allowed	UNIT
Static burn-in 504hrs @ V_{HV}=1000V; MIL STD 883 method 1015	3	22	0	n/a
Physical dimensions	3	11	0	n/a
Wire Bond Evaluation (Gold Ball Bond) per MIL STD 883 method 2011	3	20	1	n/a

Lot Acceptance Tests

PARAMETER	Lot Sampled	Sample Size	Fails Allowed	UNIT
Static burn-in 168hrs @ V_{HV}=1000V; MIL STD 883 method 1015	each	22	0	n/a
Physical dimensions	each	11	0	n/a
Wire Bond Evaluation (Gold Ball Bond) per MIL STD 883 method 2011	each	20	1	n/a

Product qualification tests are performed on 3 lots while a Lot Acceptance Test (LAT) is performed on each “diffusion lot”. LAT is considered complete if the lot was used for product qualification.

All samples used for qualification and LAT burn-in test are assembled in a ceramic DIL package with dielectric silicone gel filling the cavity to isolate wirebonds and substrate as well as to eliminate surface conduction and polarization as possible failure mechanisms.

Application Notes

Assembly:

To make best use of the 17SCT004A, the chip should be molded before high voltage is applied to it. This can either be done with a standard mold compound or with silicone gel. Care should be taken when selecting a encapsulant to ensure proper dielectric strength and resistance. We recommend that the dielectric strength of the mold compound used be greater than 1kV/mm at a thickness of 50um.

Care should also be taken to properly isolate the chip's substrate which is biased at about half V_{HV}. In no circumstances should the chip be mounted over layers providing less than 1kV of dielectric isolation. It is also strongly recommended to use non-conducting epoxy for attaching the wire bondable version of the chip.

For the wire-bondable version ball bonding should be used for attaching conductors to the chip's pad. Wedge bonding is not recommended. When using ball bonding the wire should extend vertically for at least 50um before going horizontal toward the substrate or package pad.

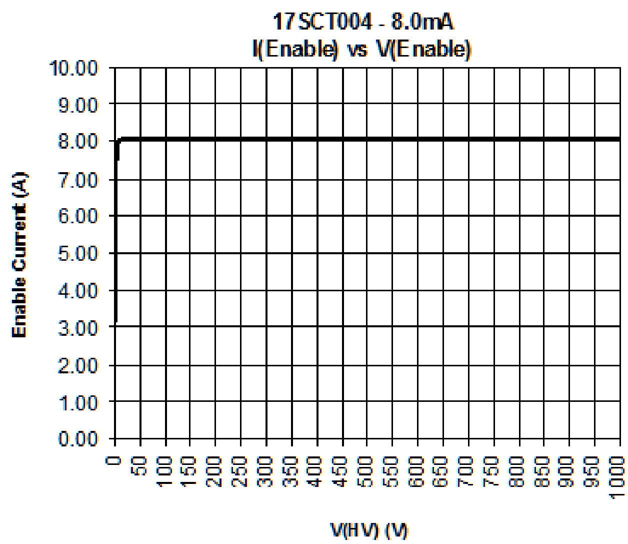
Operation:

The 17SCT004A is designed to be used as a robust current limiter with built-in over-temperature protection (patent pending). The chip acts like a FET transistor with the Enable being the equivalent of the Fet gate. The chip as 4 preset nominal currents: 6.0, 10, 19 and 24mA. The user can select the current ranges by connecting the two CurrBit inputs to either Vss (for "0") or to Enable (For "1"). The corresponding limited current are then given by the table below:

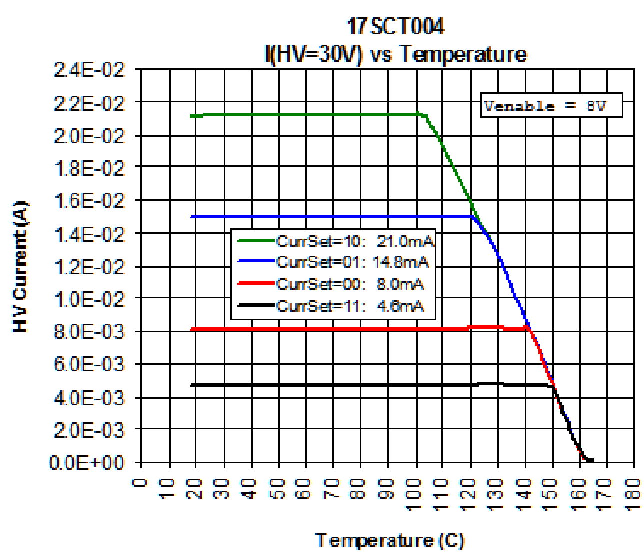
Nominal Current	CurrBit1	CurrBit0
10.0	0	0
19.0	0	1
24.0	1	0
6.0	1	1

The 17SCT004A is similar but differs from a basic Fet in the following points:

a) The current is voltage regulated to within 3% (below over-temperature protection threshold) as shown below. This provides for a very well controlled capacitor discharge when the chip is used for that purpose. It also makes the performance very predictable with trimming ensuring current will be within a narrow range around the nominal value. The 17SCT004A is currently trimmed at 8.0mA to +/-5% but any other range can be used for trimming if greater accurancy than stated in this datasheet is required.

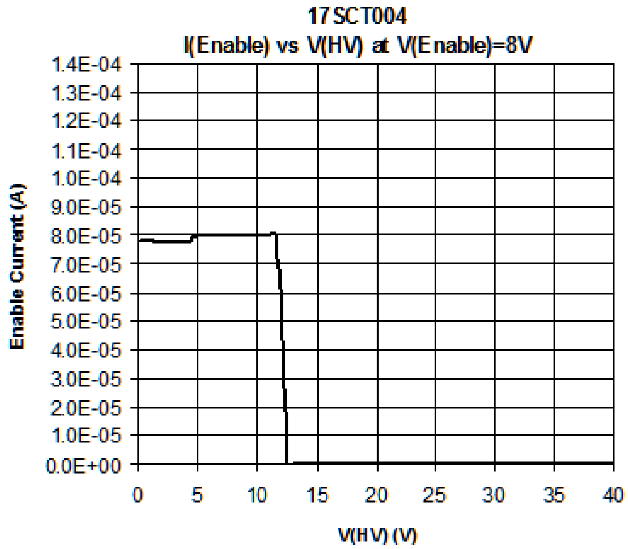


b) Over-Temperature protection: The current is temperature limited according to the typical curve below. This patent-pending characteristic ensures that the 17SCT004A will stay within a reasonable temperature range (<~150C) under normal operation. This is particularly true when high-current ranges of 15 or 21mA



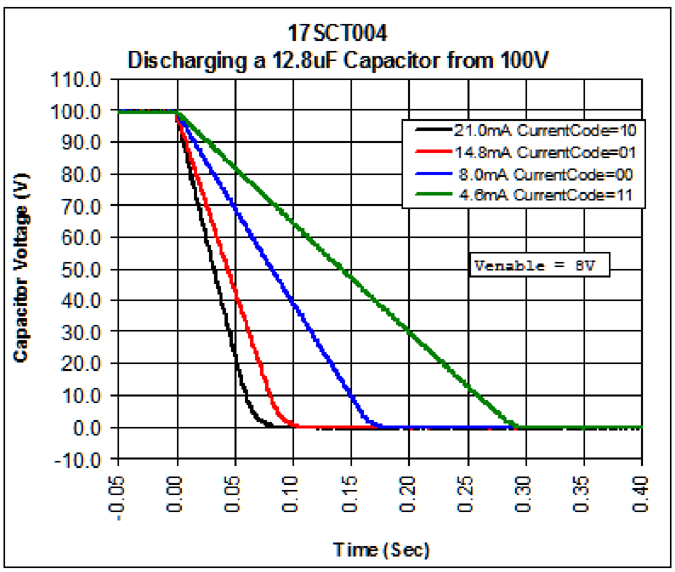
are used.

c) At V(HV) below ~V(Enable)+5V there is some current flowing from the Enable pin, see below:



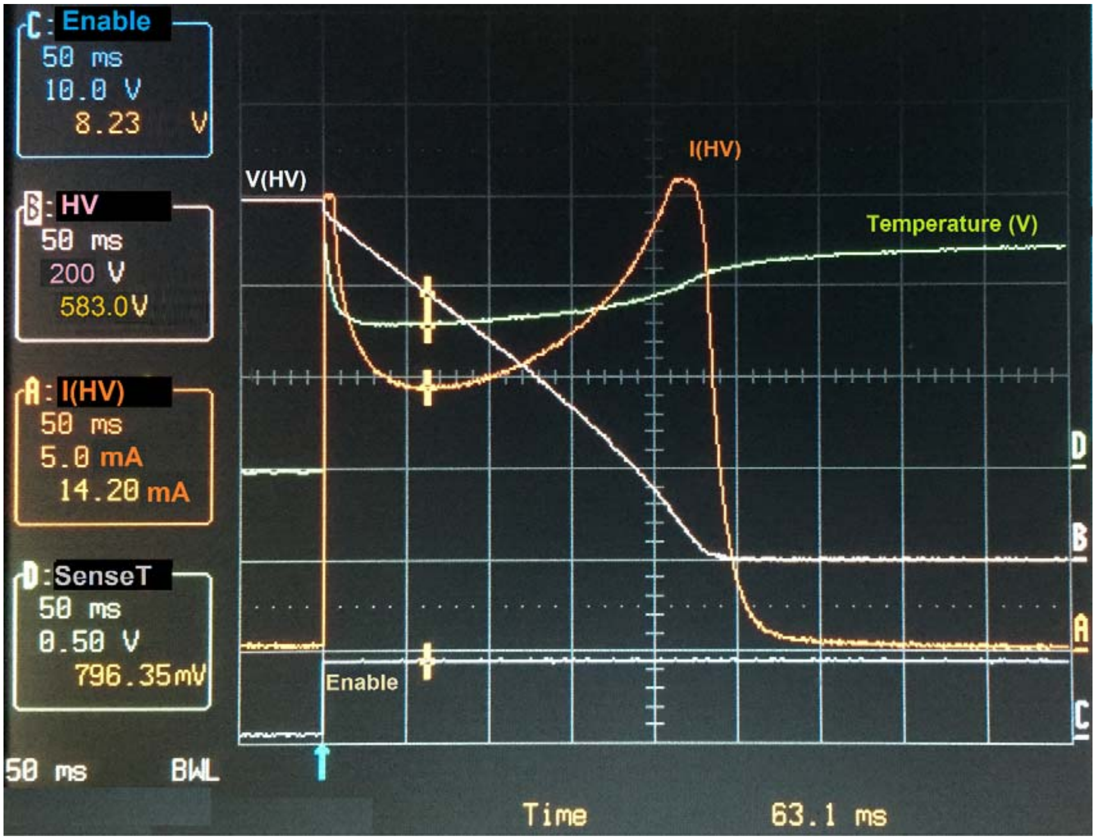
Typical Operation:

In a typical application where a capacitor has been charged to a high-voltage and the capacitor needs to be completely discharged, the 17SCT004A will perform flawlessly as shown in the chart below.



In this example the capacitor's energy is relatively small (~65mJ) and self-heating is below the threshold for over-temperature protection to be in effect.

In the other example below, a 5uF capacitor was charged to 800V (energy=1.6J) and discharged at about 25mA (the maximum current at which the device can be trimmed). The average power for this example is 6.4W. This power is sufficient to enable over-temperature protection.



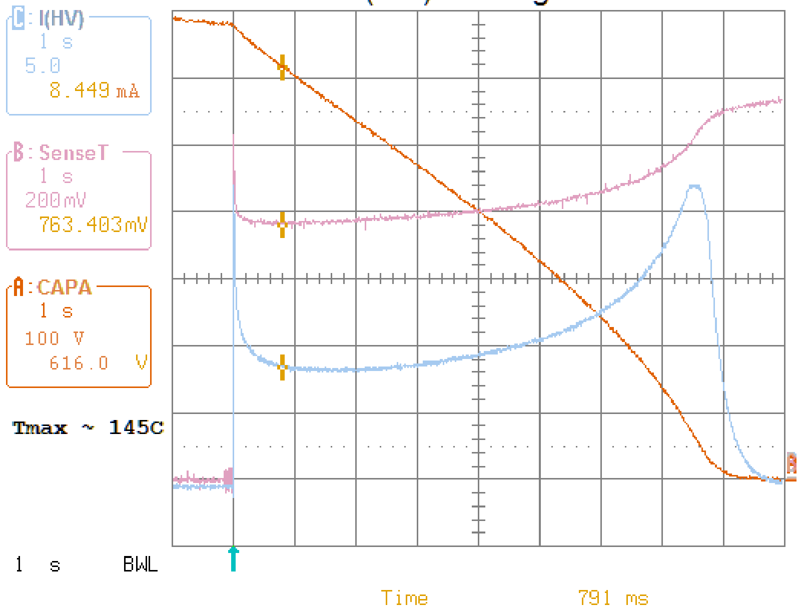
The discharge shown by trace B (HV) is essentially completed in 250-300mSec at a maximum current of ~25mA. For this example we purposely programed this chip to 25mA, somewhat above the specified maximum 21mA specification.

Trace A shows the discharge current through the 17SCT004A over time. At the discharge onset the current is maximum at about 25mA but quickly reduces to about 14-15mA as the over-temperature circuit is activated. As the discharge progresses, the capacitor voltage decreases which reduces dissipated power . At about 150mSec the current begins to significantly increase again towards 25mA which is reached around 200mSec. At these lower voltages the power dissipated by the 17SCT004A is much lower (P=V x I) and the over-temperature protection circuit allows more current for the discharge.

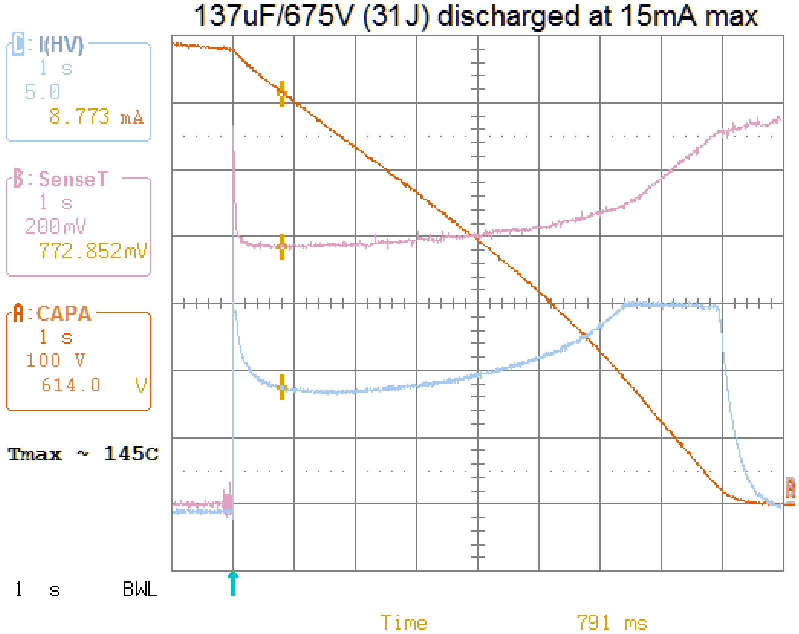
The net result is a very efficient capacitor discharge operation. The maximum junction temperature reached in this example was about 138C. Obeserve that discharge to <1V happens at about 300mS. Under similar conditions 40J of energy can be discharged in about 10 seconds or less.

Finally a few practical examples for a system similar to a Implantable Cardiac Defibrillators (ICD). These ICD typically use about 150uF capacitors which can be charged up to about 700V. We charged a similar system to 675V and fully discharged it. First using a maximum current of 21mA and second using 15mA. The charts below show the capacitor voltage A:CAPA, the sink current C:I(HV) and the temperature sensor reading B:SenseT. It can be seen that in both cases the discharge is completed in about 9 seconds, such that little is gained in using the 21mA range. In both cases the maximum junction temperature reached was 145C and the temperature-limited discharge current was about 8.5-9.0mA. The average discharge current for both example was about 11.8mA.

137uF/675V (31J) discharged at 21mA max

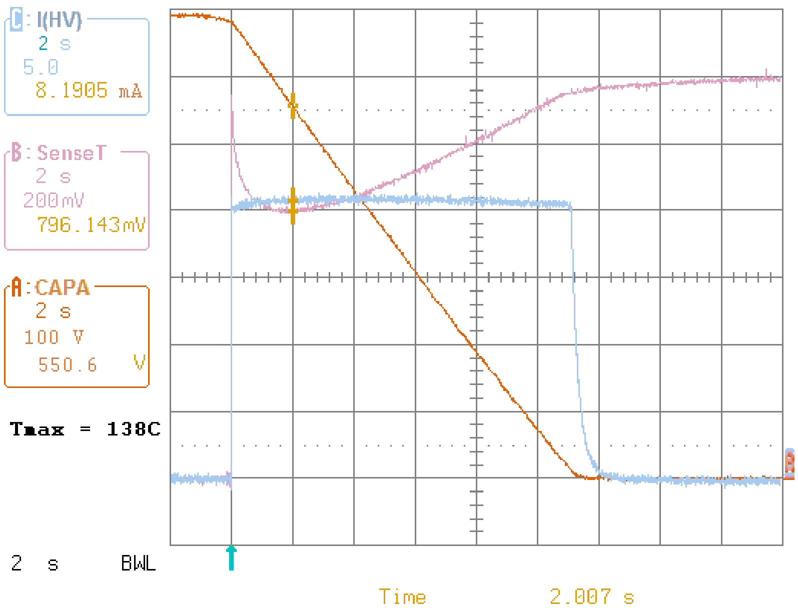


137uF/675V (31J) discharged at 15mA max



In another example of such a system the discharge current is set to 8.0mA and the capacitor is charged to 675V and then fully discharged (see top figure below). The discharge time is about 11.3 seconds and the maximum junction temperature is 138C. In this example the discharge current remains essentially constant near 8.2mA. In the second example below the capacitor is charged to 350V at an energy of 8.4J and then discharged at 21mA, requiring only about 2.5 seconds to reach 0V. In this case the maximum junction temperature was about 112C. The user will recongnize that there is substantial benefit in allowing the system to dynamically adjust the maximum current for amount of energy to dissipate.

137uF/675V (31J) discharged at 8mA max



137uF/350V (8.4J) discharged at 21mA max