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EMC and Circuit Protection Solution For LED Driver Circuit

- Jun 7th, 2011

Content

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1. Requirement of components in LED driver circuit
2. EMC and circuit protection solution for LED driver circuit
3. Sunlord related product presentation
   - Chip Varistor
   - Chip NTC thermistor
   - Chip ferrite bead
   - Chip power inductor
   - Chip solid tantalum capacitor

Requirement of Components in LED Driver Circuit

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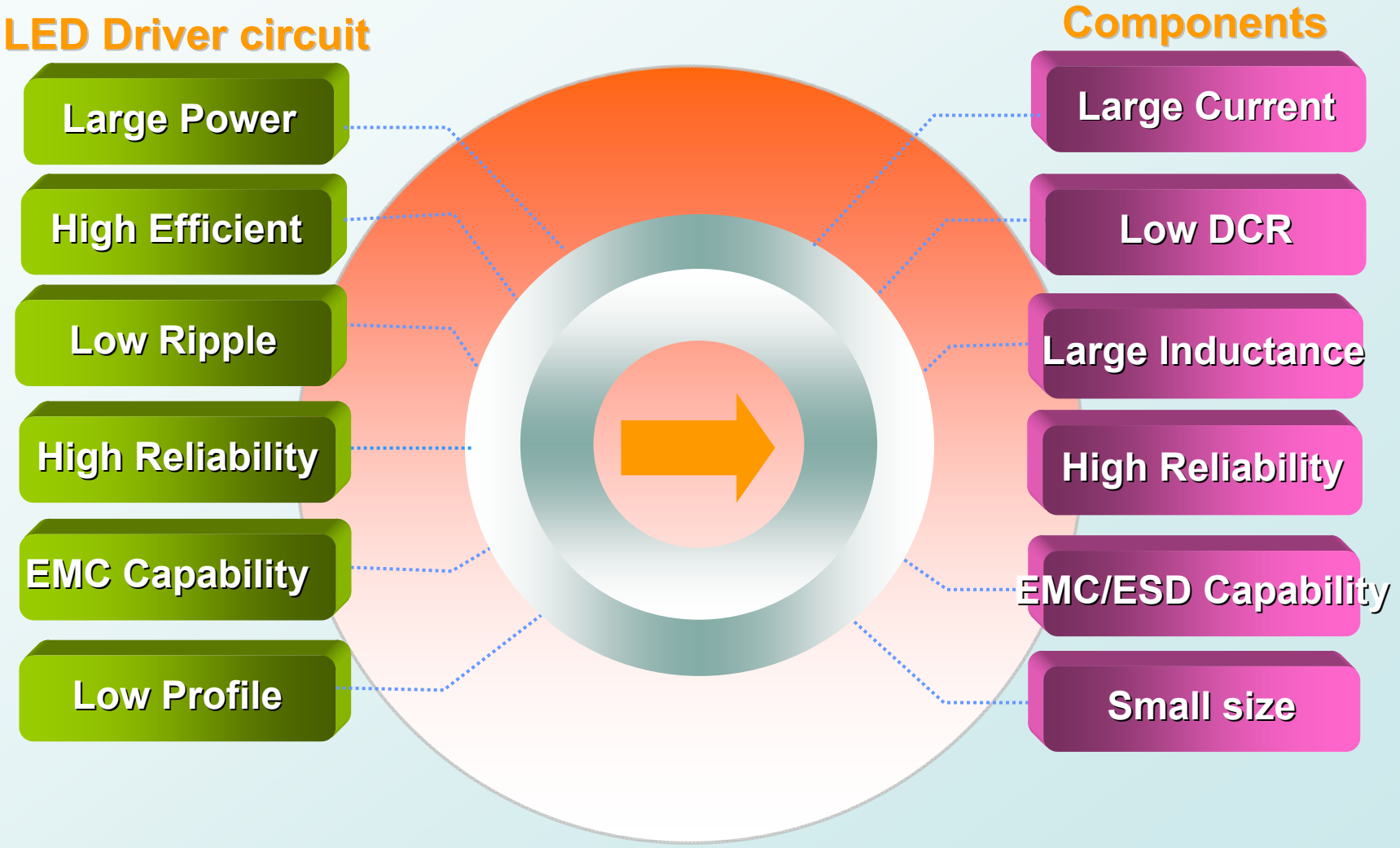

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LED Driver Circuit

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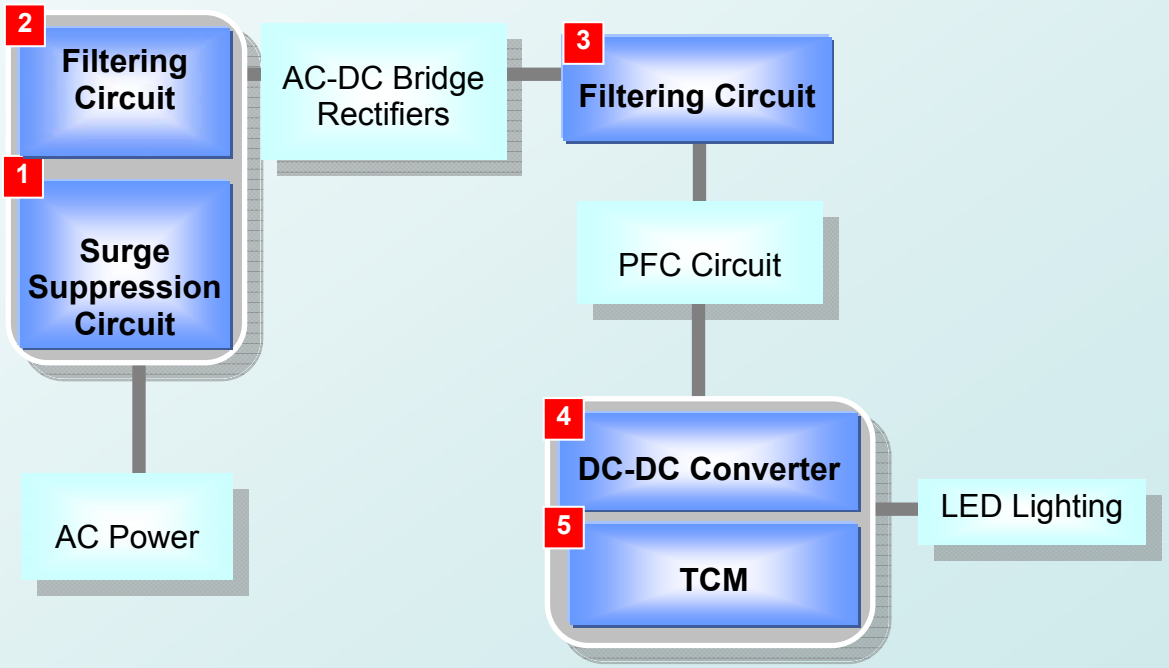

EMC and Circuit Protection Solution

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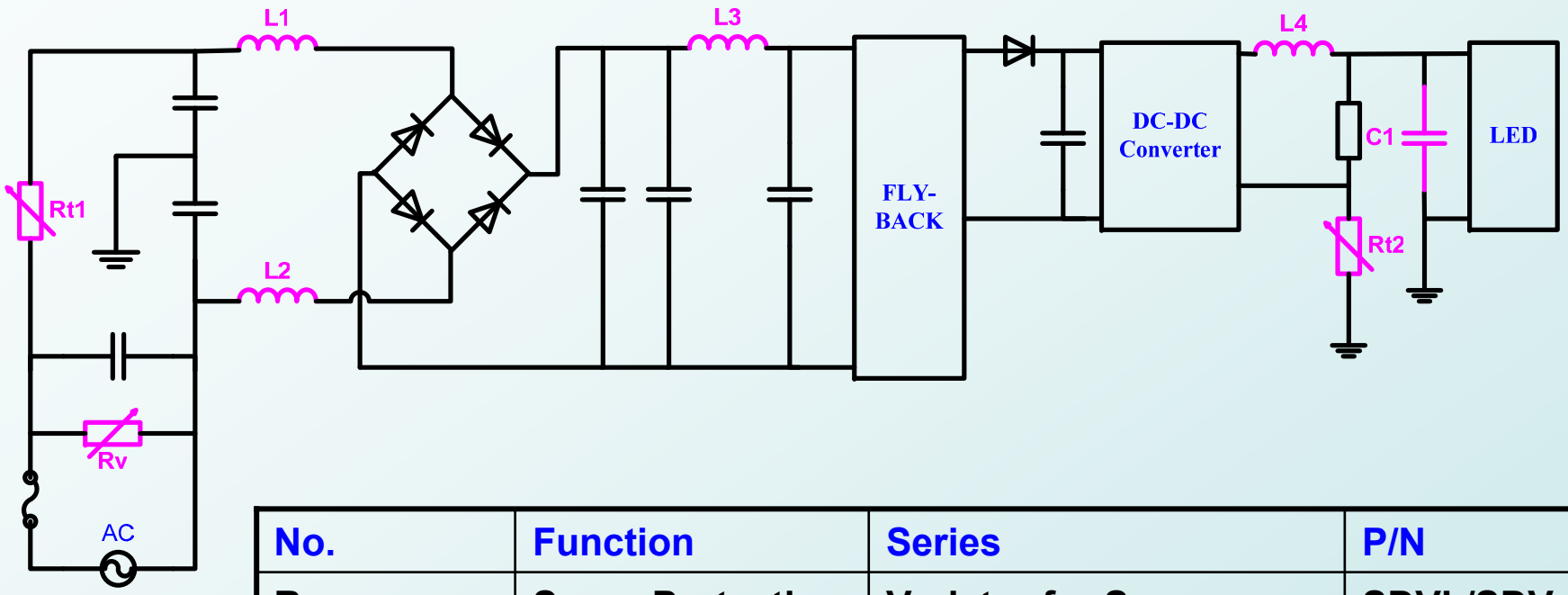

No.	Function	Series	P/N
Rv	Surge Protection	Varistor for Surge Protection	SDVL/SDV Series
Rt1	Surge Protection	Power NTC Thermistor	SPNT
L1，L2，L3	Filtering	Bead/Power inductor	Bead/SWPA
L4	Energy Storing	Power Inductor	SWPA
Rt2	Temp. Sensing	NTC Thermistor	SDNT
C1	Energy Storing	Tantalum Capacitor	TC211/212

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Varistor

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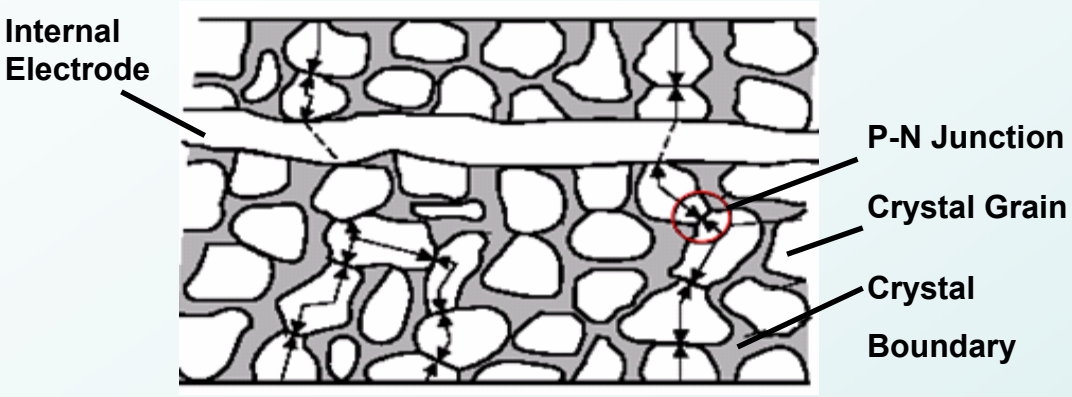
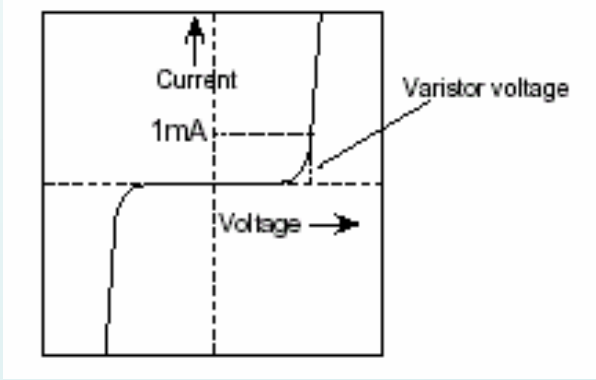
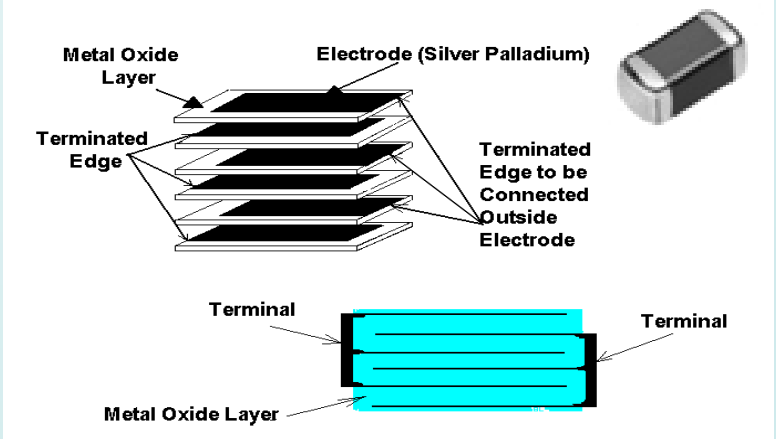


Microstructure



V-I Characteristics

Varistor is made of ZnO ceramics which have good performance of fast response time (less than 0.5ns), transmit energy absorbing and transferring to ground with millions of series-parallel P-N junctions.



Features:

- Fast response time: < 0.5nS
- High surge current capability
- Low leakage current
- Low clamping voltage
- Bidirectional V/I characteristic

Working principle of Varistor

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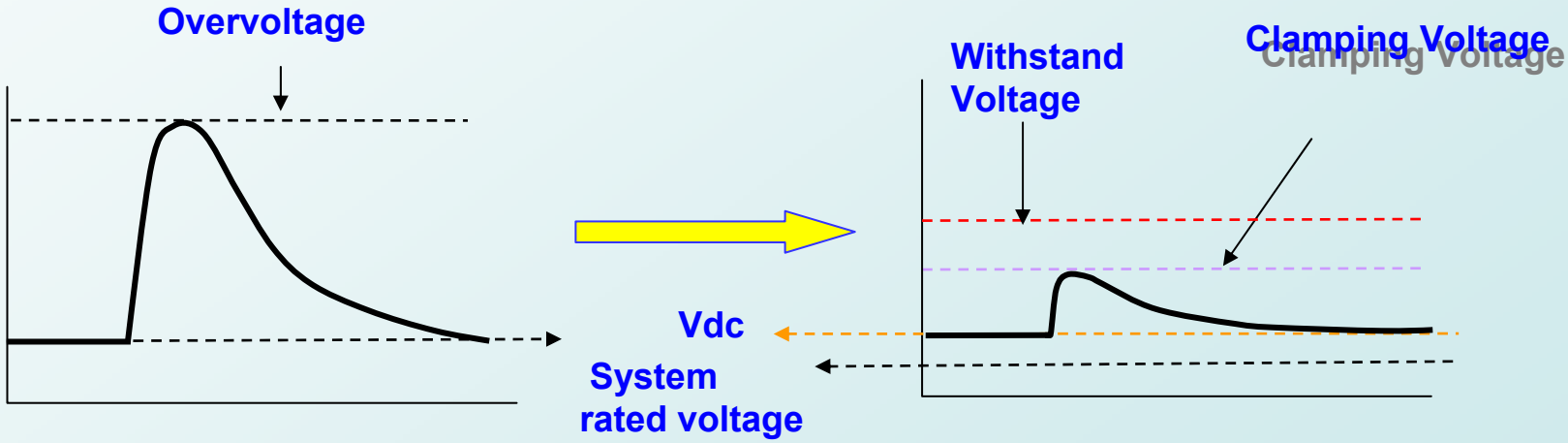
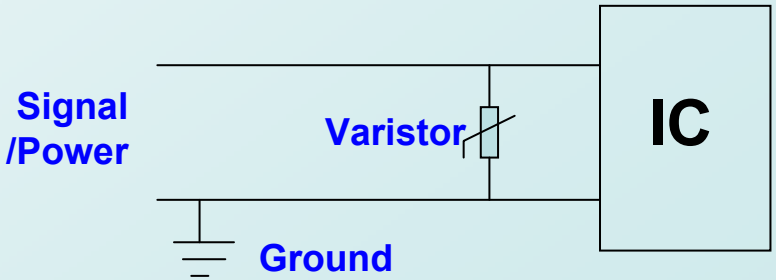
	Duration	Simulation Wave	Transmissions
Lightning discharges generate a wide range of electromagnetic radiations. The equipments will be damaged due to high transient voltage by induction or conduction.	μ S level	8/20 μ S Wave	Conduction/ Radiation





Applications of Varistor for LED Driver

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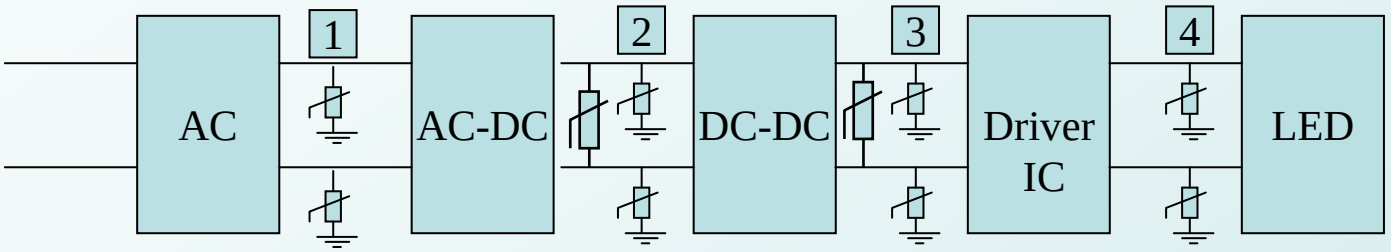

No.	Sunlord Varistor	Function	Primary Electrical Parameter
1	SDVL5650KA301PTF	Primary protection: suppress Induced over-voltage cased by power and lightning	Vc=775V、Ip=400A、Et=13.4J
2/3	SDV3216/3225	Secondary protection: suppress Induced & switching over-voltage, protecting DC-DC Module and driver IC (good replacement of SMAJ/SMBJ TVS)	Vc=40V, Ip=120～400A, Et=0.4～2.3J
4	SDV1005/1608/2012	ESD protection for LEDs	Cp=10~360pf

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Chip NTC Thermistor

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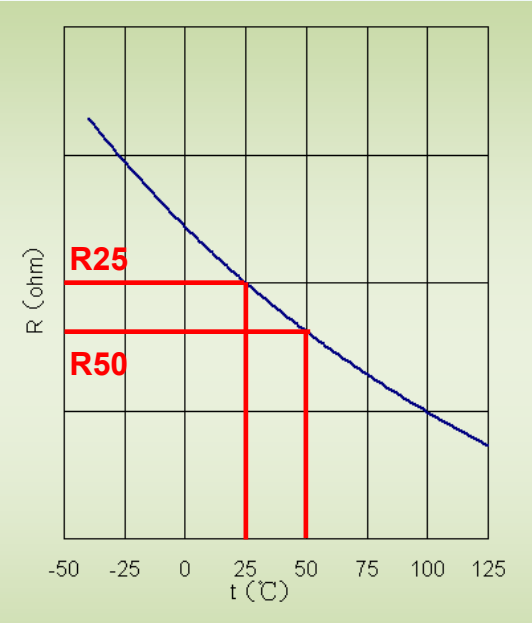


NTC Thermistor：Resistance decreases with temperature increasing ；

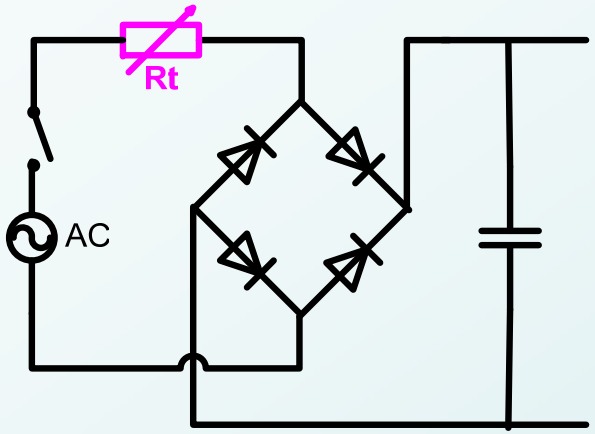
B Constant： $B = \frac{T_1 T_2}{T_2 - T_1} \ln \frac{R_{T1}}{R_{T2}}$

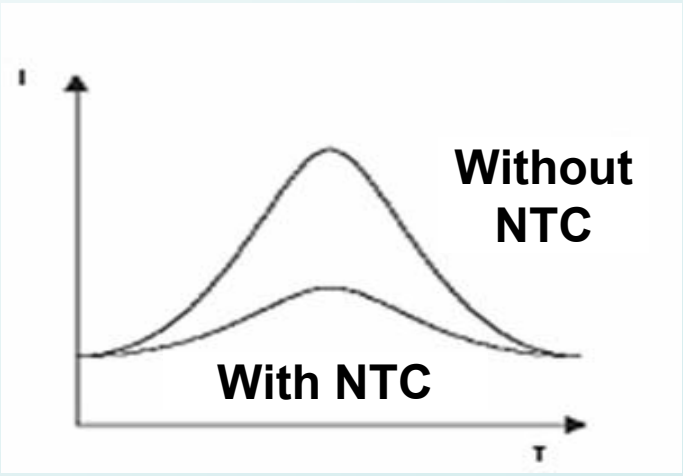
Generally，T2=323.15K（50 ℃），T1=298.15K（25℃）

Larger B constant for higher temperature sensing capability

Types: Chip power NTC Thermistor

Chip temperature sensor NTC Thermistor





- The inrush current occurs in power supply circuits (LED driver board, inverter fluorescent lamps, heaters, etc.) when electric equipment switches on. It will be hundred times higher than normal operating current.

- NTC resistance at room temperature is big enough to suppress inrush current when the equipment switches on. After that, as the body temperature of NTC rising, its resistance becomes smaller, and thus the power consumption of NTC is negligible to ensure electric equipment working normally.

Chip Power NTC Thermistor

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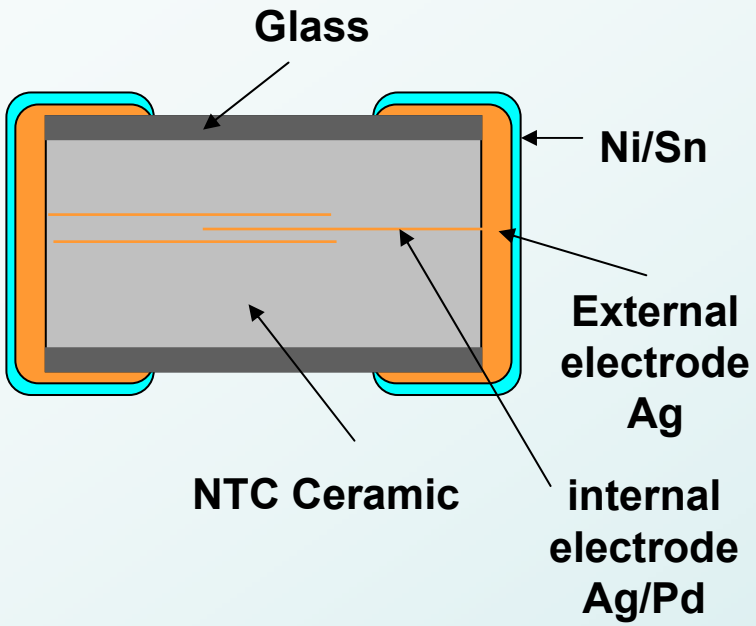

- Improved reliability and lower R25 due to use of internal electrodes
- Developed material (large resistivity and B constant) provides low residual resistance and high permissible current
- SMD type designed for high density
- Available in a standard EIA compatible case size
- Excellent long time aging stability

Excellent Performance of Chip Power NTC

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Size		B constant（K）		Residual Resistance (Ω)	
Pin-type（diameter）	Chip (L×W)	Pin-type	Chip	Pin-type	Chip
Φ5	4516	2500-3300	3500-4000	0.353-18.7	0.14-7.9
Φ7	4532	2500-3300	3500-4000	0.283-11.65	0.14-7.9
Φ9	4532/5056	2500-3300	3500-4000	0.21-30	0.14-13
Φ11	5056	2500-3300	3500-4000	0.19-3	0.14-1.3
Φ13	5056/8063	2500-3300	3500-4000	0.17-2.4	0.14-1.3
Φ15	8063	2500-3000	3500-4000	0.17-2.4	0.14-1.3
Φ20	10080	2500-3000	3500-4000	0.16-0.9	0.14-0.7

- The material resistivity of Pin-type is very low (50-200m·mΩ) which results in low B constant and high Residual Resistance.

- Chip power NTC adopts innovative materials with high resistivity (5000m · mΩ or so) and internal electrode structure, and thus provides high B constant (4000K or more) and low Residual Resistance.

Chip Power NTC Property Range Table

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SUNLORD Chip NTC	R25（Ω）	B Constant（K）	Residual Resistance（Ω）	Max. Permissible Current（A）
SPNT4516	5-200	3500-4000	0.14-7.9	0.1-1
SPNT4532	5-200	3500-4000	0.14-7.9	0.2-2
SPNT4532/5056	5-400	3500-4000	0.14-13	0.2-3
SPNT5056	5-120	3500-4000	0.14-1.3	1-4
SPNT5056/8063	5-120	3500-4000	0.14-1.3	1.5-5
SPNT8063	5-120	3500-4000	0.14-1.3	2.5-6
SPNT10080	5-50	3500-4000	0.14-0.7	4-12

Temperature Sensor NTC

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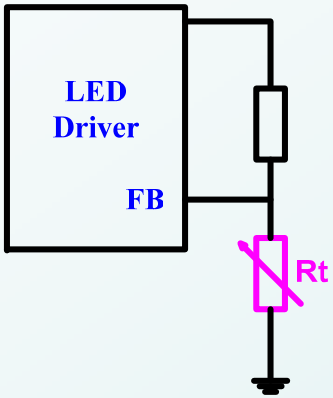

- Large B constant for higher temperature sensing capability
- Designed for high density
- Available in a standard EIA compatible case size
- Excellent long time aging stability

Part No.	Resistance at 25℃ (KΩ)	B constant (k)	Max. permissive Operating Current (mA)	Dissipation Factor (mW/℃)
SDNT1005	0.022~680	3380~4400	0.03~6.7	1.0
SDNT1608	0.1~680	3380~4500	0.03~3.1	1.0
SDNT2012	0.1~680	3380~4500	0.04~4.0	2.0

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Ferrite Bead Working Theory

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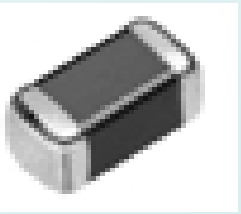
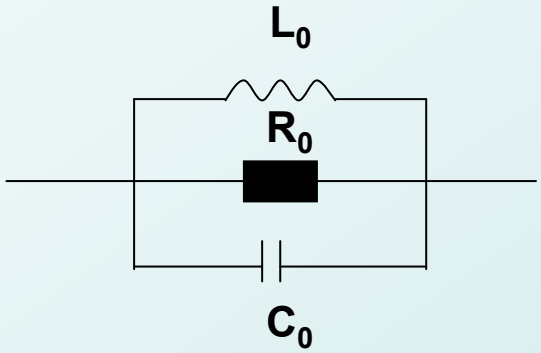
- Bead is connected in series in the circuit.
- Bead is a frequency dependent resistor.
- At low frequencies, inductive impedance is low.
- At higher frequencies, the impedance increases and becomes resistive function .
- The resistive loss attenuates the unwanted frequencies through heating of the bead's ferrite material due to eddy currents.

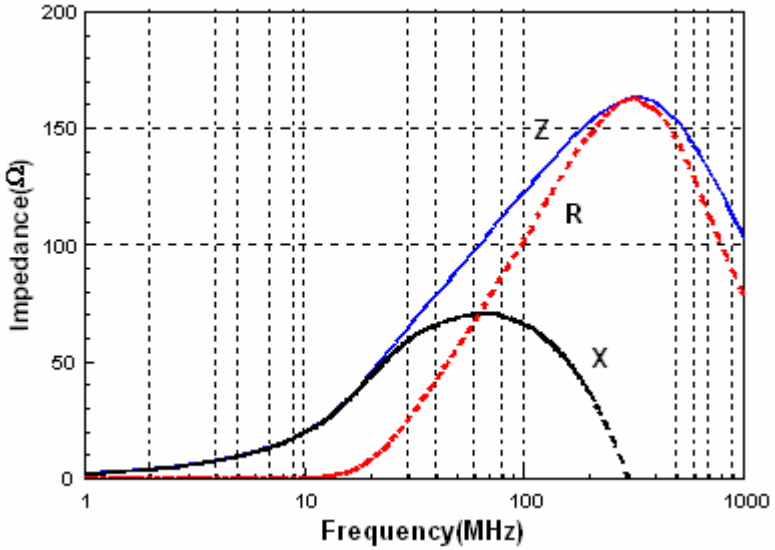




Equivalent Circuit

$Z=R+jX$

$Z^2=R^2+X^2$



Ferrite Bead Future Development

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Large Current

Sunlord large current bead PZ/UPZ series which provide large rated current and low RDC achieve low heat loss in power supply circuit.

Development plan: large current of >10A

Miniaturization

Smaller size beads are required due to limited surface of LED lightings

Main size: 2012/1608

Tendency:
→1005 → 0603 →…

Wide Frequency Range

EMI tends to higher frequency with the development of high speed transmission. Good EMC capability in high frequency beads are needed. Sunlord HZ/ HPZ series bead are effective in suppressing high frequency EMI in 30MHz~3GHz.

Development plan:
Bead for 6GHz and above EMI suppression

High impedance

High impedance is also a tendency in order to achieve a better EMC performance.

The highest impedance bead nowadays of Sunlord's is 2700Ω@100MHz.

Sunlord's Beads

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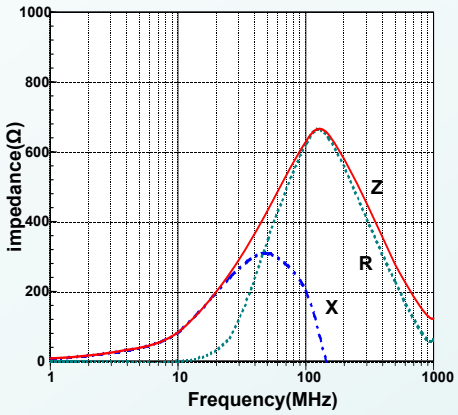
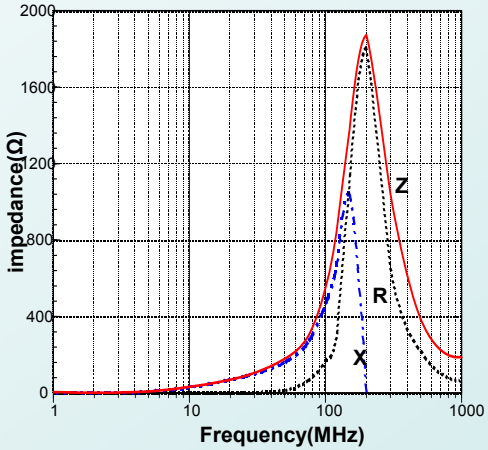
GZ2012D601



GZ Series

Attenuation Frequency Range: 30~750MHz

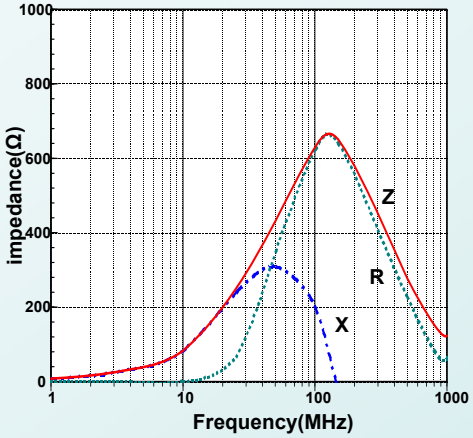
SZ2012G601



SZ Series

Attenuation Frequency Range: 100~400MHz

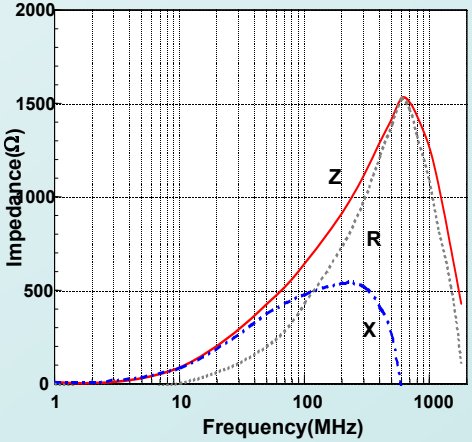
PZ2012D601



PZ or UPZ Series

Attenuation Frequency Range: 30-~750MHz

HZ1608K601



HZ or HPZ Series

Attenuation Frequency Range: 30~3000MHz

Sunlord's Beads

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Size	/	Property Range
0603（0201）	Impedance Range（Ω）	10 — 240
	Ir Range（A）	0.1 — 1.0
1005（0402）	Impedance Range（Ω）	10 — 1800
	Ir Range（A）	0.1 — 2.0
1608（0603）	Impedance Range（Ω）	10 — 2700
	Ir Range（A）	0.1 — 6.0
2012（0805）	Impedance Range（Ω）	10 — 2700
	Ir Range（A）	0.2 — 6.0
3216（1206）	Impedance Range（Ω）	10 — 1000
	Ir Range（A）	0.3 — 6.0
4516（1806）	Impedance Range（Ω）	60 — 470
	Ir Range（A）	2.0 — 6.0
……	Impedance Range（Ω）	……
	Ir Range（A）	……

Bead Selection Guide

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Ferrite bead is one of the most important EMC components.
Different type beads are recommended in different circuits:

- **Filtering in input circuit**
  PZ3216&PZ4516Series

- **LED PWM mode dimming**
  PZ3216&PZ/UPZ2012&PZ/UPZ1608 Series

Bead size is a very important element which is related with price, property, lead time.
Generally, smaller size bead has a lower price, thus, small size UPZ series bead is a good option for LED power supply circuit.

- **Know frequency range of noise**
- **Know noise attenuation required**
- **Know system rated current**
- **Know allowable space on the PCB**

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Power inductor application in DC-DC converter circuit

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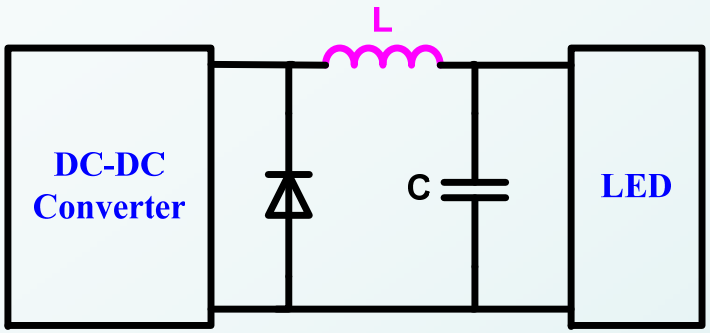
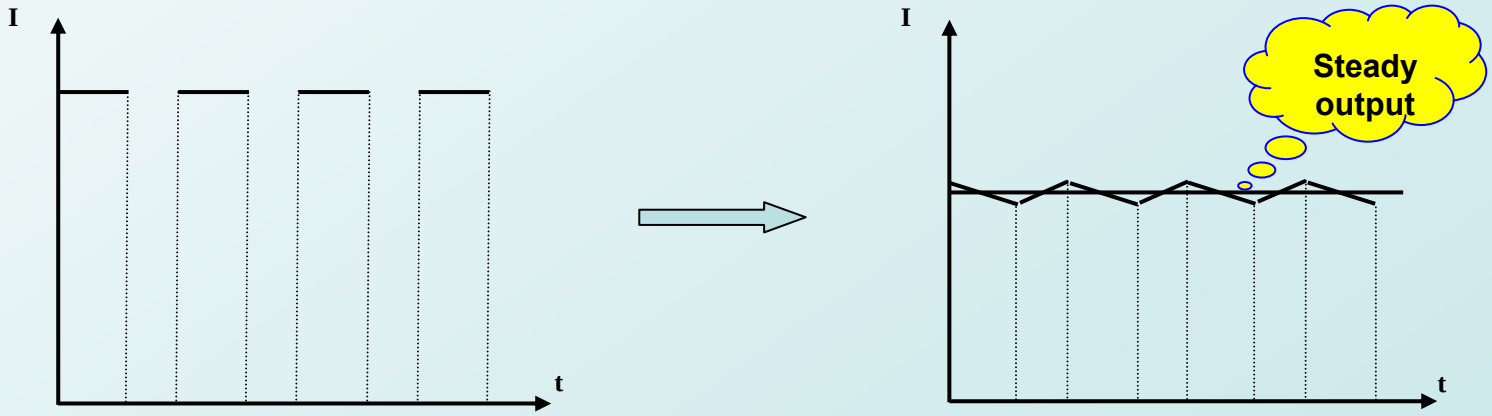


Power inductors are used in DC-DC converter circuit for energy storing, choke and smoothing. With inductors and output capacitors, DC-DC converter provide a steady output.



Rated current of power inductor

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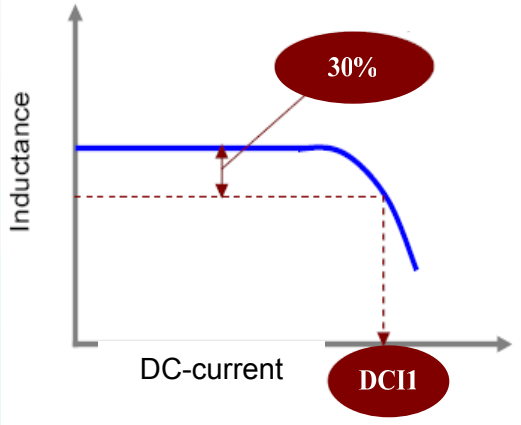
DCI1（Saturation Current）

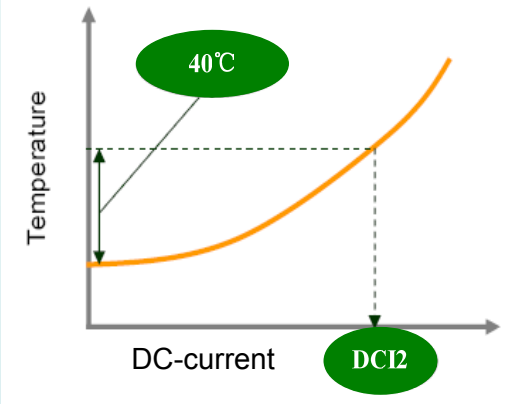
Saturation Current



The inductance will decrease under continual current. The Saturation Current is defined as the current at which the inductance drops by 30%.

DCI2（Heat Rating Current）

Heat Rating Current



The inductor body temperature will increase under continual current. The Heat Rating Current is defined as the current that causes the body temperature rise 40℃ from 20℃ ambient.

Unique Compact Component Structure

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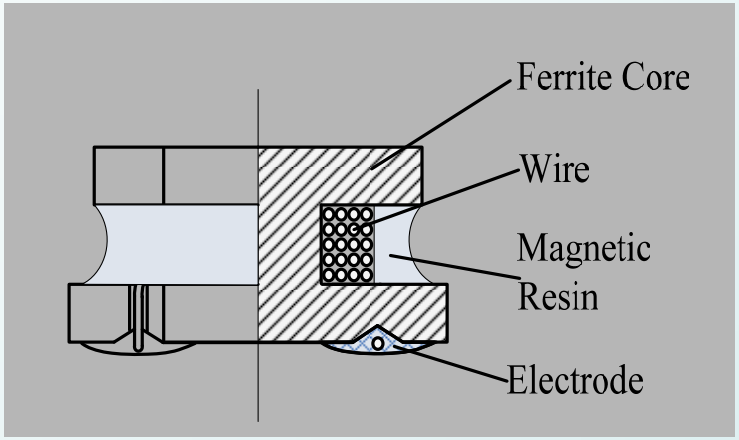
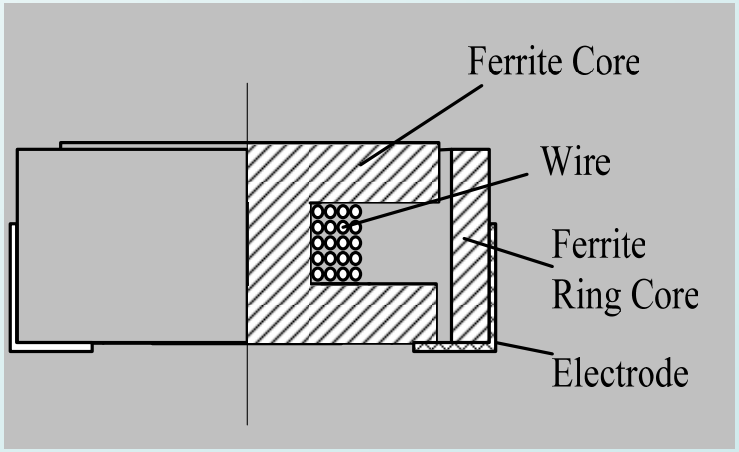
SWPA Series Structure



Conventional Structure



SWPA structure makes the lowest profile power inductor possible, offers an excellent combination of high current , high inductance and low DC resistance.

Unique Compact Component Structure

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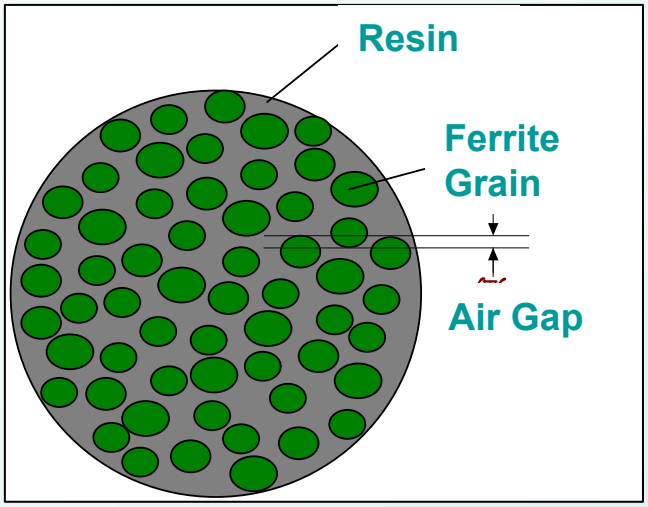
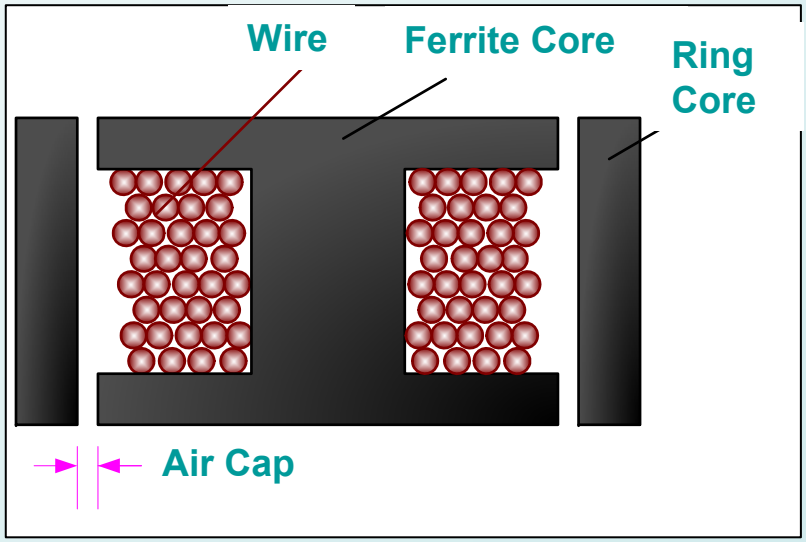


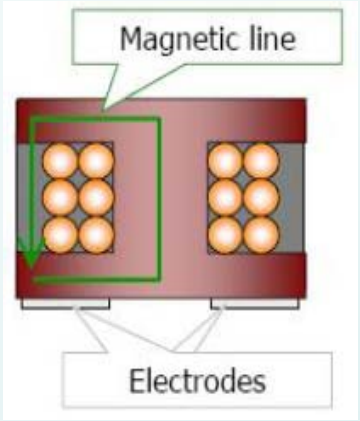


SWPA: The air gaps between magnetic powders form uniform and multiple.

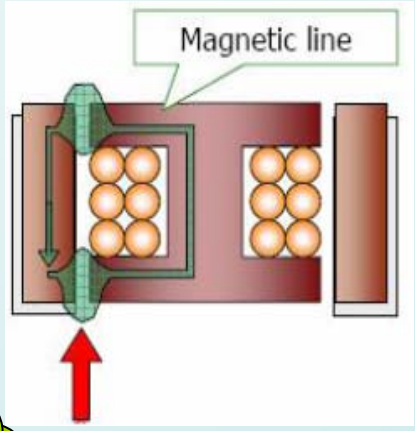
Sleeve type: The air gap between magnetic ring and core forms single and big.

Lower magnetic leakage

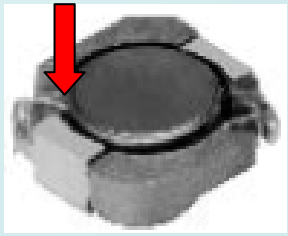
SWPA Type



Sleeve Type



magnetic leakage result in AC loss



SWPA series wire wound power inductor

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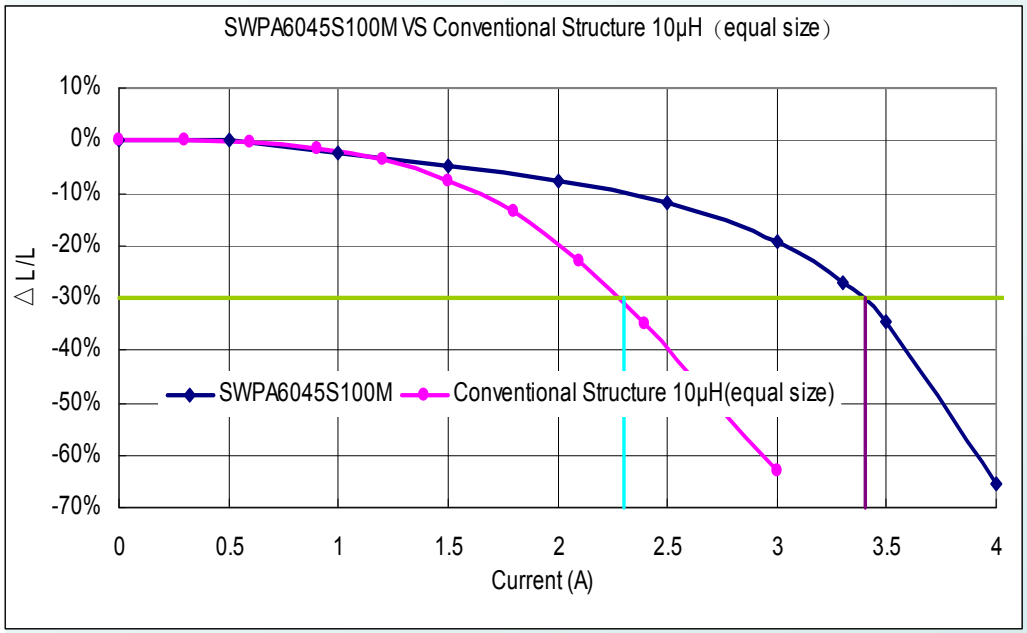
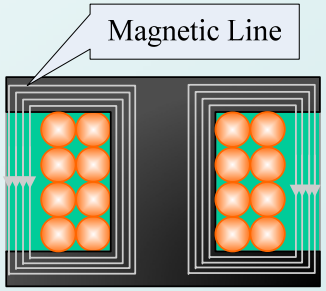
Higher Saturation Current than conventional inductors of the same size

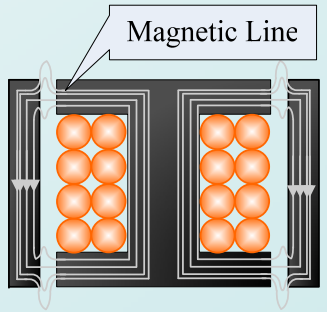


Lower AC Loss and Electro Magnetic Interference

SWPA



Sleeve Type



- SWPA with a closed magnetic circuit minimizes AC loss;
- Sleeve Type inductors with an air gap leaks flux that results in the increase of AC loss

SWPA series wire wound power inductor

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High Performance, Space & Power Savings

- Sleeveless square-core winding makes full use of core space and thickens wires inside inductor to achieve lowest possible DC resistance
- Minimizes heat generation and maximizes efficient use of battery power
- 40% Higher current rating than conventional inductors of equal size, takes up less PCB real estate
- Metallization on Ferrite Core results in excellent shock resistance and damage-free durability
- Magnetic-resin shielded construction reduces buzz noise to ultra-low levels
- Closed magnetic circuit design reduces leakage flux and Electro Magnetic Interference (EMI)

Property Range Table

Series	Dimensions（L*W*H）	Inductance Range（uH）	Rated Current（A）
SWPA252012S	2.5*2.0[mm]	0.47~22	0.38~2.27
SWPA30S	3.0*3.0[mm]	0.82~100	0.21~2.1
SWPA40S	4.0*4.0[mm]	0.82~220	0.17~3.15
SWPA50S	5.0*5.0[mm]	1.0~100	0.49~4.45
SWPA60S	6.0*6.0[mm]	0.50~330	0.57~5.90
SWPA80S	8.0*8.0[mm]	0.82~330	0.64~6.30

➢ Rated Current

◆ **The inductance will drop greatly when the loop current increases more than saturation current, and thus the peak value of current ripple cannot be suppressed due to low inductance, which may cause damage to IC.**

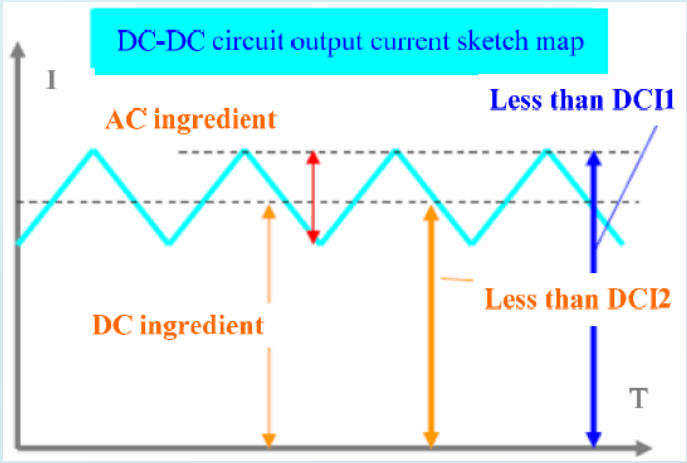
◆ **The body temperature of inductors may rise sharply when the loop current increases more than heat rating current, which may cause the worse reliability of wire insulation material and even destroy inductors.**

Generally, the smaller current is selected to set as rated current to suit the circuit.

eg: SWPA6045S100M：

DCI1=3.20 A

DCI2=2.45 A --->choose this current



Content

1. Requirement of components in LED driver circuit
2. EMC and circuit protection solution for LED driver circuit
3. Sunlord related product presentation
   - Chip Varistor
   - Chip NTC Thermistor
   - Chip Ferrite Bead
   - Chip Power Inductor
   - Chip Solid Tantalum Capacitor

Features of tantalum capacitor

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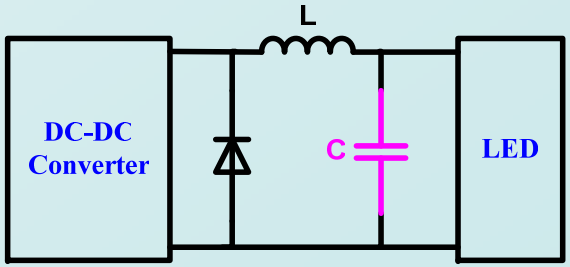
Solid chip tantalum capacitor provides excellent characteristics and can operate in a wide temperature range. It has unique features:

Advantage

- High specific capacity, good for smaller size
- Good capability of self-healing
- Can easily get large capacitance in a small size
- Brilliant stability in a wide temperature range
- Longevity of work and high reliability

Disadvantage

- Low rated voltage
- Polarity limited
- High price



Application ciruit

Features of tantalum capacitor

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Types	size	Capacitance	Rated voltage	Operating Temp.	Tem. Feature
MLCC	0402 [01005] ~5750 [2220]	0.10pF ~47uF	2.5V~3150V	-55~ +85 ℃	> ± 10%
Film Cp.	3.3*1.6*1.1 ~41.5*42.5*28	680pF ~220uF	16V~630V	-55~ +125℃	> ± 10%
Super Cp.	Φ4.8*1.4 ~ Φ35*60	0.1F~1000F	<7.5V	-40~ +70℃	>±30%
Ta Cp.	1106 [0402] ~7343 [2812]	0.22uF~ 2200uF	2.5V~50V	-55~ +125℃	< ± 10%

In general, Ta capacitor present a good performance in capacitance, operating temperature, brilliant reliability. Therefore, Ta Capacitor is fairly suitable as output capacitor in DC-DC converter circuit.

Sunlord Ta capacitor Property range

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Size	Capacitance	Rated Voltage
P case（2012）	0.1~22uF	2.5~20V
A case（3216）	0.1~100uF	2.5~50V
B case（3528）	0.15~220uF	2.5~50V
C case（6032）	0.47~220uF	4~50V
D case（7343-28）	2.2~330uF	4~50V
E case（7343-41）	10~680uF	4~50V

Ta Capacitor Selection Guide

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1. The reliability of Ta capacitor is influenced by many ambient condition elements, such as temperature, humidity, application force etc. Enough parameters margin is necessary to considered to improve the reliability of Ta capacitor.
2. Take measures to make sure that Ta capacitors work in a Min. ripple current and voltage condition.
3. Ta capacitors are inherently polar devices and may be permanently damaged or destroyed if applied reverse voltage. But if reverse voltage can't avoid, it must not exceed:

   1）10% of V_R or 1V at 25℃；
   2）5% of V_R or 0.5V at 85℃；
   3）1% of V_R or 0.1V at 125℃；

4. **In order to achieve high reliability, working voltage should obey:**

   1） For general use, working voltage should derate to 70% of VR or below. For power lines or some low-impedance circuit, working voltage should derate to 30% of VR or below.

   2） When operating temperature is above 85℃ and below 125 ℃, voltage derating is necessary:

   $$Vmax = \left(1 - \frac{T-85}{125}\right)V_R$$

   T：operating temperature； V_R： rated voltage at 85℃

5. **When Ta capacitor is used in circuit where surge current may occurred, a resistor is needed to connect in series with capacitor to prevent from damaging.**

6. **Margin designing is necessary to improve the reliability of Ta capacitor especially in some circuit that easily lead to short-circuit.**

Thank You !