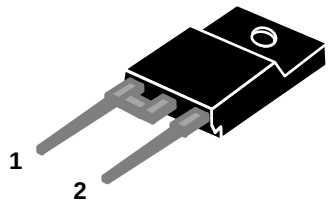
Fast Recovery Diode

Features

- High Breakdown Voltage (V_{RRM} = 300V)
- Fast Recovery Time
- Low Forward Voltage Drop
- Low Leakage Current

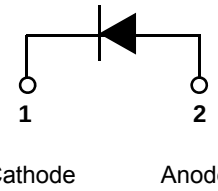
TO-220F-2P Package



Application

- Rectifiers for Switch Mode Power Supplies (SMPS)
- Free Wheeling Diodes in Converters and Motor Control Circuits

Pin Configuration



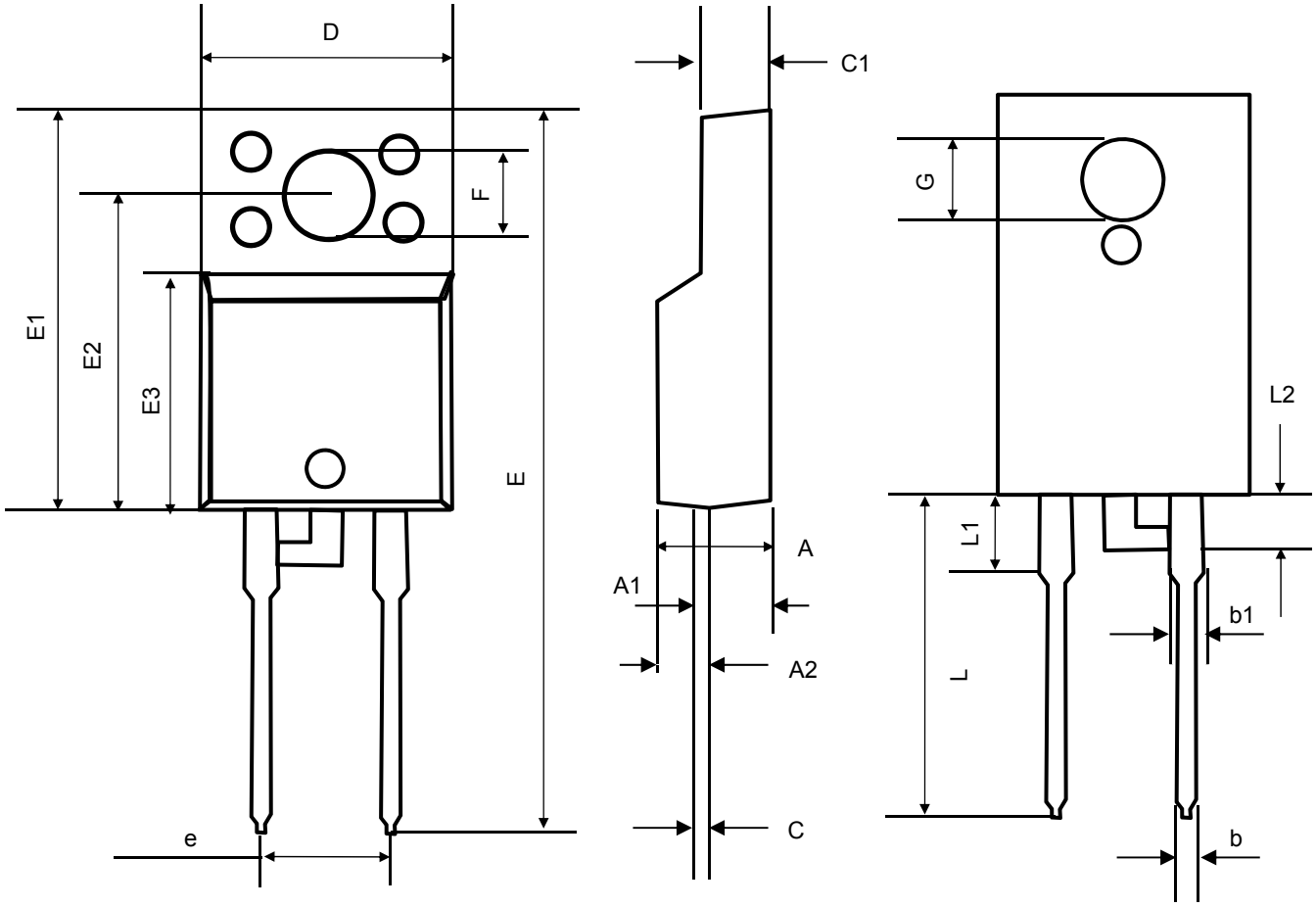
Absolute Maximum Rating (Ta = 25℃)

Parameter	Symbol	Value	Unit
Maximum Repetitive Reverse Voltage	V_{RRM}	300	V
Average Rectified Forward Current	I_o	10	A
Forward Current Surge Peak	I_{FSM}	100	A
Junction Temperature	T_J	150	˚C
Storage Temperature	T_{STG}	-55 ~ 150	˚C

Electrical Characteristics (Ta = 25℃)

Characteristics	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage	V_F	IF = 10A	-	-	1.3	V
Reverse Leakage Current	I_R	V_R = 300V	-	-	20	μA
Reverse Recovery Time	t_{rr}	I_F =1A, di/dt = -100A/μs	-	-	28	ns

Package Outline Drawing: TO-220F-2P



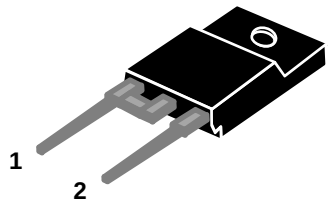
SYMBOL	MILLIMETER			NOTE
	MINIMUM	NOMINAL	MAXIMUM	
A	-	-	4.60	
A1	2.45	2.50	2.55	
A2	1.95	2.00	2.05	
b	0.65	0.75	0.85	
b1	1.07	1.27	1.47	
C	0.40	0.50	0.60	
C1	2.70	2.80	2.90	
D	9.90	10.00	10.10	
E	28.00	-	28.60	
E1	15.50	15.60	15.70	
E2	12.30	12.40	12.50	
E3	9.15	9.20	9.25	
F	3.30	3.40	3.50	
G	3.10	3.20	3.30	
e1	5.08 BSC			
L	12.40	-	13.00	
L1	3.46 BSC			
L2	2.21 BSC			

Fast Recovery Diode

Features

- High Breakdown Voltage (V_{RRM} = 400V)
- Fast Recovery Time
- Low Forward Voltage Drop
- Low Leakage Current

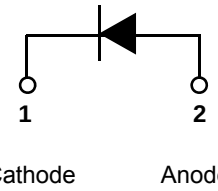
TO-220F-2P Package



Application

- Rectifiers for Switch Mode Power Supplies (SMPS)
- Free Wheeling Diodes in Converters and Motor Control Circuits

Pin Configuration



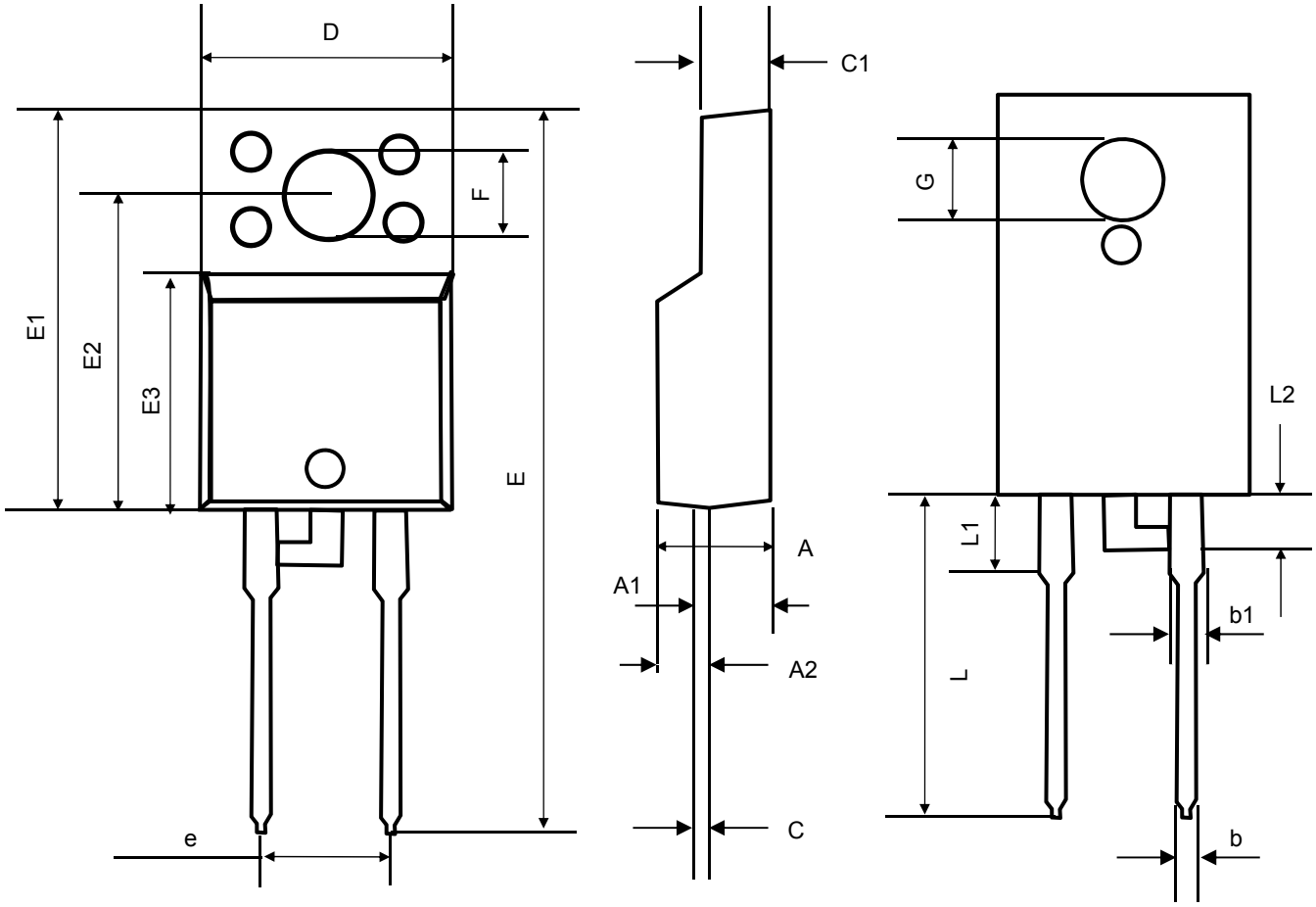
Absolute Maximum Rating (Ta = 25℃)

Parameter	Symbol	Value	Unit
Maximum Repetitive Reverse Voltage	V_{RRM}	400	V
Average Rectified Forward Current	I_o	10	A
Forward Current Surge Peak	I_{FSM}	100	A
Junction Temperature	T_J	150	˚C
Storage Temperature	T_{STG}	-55 ~ 150	˚C

Electrical Characteristics (Ta = 25℃)

Characteristics	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage	V_F	IF = 10A	-	-	1.4	V
Reverse Leakage Current	I_R	V_R = 400V	-	-	20	μA
Reverse Recovery Time	t_{rr}	I_F =1A, di/dt = -100A/μs	-	-	30	ns

Package Outline Drawing: TO-220F-2P



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	MINIMUM	NOMINAL	MAXIMUM	
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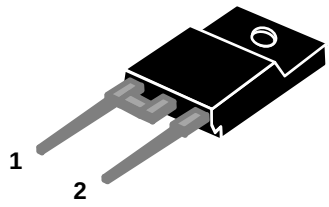
A2	1.95	2.00	2.05	
b	0.65	0.75	0.85	
b1	1.07	1.27	1.47	
C	0.40	0.50	0.60	
C1	2.70	2.80	2.90	
D	9.90	10.00	10.10	
E	28.00	-	28.60	
E1	15.50	15.60	15.70	
E2	12.30	12.40	12.50	
E3	9.15	9.20	9.25	
F	3.30	3.40	3.50	
G	3.10	3.20	3.30	
e1	5.08 BSC			
L	12.40	-	13.00	
L1	3.46 BSC			
L2	2.21 BSC			

Fast Recovery Diode

Features

- High Breakdown Voltage (V_{RRM} = 600V)
- Fast Recovery Time
- Low Forward Voltage Drop
- Low Leakage Current

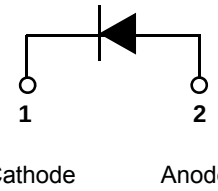
TO-220F-2P Package



Application

- Rectifiers for Switch Mode Power Supplies (SMPS)
- Free Wheeling Diodes in Converters and Motor Control Circuits

Pin Configuration



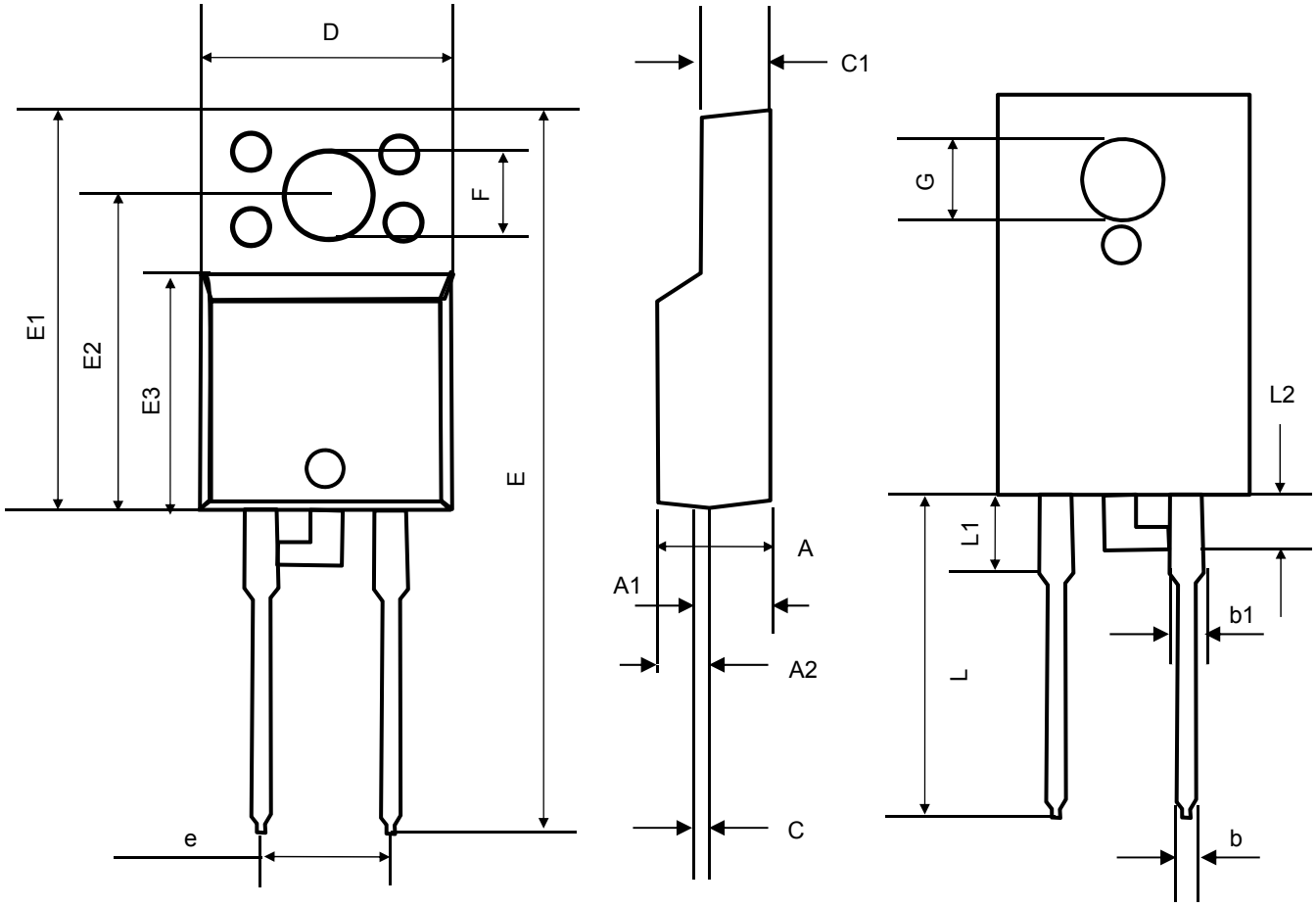
Absolute Maximum Rating (Ta = 25℃)

Parameter	Symbol	Value	Unit
Maximum Repetitive Reverse Voltage	V_{RRM}	600	V
Average Rectified Forward Current	I_o	10	A
Forward Current Surge Peak	I_{FSM}	100	A
Junction Temperature	T_J	150	˚C
Storage Temperature	T_{STG}	-55 ~ 150	˚C

Electrical Characteristics (Ta = 25℃)

Characteristics	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage	V_F	IF = 10A	-	-	1.9	V
Reverse Leakage Current	I_R	V_R = 600V	-	-	20	μA
Reverse Recovery Time	t_{rr}	I_F =1A, di/dt = -100A/μs	-	-	35	ns

Package Outline Drawing: TO-220F-2P



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A2	1.95	2.00	2.05	
b	0.65	0.75	0.85	
b1	1.07	1.27	1.47	
C	0.40	0.50	0.60	
C1	2.70	2.80	2.90	
D	9.90	10.00	10.10	
E	28.00	-	28.60	
E1	15.50	15.60	15.70	
E2	12.30	12.40	12.50	
E3	9.15	9.20	9.25	
F	3.30	3.40	3.50	
G	3.10	3.20	3.30	
e1	5.08 BSC			
L	12.40	-	13.00	
L1	3.46 BSC			
L2	2.21 BSC			

BOB
SBS
TGS

Zener Diodes for ESD/EOS Protection

SIGETRONICS

1. Basic Functions of Zener Diode

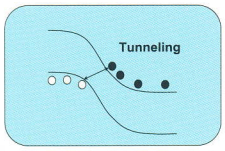
Zener breakdown

- Tunneling probability(Θ)

$$\Theta = \exp\left(-\frac{4}{3}\frac{\sqrt{2m^*}}{q\hbar}\frac{E_g^{3/2}}{\varepsilon}\right)$$

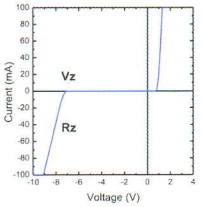
- Tunneling current(J_n)

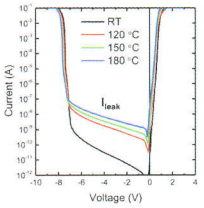
$J_n = qv_R n\,\Theta$
v_R: Richardson velocity



Key Device Parameters

- Zener voltage (Vz)
- Leakage current (I_{leak} @ -4 V)
- ESD strength (> ±8 kV)
- Current drivability (>100mA)
- Temperature coefficient($\Delta Vz/\Delta T$ < a few mV/K)



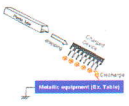


2. ESD/EOS Models and Standards

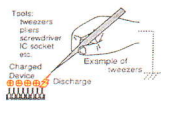
HBM

MM

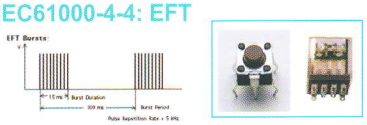
CDM



IEC61000-4-2 : HBM + CDM



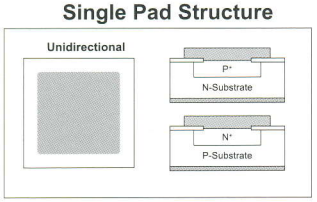
IEC61000-4-4: EFT

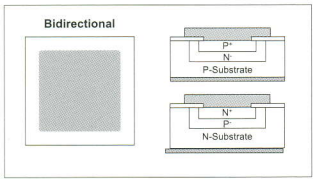


IEC61000-4-5 : Lightning Surge

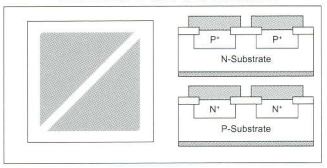
3. Species of Zener Diodes

Single Pad Structure

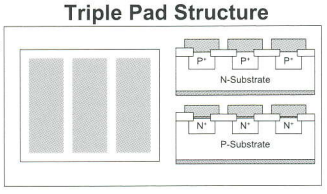




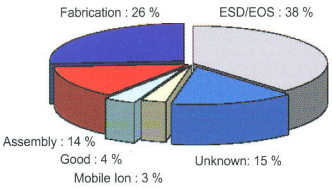
Double Pad Structure



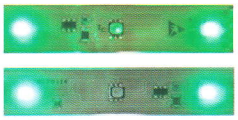
Triple Pad Structure



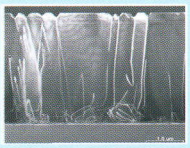
4. GaN-based LEDs need ESD/EOS Protection



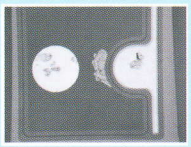
Dead & Degraded LEDs by ESD Stroke



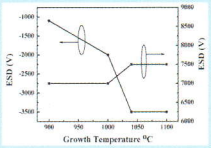
GaN Epi Structure



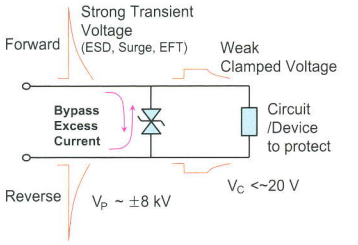
ESD damaged LEDs

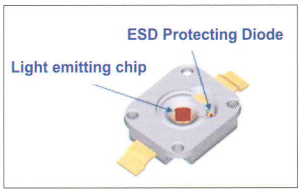


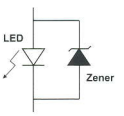
ESD Endurance



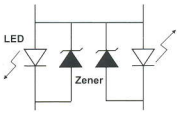
5. Configuration for LED Protection



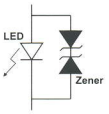




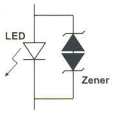
General Connection of Zener Diode with LED chip



Single Chip Dual Pad Parallel Connection



Single Chip Dual Pad Series Connection (Cathode to cathode)

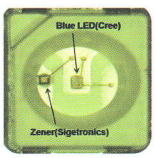


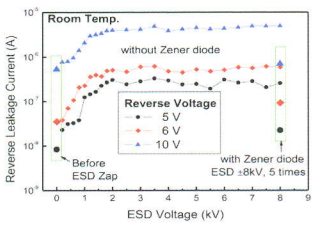
Single Chip Dual Pad Series Connection (Anode to Anode)

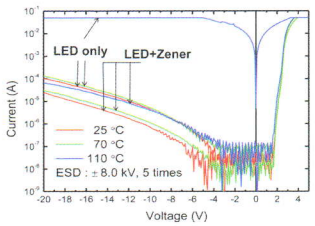
6. Effective Protection of GaN-based LEDs

ESD(HBM) Strength

- LED only : ±0.3 ~±7 kV
- LED+Zener: > ±8 kV







Various Appllcations

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http://www.i-vis.co.jp info@i-vis.co.jp
TEL:045-332-5381 Fax:045-332-5391

Sigetronics, Inc.
RM 402 & 403 SPRC, 664-14 Deokjindong, Deokjinku, Jeonju 561-756 Korea
Tel 82-63-270-4650,4164,4493 | **Fax** 82-63-270-3585 | **Email** dhcho@sigetronics.com | http://www.sigetronics.com

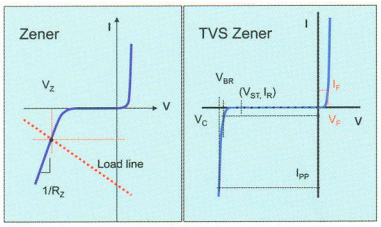
BOB
SBS
TGS

Bidirectional TVS Zener Diodes

SIGETRONICS

1. Versatile Zener Voltage Control

- TVS Zener Voltage
  - ➡ ±7 V, ±12 V, +7/−14 V, −7/+14 V
- Original Use
  - ➡ Zener: Voltage regulation
  - ➡ TVS Zener: ESD protection
- Operation Principle
  - ➡ Zener: Zener breakdown
  - ➡ TVS Zener: Zener + Avalanche breakdown



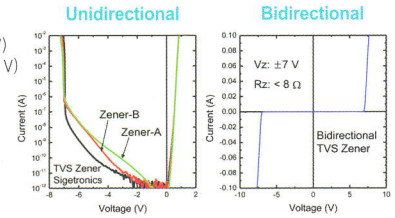
2. Bidirectional ESD Protection

- ESD Robustness
  - ➡ Zener: Weak compare to TVS Zener
  - ➡ TVS Zener:
    - On chip (HBM > ±8 kV)
    - In package (IEC61000-4-2>±30 kV)
- Small Differential Resistance
  - ➡ Zener: 20~50 ohm
  - ➡ TVS Zener: 0.5~10 ohm
- Low Clamping Voltage
  - ➡ Minimum Vc, no snap-back, no latch-up

Device	Vz Rz	Estimated Vc	
		HBM(8kV)	IEC61000-4-2(30kV)
Zener	7 V 30 ohm	167 V	2,734 V
TVS Zener	7 V < 5 ohm	< 34 V	< 462 V

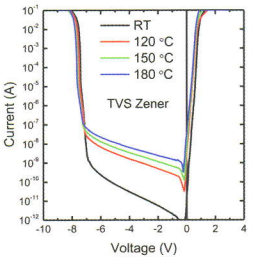
3. Extremely Low Leakage Current

- Small Leakage Current (x 1/10)
  - ➡ Unidirectional: 30 pA(@4 V, Vz=7 V)
  - ➡ Bidirectional: 2 pA(@±4 V, Vz=±7 V)
- High Light Emission Efficiency
- Improve Display
  - ➡ Minimize residual image



4. Leakage Current at High-Temperature

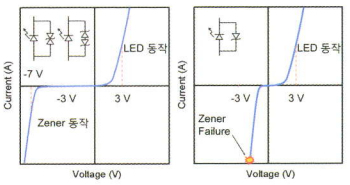
- Small Leakage Current Increase at HT(x 1/5)
  - ➡ Unidirectional: 17 pA/℃(@4 V for Vz=7 V)
  - ➡ Bidirectional: 3 pA/℃(@±4 V for Vz=±7 V)
- Flood Exposure of Heat and Light from LEDs
  - ➡ Maintain lower leakage current level
- Better Reliability
- Low Noise Incorporation



5. Precise Quality Control

- Unidirectional
  - ➡ Evaluation of leakage current is restricted from −0.5 V to 0 V
  - ➡ Zener failure may occur when wrong bias applied by accident
- Bidirectional
  - ➡ Evaluation of leakage current is possible from Vz to 0 V
  - ➡ Zener failure does not occur even if wrong bias applied by accident

Much better to control the quality and grades of LEDs in production line

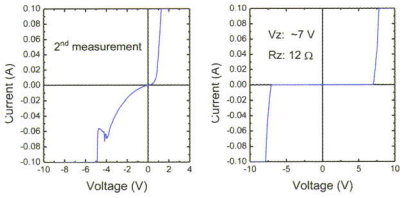


6. Flexible Design of Bias Direction

- Current Flow Directions
  - ➡ Unidirectional: Only DC operation
  - ➡ Bidirectional: DC&AC operation
- Current Driving Capability
  - ➡ Zener: 60~120 mA
  - ➡ TVS Zener: 100~500 mA

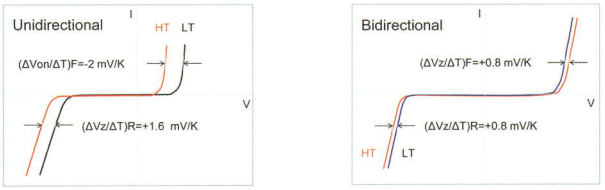
Conventional Zener

TVS Zener



7. Stable Operation at High-Temperature

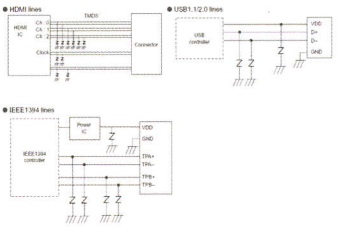
- Small Change of Zener Voltage at HT
  - ➡ Temperature coefficient (TC=⊿Vz/⊿T)
  - ➡ Forward: negative (−) TC
  - ➡ Reverse: positive (+) TC
- Self-compensation in Bidirectional Zener
  - ➡ Unidirectional: 1.6~2 mV/K
  - ➡ Bidirectional: 0.8 mV/K



8. High Speed Operation

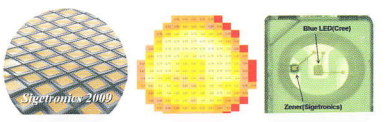
Excellent for LED communication and display applications

- Small Capacitance
  - ➡ Unidirectional: 15 pF (@0 V, Vz= +7 V)
  - ➡ Bidirectional: 8 pF (@0 V, Vz= ±7 V)
  - ➡ Small RC delay time
  - ➡ High operation speed
  - ➡ Low power consumption



Role of Bidirectional TVS Zener Diodes

TVS Zener diode is to protect your valuables from electrical shocks…



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BOB
SBS
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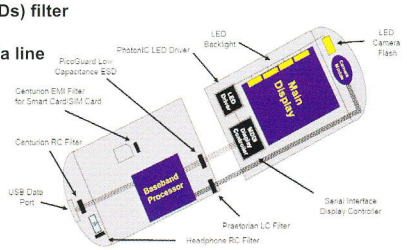
IPD ESD-EMI Filter

SIGETRONICS

1. IPD ESD+EMI Filter Chip

- **Products**
  - Integrated passive devices(IPDs) filter
  - C-R-C(Z-R-Z) filter: audio line
  - C-L-C(Z-L-Z) filter: display data line
- **Applications**
  - Computer
  - Mobile phone (6~12 EA)
  - Digital camera
  - LCD



2. Comparison of Technology

Excellent Features of Silicon-based IPD filter

- Higher performance
- Integrated ESD protection
- Small PCB footprint, better reliability
- Fewer components
- Low BOM(bill of materials)
- Low TCO(total cost of ownership)

Much better than ceramic-based filters such as MOV

Device	Merits	Demerits	Application
MOV	Low price Power proportional to volume Power capacity decrease at 85°C	Bidirectional Aging High Vc & L(leakage)	AC power cable Car ESD protection
Polymer Varistor	Ultra low capacitance Small package	High triggering voltage Small lifetime Limited use below 85°C	ESD protection FireWire USB
Zener diode	Low price Constant voltage	Small power capacity Power handling decrease at 25°C	Voltage regulation Battery pack
Avalanche TVS device	Best surge protection Response speed < 1.0 ns Low clamping voltage	Limited power capacity Power & capacitance are proportion al to area	ESD protection Cellular phone Mobile system

3. Superior ESD Protection Capability

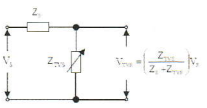
TVS zener diodes and Metal Oxide Varistors are popular voltage clamping devices.

For HBM(8 kV) ♪

$$Z_S = 1.5kohm, V_S = 8kV$$
$$Z_{TVS} = 10ohm$$
$$V_{CL} \cong 7 + \left(\frac{10}{1,500}\right)8,000 \approx 60V$$
$$Z_{TVS} = 1ohm$$
$$V_{CL} \cong 7 + \left(\frac{1}{1,500}\right)8,000 \approx 12V$$

For IEC61000-4-2(30 kV) ♪

$$Z_S = 330ohm, V_S = 30kV$$
$$Z_{TVS} = 1ohm$$
$$V_{CL} \cong 7 + \left(\frac{1}{330}\right)30,000 \approx 98V$$



$V_{TVS} \sim 1.33V_{BR}$

ESD Protection using Pi Filters (Z-R-Z, C-L-C)

Benefits
- Excellent clamping capability($V_{CL} < V_{BR} + 0.1$ V)
- Reduce noise signals during normal operation

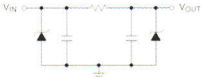
Drawbacks
- Expensive

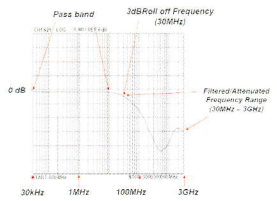
4. Frequency Dependent Applications

Integrated IPD filters are now available in small SMT IC packages to replace low pass filters that are implemented with discrete inductors, resistors and capacitors.

The main advantage of filters is that they reduce noise signals during the normal operation of the system. In contrast, crowbar and clamping devices are activated only during the transient event.

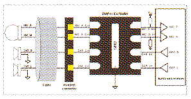
IPD ESD-EMI Filter





5. Application Samples and Packages

- **Audio (C-R-C)**



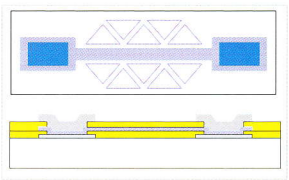
- **Display (C-L-C)**

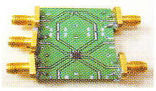

6. Original Features

- Ultra low resistance <1 ohm
- Epi layer (abrupt junction)
- Reliable junction properties
- Simple structure
- Easy fabrication procedure
- Efficient thermal conduction
- Both uni- and bi-directional TVS applicable
- Current flow of 2~6 folds (trench structure)

Patent

Patent title: Semiconductor Filter Device and Fabrication Method of thereof
Filing date: Dec. 30, 2009
Filing No: 10-2009-0133591

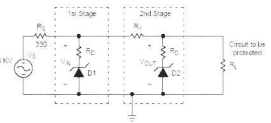



Test Kit


Inductor

7. Clamping Voltage

- V_S = IEC 61000–4–2 voltage waveform = ± 8 kV
- R_S = IEC 61000–4–2 source impedance = 330 Ω
- V_{br} = breakdown voltage = 7 V
- R_D = dynamic resistance of the Zener = 1 Ω
- I_P = peak ESD current
- R_1 = 100 Ω, $C_1 = C_2$ = 22 pF, $R_D << R_S$ and $R_D << R_1$
- Then: V_{IN} = 31.2 V, V_{OUT} = 7.3 V



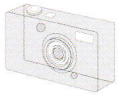
$$V_{Clamping\_voltage} = V_{br} + R_D * I_P$$
$$V_{IN} = V_{br} + \left(\frac{R_D}{R_S + R_D}\right)V_S \cong V_{br} + \left(\frac{R_D}{R_S}\right)V_S$$
$$V_{OUT} = V_{br} + \left(\frac{R_D}{R_1 + R_D}\right)V_{IN} \cong Vbr + \left(\frac{R_D}{R_1}\right)V_{IN}$$

8. Specifications

- Bidirectional EMI/RFI filter with integrated TVS for ESD protection
- ESD protection to IEC 61000-4-2 (ESD) Level 4 (±15kV (air), ±8kV (contact))
- TVS working voltage: 5V
- Termination Resistors: 100 Ohms & 47 Ohms
- Capacitance: 10pF (Typical at VR = 0V)
- Protection and filtering for four lines
- Back-to-back diode for negative signal swing
- 15pF line-to-ground capacitance
- Low leakage current below 50nA
- Small package of 0.15mm thickness

Package Dependent Surge Clamping Voltage				
Package	SOT-666	u-QFN	DFN	Flip-Chip
Shape				
V_{CL}	< 50 V	< 25 V	< 25 V	< 17 V

Sigetronics will provide IPD ESD-EMI filters to protect your valuable electronic system from overwhelming electrical RF noise as well as electrical over stresses including electrostatic discharge.

Sigetronics IPD ESD+EMI Filter Chip
- ✓ Original semiconductor IC technology
- ✓ Very small
- ✓ Excellent reliability & ESD performance
- ✓ Wide filtering band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