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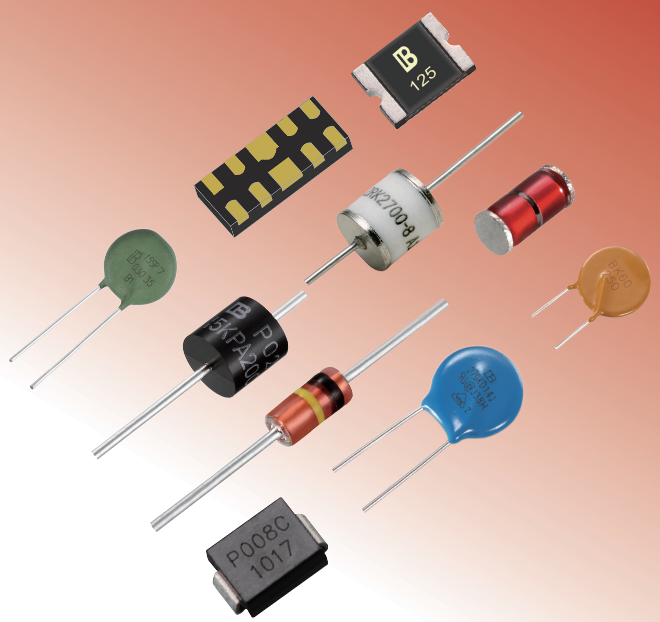
Products Selection Guide

TVS MOV ESD SPG GDT TSS PPTC NTC



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Contents

1. Introduction of Various Protection Components

1.1 Classification of Protection Component

- Transient Voltage Suppressors (TVS)
- Metal Oxide Varistors (MOV)
- Electrostatic Discharge Protection Devices (ESD)
- Gas Discharge Tubes (GDT)
- SPark Gap Protectors (SPG)
- Thyristor Surge Suppressors (TSS)
- Polymeric Positive Temperature Coefficient Thermistors (PPTC)

According to the characteristics of I-V curves, we can divide the products above into 3 categories: clamping type overvoltage protection components, switching type overvoltage protection components, and overcurretn protection component.

- TVS, ESD, MOV: Clamping Overvoltage Protection Components
- GDT, SPG, TSS: Switching Overvoltage Protection Components
- PPTC: Overcurrent Protection Component

Clamping Overvoltage Protection Components

The volt-ampere characteristic curve of the clamping overvoltage protection component is shown in Figure 1.1. When the voltage reaches the breakdown voltage of the clamping overvoltage protection component, its resistance will be reduced to the low impedance instantaneously and the surge current will be discharged so that the surge voltage can be limited to a low level. The characteristic of the clamping overvoltage protection component is that the clamping voltage will be higher than the breakdown voltage of the device after the component is turned on. The clamping voltage at both ends of the component is proportional to the instantaneous surge current. The clamping over voltage protection components are often used for the overvoltage protection of power cords and low frequency communication circuits.

Figure 1.1

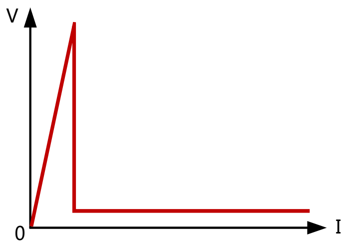


Figure 1.2

Figure 1.1 I-V Curve of the Clamping Overvoltage Protection Component

Figure 1.2 I-V Curve of the Switching Overvoltage Protection Component

Switching Overvoltage Protection Components

The volt-ampere characteristic curve of the switching overvoltage protection component is shown in Figure 1.2. When the voltage reaches the breakdown voltage of the switching overvoltage protection component, its resistance will be reduced to the low impedance instantaneously and the surge current will be discharged so that the surge voltage can be limited to a very low level. The characteristic of the switching overvoltage protection component is that the voltage at both ends of the component after the component is turned on will be lower than the breakdown voltage of the device. The switching overvoltage protection components are commonly used for the surge protection of high frequency signal lines in the communication system.

Overcurrent Protection Components (PPTC & NTC)

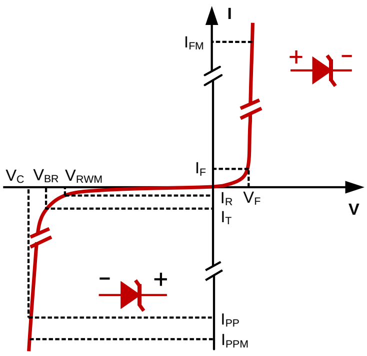
NTC and PPTC are always connected in series with the load to be overcurrent protectors.

PPTC is an overcurrent protection component that can be applied repeatedly. It is often used for the overcurrent protection of power cords with small current inputs or it is used as decoupling device between two-stage overvoltage protection devices.

NTC is not only a temperature sensing component, but also an overcurrent protector to limit Inrush current in power supplier. NTC can absorb the energy of inrush current to protect circuit.

1.2 Transient Voltage Suppressors (TVS)

TVS (Transient Voltage Suppressor) is an integrated device of a single PN junction or multiple PN junctions fabricated by the semiconductor diffusion process. TVS can be divided into two types, including unidirectional TVS and bidirectional TVS. Unidirectional TVS is generally applied to DC power supply circuits and bidirectional TVS is applied to circuits with an alternating voltage. In a DC circuit, the unidirectional TVS is reversely parallel to the circuit. When the circuit is working normally, TVS is in the off state (high-impedance state) and it won't affect the normal operation of the circuit. When an abnormal overvoltage occurs in the circuit and reaches the TVS (avalanche) breakdown voltage, TVS will change from the high impedance state to the low impedance state rapidly, discharging the transient over current caused by the abnormal over voltage to the ground. Besides, the low clamping voltage between both ends of the PN junction will be maintained, thus preventing the circuit of the post-stage from damage caused by the abnormal overvoltage. When the abnormal overvoltage disappears, the resistance of TVS will return to the high impedance state.



I_{PP}: Peak pulse current
I_{PPM}: Rated peak pulse current
V_C: Clamping voltage
V_{BR}: Breakdown voltage
I_T: Testing pulse DC current
V_{RWM}: Maximum working voltage
I_R: Standby current (leakage current)
I_F: Forward surge current
V_F: Forward surge voltage
I_{FM}: Rated forward surge current

Figure 1.2.1 Unidirectional TVS Volt-Ampere Characteristic Curve

The volt-ampere characteristic curve of TVS and the related parameters are shown in Figure 1.2.1. The first quadrant of the bidirectional TVS's volt-ampere characteristic curve has the opposite polarity to the third quadrant but their characteristics are similar. When TVS is reverse biased, it has two operating modes: standby (high impedance) or clamped (relative low impedance), as shown in the third quadrant of Figure 1.2.1. In the standby state, the current flowing through TVS is called the standby current or leakage current (IR), which varies with the junction temperature. In the volt-ampere characteristic curve of TVS, the transition from high impedance (standby) to low impedance (clamped) is the beginning of the avalanche breakdown. Under this conduction state, TVS will have a large transient current and maintain a relatively low clamping voltage that is high than the breakdown voltage of the semiconductor PN junction.

Cautions for TVS Selection

- **Maximum Operating Voltage V_{RWM}:** The cut-off voltage of the TVS diode should be greater than the maximum operating voltage or the signal voltage level in the circuit. If the selected cut-off voltage is too low, it will affect the normal operation of circuits and the life of TVS.
- **Peak Pulse Current I_{PP}:** When the TVS diode is used alone, its appropriate type should be selected in accordance with the maximum surge current that may occur in circuits. For TVS of the same voltage, the greater the power, the larger the I_{PP}. The greater the power, the better the TVS protection on circuits.
- **Clamping Voltage V_C:** It should be less than the maximum transient safety voltage that can be **withstood by the circuit. V_C is proportional to the breakdown voltage of TVS and I_{PP}.**
- **Leakage Current I_R:** Special attention should be paid to this parameter in communication lines and low-power circuits.

1.3 Electrostatic Discharge Protection Devices (ESD)

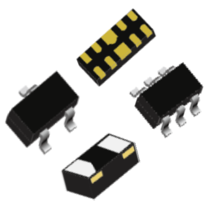
ESD is also known as TVS array. ESD is a multi-channel or single-channel ESD protection device with multiple TVS dies or diodes in different layouts. It is mainly used for the ESD protection of various communication interfaces such as USB, HDMI, RD485, RS232, VGA, RJ11, RJ45, BNC, SIM card, SD card…etc.. ESD devices have diverse packages, which cover from the single-channel DFN0201 to the multi-channel SOIC-16, QFN-10. Circuit design engineers can choose ESD devices with different packages according to the board layout and the interface type.

Pulse/BrightKing ESD products can be divided into three categories according to the junction capacitance:

I. Standard capacitance products

II. Low capacitance products

III. Ultra-low capacitance products



Cautions for ESD Selection

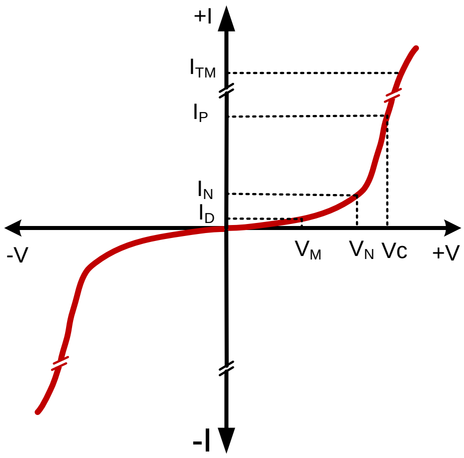
Package type: proper package types can be selected according to the circuit design layout and the number of protected channels. The package size can reflect the protection level of the device. The larger the package size, the higher the protection level of the device, and vice versa.

Junction Capacitance (C_j): High-speed data lines should select ESD devices with small junction capacitance as much as possible, otherwise the communication quality will be affected.

1.4 Metal Oxide Varistors (MOV)

Varistors are used in the surge protection of low-voltage electrical devices in the market are mostly varistors with zinc oxide as the main material. MOV is a kind of polycrystalline semiconductor ceramic device which is mainly made of zinc oxide and doped with various metal oxides through the typical electronic ceramic process. MOV has a symmetrical volt-ampere characteristic curve (as shown in Figure. 1.4). The current flowing through MOV increases exponentially with the increase in the voltage across the MOV. When MOV is applied, it is generally connected in parallel in the circuits. When the circuit works normally, it is in a high-impedance state and does not affect the normal operation of the circuit. When an abnormal transient voltage occurs in the circuit and reaches its on-state voltage (varistor voltage),MOV will change from the high-impedance state to the low-resistance state, discharging the instantaneous overcurrent caused by the abnormal transient overvoltage to the ground. At the same time, the abnormal transient voltage is clamped within a safe level so as to protect the post-stage circuit from the abnormal transient voltage. MOV has a high transient pulse absorption capability and a large junction capacitance, which is generally used for the lightning protection of AC input terminals. Because MOV's surge absorption capability depends on its physical size, different transient surge current values can be obtained by producing MOV of different chip diameters. The diameter of our MOV products can meet the requirements of 5mm~53mm. Pulse/BrightKing MOV can be divided into three series: standard MOV, high temperature MOV, and TMOV (temperature fuses integrated in MOVs)

The volt-ampere characteristic curve and parameters of MOV are shown in Figure 1.4.



I_P: Peak pulse current under specified wave form
V_C: Peak voltage across MOV measured at the specified pulse peak current (I_P)
I_N: Pulse peak current at a specified time
V_N: Peak voltage value across MOV measured within a specified duration at a specified peak pulse current (I_N). I_N is typically 1 mA (8/20 us).
I_D: Standby current
V_M: Voltage can be continuously applied at a specified temperature
I_{TM}: Maximum rated value of a specified waveform pulse which can be applied in a single time without causing MOV failure.

Figure 1.4 MOV's Volt-Ampere Characteristic Curve

Cautions for MOV Selection

Varistor Voltage (V_{1mA}/V_N): the selection of the varistor voltage should consider factors such as power supply voltage fluctuation, varistor voltage accuracy, varistor aging coefficient; it generally follows the following selection formula:

$$V_{1mA} \geqslant \frac{(1+a)}{(1-b)(1-c)} \bullet V_P$$

a：Power voltage fluctuation coefficient (0.1~0.3)
b：Varistor voltage tolerance(0.1~0.2)
c：Varistor aging factor，generally take 0.1
V_P：Power input peak voltage

For example, the 110VAC input MOV voltage should be selected as follows:

$$V_{1mA} \geqslant \frac{[1+(0.1\sim0.3)]}{(1-0.1)(1-0.1)} *110*1.414=(211\sim249)V$$

The value of a depends on the stability of the power grid. It can be selected to be small if the power grid fluctuation is small. It can also be selected to be large if the power grid fluctuation is large in remote areas or industrial application environments.

Maximum Peak Pulse Current (I_{PP}): MOV will be aging during long term usage. In practical applications, it is necessary to consider the derating number of impacts. For multiple impacts, it is necessary to select a device with a higher surge current.

1.5 Gas Discharge Tubes/ Spark Gap Protectors（GDT/SPG）

GDT is a device consisting of one or more discharge gaps packaged in a ceramic tube filled with inert gases. GDT's electrical performance depends on factors such as gas type, gas pressure, internal electrode structure and manufacturing process. It can withstand surge current impacts that up to tens or even hundreds of amps. It has a very low junction capacitance, which can be used to protect electronic equipment and humans against the damage of transient high voltages.

SPG obtains a discharge micro-gap through the distance between electrodes. The tube is filled with inert gases and it is glass sealed with a glass tube and dumet wires. When the voltage across SPG increases, the nearby gas is ionized and a discharge phenomenon occurs at the micro-gap. As the voltage drop of the two poles increases, the discharge current will also increase and the ionization zone will expand. At this time, the discharge current flows to the other pole through the gas ionization zone. When the current continues to increase to a certain extent, conversion from glow discharge to arc discharge will occur in the tube. The product changes from the high impedance state to the low impedance state and the voltage across SPG also decreases, thereby protecting the circuits. The product will return to the high impedance state after the abnormal voltage disappears.

The volt-ampere characteristics of GDT are shown in Figure 1.5. The volt-ampere characteristic curve of SPG is similar to that of GDT.

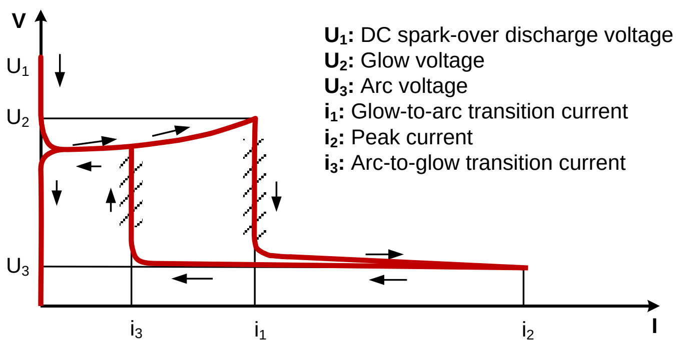


Figure 1.5 GDT's Volt-Ampere Characteristic Curve

Parameter	Definition
DC spark-over Voltage	The voltage should be applied at a rising rate that is not more than 100V/s during the measurement.
Maximum Impulse Spark-over Voltage	The voltage should be applied at a rising rate at 1000V/s during the measurement.
Nominal Impulse Discharge current	Nominal discharge current is generally applied with a 8/20μs pulse current for 10 times per 1min duration
Minimum Insulation Resistance	Minimum insulation resistance, which is measured with a certain DC voltage
Maximum Capacitance	Maximum junction capacitance

Cautions for GDT/SPG Selection

DC Breakdown Voltage: The lower limit of the DC breakdown voltage of the discharge tube should be higher than the maximum normal operating voltage of the circuit during applications, otherwise it will affect the normal operation of the circuit.

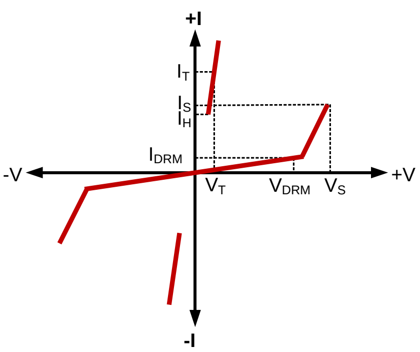
Maximum Impulse Spark-over Voltage: The device's Impulse Spark-over Voltage should be ensured to be lower than the highest transient voltage that the protected circuit can withstand.

Nominal Discharge Current: Nominal discharge current is determined based on the impulse current that may occur in the circuit.

Follow Current Issue: The active circuit with a high voltage cannot use a gas discharge tube alone as an overvoltage protection device. To enable the discharge tube to normally extinguish the arc, the current limiting component such as a varistor or a resettable fuse can be used in series on the discharge tube where there may be a follow current.

1.6 Thyristor Surge Suppressors (TSS)

TSS is a PNPN junction four-layer structure device fabricated by the semiconductor process. Its volt-ampere characteristics are similar to thyristors (see Figure 1.6). TSS has typical switching characteristics and it is generally applied in parallel in circuits. Under normal working conditions, TSS is in the off state. When an abnormal overvoltage occurs in the circuit due to inductive lightning or operating overvoltage, TSS will be quickly conducted to discharge the current so as to protect the backend equipment from damage caused by the abnormal overvoltage. When the abnormal overvoltage disappears, TSS will return to the off state. The volt-ampere characteristics and parameters of TSS are shown in Figure 1.6.



V_{DRM}: Peak Off-state voltage
V_T: On-state voltage
I_H: Holding current
I_S: Switching current
I_{DRM}: Leakage current
I_T: On-state current
V_S: Switching voltage

Figure 1.6 TSS's Volt-Ampere Characteristic Curve

Cautions for TSS Selection

Junction Capacitance (C_j): Communication lines should pay attention to the junction capacitance of the component that cannot affect the communication.

Follow Current Issue: it cannot be directly applied to the protection of the power cords. There is a follow current issue.

1.7 Polymeric Positive Temperature Coefficient Thermistors (PPTC)

PPTC is also known as resettable fuse. It consists of a polymer matrix and conductive carbon particles. When an abnormal overcurrent flows through PPTC, the generated heat (I^2R) will make the polymer matrix expand and the carbon particles wrapped outside the polymer matrix will separate to cut off the conductive path of PPTC, so that PPTC's resistance will rise, thereby reducing the abnormal overcurrent. When the abnormal overcurrent is eliminated, the PPTC polymeric molecules will shrink to the original shape and reconnect the carbon particles. The conductive path will recover and PPTC's resistance will return to the original low resistance state. The above process can be cycled multiple times. The biggest feature of PPTC is that it does not need to be replaced after each current fault within its rated range of application. It can be used repeatedly for the overcurrent protection, which can effectively save the maintenance time and cost.The resistance-temperature curve of PPTC is shown in Figure 1.7. The main parameters of PPTC are shown in Table 1.7.

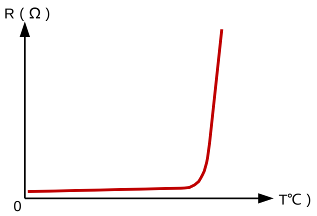


Figure 1.7 PPTC's Resistance-Temperature Curve

Table 1.7 PPTC parameters

I_{hold}	Holding current: maximum current device will pass without tripping in 23℃ still air.
$V_{max.}$	Maximum voltage that can be withstood
T_{trip}	Minimum current at which the device will trip in 23℃ still air.
R	Zero power resistance measured at a certain temperature
I_{trip}	Trip current: minimum current at which the device will trip in 23℃ still air
$I_{max.}$	Maximum current that can be withstood
P_d	Power dissipated from device when in the tripped state at 23℃ still air.
$R_{1max.}$	Maximum resistance of device at 23℃ measured one hour after tripping or reflow soldering of 260℃ for 20 sec.

Cautions for PPTC Selection

Holding Current I_h: The holding current of the resettable fuse should be greater than the normal working current of the circuit, otherwise it will affect the normal operation of the circuit.

Maximum Withstand Voltage V_{max}: it should be greater than the working voltage of the circuit, otherwise it will easily lead to the failures of PPTC.

Ambient temperature: PPTC is sensitive to ambient temperature. The holding current of PPTC should be selected according to derating in the ambient temperature. PPTC is not recommended for use when the ambient temperature is greater than 85 °C.

1.8 Negative Temperature Coefficient Thermistor (NTC & Sensor)

NTC thermistors use sintered ceramic disc made from a mixture of MnO2, NiO, Co2O3, CuO2, FeO2. A thermistor is an electronic component whose resistance is highly dependent on temperature. NTC thermistor (NTC：Negative Temperature Coefficient) is one kind of thermistors whose resistance decreases as the ambient temperature rises (Figure 1.8.1). Therefore, NTC thermistor can be used for temperature sensing or compensation.

However, NTC is not only a temperature` sensing component, but also an overcurrent protector to limit Inrush current. The sizes of Power NTCs are usually much larger than NTC of temperature sensing type. As an inrush current limiter in the application of a power line, NTC thermistor is always connected in series with the load to be an overcurrent protector. NTC presents a higher resistance initially, and its resistance changes as the overcurrent flow through (Figure 1.8.2). NTC can absorb the energy of inrush current (Figure 1.8.33). In the meantime, NTC heats up and the resistance becomes much lower. Thus, the power loss of NTC that is lower than when a fixed resistor is used in the circuit.

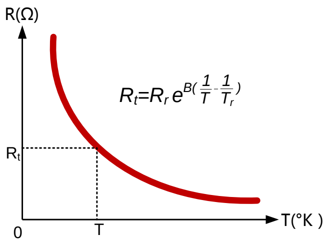


Figure 1.8.1 R-T curve

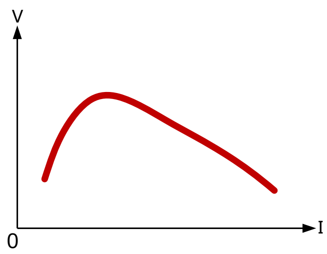


Figure 1.8.2 V-I curve

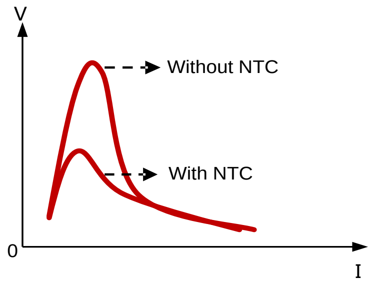


Figure 1.8.3 overcurrent with NTC or without NTC

Cautions for Temperature NTC Selection

- **R-T Curve**

  NTC thermistor is non-linear resistor that alters their resistance characteristic with temperature. (Figure 1.8.1)

  If R_r is the Resistance at reference temperature T_r (∘K).A simple approximation for the relationship between the resistance and temperature as follows

  $R_t = R_r e^{B(\frac{1}{T}-\frac{1}{T_r})}$, R_t is the Resistance at temperature t(℃) → T (∘K)=273.15+ t

- **Zero Power Resistance of reference temperature (R25 or others)**

Usually we choose NTC temperature sensor by two parameters (temperature and Beta Value).R25 is the common reference resistance (KΩ↑) for temperature sensing application, and usually higher than KΩ.

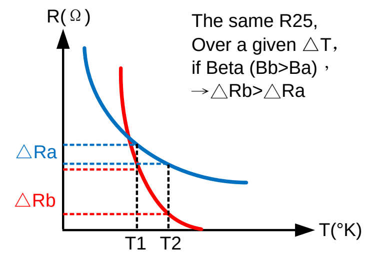


Figure 1.8.4 R-T curve of different B Value

- **Beta Value**

$$Beta\ Value = \frac{\ln\left(\frac{R_{t1}}{R_{t2}}\right)}{\left(\frac{1}{t1}-\frac{1}{t2}\right)}$$

The Beta value of NTC thermistor is calculated by using resistance values of two temperatures in a given range. (ex: B(25/85)：25 to 85℃).
Beta value gives the characteristic for a reference of NTC's application.
Higher Beta Value can define fine scale of temperature.(Figure 1.8.4)
Common Beta Value type: B(25/50), B(25/85) .

Cautions for Power NTC Selection

- **Zero Power Resistance at 25℃ (R25)**

$$R_{25} \geq \frac{V_{peak}}{I_{surge}}$$

V_{peak}=1.414Vac , I_{surge}=Max. Surge Current

For power conversion, power reverse, switch power, UPS power I_{surge}=100 times operating current For light filament, heater I_{surge}= 30 times operating current

- **Max Energy & Recommend Capacitance**

For example: Full-wave rectifier

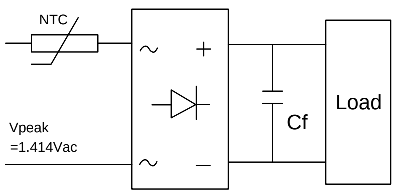


Figure 1.8.4 Full-wave Rectifier

When power is applied to a power supply. The filter capacitor is charging through NTC in a relatively short time that can exhibit high inrush current. The capacitor will store an amount of energy as following:

$$\text{Max. } Energy(J) = \frac{C(Vpeak)^2}{2}$$

The ability of the NTC to handle this energy surge can be an approximation that equal to the capacitor's energy Because the amount of energy is dependent on the voltage waveform, the recommended capacitance is defined under the condition of 1.1*220Vac=240Vac→340Vdc

- **Max Steady State Current**

Maximum steady state current > Actual operating current in the power loop

1.9 Comprehensive Comparison of Overvoltage Protection Components

The comprehensive comparison of overvoltage protection components is shown in Figure 1.9 & Table 1.9.

Table 1.9 Comparison of various overvoltage protection components

Components / Characteristics	Clamping Type Overvoltage Protective Components				Switching Type Overvoltage Protective Components		
	MOV	Hyperfix TVS	TVS	ESD	GDT	SPG	TSS
Peak Pulse Current (8/20μs)	Large	Larger	Ordinary	Small	Large	Larger	Ordinary
Response Speed	Slow	Very Fast	Very Fast	Very Fast	Very Fast	Fast	Fast
Capacitance	Large	Large	Large	Small	Extra Small	Extra Small	Small
DC Breakdown Voltage Accuracy	Ordinary	Accurate	Accurate	Accurate	Ordinary	Ordinary	Accurate
Pulse Breakdown Voltage	Low	Low	Low	Low	High	High	Low

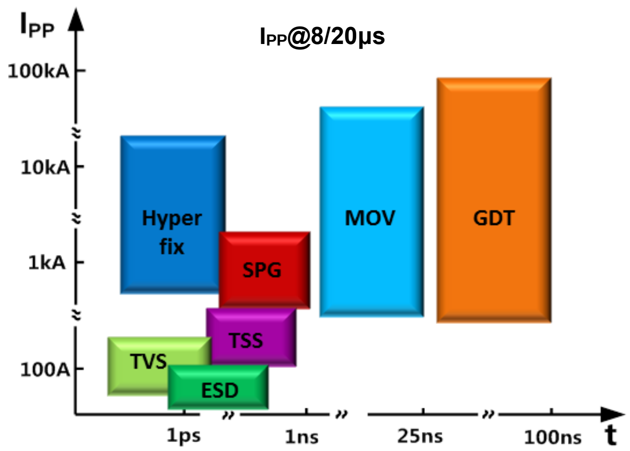


Figure 1.9 Peak Pulse Current and Response Time of Various Overvoltage Protection Components

It can be seen from Figure 1.9 and Table 1.9 that GDT is a component with the largest peak pulse current in all kinds of overvoltage protection components. Pulse/BrightKing GDT single device can reach 100kA (8/20μs). The conduction of GDT is a gas ionization to form a conductive channel, which requires a large amount of energy to stimulate it. There is a process of energy accumulation. So the response time of GDT is the slowest one of all over voltage protection components. The advantages of GDT include the low junction capacitance and the large insulation resistance, which can be used for the lightning protection of high-speed communication lines, such as coaxial cable, telephone line interface, high-definition video interface, Ethernet ports, etc.

MOV's pulse current is the second only to that of GDT and its response speed is nanosecond. It is widely used in AC power lines and the lightning protection of low frequency signal lines. Pulse/BrightKing's MOV pulse current can be 70kA (8/20μs), and the varistor voltage can reach 1800V. MOV is a polycrystalline semiconductor material made of ZnO and other metal oxides by mixing and high-temperature sintering. Its lattice structure determines its aging during application after long-term usage. GDT and SPG have large insulation resistances. At the AC input, they are often used in series with MOV in the common mode to slow down the aging of MOV.

In Figure 1.9, there is a component called hyperfix, which is an ultra-high power TVS. It is made by overlapping several large-area chips. Its power is several tens or even hundreds of times larger than that of an ordinary TVS. It can directly replace MOV to be applied to the AC input for the primary level of lightning protection. It has advantages such as large surge current, fast response, no aging and low clamping voltage. It is suitable for applications requiring high reliability protection devices, such as communication power, aircraft, trains and other fields.

TSS is a surge protection component with negative resistance. Due to its special PNPN junction structure design, TSS's surge current can be several times larger than that of TVS of the same size and voltage in the same chip area. TSS's capacitance is several times smaller than that of TVS of the same specification. It can be used for the surge protection of some communication lines, such as RS485, RS232, CAN bus. TSS has a high price-performance ratio and is ideal for the surge protection in low-speed communication lines.

TVS diode is a component with a single PN junction or integrated by multiple PN junctions, which has the advantages of fast response speed, low clamping voltage and high voltage accuracy. TVS is generally packaged in a chip or a through-hole package. It is small in size and is often used for the surge protection of DC power lines or low-speed communication lines.

ESD is a specially designed anti-electrostatic component. It is a TVS array with a specific layout composed of multiple diodes or TVS dies combinations. It has a shorter conducting state than that of TVS. Generally, electrostatic discharge is a nanosecond pulse whose destructive power is relatively small, so the chip area of the ESD component is also small to realize the miniaturized package. Through circuit structure designs, the ESD component has a minimum junction capacitance which can be lower than 1pF. It is suitable for the ESD protection of high-speed data lines, such as HDMI, USB3.0, IEEE1394, etc.

As the world's leading manufacturer of circuit protection components, Pulse/BrightKing provides customers with cost-effective circuit protection components and solutions. We provide the best circuit protection solutions for customers based on different applications.

2. Surge Protection Principle

Generally, it uses the “multi-level protection and step-by-step reduction” mode for circuit surge protection. Figure 2.1 shows the diagram of the surge protection principle.

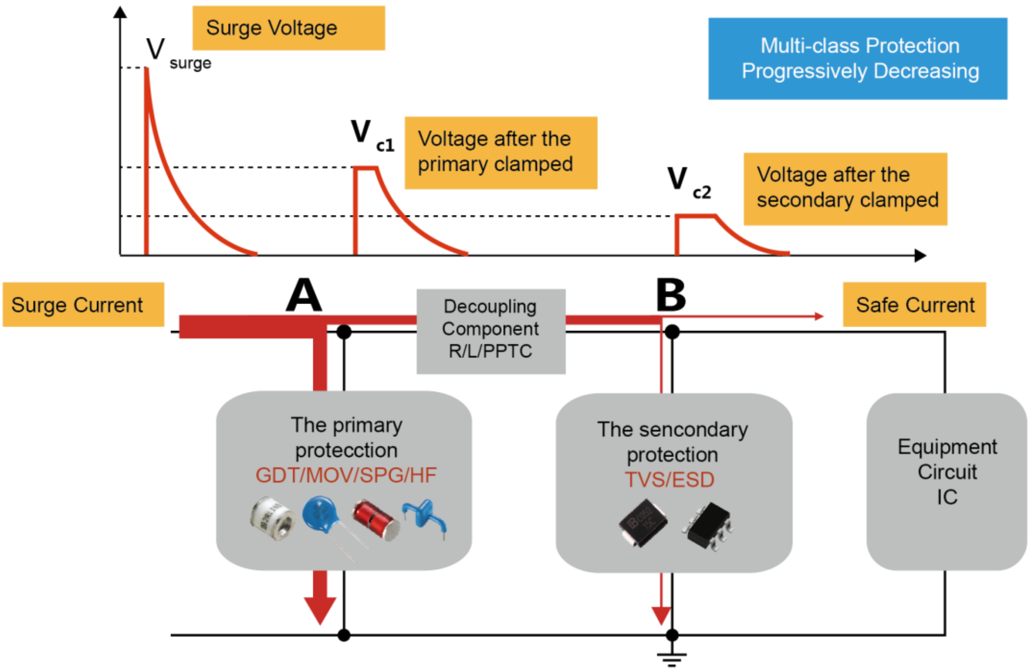


Figure 2.1 Surge protection principle

Primary Protection

Generally, the primary protection is used for the port that is most likely to introduce lightning, such as inlets of buildings, input ports of AC power supplies. Generally, different types of large surge protection devices are selected according to the application.

The primary protection of the power port generally uses a clamping-type high surge protection component. The power port is a port that provides energy to the system, which has a high voltage or a high current. If a switching protection component is selected at the power port, the voltage of the switching component is low when it is in on-state at the overvoltage, affecting the supply voltage of the system. On the other hand, the system voltage may remain in the on-state and cannot be normally cut-off. If there is a large current (such as an ampere-level current) flowing through the system for a long time, it may cause fatal damage to the circuit board and even cause fires.

For the primary clamping-type overvoltage protection device of the power port, the metal oxide varistor (MOV), the ultra-high power TVS (hyper-fix series), or the lightning protection module (SPD, surge protection device) composed of these components are generally selected.

The primary protection of the signal port generally uses the gas discharge tubes, such as GDT, SPG, TSS and signal lightning protection modules (SPD). Of course, the low-speed signal port can also select the clamping type components for the primary protection, provided that the junction capacitance of the clamping type component will not affect the normal operation of communication lines.

Secondary Protection

The secondary protection is similar to the primary protection. Generally, TVS and ESD with high response speeds and low clamping voltage are selected.

Decoupling Component

Since the primary protection and the secondary protection adopt different types of overvoltage protection components, they have different breakdown voltages and different response times, it is necessary to add decoupling components between the two-stage overvoltage protection devices so as to ensure that the overvoltage protection components in primary and secondary protection can work together. The decoupling component requires a certain impedance so as to function as a decoupling.

The working principle of the decoupling component is shown in Figure 2.1. Generally, the secondary overvoltage protection device adopts a small surge current and low-voltage component with a fast response speed. The component needs to be turned on first when the surge voltage is impacted. The decoupling component has a certain internal resistance. When there is a large surge current, the voltage before the decoupling component (point A in Figure 2.1) is raised above the breakdown voltage of the overvoltage component for primary protection. The primary protection component is turned on to discharge the surge current, thus sharing the pressure of the secondary protection component. If no decoupling component is added between the two-stage overvoltage protection components, the secondary protection components will always be in the on-state, which will cause damage when the surge current exceeds the capability of the secondary protection components.

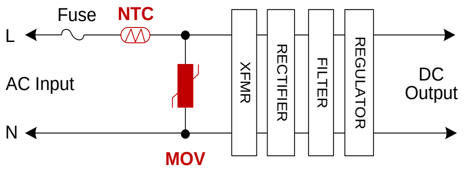
The selection of the decoupling component should be selected according to the working current of the circuits. For example, some signal circuits have small operating currents. In the case of ensuring the normal communication, a power-type resistor or a resettable fuse (PPTC) can be selected. The decoupling resistance is generally selected within 10Ω. From the perspective of the surge protection, the larger the decoupling resistance, the better the protectio, but it should not be too large. Otherwise, it will affect the normal working current of the circuits. Engineers should consider these factors comprehensively during the circuit design.

For some low-frequency circuits with large input current, inductors can be used for decoupling. The calculation formula of the inductor impedance is $Z=2\pi fL$. After the decoupling impedance value is determined, the magnitude of the inductance can be calculated from the formula.

3. Typical Application Cases

3.1 Power System Typical Application Cases

3.1.1 AC Power Port Surge Protection

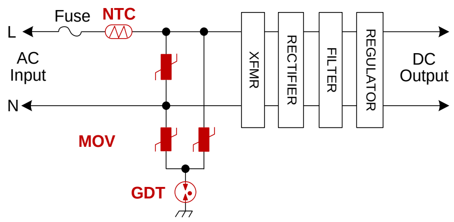


MOV Protection Scheme

The scheme adds a MOV between L and N for the differential mode protection, which is suitable for low power supplies. According to the application and test requirements, please consult our technical staff to select the specific model.

Solution： MOV, NT/SP

Testing Standard： IEC61000-4-5，GB/T 17626.5，UL1449



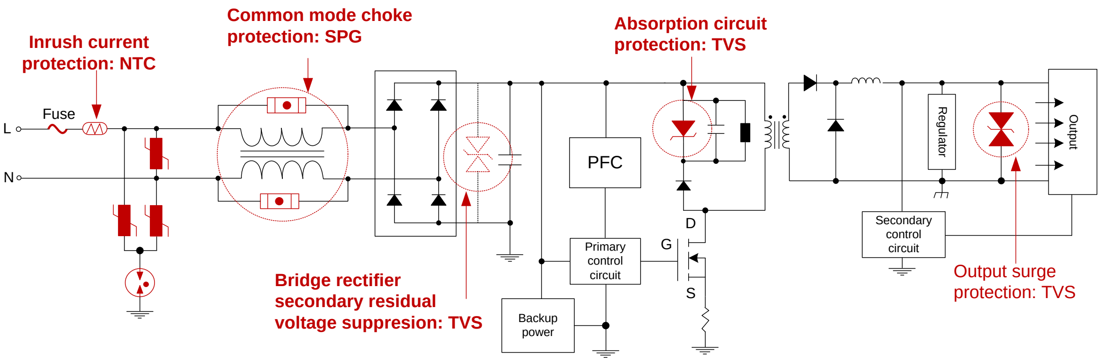
MOV and GDT Protection Scheme

The common mode protection by a MOV used in series with a GDT to ground to slow down the aging of the MOV. This scheme is suitable for medium and large power supplies. According to the application and test requirements, please consult our technical staff to select the specific model.

Solution： MOV， GDT, NT/SP

Testing Standard： IEC61000-4-5，GB/T 17626.5，UL1449

3.1.2 Protection of Other Portions of the Power System



Common Mode Choke Protection:
BK13001502/BK1301502-M/BK23001502/BK23001502-M/BK33001502/BK33001502-M

Absorption Circuit Protection: P6KE200A/SMBJ170A

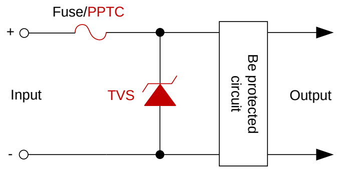
Output Surge Protection: TVS (Consult our technicians to choose the specific model according to the output voltage value)

Bridge Rectifier Secondary Residual Voltage: P6KE440CA/SMBJ400CA

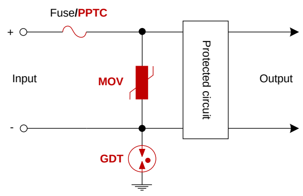
Inrush current protection NTC: NT/SP

Test standard: IEC61000-4-5,GB/T17626.5

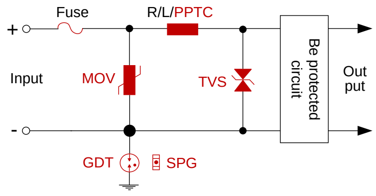
3.1.3 DC Power Port Surge Protection



Solution 1



Solution 2



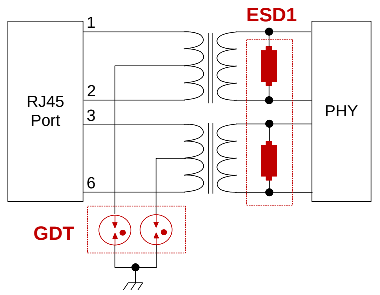
Solution 3

Working voltage /PPTC	Solution 1	Solution 2	Solution 3
DC5V	TVS： SMBJ5.0A 1.0SMB6.8A SMCJ5.0A	Not applicable	MOV：820KD14 GDT：4532-091-LF SPG：BK13001502/ BK1301502-M TVS：SMBJ5.0CA
DC12V	TVS： SMBJ18A 1.0SMB18A SMCJ18A	MOV：180KD10 GDT：B32-150-LF SPG：BK33001502/ BK33001502-M	MOV：820KD14 GDT：4532-091-LF SPG：BK13001502/ BK1301502-M TVS：SMBJ18CA
DC24V	TVS ： SMBJ28A 1.0SMB33A SMCJ28A	MOV：330KD10 GDT：B32-150-LF SPG：BK33001502/ BK33001502-M	GDT：4532-091-LF SPG：BK13001502/ BK1301502-M TVS：SMBJ28CA
DC48V	TVS ： SMBJ58A 1.0SMB68A SMCJ58A	MOV：820KD10 GDT：B32-150-LF SPG：BK33001502/ BK33001502-M	MOV：820KD14 GDT：4532-091-LF SPG：BK13001502/ BK1301502-M TVS：SMBJ58CA
PPTC	SMD1812/BK60[1]	SMD1812/BK60[1]	SMD1812/BK60[1]

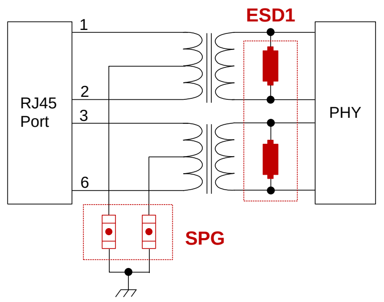
Note1: The specific model of PPTC can consult our technicians according to the actual application.

3.2 Communication Interfaces Protection

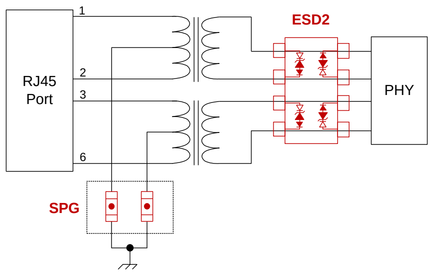
3.2.1 100M RJ45 Port Protection



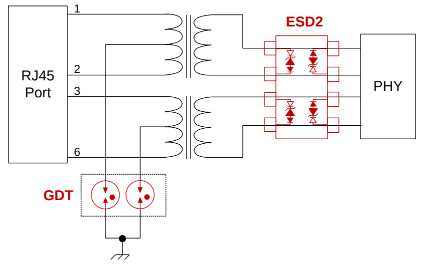
GDT and discrete ESD device protect solution



SPG and discrete ESD device protect solution



SPG and integrated multi-line ESD device protect solution



GDT and integrated multi-line ESD device protect solution

GDT or SPG are used for the common mode protection for Ethernet port on the primary side of the isolating transformer. For POE port, clamping type overvoltage protection device should be chosen for the common mode protection because of its high supplying power voltage. ESD devices are used for differential mode protection on the secondary side of the isolation transformer. Specific models can consult our technical engineer.

GDT: 2RL075L/M-5, 2RM075L/M-8, 4532-075/091-LF

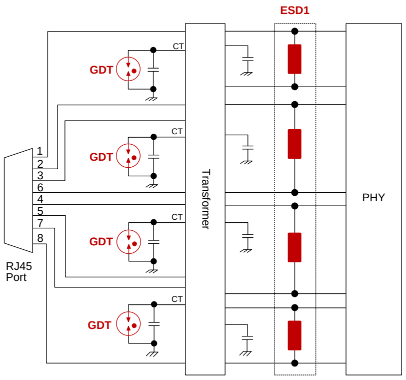
SPG: BK13001502/BK1301502-M/BK23001502/BK23001502-M/BK33001502/BK33001502-M

ESD1: UCD32C05L01, UDD32C03/05L01

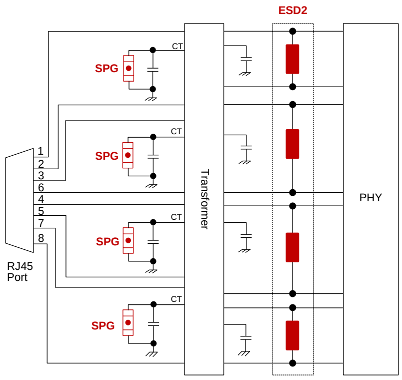
ESD2: UFS08A2.8L04

Reference test standards: IEC61000-4-2, GB/T 17626.2, ISO10605, GB/T 19951, IEC61000-4-5, GB/T17626.5, ITU-T K.12

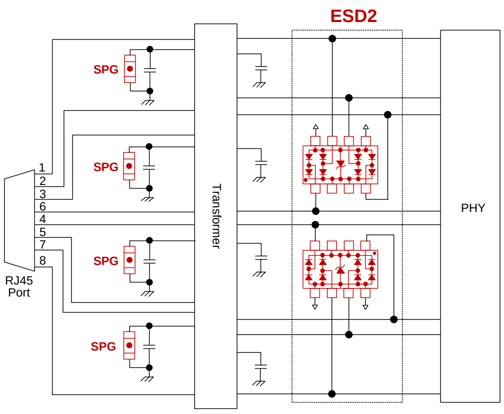
3.2.2 1000M RJ45 Port Protection



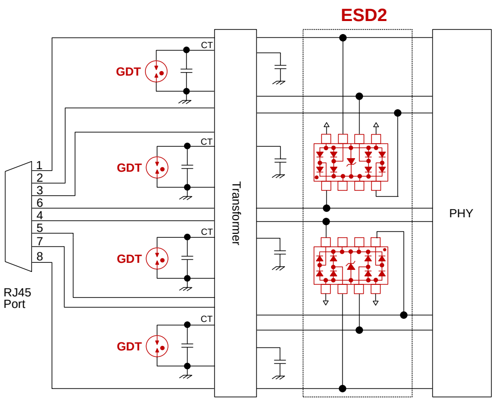
GDT and discrete ESD device protect solution



SPG and discrete ESD device protect solution



SPG and integrated multi-line ESD device protect solution



GDT and integrated multi-line ESD device protect solution

GDT or SPG are used for the common mode protection for Ethernet port on the primary side of the isolating transformer. For POE port, clamping type overvoltage protection device should be chosen for the common mode protection because of its high supplying power voltage. ESD devices are used for differential mode protection on the secondary side of the isolation transformer. Specific models can consult our technical engineer.

GDT： 2RL075L/M-5, 2RM075L/M-8, 4532-075/091-LF

SPG： BK13001502/BK1301502-M/BK23001502/BK23001502-M/BK33001502/BK33001502-M

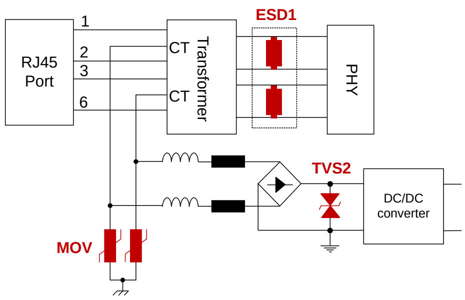
ESD1： UCD32C05L01, UDD32C03/05L01

ESD2： UES08A03L05

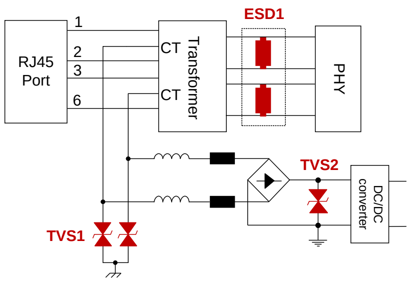
Reference test standards:

IEC61000-4-2, GB/T 17626.2, ISO10605, GB/T 19951, IEC61000-4-5, GB/T17626.5, ITU-T K.12

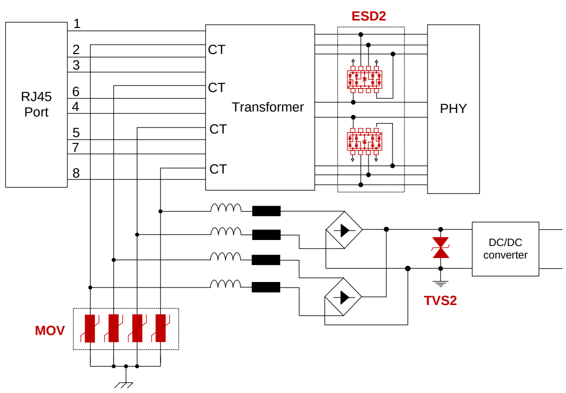
3.2.3 100M /1000M PoE（Power on Ethernet）Protection



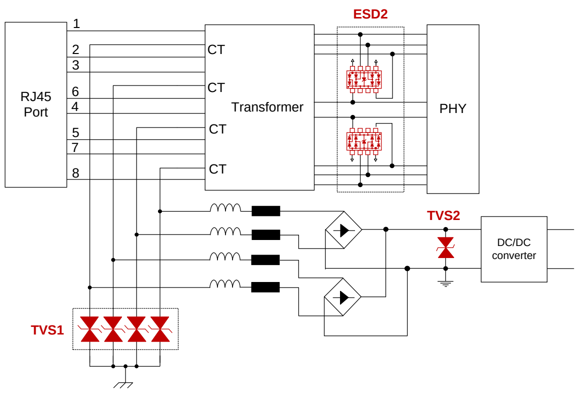
MOV and discrete ESD device protect solution (100M)



TVS and discrete ESD device protect solution (100M)



MOV and integrated multi-line ESD device protect solution



MOV and integrated multi-line ESD device protect solution

The primary side of the Ethernet generally uses the discharge tube for common mode surge interference absorption. The primary side of the Ethernet with PoE power supply needs to be clamped type protection device, such as TVS or MOV string gas discharge tube for protection. The secondary side generally uses ESD for the absorption of differential mode surge interference, and the discrete device or integrated device can be flexibly selected according to the design requirements. The following are the more commonly recommended models. Different discharge tubes correspond to different test levels. According to the application and test requirements, please consult our technical staff to select the specific model.

MOV: 101KD14 **TVS1:** 5.0SMDJ58CA

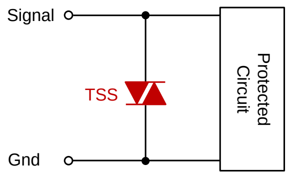
TVS2: SMCJ58CA **ESD1:** UCD32C05L01

ESD2: UES08A03L05

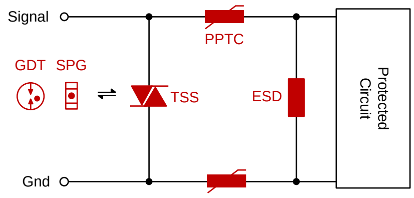
Reference test standards:

IEC61000-4-2, GB/T 17626.2, ISO10605, GB/T 19951, IEC61000-4-5, GB/T17626.5, ITU-T K.12

3.2.4 BNC Port Surge Protection



One stage surge protection



Two stage surge protection

For two stage surge protection, TSS or SPG or GDT can be used for the primary protection device, PPTC is used as the decoupling device, ESD is used as the secondary protection device. Consult our technical engineer for specific models.

TSS: P0080SX（X: A/B/C）

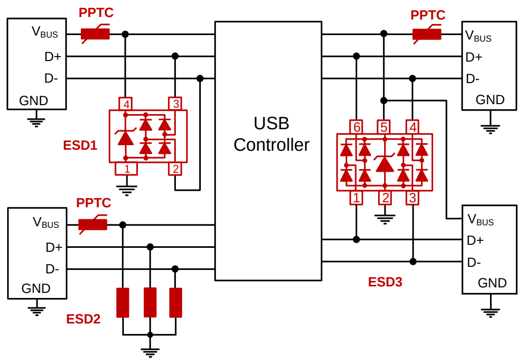
PPTC: SMD 1812

ESD: UDD32C05L01

Reference test standards:

IEC61000-4-2, GB/T 17626.2, IEC61000-4-5, GB/T17626.5

3.2.5 USB2.0 Port ESD Protection



Circuit connection diagram

SOT-143 packaged device can used for one USB2.0 port data line and power line ESD protection. SOT23-6L packaged device can simultaneously protect two USB2.0 port data line and power line. Discrete ESD protection device also can be chosen for one or two USB2.0 ports protection.

Device selection:

ESD1: UET14A05L03-BK

ESD2: UCD32C05L01 / UAD8C05L01-TIP

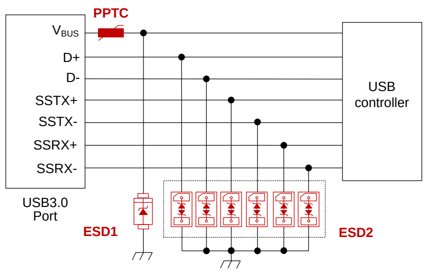
ESD3: UDT26A05L05-LC1, UCT26A05L05-HP1

PPTC: SMD1812 B110TF

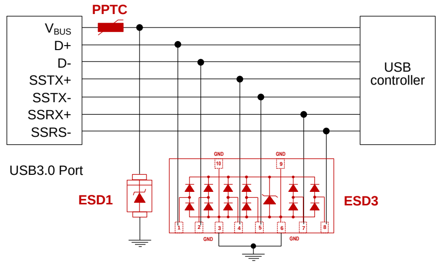
Reference test standards:

IEC61000-4-5, GB/T17626.5, ISO10605, GB/T 19951

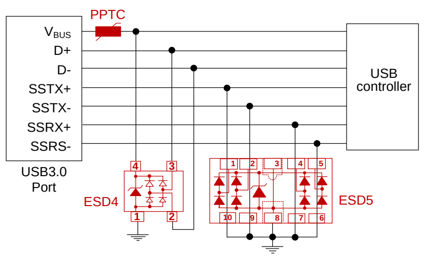
3.2.6 USB3.0 Port ESD Protection



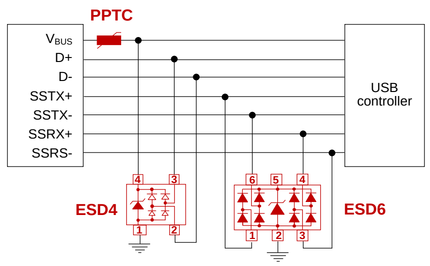
Solution one



Solution two



Solution three



Solution four

The data lines are protected with ultra-low capacitance ESD devices. The power line is protected with PPTC and a larger power ESD device.

Device selection:

ESD1: SDD32A05L01, SFD52A05L01, SFD52A07L01

ESD2: UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAD03C05L01, UAD52A05L01, UAQ02C05L01-R0.5

ESD3: UAD33A05L06

ESD4: UET14A05L03-BK

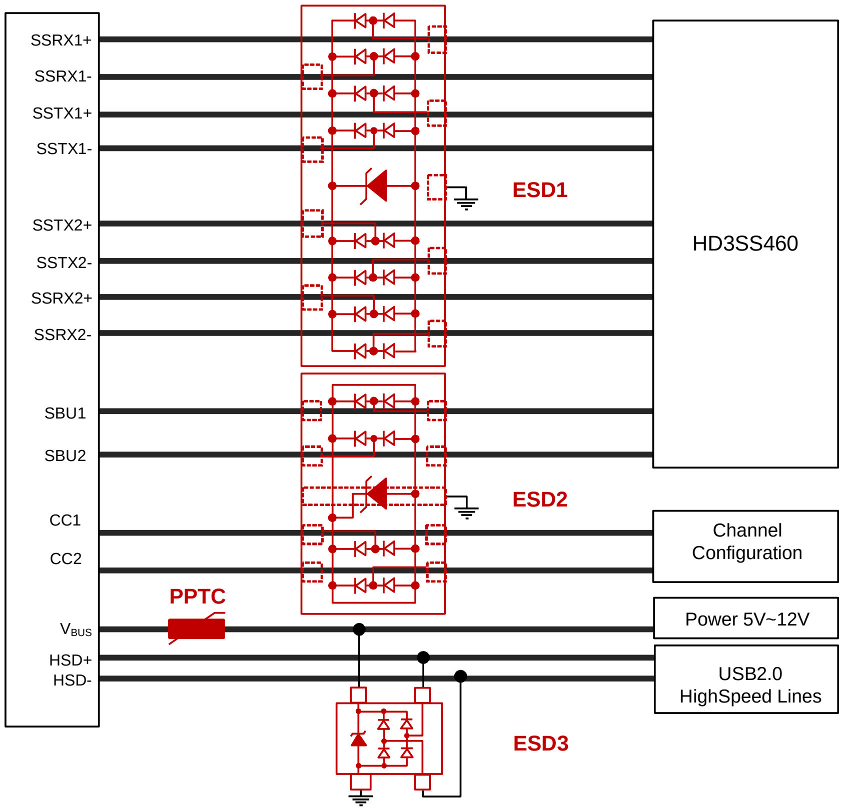
ESD5: UBQ10A05L04HI, UAD20A05L04

ESD6: UAT36A03L05, UAT56A03L05

PPTC: SMD1812B110TF, SMD1812B150TF/8

Reference test standards: IEC61000-4-5, GB/T17626.5, ISO10605, GB/T 19951

3.2.7 USB Type-C ESD Protection

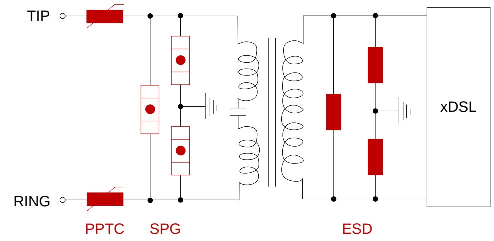
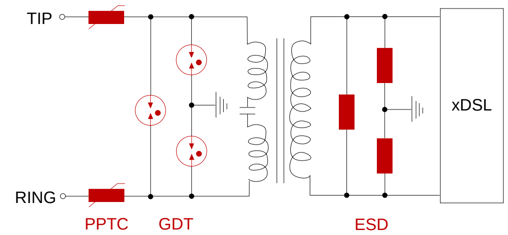
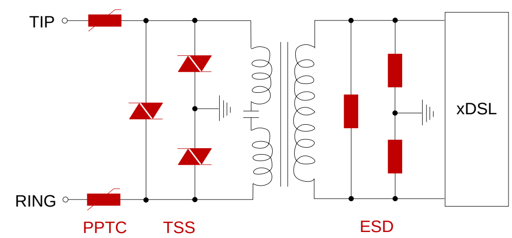


The USB3.1 interface still uses two pairs of transceiver differential lines, but the rate is increased up to 10Gbps, the rising edge of the signal is 0.02~0.03ns, the protection device junction capacitance is recommended to be less than 0.4pF. The figure above shows the protection scheme of the USB 3.1 protocol using the most popular Type C physical interface.

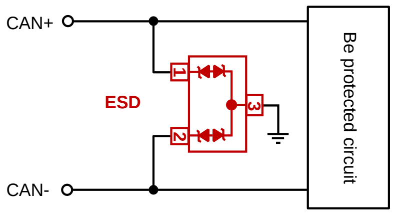
PPTC: SMD1812B150TF/8
ESD1: UAD38A05L08
ESD2: UAD20A05L04
ESD3: UAT14A15L03

Reference test standards: IEC61000-4-5, GB/T17626.5, ISO10605, GB/T 19951

3.2.8 RJ11 Port Surge Protection

 RJ11 port surge protection using SPG	The primary side uses SPG for differential and common mode protection, and the PPTC is connected in series to protect the power line. The secondary side uses the low capacitance and high surge capability ESD for secondary protection. **PPTC:** BK250/BK600 **SPG:** BK12001502/BK12001502-M **ESD:** UDD32C05L01 **Reference test standards:** IEC61000-4-2, GB/T 17626.2, IEC61000-4-5, GB/T17626.5, ITU-T K.21
 RJ11 port surge protection using GDT	The primary side uses GDT for differential and common mode protection, and the PPTC is connected in series to protect the power line. The secondary side uses the low capacitance and high surge capability ESD for secondary protection. Recommended models are as follows: **PPTC:** BK250, BK600 **GDT:** 2RL350L/M-5, 2RM350L/M-8 **ESD:** UDD32C05L01 **Reference test standards:** IEC61000-4-2, GB/T 17626.2, IEC61000-4-5, GB/T17626.5, ITU-T K.21
 RJ11 port surge protection using TSS	The primary side uses TSS for differential and common mode protection, and the PPTC is connected in series to protect the power line. The secondary side uses the low capacitance and high surge capability ESD for secondary protection. **PPTC:** BK250/BK600 **GDT:** P3100SC **ESD:** UDD32CXXL01 **Reference test standards:** IEC61000-4-2, GB/T 17626.2, IEC61000-4-5, GB/T17626.5, ITU-T K.21

3.2.9 CAN Bus Protection



CAN bus ESD protection

SOT-23 package devices are used for CAN bus protection, SDT23C24L02 is used for low speed CAN bus, and LEB23C24L02 can be used for high speed CAN bus.

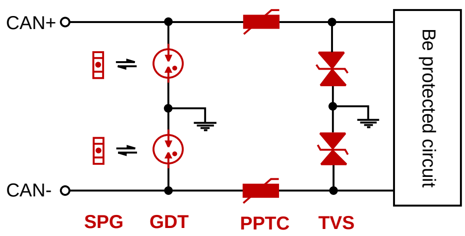
Device selection:

ESD: SDT23C24L02, LBT23C24L02

Reference test standards:

IEC61000-4-5, GB/T17626.5

ISO10605, GB/T 19951



Two stage protection for CAN bus

The first stage protection device uses GDTs, the secondary protection uses TVSs. PPTCs are used as decoupling device and overcurrent protection. This solution can gain high protection level and low clamping voltage at the same time.

GDT: 2RL075L/M-5, 2RM075L/M-8

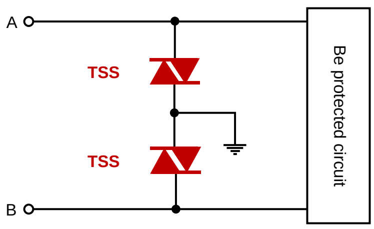
SPG: BK13001502/BK1301502-M

PPTC: SMD1812B010TF

TVS: SMAJ24CA

Reference test standards:

IEC61000-4-5, GB/T17626.5, ISO10605, GB/T 19951



One stage surge protection

Use TSS for common mode protection, TSS has high protection level and low capacitance compare to the same size TVS. One more TSS can be add to CAN+ and CAN- for differential mode protection to gain lower differential mode clamping voltage.

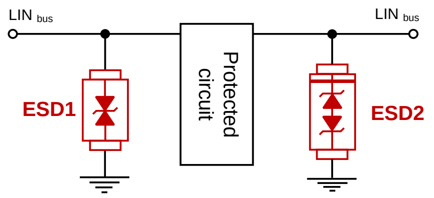
TSS: P0300SB

Reference test standards:

IEC61000-4-5, GB/T17626.5

ISO10605, GB/T 19951

3.2.10 LIN Bus ESD Protection

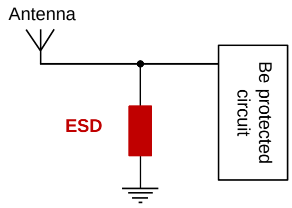
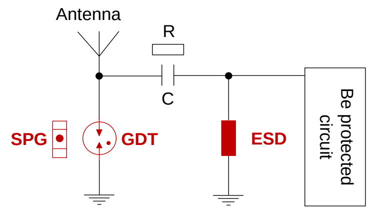


This solution is mainly used in automotive protection. The following two models can be selected.

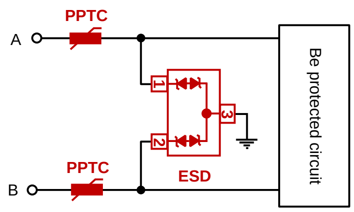
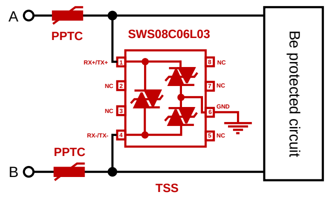
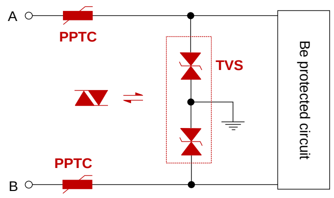
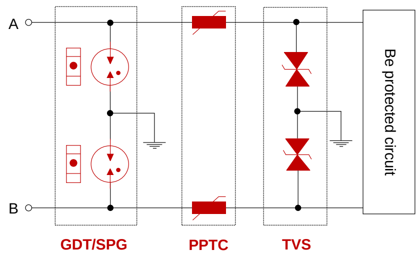
ESD1: SDD32C24L01
ESD2: LBD32C1524L01

Reference test standards:
IEC61000-4-5, GB/T17626.5
ISO10605, GB/T 19951

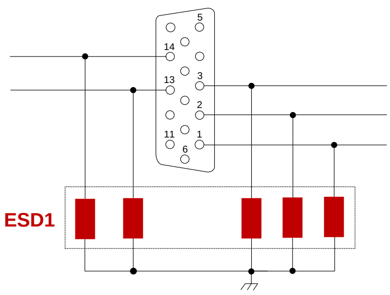
3.2.11 Antenna (RF port) Protection

 ESD protection	 Surge protection
Ultra-low capacitance ESD device are recommended for RF port ESD protection. The following are commonly used models. **ESD:** UAQ02C05L01, UCD32C05L01 , UBD32C05L01, UAD8C05L01-TIP, UAD52A05L01 **Reference test standards:** IEC61000-4-5, GB/T17626.5 ISO10605, GB/T 19951	Two stage protection solution can be used for some high protection level require circuit. **GDT:** 2RL075L/M-5, 2RM075L/M-8 **SPG:** BK13001502/BK1301502-M **ESD:** UAQ02C05L01, UCD32C05L01 , UBD32C05L01, UAD8C05L01-TIP, UAD52A05L01 **Reference test standards:** IEC61000-4-2, GB/T 17626.2 ISO10605, GB/T 19951 IEC61000-4-5, GB/T17626.5

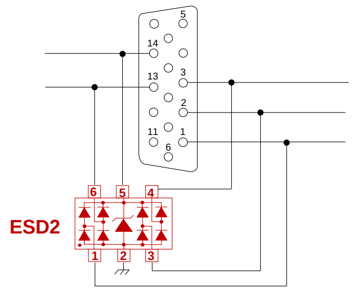
3.2.12 RS485 Port Protection

 RS485 port ESD protection	Dedicated RS485 ESD protection device is used for common mode and differential mode protection. This device has an asymmetric 7V and 12V operating voltage. **ESD:** SDT23C712L02 **PPTC:** SMD1812B010TF/ BK250-110 **Reference test standards:** IEC61000-4-2, level 4
 Integrated TSS protect solution	Integrated multi-line TSS is used for RS485 port common mode and differential mode protection. Compare to the same size TVS, TSS can gain higher protection level. **TSS:** SWS08C06L03 **PPTC:** SMD1812B010TF/ BK250-110 **Reference test standards:** IEC61000-4-5, 10/700μs, 40Ω, 3kV, ±5 times, 1minute interval.
 Power TVS or TSS protection solution	Using power TVS or TSS for RS485 port surge protection can gain high protection level. **TVS:** SMBJ6.5CA, SMB package **TSS:** P0080SB, SMB package **PPTC:** BK250-110 **Reference test standards:** IEC61000-4-2, level 4 IEC61000-4-5, 10/700μs, 40Ω, 4kV, ±5times, 1 minute interval.
 Two stage protect solution	The first stage protection device can choose SPG or GDT, the secondary protection devices can choose TVS. Two stage protect solution can gain high protection level and low clamping voltage at the same time. **GDT:** 2RM090M-5 **SPG:** BK13001502/BK1301502-M **PPTC:** SMD1812B010TF/ BK250-110 **TVS:** SMAJ5.0CA **Reference test standards:** IEC61000-4-2, level 4 IEC61000-4-5, 10/700μs, 40Ω, 6kV, ±5 times

3.2.13 VGA Port ESD Protection



Discrete ESD device



Integrated ESD device

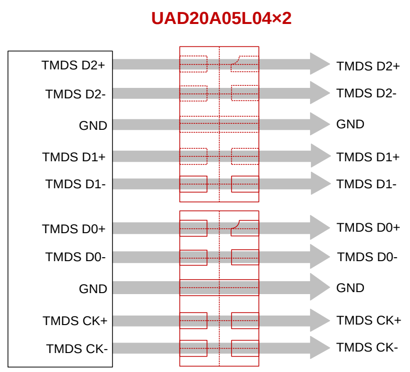
ESD1：[UCD32C05L01](), [UBD32C05L01](), [UAD8C05L01-TIP]()

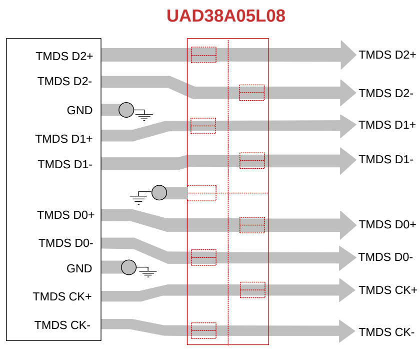
Reference test standards:
IEC61000-4-5, GB/T17626.5
ISO10605, GB/T 19951

ESD2：[UCT26A05L05-HP1](), [UDT26A05L05-LC1]()

Reference test standards:
IEC61000-4-5, GB/T17626.5
ISO10605, GB/T 19951

3.2.14 HDMI Port ESD Protection

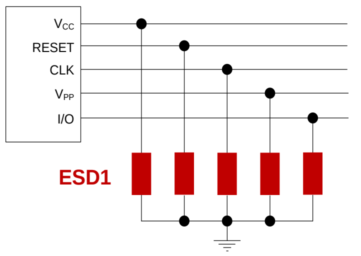




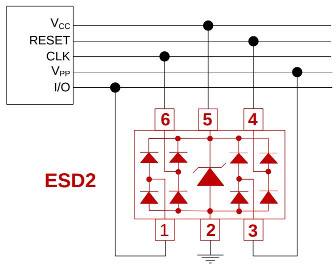
ESD: [UAD20A05L04]()
ESD test level: IEC610000-4-2, 20kV(Air/contact)

ESD: [UAD38A05L08]()
ESD test level: IEC610000-4-2, 20kV(Air/contact)

3.2.15 SIM Card ESD Protection



Discrete ESD devices



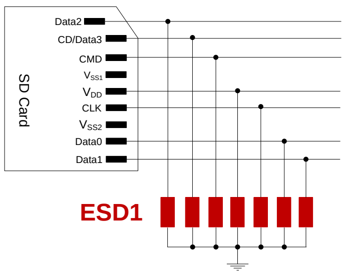
Integrated multi-line ESD device

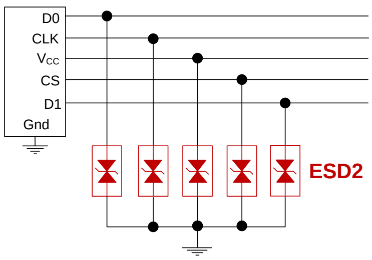
ESD1: UAQ02C05L01, UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD52A05L01

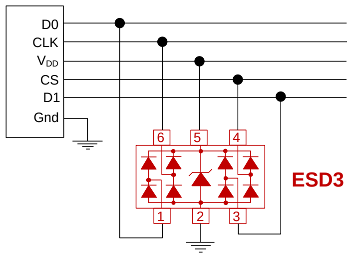
ESD2: UCT26A05L05-HP1, UDT26A05L05-LC1

Reference test standards: IEC61000-4-5, GB/T17626.5, ISO10605, GB/T 19951

3.2.16 SD Card ESD Protection







ESD1: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAD52A05L01, UAQ02C05L01-R0.5

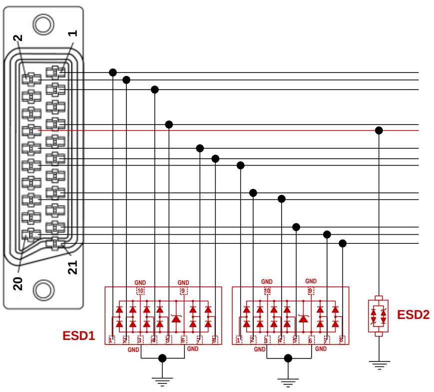
ESD2: LBQ02C05L01

ESD3: UCT26A05L05-HP1, UDT26A05L05-LC1

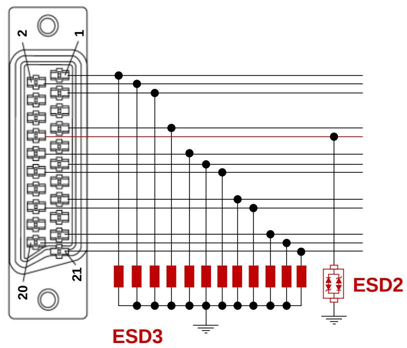
Reference test standards:

IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.17 SCART Card ESD Protection



Integrated multi-line ESD protection devices



Discrete ESD devices

ESD1: UAD33A05L06

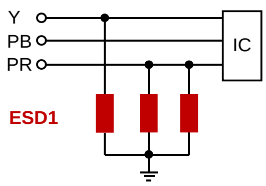
ESD2: UDD32C12/15L01

ESD3: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAD52A05L01, UAQ02C05L01-R0.5

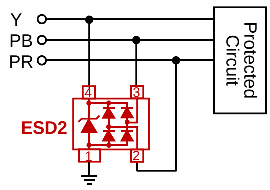
Reference test standards:

GB/T17626.2, IEC61000-4-2

3.2.18 YCRCB/YPRPB Port ESD Protection



Discrete ESD Device



Integrated multi-line ESD Device

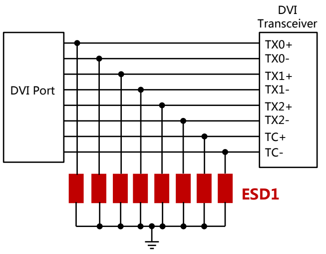
ESD1: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAD52A05L01, UAQ02C05L01-R0.5

ESD2: UET14A05L03-BK

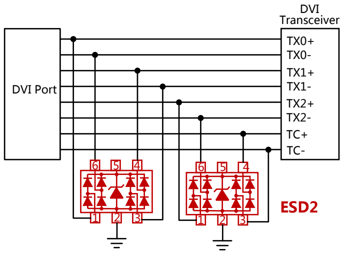
Reference test standards:

GB/T17626.2, IEC61000-4-2

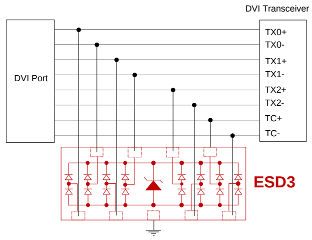
3.2.19 DVI Port ESD Protection



Discrete ESD device



Integrated multi-line ESD device



Integrated multi-line ESD device

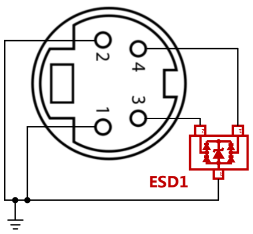
ESD1: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAQ02C05L01-R0.5, UAD52A05L01, UAD03C05L01

ESD2: UCT26A05L05-HP1, UDT26A05L05-LC1

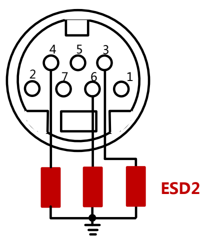
ESD3: UAD38A05L08

Reference test standards:
GB/T17626.2, IEC61000-4-2

3.2.20 S-Video ESD Protection



Integrated multi-line ESD device



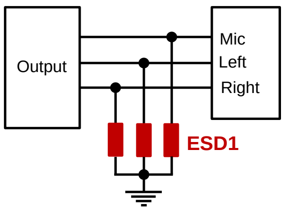
Discrete ESD device

ESD1: UAT52A05L02/UBT23A05L02

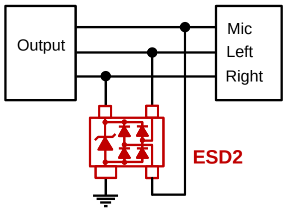
ESD2: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD8A05L01, UAQ02C05L01-R0.5, UAD52A05L01, UAD03C05L01

Reference test standards: GB/T17626.2**,** IEC61000-4-2

3.2.21 Headphone Interface ESD Protection



Discrete ESD device



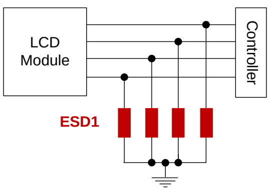
Integrated multi-line ESD device

ESD1: SDD32C05L01, SBD52C05L01, SDD52C05L01, SED52C05L01, LAD52C05L01, LAD8C05L01, LBD8C05L01, LAD92C5.0L01

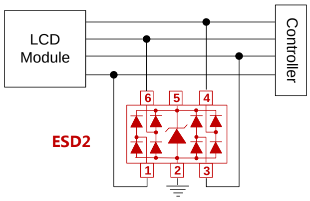
ESD2: UET14A05L03-BK

Reference test standards: GB/T17626.2, IEC61000-4-2, ISO10605, GB/T 19951

3.2.22 LCD Module ESD Protection



Discrete ESD device



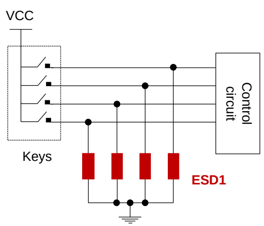
Integrated multi-line ESD device

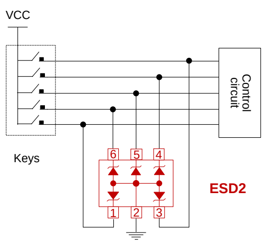
ESD1: UCD32C05L01, UAD8C05L01-TIP, UAD03C05L01

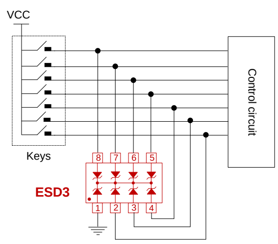
ESD2: UCT26A05L05-HP1, UDT26A05L05-LC1

Reference test standards:IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.23 Key-pads ESD Protection







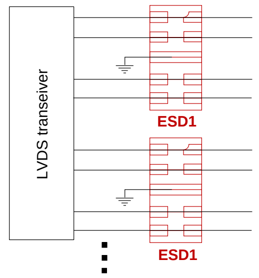
ESD1: SBD52C05L01, SJD12A(C)XXL01, SED52C05L01, SDD8A12L01

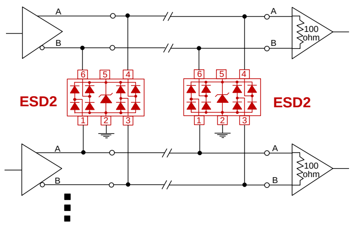
ESD2: SAT36A05L05

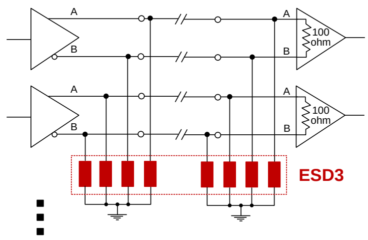
ESD3: SCS08C05L07/SCS08C12L07/SCS08C15L07/SCS08C24L07

Reference test standards:IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.24 LVDS ESD Protection







ESD1: UAD20A05L04, UAD20C05L04-R0.4, UBQ10A05L04HI, UBQ10A05L04-LV

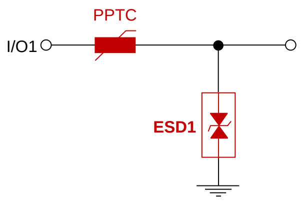
ESD2: UCT26A05L05-HP1, UDT26A05L05-LC1

ESD3: UAQ02C05L01, UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAD52A05L01

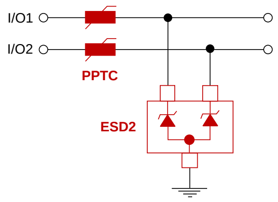
Reference test standards:

IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

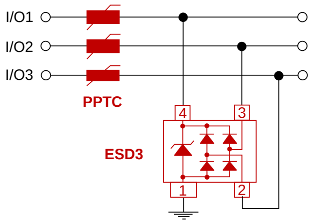
3.2.25 I/O Port ESD Protection



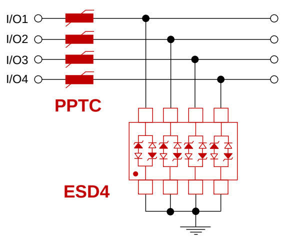
One I/O port



Two I/O Ports



Three I/O ports



4 I/O ports

Different number of I/O lines can choose different package ESD device. Above are some typical applications, other needs can consult our technical engineer.

Device selection:

PPTC: SMD0603, SMD0805, SMD1206, SMD1210, SMD1812

ESD1: SBD52C05L01, SJD12A(C)XXL01, SED52C05L01

ESD2: SDT23C05L02/SDT23C12L02/SDT23C15L02SDT23C24L02(Bidirectional)

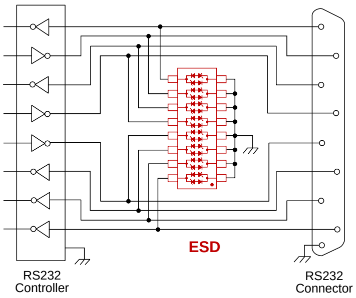
SET23A03L02/SET23A05L02/SET23A12L02/SET23A15L02/SET23A24L02/SET23A36L02(Unidirectional)

ESD3: UDT14A05L03

ESD4: LES08C05L04/LES08C12L04/LES08C15L04/LES08C24L04

Reference test standards: IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.26 RS232 Port ESD Protection

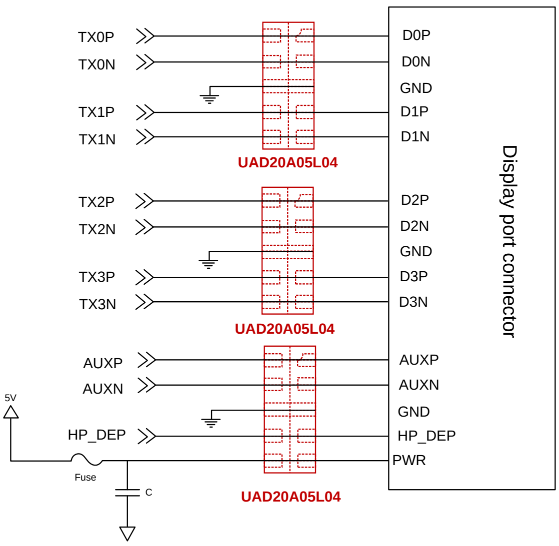


ESD:LES16C05L08/LES16C12L08/LES16C15L08/LES16C24L08

Reference test standards

IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.27 Display Port ESD Protection

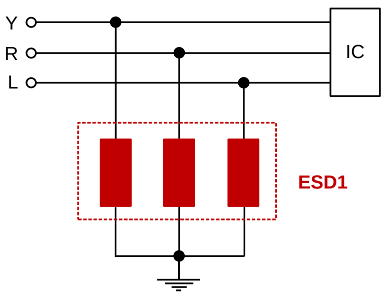


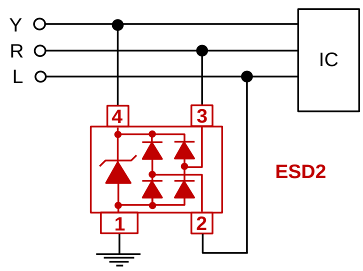
ESD: UAD20A05L04

Reference test standards:

IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

3.2.28 AV Terminal ESD Protection





ESD1: UCD32C05L01, UBD32C05L01, UAD8C05L01-TIP, UAQ02C05L01-R0.5, UAD52A05L01

ESD2: UET14A05L03-BK

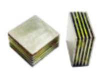
Reference test standards: IEC61000-4-2, GB/T17626.2, ISO10605, GB/T 19951

4. Pulse/BrightKing TVS Products Line

Automotive Products (AEC-Q101 Qualified)

Series	Polarity	Minimum Peak Pulse Power@10/1000µs P_{PPM} (W)	Figures	Package	Reverse Stand-Off Voltage V_{RWM}(V)	Maximum Clamping Voltage @I_{PP} V_C(V)	Peak Pulse Current I_{PP}(A)
SMAJ-AT	Uni//Bi	400		SMA/DO-214AC	5.0~440.0	9.2~713.0	43.5~0.6
P4SMA-AT	Uni//Bi				5.80~467.00	10.5~760.0	39.0~0.5
P4KE-AT	Uni//Bi			DO-204AL/DO-41	5.80~467.00	10.5~760.0	39.0~0.52
SMBJ-AT	Uni//Bi	600		SMB/DO-214AA	5.0~440.0	9.2~713.0	65.3~0.9
P6SMB-AT	Uni//Bi				5.80~467.00	10.5~760.0	58.1~0.8
P6KE-AT	Uni//Bi			DO-204AC/DO-15	5.80~512.00	10.5~828.0	58.1~0.75
SMCJ-AT	Uni//Bi	1500		SMC/DO-214AB	5.0~440	9.2~713.0	163.0~2.1
1.5SMC-AT	Uni//Bi				5.80~467.00	10.5~760.0	144.8~2.0
1.5KE-AT	Uni//Bi			DO-201	5.80~467.00	10.5~760.0	144.8~2.0
SMDJ-AT	Uni//Bi	3000		SMC/DO-214AB	5.0~220.0	9.2~356.0	326.1~8.4
3KP-AT	Uni//Bi			P600	5.0~220.0	9.2~356.0	326.1~8.4
5.0SMDJ-AT	Uni//Bi	5000		SMC/DO-214AB	11.0~170.0	18.2~275.0	275.00~18.2
5KP-AT	Uni//Bi			P600	5.0~250.0	9.2~425.0	554.3~12.0
ATS	Uni//Bi	10000			22~40	35.5~64.5	287~155

Other TVS Products

Series	Polarity	Package	I_{PP} (KA)	V_C(V) @I_{PP}	V_{AC}	V_{DC}	$V_{BR\ MIN.}$ (V)
HF-L	Bi		3	80~868	8.5V~385V	12.8~500	14~558
			6	80~625	8.5V~310V	12.8~430	14~440
			10	80~625	8.5V~310V	12.8~430	14~440
			16	80~330	8.5V~150V	12.8~200	14~222
HF-C	Bi		3	80~868	8.5V~385V	12.8~500	14~558
			6	80~520	8.5V~275V	12.8~380	14~401
			10	80~210	8.5V~145V	12.8~190	14~200
HF-S	Bi		3	80~868	8.5V~385V	12.8~500	14~558
			6	80~520	8.5V~275V	12.8~380	14~401
			10	80~290	8.5V~145V	12.8~190	14~200

Other TVS Products

Series	Polarity	Minimum Peak Pulse Power@10/1000μs P_{PPM} (W)	Figures	Package	Reverse Stand-Off Voltage V_{RWM}(V)	Maximum Clamping Voltage @I_{PP} V_C(V)	Peak Pulse Current I_{PP}(A)
SMAJ	Uni//Bi	400		SMA/DO-214AC	5.0~440.0	9.2~713.0	43.5~0.6
P4SMA	Uni//Bi				5.80~467.00	10.5~760.0	39.0~0.5
P4KE	Uni//Bi			DO-204AL/DO-41	5.80~467.00	10.5~760.0	39.0~0.52
SA	Uni/Bi	500		DO-204AC/DO-15	5.0~220.0	9.2~356.0	55.4~1.4
SAC(50pF)	Uni				5.0~50.0	10.0~88.0	44.0~5.8
P6KE	Uni/Bi	600			5.80~512.00	10.5~828.0	58.1~0.75
SMBJ	Uni/Bi			SMB/DO-214AA	5.0~440.0	9.2~713.0	65.3~0.9
P6SMB	Uni/Bi				5.80~467.00	10.5~760.0	58.1~0.8
1.0SMB	Uni/Bi	1000			5.8~58.1	10.5~92.0	96.8~11.0
SMCJ	Uni/Bi	1500		SMC/DO-214AB	5.0~440.0	9.2~713.0	163.0~2.1
1.5SMC	Uni/Bi				5.80~467.00	10.5~760.0	144.8~2.0
1.5KE	Uni/Bi			DO-201	5.80~467.00	10.5~760.0	144.8~2.0
LCE(100pF)	Uni				6.5~28.0	11.2~45.5	100~33
SMDJ	Uni/Bi	3000		SMC/DO-214AB	5.0~220.0	9.2~356.0	326.1~8.4
3KP	Uni/Bi			P600	5.0~220.0	9.2~356.0	326.1~8.4
5.0SMDJ	Uni/Bi	5000		SMC/DO-214AB	11.0~170.0	18.2~275.0	275.00~18.2
5KP	Uni/Bi			P600	5.0~250.0	9.2~425.0	554.3~12.0
ATS	Uni/Bi	10000			22~40	35.5~64.5	287~155
15KPA	Uni/Bi	15000			17.0~280.0	29.3~454.5	515.4~33.2
20KPA	Uni/Bi	20000			20.0~300.0	36.8~483.0	548.9~41.8
30KPA	Uni/Bi	30000			28.0~288.0	50.0~469.9	606.0~64.5

5. Pulse/BrightKing MOV Products Line

105℃ MOV

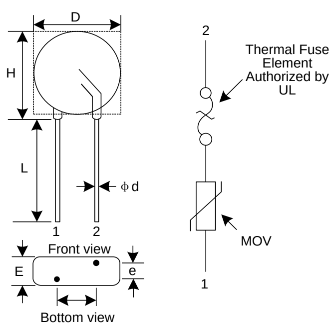
Series	Figures	Breakdown Voltage	Maximum Operating Voltage		Maximum Single Peak Pulse Current		Maximum Energy (10/1000μs)	
		V_{1mA}(V)	V_{AC}(V)	V_{DC}(V)	Standard type I(A)	High Energy type I(A)	Standard type (J)	High Energy type (J)
05Φ		18~68	11~40	14~56	100	250	0.4~1.6	0.6~2.2
		82~750	50~460	65~615	400	800	2.5~22.4	4.0~32
07Φ		18~68	11~40	14~56	250	500	0.9~3.6	2.0~7.0
		82~820	50~510	65~670	1200	1750	5.0~67.2	10.0~70.0
10Φ		18~68	11~40	14~56	500	1000	2.1~8.2	3.0~15.0
		82~1100	50~680	65~895	2500	3500	12.0~115.0	17.0~155.0
14Φ		18~68	11~40	14~56	1000	2000	4.0~14.0	7.0~24.0
		82~1800	50~1100	65~1465	4500	6000	22.0~250	27.0~335
20Φ		18~68	11~40	14~56	2000	3000	11~46	13~49
		82~1800	50~1100	65~1465	6500	10000	38~625	56~990
25Φ		18~68	11~40	14~56	4500		20~70	
		82~1800	50~1100	65~1465	15000		80~1092	
32Φ		100~1600	60~1000	85~1280	25000		170~1080	
34S		82、100	50、60	65、85	30000		156、195	
		120~1600	75~1000	100~1280	40000		235~1500	
40Φ		100~1600	60~1000	85~1280	40000		241~1700	
53Φ		120~1600	75~1000	100~1280	70000		390~2500	

125℃ MOV

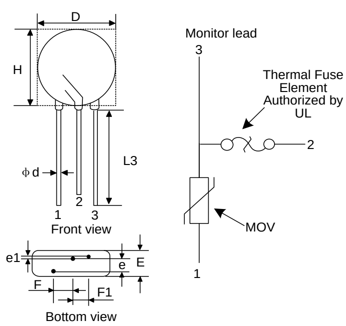
Series	Figures	Breakdown Voltage	Maximum Operating Voltage		Maximum Single Peak Pulse Current		Maximum Energy (10/1000μs)	
		V_{1mA}(V)	V_{AC}(V)	V_{DC}(V)	Standard type I(A)	High Energy type I(A)	Standard type (J)	High Energy type (J)
5H		18~68	11~40	14~56	100	250	0.4~1.6	0.6~2.2
		82~750	50~460	65~615	400	800	2.5~21.8	4.0~32.0
7H		18~68	11~40	14~56	250	500	0.9~3.6	2.0~7.0
		82~910	50~550	65~745	1200	1750	5.0~57.0	10.0~78.0
10H		18~68	11~40	14~56	500	1000	2.1~8.2	3.0~15.0
		82~1200	50~750	65~990	2500	3500	12.0~127.0	17.0~165.0
14H		18~68	11~40	14~56	1000	2000	4.0~14.0	7.0~24.0
		82~1600	50~1000	65~1280	4500	6000	22.0~243	27.0~331
		1800	1100	1465	4500	5000	250	335
20H		18~68	11~40	14~56	2000	3000	11~41	13~49
		82~1800	50~1100	65~1465	6500	10000	45~625	56~990

TMOV

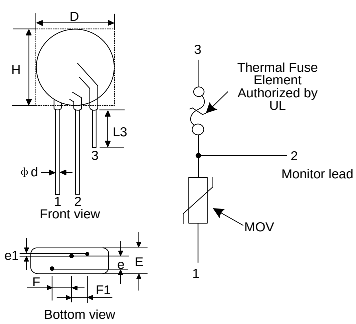
Series	Figures	Varistor Voltage	Maximum Allowable Voltage		Maximum Peak Current (8/20μs)		Maximum Energy (J)	
		V_{1mA}(V)	V_{AC}(V)	V_{DC}(V)	1 time I(A)	2 time I(A)	10/1000μs	2ms
14M(E,N)		82~120	50~75	65~100	4500	2500	27~40	22~329(2ms)
		150~1200	95~750	125~990	6000	4500	50~338	35~215(2ms)
20M(E,N)		18~39	11~25	14~32	3000	2000	13~28	10~21(2ms)
		47~68	30~38	38~56	5000	3000	34~49	25~37(2ms)
		82~120	50~75	65~100	6500	4500	56~85	42~63(2ms)
		150~1200	95~750	125~990	10000	8000	100~650	70~460(2ms)
25M(E,N)		150~1200	95~750	125~990	15000	12000	160~840	105~590(2ms)



N Series



M Series



E Series

6. Pulse/BrightKing GDT&SPG Products Line

Two electrodes						
Series	DC Breakdown Voltage (V) 100V/s	Pulse Breakdown Voltage (V) 1000V/μs	Nominal Discharge Current (kA) 8/20μs	Capacitance (pF) 1MHz	Figures	Size(mm) L*W*H (L*Φ)
B32	(150~470) ±30%	750~1050	0.5	0.5		3.2*1.6*1.6
B32-H2.5	(50~400) ± xx% xx=±20,±30,-10~+45%	700~950	1.0	0.5		3.2*2.5*2.5
4532	(75~600) ±30%	600~1200	2	0.5		4.5*3.2*2.7
2R-4	(75~1200) ±20%	800~1900	3	1.0		4.0*4.2*4.2
2R-5-SST4.2	(75~1000) ±20%	700~1800	5	1.0		4.2*5.0*5.0
2R-5-SS	(1000~2500) ±20%	1900~3600	3	1.5		6.0*5.6*5.6
2R-5	(70~800) ±20%	800~1700	5	1.5		6.0*Φ5.5
	(70~230) ±20%	600~700	10			
2R-6	(75~800) ±20%	700~1200	5	1.0		4.2*6.2*6.2
	(1000~1800) ±20%	1600~2600	3			
2R-6*7	(1000~3600) ±20%	2000~4700	3	0.5		7.0*Φ6.0
2R-8*6(T6)	(1000~1600) ±20%	1900~2400	10	1.5		6.0*Φ8.0
	(2000~3000) ±20%	3200~4200	5			
2R-8*6	(75~800) ±20%	600~1500	10/20	1.5		6.0*Φ8.0
2R-8*6(D1)	(75~800) ±20%	600~1500	20	1.5		6.0*8.0
2R-8*6(S)	(75~1000) ±20%	600~1700	10/20	1.5		6.0*8.3*8.3
2R-8*8	(1000~2500) ±20%	1400~3600	5	1.5		8.0*Φ8.0
	(1400~3600) ±20%	2200~5200	2.5	1.5		
	(2700~4000) ±20%	4000~5500	3	1.5		
B600-60KA(003)	600±20%	1400	60(8/20μs)/10(10/350μs)	5		See datasheet
B800-60KA(003)	800±20%	1600	60	5		See datasheet
B600-80KA(F14)	600±20%	1400	80(8/20μs)/25(10/350μs)	8		See datasheet
B600-80KA-T(013)	600±20%	1400	80(8/20μs)/15(10/350μs)	7		See datasheet
B600-100KA(004)	600±20%	1400	100(8/20μs)/20(10/350μs)	8		See datasheet

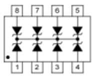
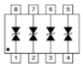
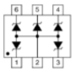
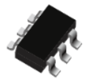
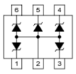
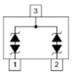
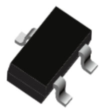
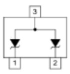
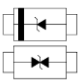
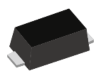
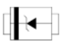
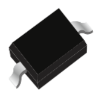
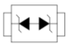
Three electrodes

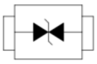
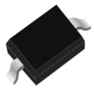
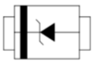
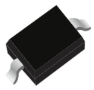
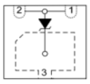
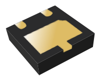
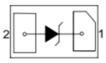
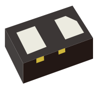
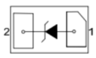
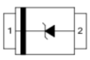
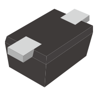
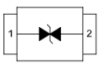
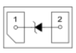
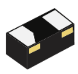
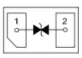
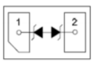
Series	Figures	DC Breakdown Voltage (V) 100V/s	Pulse Breakdown Voltage (V) 1000V/μs	Nominal Discharge Current (kA) 8/20μs	Capacitance (pF) 1MHz	Size(mm) L*W*H (L*Φ)
3R-5-S		(75~600) ±20%	700~1000	5	2.0	7.2*5.0
3R-6-SSS		(75~600) ±20%	750~1300	5/10	2.0	8.5*6.0
3R-6	 	(75~600) ±20%	750~1300	5/10	2.0	8.5*6.0
3R-8	 	(75~800) ±20%	700~1500	10/20	2.0	10.0*8.0
3R-8-SSS		(75~800) ±20%	700~1600	10/20	2.0	10.0*8.0
3R-8-S		(75~600) ±20%	700~1300	10/20	2.0	10.0*8.0

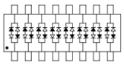
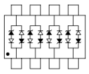
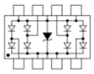
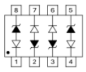
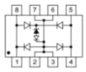
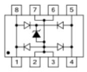
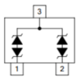
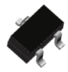
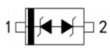
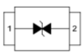
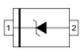
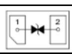
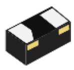
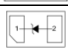
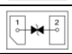
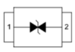
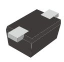
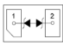
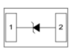
SPG Products Line

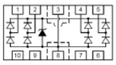
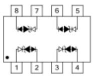
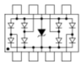
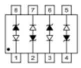
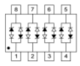
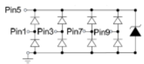
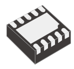
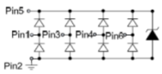
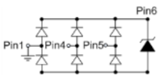
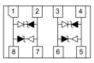
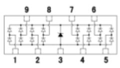
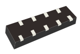
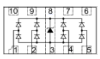
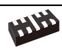
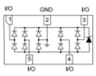
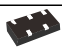
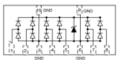
Series	DC Breakdown Voltage Range V	Surge Current Capacity (8/20μs) kA	Maximum Capacitance (1KHz-6VMAX) pF	Figures	Size (mm) L，Φ
BK1-M	140~1000	3	0.8		(6.0±0.5) * (Φ3.3±0.5)
BK1-H	1000~5000	3	1.0		(9.0±1.5) * (Φ4.1±0.5)
BK1	140~700	3	0.8		(4.0±0.5) * (Φ3.1±0.5)
BK1-MS	140~1000	3	0.8		(6.0±0.5) * (Φ3.2±0.2)
BK2	140~1500	1	0.8		(4.3±0.5) * (Φ2.6±0.5)
BK2-M	140~1000	1	0.8		(5.0±0.5) * (Φ2.6±0.5)
BK3	140~700	0.5	0.8		(4.0±0.5) * (Φ2.0±0.5)
BK3-M	140~300	0.3	0.8		(3.4±0.5) * (Φ1.4±0.5)
BK3-M(H)	140~1000	0.5	0.8		(4.0±0.5) * (Φ2.1±0.5)

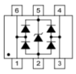
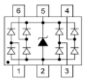
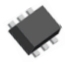
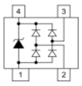
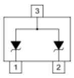
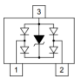
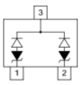
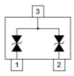
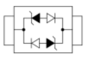
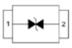
7. Pulse/BrightKing ESD Products Line

Standard Capacitance					
Part Number	**Internal Configuration**	**ESD Test Level IEC61000-4-2 Contact/Air**	**Reverse stand-off voltage V_{RWM} (V)**	**Junction Capacitance C_j (pF)**	**Figures**
SCS08C05L07 SCS08C12L07 SCS08C15L07 SCS08C24L07		±8kV/±15kV	5 12 15 24	350 120 75 50	 SOIC-08
SES08C15L04		±8kV/±15kV	15	80	
SDT26A15L05 SDT26A24L05		±8kV/±15kV	15 24	70 50	 SOT23-6L
SAT36A05L05		±8kV/±15kV	5	50	 SOT-363
SDT23C712L02		±8kV/±15kV	7(pin1/2 to pin3) 12(pin1/3 to pin2)	75	 SOT-23
SDT23C05L02 SDT23C12L02 SDT23C15L02 SDT23C24L02		±8kV/±15kV	5 12 15 24	150 65 60 40	
SET23A03L02 SET23A05L02 SET23A12L02 SET23A15L02 SET23A24L02 SET23A36L02		±8kV/±15kV	3.3 5 12 15 24 36	200 220 100 90 80 70	
SJD12AXXL01 SJD12CXXL01		±8kV/±15kV	5.0~170.0	-	 SOD-123S
SDD32A05L01 SDD32A12L01 SDD32A36L01		±8kV/±15kV	5 12 36	350 150 70	 SOD-323
SDD32C36L01		±8kV/±15kV	36	70	

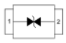
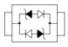
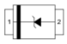
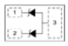
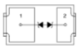
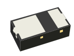
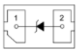
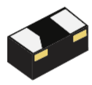
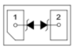
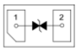
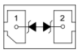
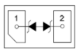
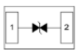
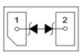
Standard Capacitance					
Part Number	Internal Configuration	ESD Test Level IEC61000-4-2 Contact/Air	Reverse stand-off voltage V_{RWM} (V)	Junction Capacitance C_j (pF)	Figures
SDD32C05L01		±8kV/±15kV	5	100	 SOD-323
SDD32C18L01			18	40	
SDD32C24L01			24	37	
SDD32C30L01			30	20	
SDD32C30L01-IP6		±30kV/±30kV	30	25	
SJD32A05L01-J		±30kV/±30kV	5.0	-	 SOD-323J
SJD32A07L01-J			7.0	-	
SJD32A10L01-J			10.0	-	
SJD32A12L01-J			12.0	-	
SJD32A15L01-J			15.0	-	
SJD32A18L01-J			18.0	-	
SJD32A24L01-J			24.0	-	
SJD32A36L01-J			36.0	-	
STD22A07L01		±30kV/±30kV	7	2800	 DFN-2020
STD22A10L01			10	1600	
STD22A15L01			15	1200	
STD22A18L01			18	1200	
SJD16A05L01		±30kV/±30kV	5.0	350	 DFN1610
SJD16A07L01			7.0	650	
SJD16A10L01			16.0	400	
SJD16A12L01			12.0	365	
SJD16A15L01			15.0	300	
SJD16A18L01			18.0	220	
SJD16A24L01			24.0	165	
SFD52A05L01 SFD52A07L01		±25kV/±25kV	5.0 7.0	200	 SOD-523
SDD52A12L01		±8kV/±15kV	12	55	
SBD52C05L01		±8kV/±15kV	5	30	
SDD52C05L01		±30kV/±30kV	5.0	30	
SED52C05L01		±30kV/±30kV	5	80	
SDD8A12L01		±30kV/±30kV	12	55	 SOD882
SBD8C05L01		±8kV/±15kV	5	30	
SHD8C4.5L01		±30kV/±30kV	4.5	80	

Low Capacitance					
Part Number	Internal Configuration	ESD Test Level IEC61000-4-2 Contact/Air	Reverse stand-off voltage V_{RWM} (V)	Junction Capacitance C_j (pF)	Figures
LES16C05L08 LES16C12L08 LES16C15L08 LES16C24L08		±8kV/±15kV	5 12 15 24	15	 SOIC-16
LES08C05L04 LES08C12L04 LES08C15L04 LES08C24L04		±8kV/±15kV	5 12 15 24	15	 SOIC-08
LES08A05L05			5	15	
LHS08A12L04			12	25	
LTS08A3.3L02			3.3	30	
LTS08A06L02			6	30	
LBT23C12L02		±30kV/±30kV	12	15	 SOT-23
LBT23C24L02		±8kV/±15kV	24	12	
LBD32C1524L01		±8kV/±15kV	15(pin1 to pin2) 24(pin2 to pin1)	20	 SOD-323
LAD52C03L01		±8kV/±15kV	3.3	10	 SOD-523
LAD52C05L01			5	12	
LBD52A24L01			24	30	
LBD52A36L01			36	20	
LAD8C05L01		±8kV/±15kV	5	10	 SOD-882
LBD8A24L01			24	5	
LBD8C05L01		±30kV/±30kV	5	10	
LAD92C5.0L01		±8kV/±15kV	5	15	 SOD-923
LBQ02C05L01		±8kV/±15kV	5	8	 DFN0603/QFN-0201
LAQ02A05L01			5	40	
LAQ02A12L01			12	20	

Ultra-Low Capacitance					
Part Number	Internal Configuration	ESD Test Level IEC61000-4-2 Contact/Air	Reverse stand-off voltage V_{RWM} (V)	Junction Capacitance C_j (pF)	Figures
UBQ10A03L04		±20kV/±25kV	3.3	0.6	 DFN-10/DFN2510
UBQ10A05L04		±8kV/±15kV	5	0.6	
UBQ10A05L04HI		±20kV/±20kV	5	0.6	
UBQ10A05L04-LV		±10kV/±10kV	6	0.35	
UFS08A2.8L04		±8kV/±15kV	2.8	3	 SOIC-8
UDS08A03L04		±30kV/±30kV	3.3	1.5	
UES08A03L05		±8kV/±15kV	3.3	5	
UDS08A24L04			24	3	
UDS08C24L04			24	3	
UED26A03L05		±30kV/±30kV	3.3	5.0	 DFN2626
UCQ06A05L05		±30kV/±30kV	5.0	1.0	 DFN1616
UAD11A05L03		±10kV/±10kV	5.0	0.25	 DFN1109
UAD20C03L02		±30kV/±30kV	3.0	3	 DFN2010-8
UAD38A05L08		±20kV/±20kV	5	0.6	 DFN3810
UAD20A05L04		±20kV/±20kV	5	0.6	 DFN2010-10
UAD20C05L04-R0.4		±10kV/±10kV	5	0.4	 DFN2010-5
UAD33A05L06		±10kV/±10kV	5	0.2	 DFN3310

Ultra-Low Capacitance					
Part Number	**Internal Configuration**	**ESD Test Level IEC61000-4-2 Contact/Air**	**Reverse stand-off voltage V_{RWM} (V)**	**Junction Capacitance C_j (pF)**	**Figures**
UBT26A05L03		±8kV/±15kV	5.25	3.5	 SOT23-6L
UAT26A03L05		±8kV/±15kV	3.3	0.5	
UCT26A05L05-HP1			5	2.0	
UDT26A05L05-LC1			5	1.0	
UAT36A03L05			3.3	0.5	 SOT-363
UAT36A05L05			5	1	
UAT56A03L05			3.3	0.5	 SOT-563
UAT56A05L05			5	1	
UDT14A05L03		±8kV/±15kV	5	3	 SOT-143
UET14A05L03-BK			5	0.8	
UAT14A07L03			7.5	1	
UAT14A15L03			15	1	
UBT32A05L02		±8kV/±15kV	5	0.8	 SOT-323
UAT52A05L02		±8kV/±15kV	5	0.8	 SOT-523
UBT23A05L02			5	0.8	 SOT-23
UDT23A03L02 UDT23A05L02 UDT23A12L02 UDT23A15L02 UDT23A24L02		±8kV/±15kV	3.3 5 12 15 24	0.8	
UCT23C03L02		±30kV/±30kV	3.3	2.5	
UCT23C05L02			5	2.5	
UDD32C03L01-HT		±30kV/±30kV	3.3V	0.8	 SOD-323
UDD32C03L01 UDD32C05L01 UDD32C08L01 UDD32C12L01 UDD32C15L01 UDD32C24L01		±8kV/±15kV	3.3 5 8 12 15 24	0.8 0.8 1 0.8 0.8 0.8	
UBD32C05L01		±8kV/±15kV	5	0.4	

Ultra-Low Capacitance

Part Number	Internal Configuration	ESD Test Level IEC61000-4-2 Contact/Air	Reverse stand-off voltage V_{RWM} (V)	Junction Capacitance C_j (pF)	Figures
UCD32C05L01		±30kV/±30kV	5	2.0	 SOD-323
UCD32C03L01			3.3	2.0	
UCD32C08L01		±30kV/±30kV	8	2	
UCD32C12L01			12	2	
UCD32C15L01			15	2	
UCD32C24L01			24	2	
UDD32C08L01-DS035			8	2	
UDD32C12L01-DS035			12	2	
UDD32C15L01-DS035			15	2	
UDD32C24L01-DS035			24	2	
UAD52A05L01		±8kV/±15kV	5	0.8	 SOD-523
UAD8A05L02		±8kV/±15kV	5	0.75	 DFN1006-3L
UAD03C05L01		±8kV/±15kV	5	0.7	 DFN1608
UAD8A05L01		±20kV/±20kV	5	0.6	 SOD882
UAD8C05L01		±8kV/±15kV	5	0.4	
UAD8C05L01-TIP			5	0.4	
UAD8C05L01-R0.4		±20kV/±20kV	5	0.4	
UAD8C12L01			12	5.0	
UBD8C05L01		±8kV/±15kV	5	0.4	
UCD8C05L01		±30kV/±30kV	5	1.3	
UAD8C03L01		±8kV/±15kV	3	0.5	
UBD8C18L01			18	0.6	
UAQ02C05L01		±8kV/±15kV	5	5	 DFN0603/QFN-0201
UAQ02C05L01-R0.5		±20kV/±20kV	5	0.5	

8. Pulse/BrightKing NTC Products Line

Temperature NTC

Series	Figures	Zero Power Resistance At 25 ℃	Beta Value	Operating Temperature Range	Max Power
TDC03		0.01K~470KΩ	B(25/50) 3000~4600	-20~+125℃	250mW
TDC05		0.01K~470KΩ	B(25/50) 2600~4750	-40~+125℃	450mW
NS03		0.01K~470KΩ	B(25/50)3000~4600	-40~+125℃	250mW
NS05		0.01K~470KΩ	B(25/50)2600~4750	-40~+125℃	450mW
NA		1K~150KΩ	B(25/85)3435~4262	-40~+125℃	75mW
SMD0603		10K~470KΩ	B(25/85)3430~4500	-40~+125℃	100mW
SMD0402		10K~470KΩ	B(25/85)3430~4500	-40~+125℃	170mW

Power NTC

Series	Figures	Disc	Zero Power Resistance At 25 ℃	Max. Steady State Current	Max Steady Energy	Recommend Capacitance at 340Vdc
SP		8Φ~25Φ	0.7~120Ω	1~15A	6.9~71.4J	120~1240μF
NT (High Surge)		5Φ~20Φ	1~50 Ω	1~12A	2.7~47.4J	30~820μF

9. Pulse/BrightKing TSS Products Line

Series	Figures	V_{DRM} (V)	I_H (mA)	C_O (pF)	V_{PP} 10/700μs (V)	I_{PP} 10/1000μs (A)	Package
PxxxxTA		6~320	50、150	30~70	2000	45	DO-214AC(SMA)
PxxxxSX		6~320	50、150	30~100	A:2000,B:4000,C:6000	A:45,B:80,C:100	DO-214AA(SMB)
B0300SB		25	10	50	4000	75	
P61089B		-170	-150	50(V_D=-48V) 100(V_D=-3V)	-	30	SOP-8
SWS08C06L03		6	10	50	3000	45	SOIC-8

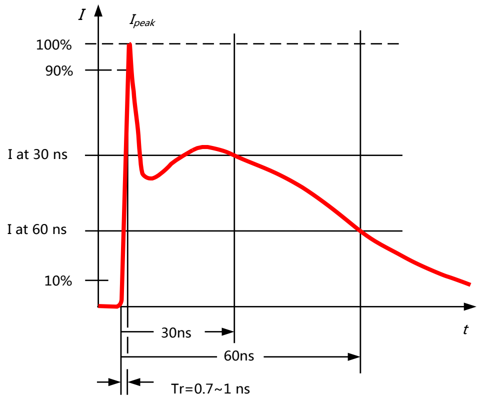
Note: x can be any of 0~9,
X can be any of A or B or C

10. Pulse/BrightKing PPTC Products Line

Series	Figures	I_{hold} (A)	I_{trip} (A)	$V_{max.}$ (Vdc) (V)	$I_{max.}$ (A)	$R_{min.}$~ $R_{max.}$(Ω)	Size, L*W(Max)
SMD 0603		0.04~0.5	0.12~1.00	6~24	40	0.10~40.0	1.8*1.0
SMD 0805		0.10~1.10	0.30~2.00	6/9/15	40/100	0.03~6.00	2.2*1.5
SMD 1206		0.05~2.00	0.15~3.50	6~30	100	0.018~50.00	3.4*1.8
SMD 1210		0.05~2.00	0.15~4.00	6~30	10/100	0.015~50.0	3.43*2.80
SMD 1812		0.10~3.00	0.30~5.00	6~60	10/20/40/100	0.012~15.00	4.73*3.41
SMD 2016		0.30~2.00	0.60~4.20	6~60	20/40	0.03~2.30	5.44*4.43
SMD 2920		0.30~5.0	0.60~10.0	6~60	10/40	0.005~4.800	7.98*5.44
BK 16		2~14	4~28	16	40/100	0.003~0.120	See datasheet
BK 30		0.90~9.00	1.80~18.00	30	40	0.005~0.220	See datasheet
BK 60		0.05~5.00	0.10~10.00	60	40	0.025~25.00	See datasheet
BK 130		0.10~1.35	0.20~2.70	130	20	0.2~18.0	See datasheet
BK 250		0.030~2.000	0.060~4.000	250	1/3/10	0.1~90.0	See datasheet
BK 600		0.11~0.16	0.22~0.32	500(ac)	3	4.0~18.0	See datasheet

11. Appendix: Summary of Test Standards

11.1 IEC61000-4-2：ESD



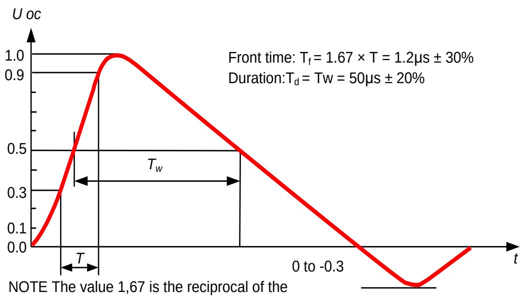
Electrostatic discharge waveform parameters					
Level	Indicated voltage	First peak current of discharge (±15%)	Rise time T_r (±25%)	Current (±30%) at 30 ns	Current (±30%) at 60 ns
	kV	A	ns	A	A
1	2	7.5	0.7~1	4	2
2	4	15	0.7~1	8	4
3	6	22.5	0.7~1	12	6
4	8	30	0.7~1	16	8

The reference point for measuring the time for the current at 30 ns and 60 ns is the instant when the current first reaches 10 % of the 1st peak of the discharge current.
NOTE The rise time, Tr, is the time interval between 10 % and 90 % value of 1st peak current.

Test level				
Test level	Level 1 (KV)	Level 2 (KV)	Level 2 (KV)	Level 2 (KV)
Contact discharge	2	4	6	8
Air discharge	2	4	8	15

11.2 IEC61000-4-5: Surge

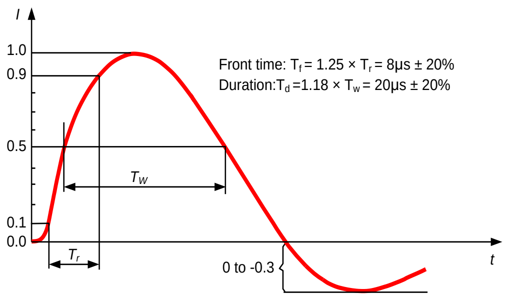
1.2/50µs & 8/20µs combination waveform



NOTE The value 1,67 is the reciprocal of the difference between the 0,9 and 0,3 thresholds.

IEC 1143/14

Waveform of open-circuit voltage (1.2/50µs)



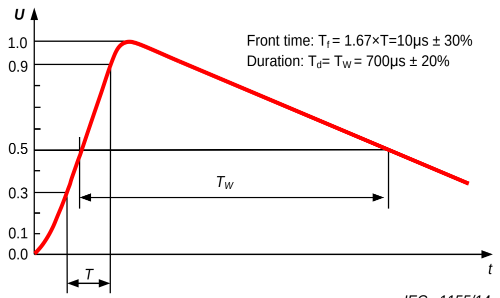
IEC 1144/14

NOTE 1 The value 1,25 is the reciprocal of the difference between the 0,9 and 0,1 thresholds.
NOTE 2 The value 1,18 is derived from empirical data.

Waveform of short-circuit current (8/20µs)

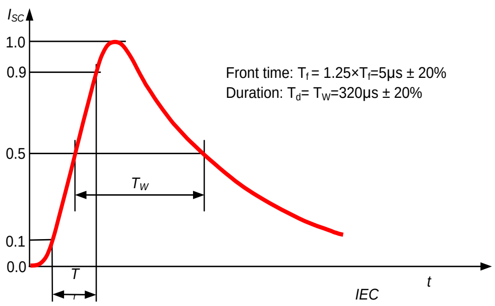
Relationship between peak open-circuit voltage and peak short-circuit current		
Open-circuit peak voltage at generator output±10 %	Short-circuit peak current ±10 % (18µF)	Short-circuit peak current ±10 % (9µF+10Ω)
0.5kV	0.25kA	41.7A
1.0kV	0.5kA	83.3A
2.0kV	1.0kA	166.7A
4.0kV	2.0kA	333.3A

10/700µs & 5/320µs



IEC 1155/14

Waveform of open-circuit voltage (10/700µs)



IEC 1156/14

Waveform of the 5/320µs short-circuit current waveform

Relationship between peak open-circuit voltage and peak short-circuit current	
Open-circuit peak voltage ± 10 % at generator output	Short-circuit peak current ± 10 % at generator output
0.5kV	12.5A
1.0kV	25A
2.0kV	50A
4.0kV	100A

Table 1. Test levels

level	Open-circuit test voltage (kV)	
	Line-to-line	Line-to-ground [b]
1	...	0.5
2	0.5	1
3	1	2
4	2	4
X[a]	Special	Special

a "X" can be any level, above, below or in between the others. The level shall be specified in the dedicated equipment specification.
b For symmetrical interconnection lines the test can be applied to multiple lines simultaneously with respect to ground, i.e. "lines to ground".

Table B.1 – Power ports: selection of the test levels (depending on the installation class)

Installation class	Test levels (kV)							
	AC power supply and a.c. I/O External ports [a]		AC power supply and a.c. I/O Internal ports [a,d]		DC power supply and d.c. I/O External ports [a]		DC power supply and d.c. I/O Internal ports [a,d]	
	Coupling mode		Coupling mode		Coupling mode		Coupling mode	
	Line-to-line	Line-to ground	Line-to-line	Line-to ground	Line-to-line	Line-to ground	Line-to-line	Line-to ground
0	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	0.5	NA	NA	NA	NA	NA	NA
2	0.5	1.0	NA	NA	NA	NA	NA	NA
3	1.0	2.0	1.0	2.0	1.0	NA	1.0	1.0
4	2.0[b]	4.0[b]	2.0[b]	4.0[b]	2.0[b]	4.0[b]	2.0[b]	4.0[b]
5	[c, b]	[c, b]	2.0[b]	4.0[b]	2.0[b]	4.0[b]	2.0[b]	4.0[b]

[a] No test is advised if the cable length is shorter than or equal to 10 m.
[b] Where the port is always intended to be used with specified primary protection, testing is performed with the primary protection in place to ensure coordination with the protection elements. If primary protection is required to protect the interface but not provided, testing is also performed at the maximum let through level of the specified primary protection and with a typical primary protector.
[c] Depends on the class of the local power supply system.
[d] The testing of intra-system ports is generally not required.

Table B.2 – Circuits/lines: selection of the test levels (depending on the installation class)

Installation class	Test levels (kV)											
	Unsymmetrical operated circuits/lines [a,c,e]				Symmetrical operated circuits/lines [a, c, e]				Shielded circuits/lines [a, d, e]			
	External port		Internal port		External port		Internal port		External port		Internal port	
	Line to line	Line to ground	Line to line	Line to ground	Line to line	Line to ground	Line to line	Line to ground	Line to line	Line to ground	Line to line	Line to ground
0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	0.5	NA	NA	NA	0.5	NA	NA	NA	NA
2	NA	NA	0.5	1.0	NA	NA	NA	1.0	NA	NA	NA	0.5
3	NA	NA	1.0	2.0	NA	NA	NA	2.0	NA	NA	NA	2.0
4	2.0[b]	4.0[b]	2.0[b]	4.0[b]	NA	4.0[b]	NA	4.0[b]	NA	4.0[b]	NA	4.0[b]
5	2.0[b]	4.0[b]	2.0[b]	4.0[b]	NA	4.0[b]	NA	4.0[b]	NA	4.0[b]	NA	4.0[b]

[a] No test is advised for data connections intended for cables shorter than 10 m.
[b] Where the port is always intended to be used with specified primary protection, testing is performed with the primary protection in place to ensure coordination with The protection elements. If primary protection is required to protect the interface but not provided, testing is also performed at the maximum let through level of the specified Primary protection and with a typical primary protector.
[c] Line-to-line surgEs (transverse) may occur in networks where SPDs (surge protective devices) with connection to ground are used for protection. Such surgEs are outside the scope of this standard. This phenomenon can however be simulated by applying common mode surges through the defined primary protection elements.
[d] The testing of ports connecting to antennas is outside the scope of this standard.
[e] The testing of intra-system ports is generally not required.

BrightKing Electronics Headquarters
A:#3 Building, Modern enterprise
accelerator park, SongShan Lake
High-tech Industrial development zone,
Dongguan City, Guangdong Province,P.R.C
T:+86- 769-26626898
F:+86-769- 26626198
E:LinCheung@pulseelectronics.com

BrightKing Taiwan
2F, No. 2, Alley 1, Lane 235, Baoqiao Rd,
Xindian Dist,New Taipei City 231, Taiwan
T: +886-2-6629-9999 #3896

Pulse A Yageo Company
Worldwide Headquarters
15255 Innovation Drive Ste 100
San Diego, CA 92128
P: +1 858-674-8100
F: +1 858-674-8262

Pulse Europe
Pulse Electronics GmbH
Feringastr. 10b
D-85774 Munich-Unterföhring
E:PulseEMEACPC@pulseelectronics.com

Pulse Taiwan
2F, No. 2, Alley 1, Lane 235, Baoqiao Rd,
Xindian Dist,New Taipei City 231, Taiwan
Office: +886.2.6629.9999 #3511