1. What is Varistor

Definition

Varistor is variable resistance device which changes with the applied voltage.

Features

■ **Main composition**

- Ceramic material : ZnO + additives
- Internal Electrode : Pd, Ag-Pd, etc.

■ **Semi-conductive property**

- It is a insulator under a certain voltage level but the varistor becomes a low ohmic conductor within 0.5 ns for the duration of the over-voltage.

■ In communications equipment and systems for data transmission, it thus offers perfect protection by clamping the over-voltage to a safe level.

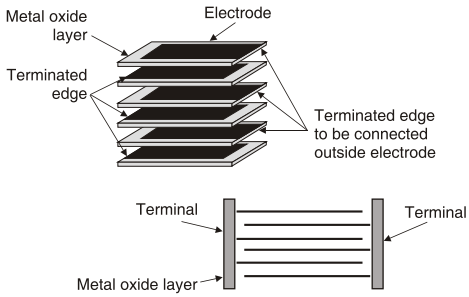


Fig. 1 Chip varistor structure

Application

- IC and Transistor Protection
- Telecommunication Transient Protection
- LCD Module Protection Circuit
- USB, IEEE 1394 data line protection
- Protection Circuit Module [Li ion and Li Polymer 2nd Battery], etc.

2. Technical Information on Varistor

Working Voltage (V_W)

- The maximum continuous DC working voltage which may be applied up to the maximum operating temperature of the Varistor.
- The reference voltage for measurement of leakage current
- It is always less than the breakdown voltage.

Breakdown Voltage (V_B)

- This is the voltage across the Varistor when drawing a DC current of 1mA and this voltage has a specific range [min. & max.].
- It is this point that is notionally the start of the region of normal operation.

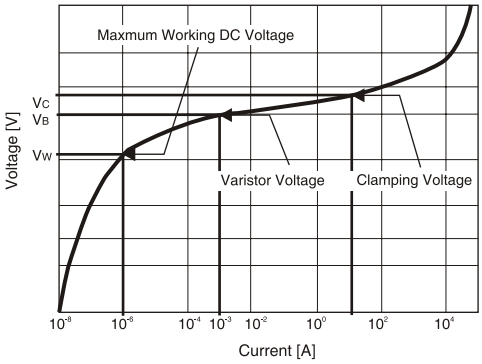


Fig. 2 V-I curves

Capacitance (C_P)

- Specified 1MHz [or 1kHz] and 0.5~1Vrms.
- For using protection of high speed data lines, the capacitance should generally be kept low or within a defined range. Excessive capacitance on the signal line could have an undesired effect on the signal.

  * Low Cp : a part of a low-pass filter needed in high speed data lines
  * Defined Cp : Replace a capacitor for filtering purposes at I/O ports
  * High Cp : For noise suppression

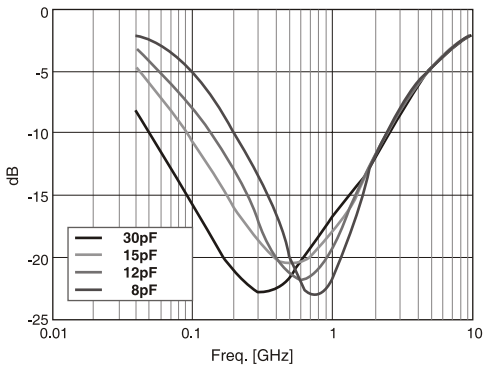


Fig. 3 Insertion loss of frequency with Cp of varistor

Clamping Voltage [Vc]

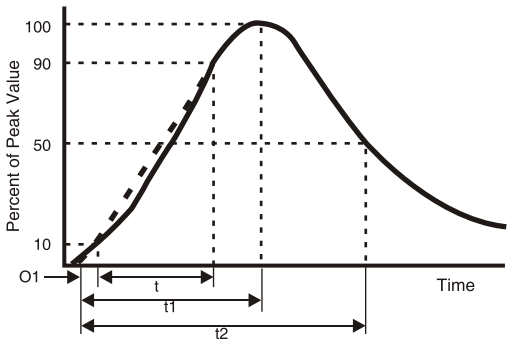
- The Clamping Voltage of a Varistor is the peak voltage appearing across the device when measured under the conditions of a specified pulse current and a specified waveform [8㎲/20㎲].
- 8㎲[Ts] is the time taken for the current pulse to rise from 10% of its peak value to 90% of its peak value.
- 20㎲[Tr] is the time taken to decay to 50% of its peak value ; this is measured from the time of pulse initiation.

Surge(Peak) Current [Ip]

- The maximum peak current which may be applied for a 8㎲/20㎲ impulse, with rated line voltage also applied, without causing device failure.
- The pulse can be applied to the device in either polarity with the same confidence factor.

Transient Energy [Et]

- The maximum rated transient energy which may be dissipated for single current pulse at a specified impulse duration [10㎲/1000㎲], with rated DC or RMS voltage applied, without causing device failure.



O1: Virtual Origin of Wave
t : Time from 10% to 90% of Peak
t1 : Virtual Front Time t1=1.25×t
t2 : Virtual Time to Half Value [Impulse Duration]

Item	Waveform	t1	t2
VC	8/20㎲	8㎲	20㎲
IP	8/20㎲	8㎲	20㎲
ET	10/1000㎲	10㎲	1000㎲

Fig. 4 Waveform for Vc, Ip, Et

ESD [Electrostatic discharge]

- ESD is a high voltage transient with fast rise time [0.7~1.0ns] and fast decay time [max. 60ns]
- For protection the circuit or IC from ESD, the protective device should have a fast enough response time to clamp ESD peak
- ESD protection capability depends on a kind of devices and ceramic composition in chip varistor

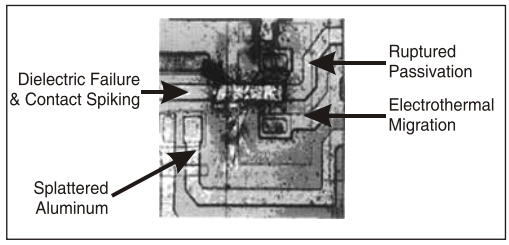


Fig. 5 Circuit break-down by ESD

Severity Level	Contact Discharge	Air Discharge
1	2kV	2kV
2	4kV	4kV
3	6kV	8kV
4	8kV	15kV

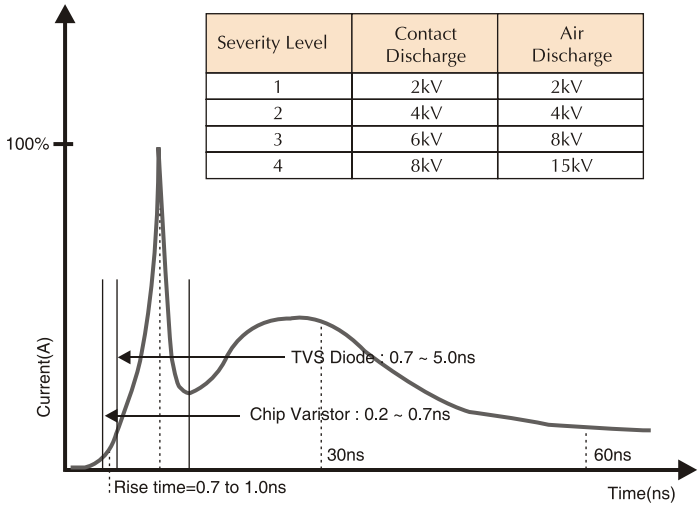


Fig. 6 Waveform % rising time of ESD in IEC1000-4-2

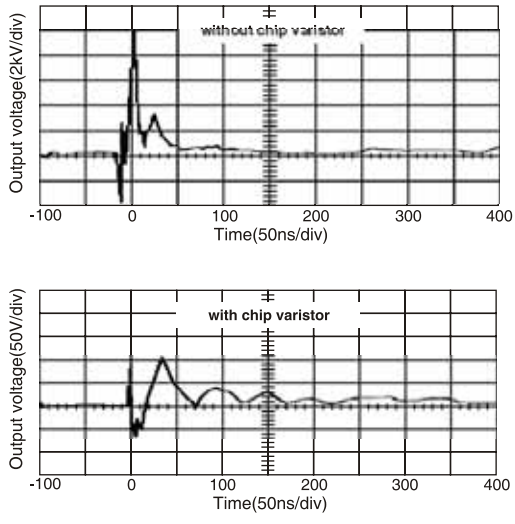


Fig. 7 Output voltage peak w/, w/o chip varistor on ESD

• ESD protection capability ; ZnO-Pr based & ZnO-Bi based Chip Varistor

* Comparative product : 1608 18Vw, 120pF
* Joinset chip varistor : ZnO-Pr based ceramic composition
* ZnO-Bi2O3 based chip varistors is not available in protecting the electronic circuit from ESD over 5kV
* Test condition : contact discharge with ESD waveform in IEC1000-4-2 method

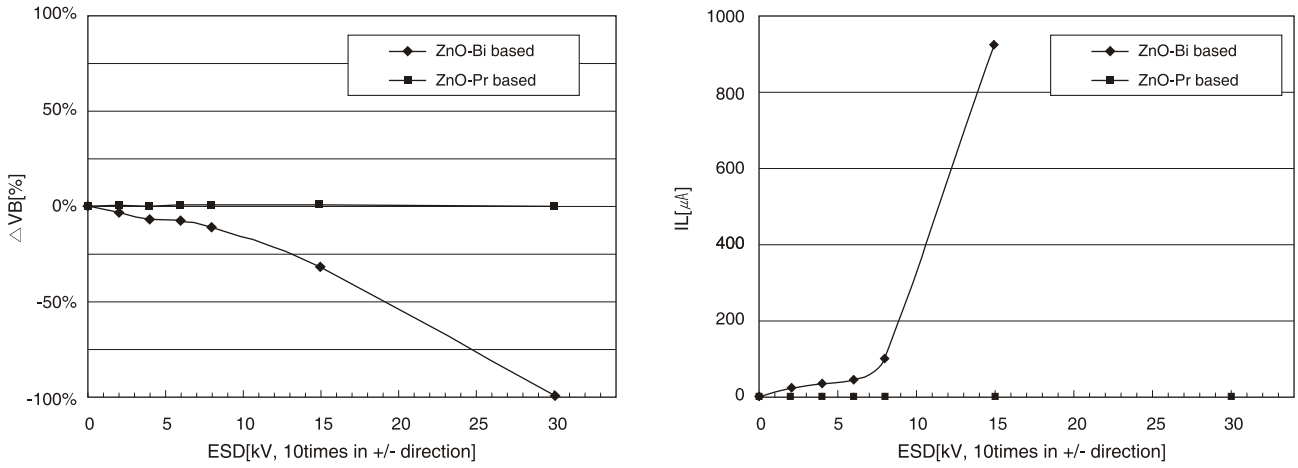
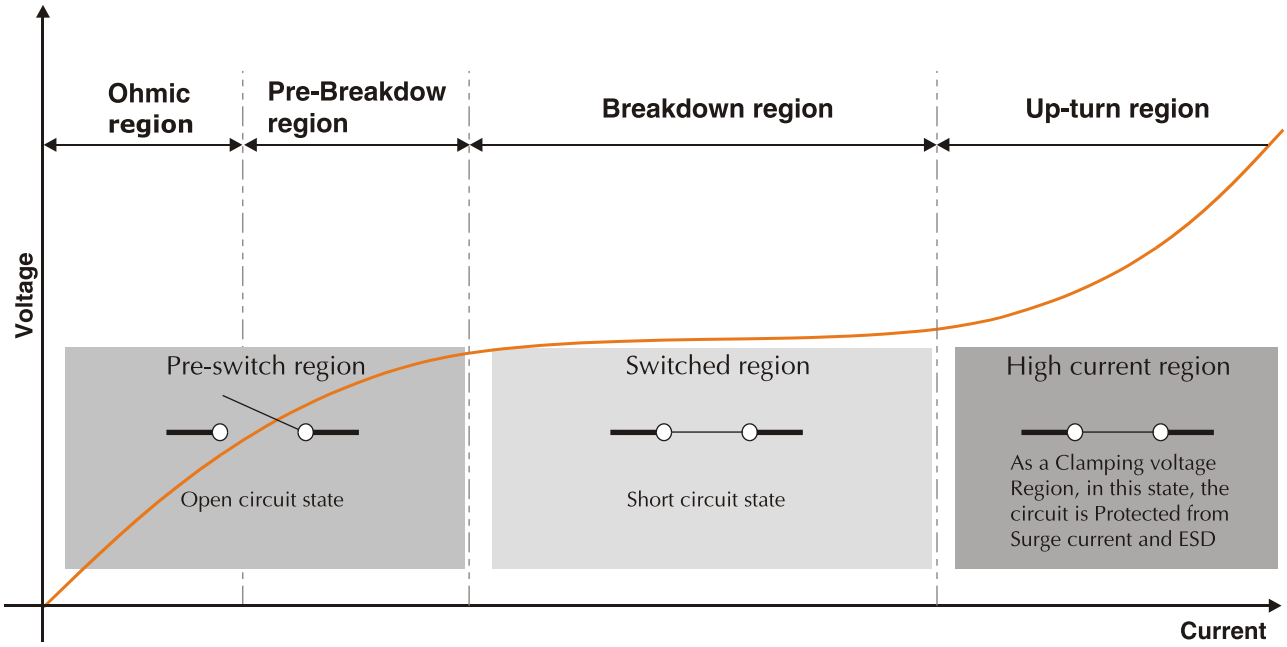
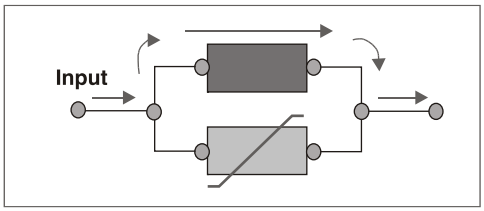


Fig. 8 Varistor voltage & leakage current deviation with ESD

V-I Characteristics

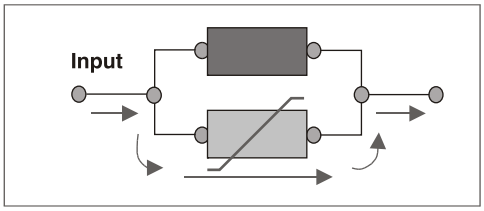


How to play in Circuit



When the rated voltage, which is needed to drive the system or component, may be applied in an electronic circuit, a AC or DC input current flows through components or systems because varistor have high impedance.

Steady State : Varistor ⇒ High Impedance
[The region below working voltage]



In case that it will be applied over-voltage through the input, Varistor will be change to a conductor with low impedance.

The input current flows through the varistor to the ground, so components or systems can be protected.

Protective State : Varistor Y Low Impedance
[The region over Varistor voltage]

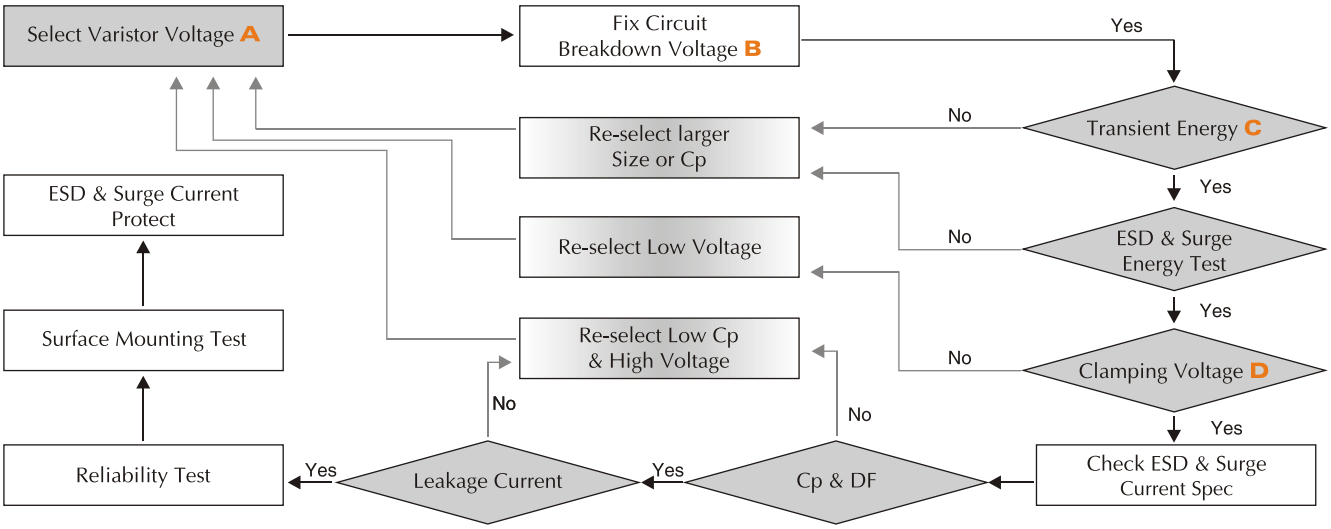
Multilayer Chip Varistor

System or Component to be protected from ESD and Surge Current

3. How to Select the adequate Varistor

Step 1

Step 2



A : Varistor Voltage (V_B)

- It is determined by max. voltage in a circuit
- In the case of normal operation, it must be selected to not affect the circuit
- Varistor and circuit voltage

  $V_{IN(DC)} \leq V_{1mA,min.} \times 0.9$; $V_{IN(DC)} \leq V_W$

  * $V_{IN(DC)}$: high limit of input voltage in circuit
  * $V_{1mA,min}$: minimum value of V1mA
  * V_W : working voltage of Varistor

B : Fix the ESD and Surge current of Circuit

- wave form, frequency, time, etc.

C : Transient Energy (E_T)

- It can be expressed as following.

  $E = K \times I_P \times V_P \times t_1[J]$

  * K : Integer value according to surge wave form (Waveform 8/20us, 10/1000us, K=1.43)
  * I_P : Surge currnt
  * V_P : Limit voltage with IP
  * t_1 : Duration time of Surge current
- Energy of Varistor ≥ max. energy of circuit

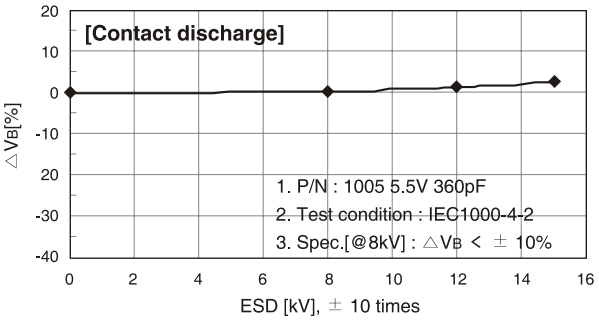
D : Clamping Voltage (V_C)

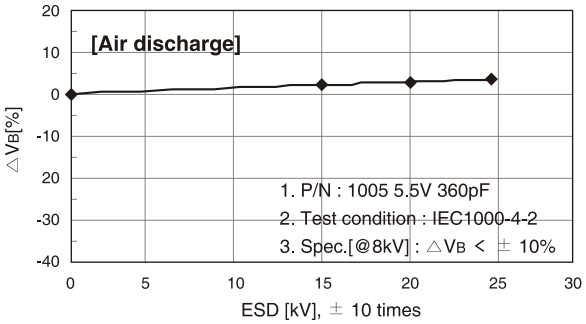
- Voltage which is applied with a specified surge (8/20us, 1A or 2A)
- $V_C \leq$ Endurance voltage of circuit

4. Advantage of Joinset's Varistor

Excellent properties of circuit protection against an electrostatic discharge, ESD

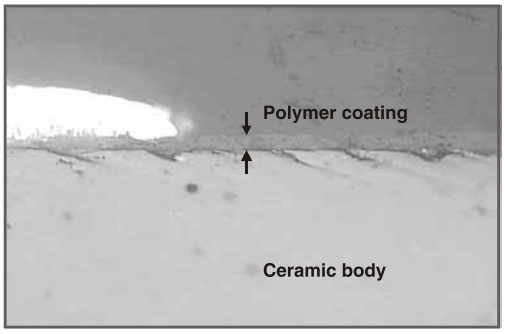
- No degradation of electrical properties of chip varistor although high ESD voltage is repeatedly applied.
  * Low leakage current, I_L & stable variation of breakdown voltage, $\triangle V_B$
  * IEC 1000-4-2 LEVEL 4 [contact discharge 8kV, air discharge 15kV, withstand 1000 times]
- Useful device to protect from ESD in mobile communication unit, etc.

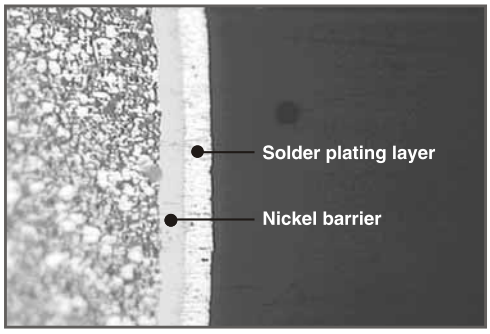


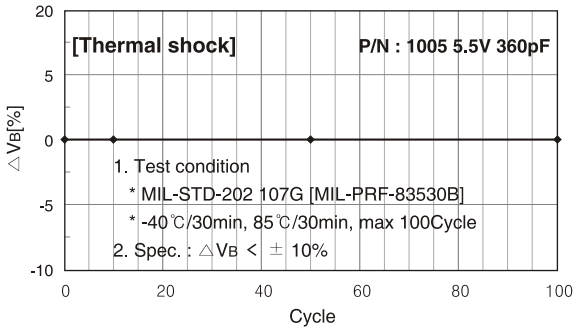


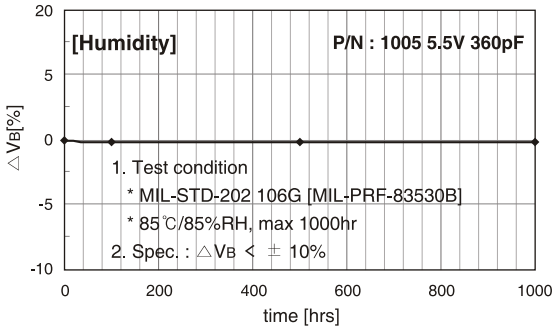
High environmental reliability

- High resistance against thermal shock, humidity, solvent, etc.
- It is due to our original manufacturing processes such as polymer coating on ceramic body, raw material composition, electrolyte plating technique and precision line control.







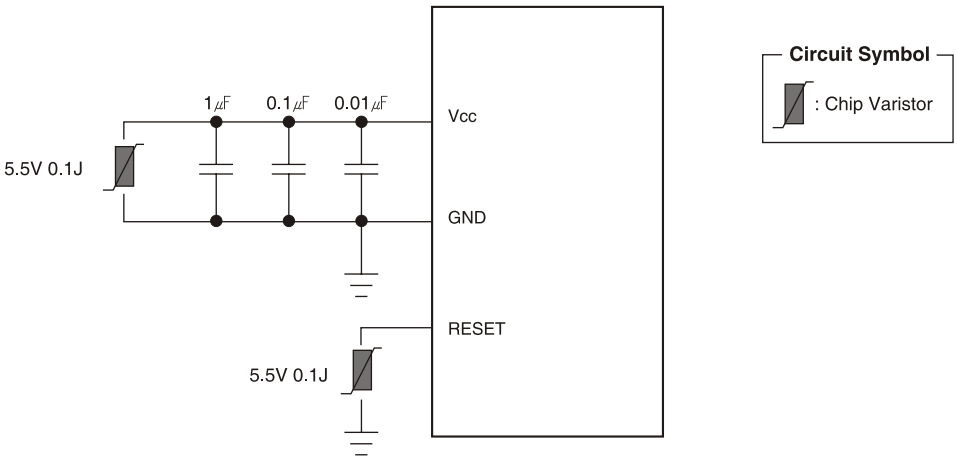


Green product

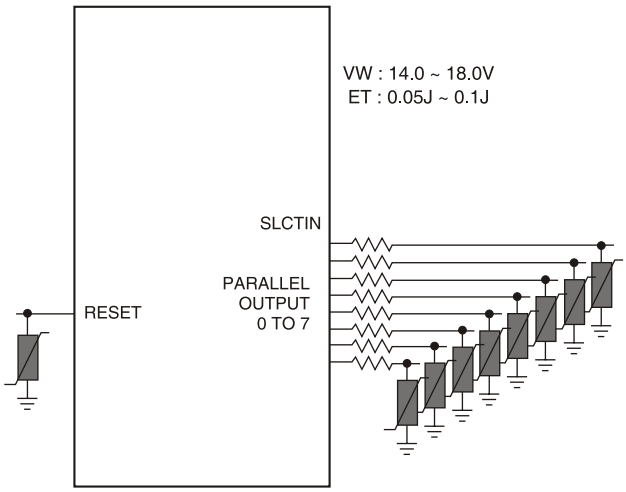
- The harmful objects in product are controlled below 100ppm [EU RoSH regulations satisfied]
  * Pb : <50ppm, Cd : <5ppm
- Lead free solder plating

Application

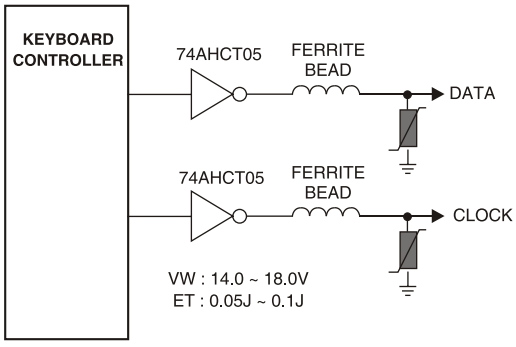
1. ASIC Reset & Vcc Protection Circuit



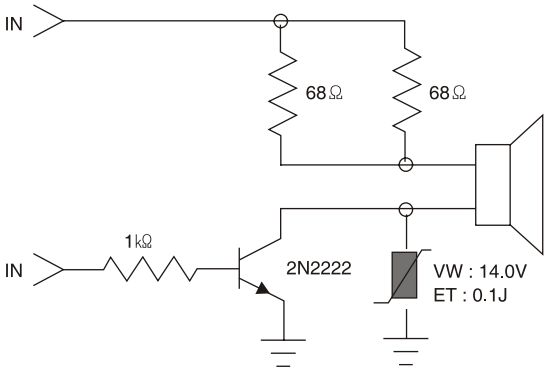
2. I/O Port Protection



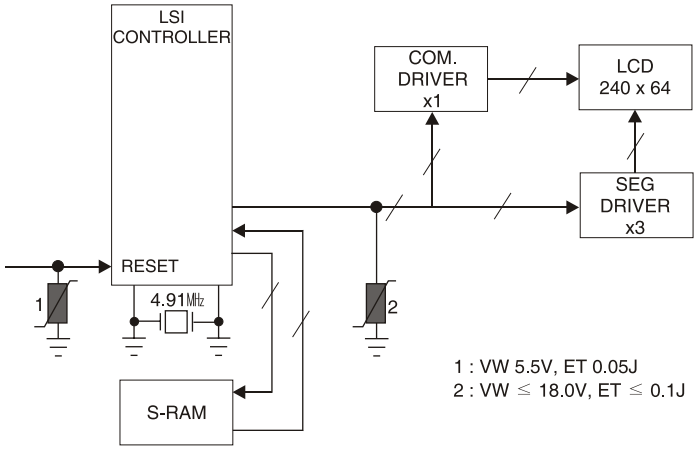
3. Keyboard



4. Audio Circuit



5. LCD Protection Circuit



6. Protection Circuit Module

• Li ion and Li Polymer Rechargeable Battery Application