

Preventing Portable And Wireless Device Field Failures From ESD

With the increasing sophistication of portable and wireless devices, the potential for field failures due to electrostatic discharge exposure also increases. Every new access point, including network connections, user interface, speaker, microphone, memory cards and antennas multiply risk of both immediate and latent damage that can occur when these areas form an electrical path for high potential currents built up by users in every day activities. Cellular phones and other wireless devices exist in a non-ideal world where their survival depends not just on good circuit design but forethought as to the conditions in which they should reliably function.

Although all portable and handheld devices (such as pagers, wireless LAN units, GPS units, and wireless-enabled PDA's) that are in direct contact with users are increasing in ESD exposure, the principles involved are well illustrated in design of a typical cellular telephone. When performing an ESD survival analysis on a typical cell phone (Figure 1), every data or power interface can also be classified as a gateway for ESD into the system. These necessary breaks in the insulation and shielding in the body of the unit are also opportunities for transient incursions. The goal of any ESD mitigation effort is to "clamp" or limit the inbound ESD transients to non-destructive levels. Many technologies exist for this process including silicon transient voltage suppression (TVS) diodes, ceramic multilayer varistors (MLV) and composite polymer suppressors. But each has an optimum application profile in terms of cost, response, clamping thresholds, and packaging. Each electrical portal into the device must be analyzed in terms of its particular functionality and ESD protection need.

Earphone/microphone

Even with this very common audio port, an ESD discharge in the vicinity of the earphone may pass into the interior of the phone and arc via the speaker circuit. Since the signals found on this circuit are very low speed (< 20 kHz), a high capacitance suppression device is recommended. A typical protection choice would be a multilayer varistor with a capacitance value higher than 100 pF. This will provide ESD suppression by clamping the transient to a safe level and also provide EMI/RFI filtering of noise from the ambient environment.

Although microphone and headphones are combined in many phones, some wireless and portable devices separate the “jacks.” If so, the ESD entry mechanism and circuit parameters for the microphone circuit are very similar to those of the earphone, so a similar solution is recommended. However, if the board layout is such that these circuits are adjacent to each other, another valid solution is a multi-line diode array. The advantage in this approach is that a single device can be placed on the circuit board to provide protection to the vulnerable lines. In this case, the lines for the speaker and microphone can be protected by a three-diode array. This approach can save board space and pick-and-place costs in manufacturing.

Keypad/push buttons/switches

These simple components can provide a path for ESD to the circuit board if the transient arcs from the switch structures to the circuit board. Since they are essentially DC lines, a suppressor with high capacitance is recommended. Multilayer varistors and diode arrays are appropriate choices. If it is determined that a small number of lines are the problem, then discrete MLV's may be the better choice. If on the other hand, there are a large number of lines in close proximity, a multi-line diode array may be the better choice due to its ability to protect multiple lines in a single package.

Power port

This low voltage input is used to charge the battery and to provide direct power to the circuits. As a true DC circuit, a high-capacitance suppressor is recommended. Since this circuit could also experience higher-energy transients (lightning, system surges, EFT), a multilayer varistor is recommended since it has capabilities beyond ESD protection. Also, in the event of a sustained overcurrent event (battery malfunction, circuit failure, etc.), a fuse could be used to disrupt the overcurrent condition and protect the system. Surface mount fuses with the appropriate current handling values are now available in sizes as small as 0402 (EIA 1005) to conserve board space.

I/O port – Edge connector

The primary factor to consider for protecting this signal port is the data rate of the signals. As data rates increase, it is crucial to consider the capacitance of the chosen suppressor so as not to introduce any signal integrity issues into the system. For example, circuits in this port running at low speeds (analog audio, RS232, etc.) should be protected with higher capacitance multilayer varistors or TVS diode arrays. Again, the decision to use discrete MLV's versus multi-line diodes will be made by the board designer according to their desire to maintain placement flexibility (discrete devices) or minimize part count (array products).

For extremely high data rate protocols (USB 2.0 – 480 Mbps), it is necessary to use suppressors with virtually no capacitance so that the system is able to transmit and receive the data with no loss of signal quality (due to the suppressor). There are now polymer-based ESD suppressors available with capacitance values far below 1.0 pF that can operate at these higher data transfer rates.

Antenna

With operating frequencies between 800 and 1,900 MHz, an ESD suppressor added to the circuit must present as much impedance as possible so as to not attenuate the communication signal. In this case, the best choice is the polymer suppressor device with capacitance values below 1.0 pF. Many antennas today are encased in plastic or embedded within the cell phone enclosure; however for those phones with exposed antenna elements or an optional antenna plug, the probability of the user introducing ESD into this circuit exists.

An Integrated Future

While most circuit protection needs for portable and wireless devices can be met with discrete devices, space and higher volume manufacturing is also dictating use of Integrated Passive Devices (IPD's). Using USB 1.1 as an example, there are products available which combine the ESD protection, EMI filtering, line resistance and termination resistance functions into one package. These devices provide an opportunity to significantly reduce component part counts. In the future more functionality will be combined, offering designers full applications for ESD and other circuit protection functions.