

## EMI/ESD Filters for Cellular Phones

Cellular phones, as with all handheld and wireless devices are susceptible to the damaging effects of Electrostatic Discharge (ESD) transients. As much as 40 kilovolts of ESD can be generated by the human body or through air discharge. In addition, cellular phones, because of their higher operating frequencies, are more sensitive to EMI/RFI interference. Global authorities are now imposing very strict regulations to ensure that cellular phones are electrically 'clean' before being released to the market.

Unwanted radiated electromagnetic fields or conducted voltages and currents cause EMI. The coupling path may involve one or more of the following mechanisms

- Conduction – electric current
- Radiation – electromagnetic field
- Capacitive Coupling – electric field
- Inductive Coupling – magnetic field

ESD Transients are normally

- Less than 8.4 $\mu$ s in duration
- Characterized by sinusoidal or exponential waveform
- Normally associated with high impedance sources
- Can range from a few millivolts to 18,000 Volts under normal conditions

The IEC 61000-4-2 (ESD) transient is characterized as shown below

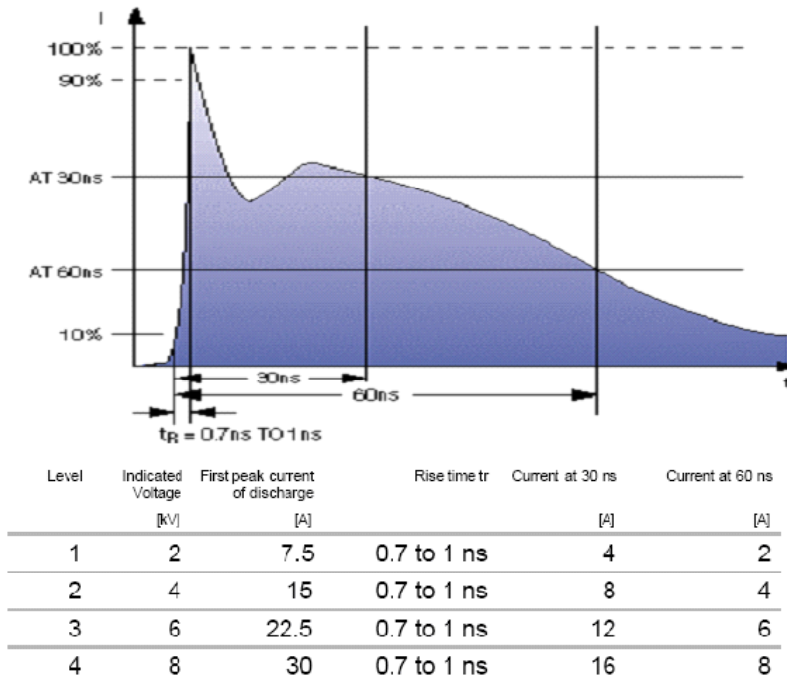


Figure 1 ESD Transient Waveform

A double exponential waveform with a rise time  $t_r$  of 0.7ns to 1.0ns and fall time of 30ns measured at 50% of the decay.

If not suppressed, an ESD transient applied to the external interface of a cell phone causes untold permanent and latent damage to sensitive CMOS type devices. The picture shown below is actual damage on a transceiver chip that contained 2kV internal protection for manufacture handling. The transient applied was 8kV contact discharge as per IEC 61000-4-2.

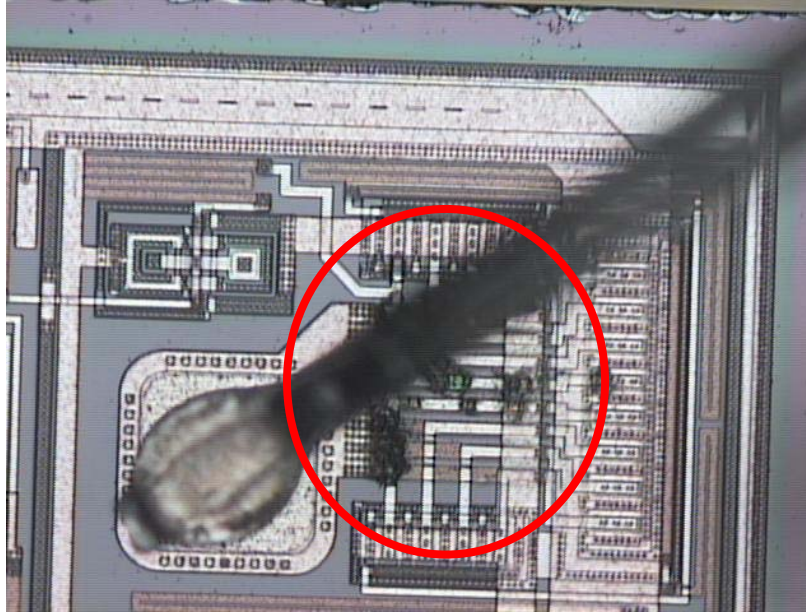


Figure 2 ESD Damage to Transceiver before TVS was added

Responding to the need for space-efficient, noise filtering and ESD protection components, ProTek Devices has introduced a series of convenient devices:

- EMIFx-100x Series: Chip scale modular devices in 2,4,6,8 line configurations with line capacitance values of 18pF, 30pF, 49pF and 60pF
- EM10Q-100, EM8Q-100: Quad, Flat, No-lead Packages For LCD Displays
- EM4D-100L, EM6D-100L: Dual-in-line, Flat, No-lead Packages
- EM1402: ESD/EMI filter for application specific SIM Modules

ProTek Devices EMI/ESD Filters are designed and characterized to safely dissipate ESD strikes at levels well beyond the maximum requirements set in the IEC 61000-4-2 standard. The IEC 61000-4-2 (ESD) pulse requires 8Kv (contact) 15Kv (air discharge). All I/Os are rated at greater than  $\pm 25\text{kV}$  using the IEC 61000-4-2 (1/30nSec) contact discharge method. Using the MIL-STD-883D (Method 3015) specification for Human Body Model (HBM) ESD, all pins are protected for contact discharges to greater than  $\pm 30\text{kV}$ .

The C-R-C combination of the EMI filter device will filter out high frequency signals such as 800 MHz 900MHz and 1900MHz that are frequencies used by most GSM cellular phones. It will also attenuate Bluetooth and Wireless LAN 802.11B (2.4GHz) frequencies better than  $-25\text{dB}$ . High integration of the components minimizes the parasitic self-inductances and, compared to discrete solutions, provides much better attenuation.

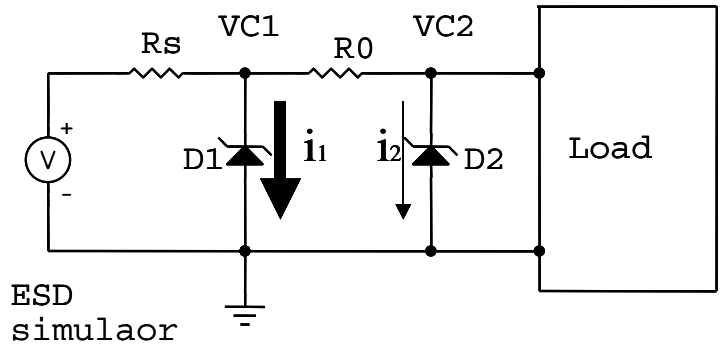


Figure 3 Two-Stage ESD Protection Circuit

The C-R-C filter also acts as a two-stage ESD protection circuit, by utilizing the TVS diodes that are designated as the capacitive part of the low pass PI filter. The first stage D1 will clamp (Vc1) the incoming transient and the second stage D2 will clamp (Vc2) any residual pulse that passes through the first stage.

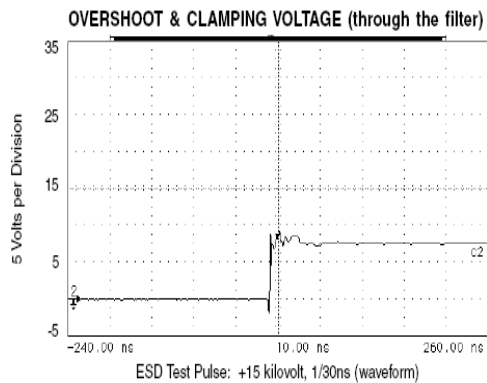
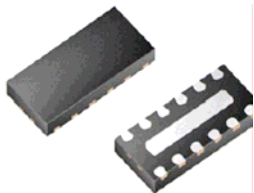


Figure 4 Overshoot & Clamping Voltage



**The EM6D-100L** contains 6 Filters in a 3mm x 1.5mm DFN package. Each is an independent second-order  $-40\text{dB/decade}$  low pass filter, the component values are  $10\text{pF}-100\Omega -10\text{pF}$  this allows a cutoff frequency of  $160\text{MHz}$  and an attenuation of greater than  $-25\text{dB}$  for the frequency band  $800\text{MHz} - 2.4\text{GHz}$

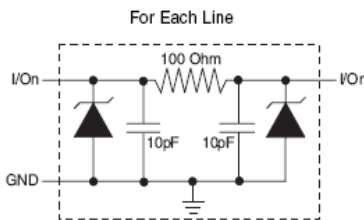


Figure 5 EMI Filter

In standby mode, the integrated TVS filter has a very low leakage current (less than 100pA); an essential feature for battery powered handheld devices. In addition, the low profile durable 12-pin DFN package is useful in many applications.

Digital Crosstalk between the adjacent channels for the cutoff frequency and maximum attenuation, is minimal as shown in the figures below

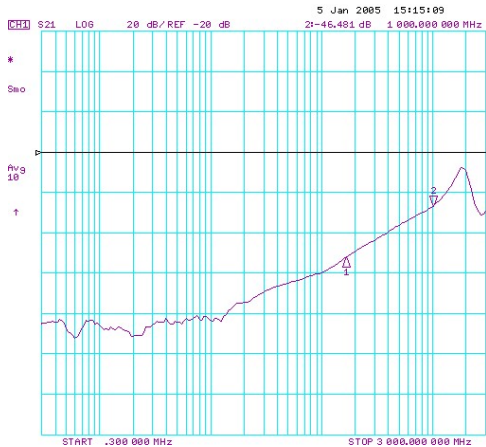


Figure 6 Adjacent Channel Crosstalk

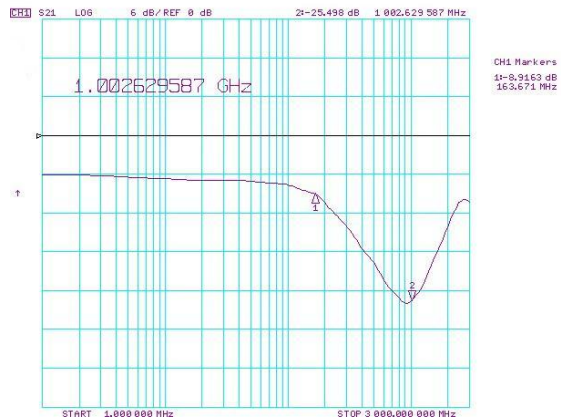
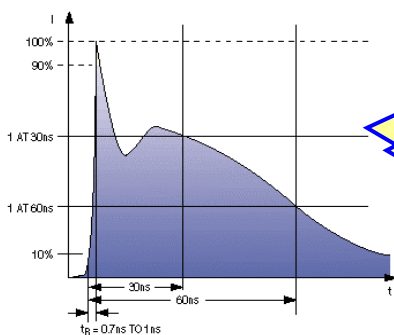
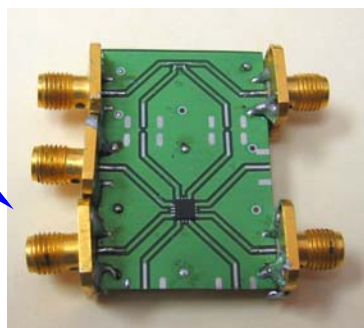


Figure 7 Attenuation at 1.0GHz

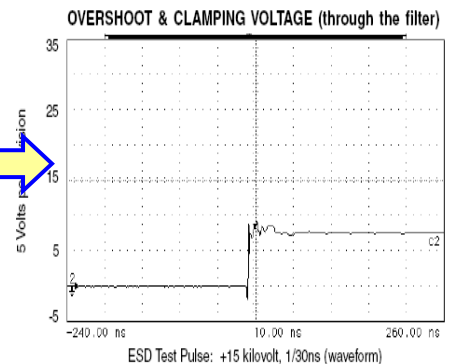
**Test board for ESD, Insertion and crosstalk measurement  
Showing the EM8Q-100 mounted.**



Transient In

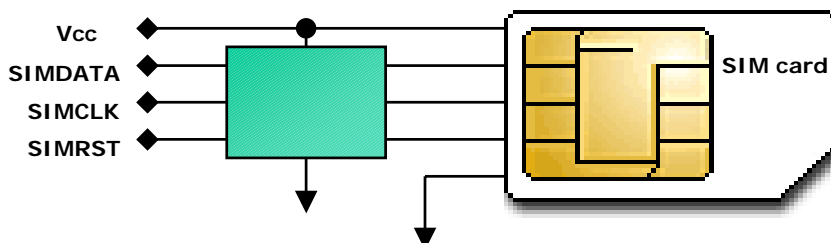


Top connectors are throughputs for calibration of network analyzer



Clamped Transient

The EM1402 provides a bi-directional filter and protection for all the signals and power line on the SIM. SIM cards are found in all GSM cellular phones and in other handheld devices and card readers.



The TVS diodes protect the controller against possible ESD transients that may occur when connector pins are exposed for insertion and removal of the SIM card.

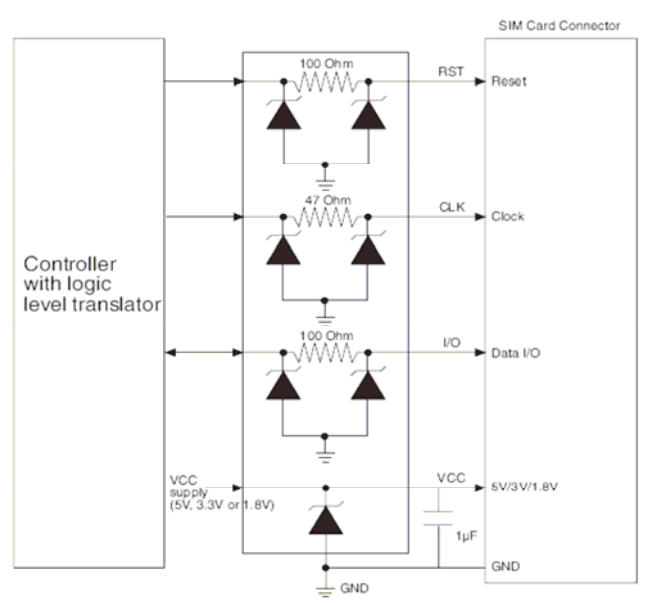


Figure 1. Typical Application for SIM Card Interface

Figure 8 SIM Card Application

The EMI filter suppresses all high frequency noise, preventing the unwanted EMI signal from both entering and exiting the main board. The signals that interface with the SIM card (Reset, Clock and bi-directional data) is also cleaned up by the filter characteristics removing unwanted spikes preventing data corruption.

For best results both ground bumps should be directly connected to the ground plane. An additional 1µF is required for stability of the supply rail.