EPD Transient Voltage Suppressors for Low Voltage Electronics

At voltages below 5V, conventional avalanche technology is impractical. In order to achieve stand-off voltages below 5V, very high impurity concentrations ($\geq 10^{+18} cm^{-3}$) must be used. This leads to detrimental performance characteristics such as high capacitance and very high reverse leakage current. In a joint development effort, Semtech Corporation and the University of California at Berkeley have developed a proprietary device architecture called the Enhanced Punch-Through Diode (EPD).

Enhanced Punch-Through Mechanism

In contrast to the traditional pn structure of silicon avalanche TVS diodes, the EPD device employs a more complex n+p+p-n+ 4-layer structure (Figure 1). The structure has light doping in the p+ and p- layers so the reversed biased n+p+ junction does not avalanche. An npn structure was chosen over a pnp structure because it promotes higher electron mobility, improving device clamping characteristics. A key difference between the EPD device and traditional punch-through devices is the base region in the npn structure. A thin base is used to minimize the space charge voltage, thus lowering the clamping voltage at high transient currents. Wide base regions employed by traditional punch through devices result in poor clamping performance. By carefully engineering the p-base region, the resulting device has superior leakage, clamping, and capacitance characteristics at voltages of 2.8V and 3.3V.

EPD TVS Device Operation

The IV characteristic curve of the EPD device is shown in Figure 3. The device represents a high impedance to the circuit up to the working voltage (V_{RWM}). During a transient event, the device will begin to conduct as it is biased in the reverse direction. When the punch-through voltage (V_{PT}) is exceeded, the device enters a low impedance state, diverting the transient current away from the protected circuit. When the device is conducting current, it will exhibit a slight "snap-back" or negative resistance characteristic due to its structure. To return to a non-conducting state, the current through the device must fall below the snap-back current (approximately < 50mA). In the reverse direction, the device looks like a diode with a reverse breakdown voltage (V_{BRR}) of approximately 30V.

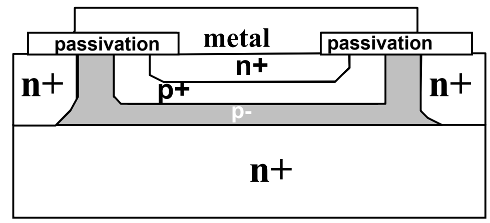

Figure 1 - EPD TVS Device Structure

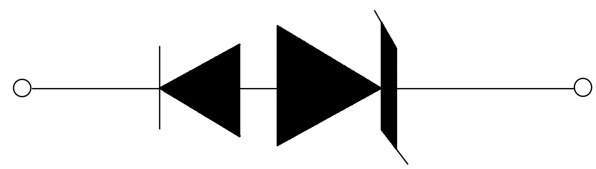

Figure 2 - EPD TVS Schematic Representation

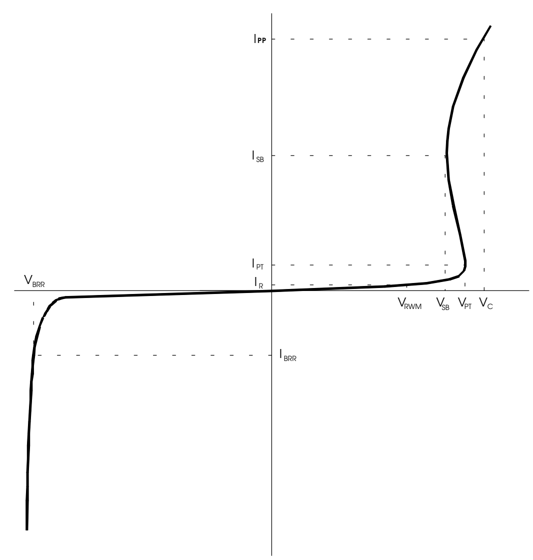

Figure 3 - EPD TVS IV Characteristic Curve

These devices are targeted towards the protection of today's low voltage, sub-micron ICs. The devices are designed primarily to protect against electrostatic discharge (ESD) on power and transmission lines, but are also rated for switching and low level lightning induced transients.