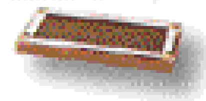
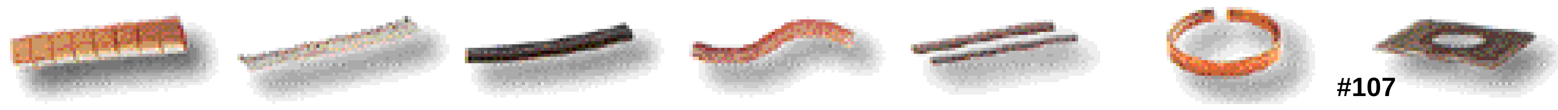
Laird Technologies

TECH NOTES

LAIRD TECHNOLOGIES





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ELECTROSTATIC DISCHARGES

By Kevin Focht

Electrostatic discharge (ESD) is created from the electrostatic potential developed when two non-conductive materials with different dielectric constants are rubbed against each other. Materials take on a charge by giving up or receiving electrons from another dielectric material. This effect is called electrostatic charging. The dielectric will take on either a positive charge by losing electrons, or a negative charge by gaining electrons. After a material is charged, it will seek the first opportunity to neutralize its unbalance by either self recombination or by an ESD discharge.

In today's industrial environment the two major sources of electrostatic discharge are humans and furniture. Of the many outside parameters which influence an ESD event, the most important are relative humidity and the material's intrinsic impedance. Other are: temperature, dielectric constants of the two materials, capacitance, pressure, speed, perspiration, sex, and rhythmic motion. Important discharge parameters are: the speed of the approaching object, and the wave shape, amplitude, and pulse duration.

With high humidity, the mositure content tends to lower surface resistance by creating a somewhat conductive coating of wet particles. Studies have shown that personal current is highly dependent upon the Relative Humidity (RH factor). The current increases approximately with the inverse cube of the RH factor. With a relative humidity factor of 15% the currents will be 20 to 40 times greater than a factor of 45%. The number of ESD events is also directly related to the relative humidity. System failures therefore increase in the less humid winter months.

The relative humidity indicated by the weatherman is rarely the same as the humidity inside a building. Since the air is processed through filters, or heating and cooling systems, the humidity tends to decrease. There are many cases where the relative humidity has decreased as much as 40% as a result of heating systems.

The amount of electrical charge a material will acquire depends upon its surface resistance in ohms per square. If a material has a low ohms per square value the free electrons can move more easily throughout the material and recombine to neutralize the charge. Materials with more than 10 Gigaohms per square will not self recombine due to their high intrinsic impedance. It is this high impedance which allows the potential difference to increase until a high field gradient is reached, producing either a mechanical attraction or an arc. The arc which is produced is usually within the kilovolt region. Theoretically, a human body can generate as much as 32 kilovolts, given the right conditions. However, the accepted high range the body can maintain for a short period of time is around 15 kilovolts. It should be pointed out that discharges of less than 1.5 to 2.0 kilovolts cannot be felt by the average person, yet are frequently high enough to cause permanent damage to electronic equipment.

During the discharge it is the fast current change in relationship to time ($\Delta I / \Delta t$), which produces the electromagnetic field that causes system failures. The human discharge has a much faster rise time than furniture and will produce higher amp/nsec, while the furniture discharge will produce a prolonged current spike. The amp/nsec current change of the furniture discharge is less but can be as much as ten times longer in duration with an overall higher amperage than that of a human. This extended rise time combined with a higher amplitude of current will create interference which will fall within the DC noise margin of most logic families. For instance, a TTL gate with a 10 nsec speed and a noise margin of .8 volts would need a higher amplitude of current within the 2 nsec region (human), than the 18 nsec region (furniture), to create an erroneous high or low logic state.

The waveforms of the ESD discharge for both human and furniture are dependent upon the self inductance, resistance of the discharge loop, and the capacitance. The pulse width of the discharge and consequently the band width of emissions are dependant upon the RC network formed. Research is still attempting to find the exact rise time created by this discharge. It is felt by some that today's test equipment does not have sufficient width to measure the exact rise time of the leading edge of the discharge. With this limitation in the measurement capabilities, it is estimated that the exact amplitude of current produced may be as much as 2.5 times greater than the measured value.

At low voltage levels the wave shape of the ESD discharge resembles a lightning strike in that a precursor or overshoot is developed. The ESD discharge percursor is only developed if an object such as a finger or screw driver approaches the point of discharge at a fast rate of speed or if the charge is relatively low in voltage: i.e.(6-8kV). This is attributed to the corona effect and surface-to-surface inductance distributions between the finger and the load. If the inductance is low, the charge transfers so fast that it electrically disconnects the finger from the rest of the body, discharging only the finger's charged potential first. Once the finger and its initial path deionizes, the main discharge is allowed to come from the rest of the body causing a long exponential decay. If the voltage level increases the voltage arc gap will also increase, creating a greater inductance. This increase of inductance will slow down the rise time and permit a more complete transfer of the charge without this extremely fast spike. If the speed of the finger approaching the object is slowed, the voltage will arc at a greater distance and the percursor will not develop, but the decay will still be maintained.

Simple field theory states that in the near field, low impedance (< 377 ohms), sources will radiate predominately magnetic fields, while high impedance sources (> 377) ohms) radiate predominately electric fields. Since furniture has a much lower resistance than the human body, it is understandable that the field developed will be predominately magnetic while the human discharge will be predominately electric. For direct discharges, it is this increased current along with the resultant magnetic field which create severe problems for high speed, high impedance logic families. For recessed areas, plastic barriers, and remote areas where a tremendous amount of voltage is needed to break the air gap the electric field created by the human discharge is more severe.