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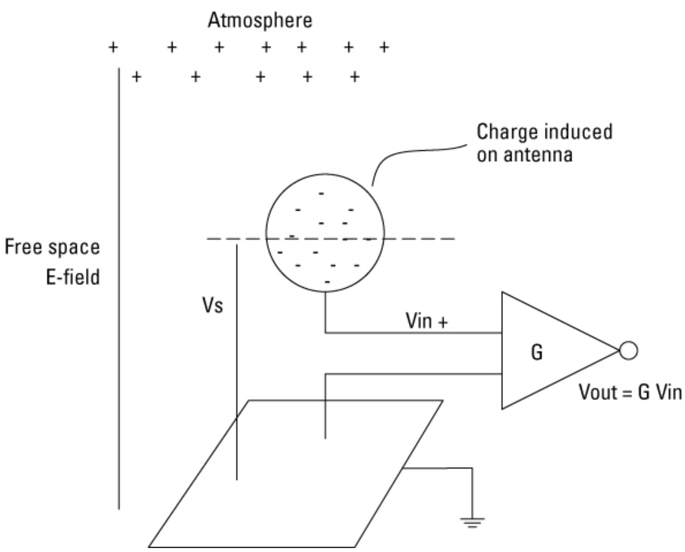
TECHNICAL NOTE

Remote Voltage Sensor

Theory of Operation

Measurement of an Electric Potential

The physical basis for assessment of electrostatic discharge (ESD) hazard is measurement of the electric field at the subject. This field arises due to a potential difference between the subject and his/her environment. It is the electric field that leads to breakdown of the air and the resulting spark that comprises ESD. For example, the breakdown field in dry air is 3000 kV/m (at normal pressures and temperatures).



Measurement of the free-space electric potential by allowing a charge to flow onto a conducting test probe

An electric field exists around a single charge or between distributions of charges. There is an associated potential distribution in space. The net potential is the average over the volume of the body. Typical potential meters only measure a voltage difference relative to "ground" or measure V at two points where the electric field is given by $E = \Delta V/d$. Charges flow onto a metal object in the field to minimize the field energy. The amount of charge is equal to the voltage times the self capacitance, $Q = CV$. Q can be measured by transferring an image charge to the input of an amplifier. Typically, the electric potential of an object is measured by an Electric Field Mill, which has a response from DC to about 30 Hz and a sensitivity of 0.5 Vrms.

Remote Voltage Sensor (RVS)

The RVS is a stable electrometer that can read the free space potential directly. The patented circuit takes advantage of the internal design of the most recent generation of instrumentation amplifier chips and their very low internal noise level. By utilizing a combination of novel stabilization and feedback circuits, the device removes the DC drift issue caused by the input bias current. With the drift canceled, the circuit is able to connect the readout circuit directly to a purely capacitive antenna. Due to the ultra-low noise of the circuit, the sensor is at least 1000x more sensitive than traditional electric field mills. That sensitivity allows remote monitoring of a charged wafer. The new sensor is also much more compact than an electric field mill. The remote voltage sensor (RVS) developed for the semiconductor wafer monitoring is only the size of a dime.

The self-capacitance of a dime-sized electrode is of order 0.05 pF, while the input capacitance of present electrometer-grade amplifiers is of order 0.2 pF to 3 pF. By calibrating Cs/(Cin + Cs) – defined as the transfer function, the circuit yields a near ideal measurement of the electric potential at the sensor location. This potential at the position of the sensor allows strong correlation to electrostatic surface voltages (or voltage mirrors of insulator charge levels). The circuit has a flat frequency response from 100 mHz to 50 kHz. During the semiconductor wafer process, the movement of a charged wafer induces a change of the electric potential at the sensor location. Such a response on the sensor is proportional to the voltage on the wafer.

Specification of Remote Voltage Sensor

Bias Voltage	V+: positive 3-5V; V-: negative 3-5V
Bias Current	75 µA
Cable Length	2m, standard (extension available)
Dimensions	18 dia x 5H mm
Transfer Function	0.04 @ 1 Hz and above
Corner Frequency	200 mHz
Noise (typ)	30 µVrms/√Hz @1 Hz; 6 µVrms/√Hz @10 Hz
DC Offset	<3 mV

For more information or application assistance, please contact the Application Engineering Group.

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