SIMCO ION™

An ITW Company

Charging Fundamentals

Application Note

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Materials become charged through transfer and movement of electrons.

Materials that gain electrons become negatively charged, while materials that lose electrons become positively charged.

Selecting the appropriate charging polarity ensures optimal charge application, improving adhesion, stability, and overall system efficiency.

The Triboelectric Series organizes materials according to their ability to remain: NEUTRAL, GAIN or LOSE electrons. The materials sequential order gives insight into the susceptibility of a material to develop a charge relative to others.

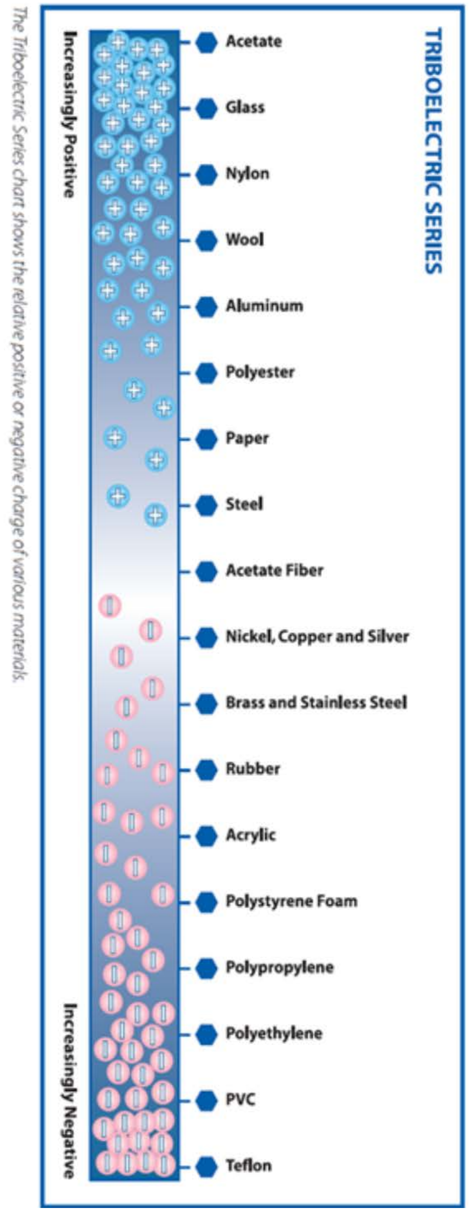
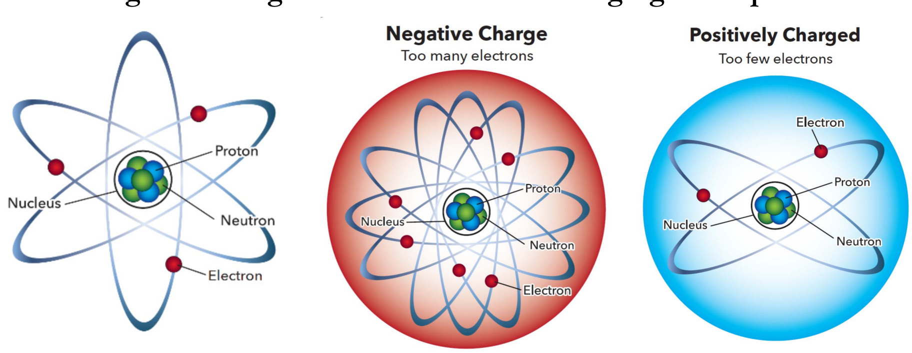


Figure 1: The Triboelectric Series

Figure 2: Diagram of Electrostatic Charging Principles



Electrostatic Charging Principles

Insulated materials can be temporarily bonded-by electrostatic attraction. A charge applicator connected to the High Voltage (HV) power supply generates ions of appropriate polarity directed to a ground/counter electrode. The target material accepts the ion current resulting in an electrostatic charge.

Counter-electrodes influence charge application and system configuration, optimizing charge distribution. This can take the form of an opposite polarity charge applicator or a grounded machine component such as the following:

- Metal roller – idlers
- Conductive plate
- Conductive belts
- Other ground reference

A "ground reference", "earth", "chassis ground", "common ground", or "0 V" is an assigned voltage of "ZERO" and is a baseline starting point of comparison for voltage or current measurements.

Best Mounting Practices

- Charging applicators should be installed closer to the material than other conductive surfaces to improve efficiency
- Maintain a **1.5-inch distance** between the charging bar and a ground reference for optimal performance (a*ctual distance can vary depending on material and installation*).

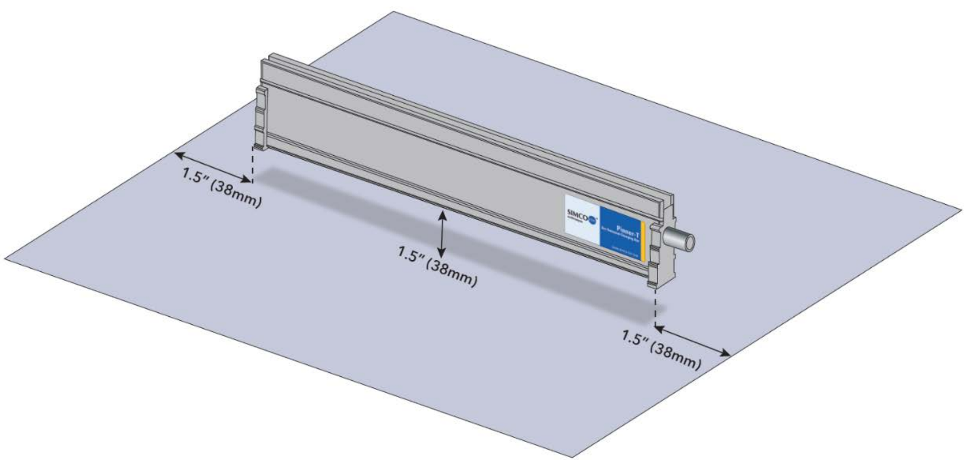


Figure 3: Typical Mounting Setup

Processing at High Speeds (1700-3000 fpm)

At higher speeds, place the applicator closer to the material to maintain consistent charging for one or multi-layer applications.

Charging System Configurations

- **Grounded conductive surface (machine frame, roller, etc.)** acts as a ground reference ZERO VOLT, attracting ion current flow.

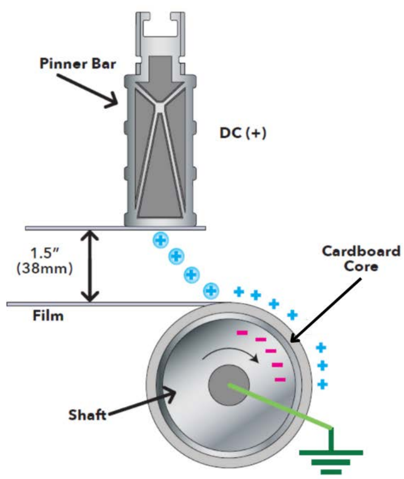


Figure 4

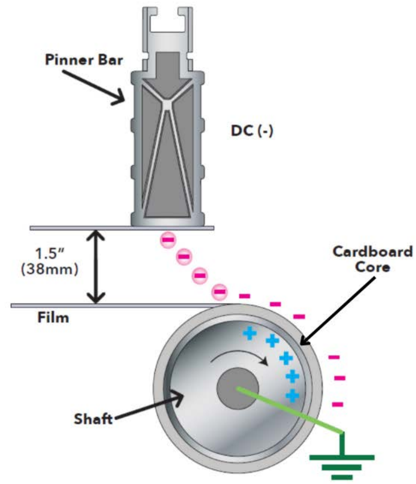


Figure 5

- **Bi-polar charging bar** enhances electrostatic attraction and offers the strongest charging forces

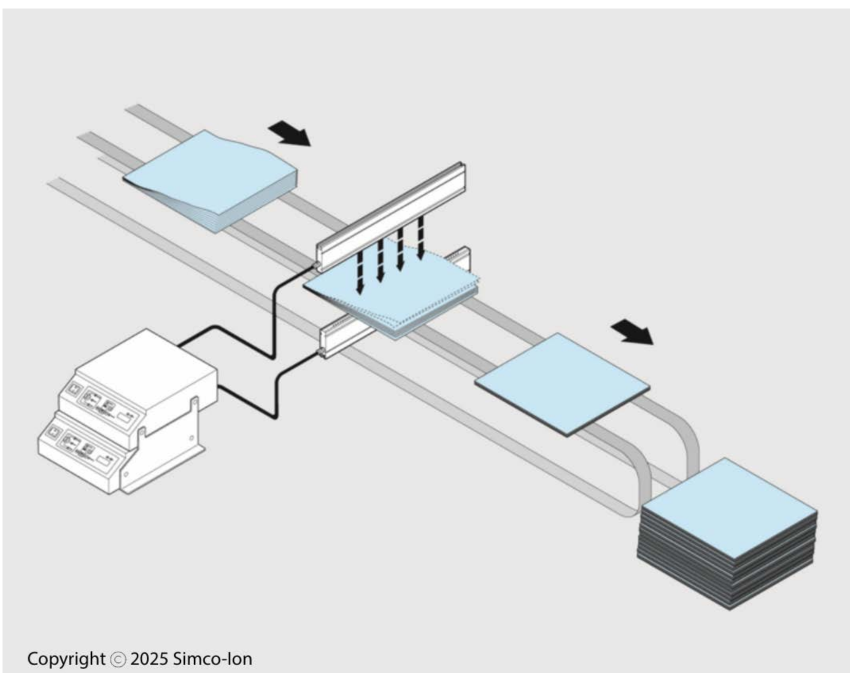


Figure 6

- A **static eliminator**, if necessary, removes excess charge of appropriate polarity to prevent static buildup

Using Both Polarities (Positive & Negative)

Maintain a **minimum of 3-inch spacing** between opposite polarity charging devices to prevent excessive charging current, overheating, and equipment damage. (*Actual distance can vary depending on material and installation.)* If a higher charging current is needed, position the applicator **closer to the material** for greater pinning force and more efficient charge transfer.

Note: If a blue haze (plasma) appears, lower the output on the HV power supply.

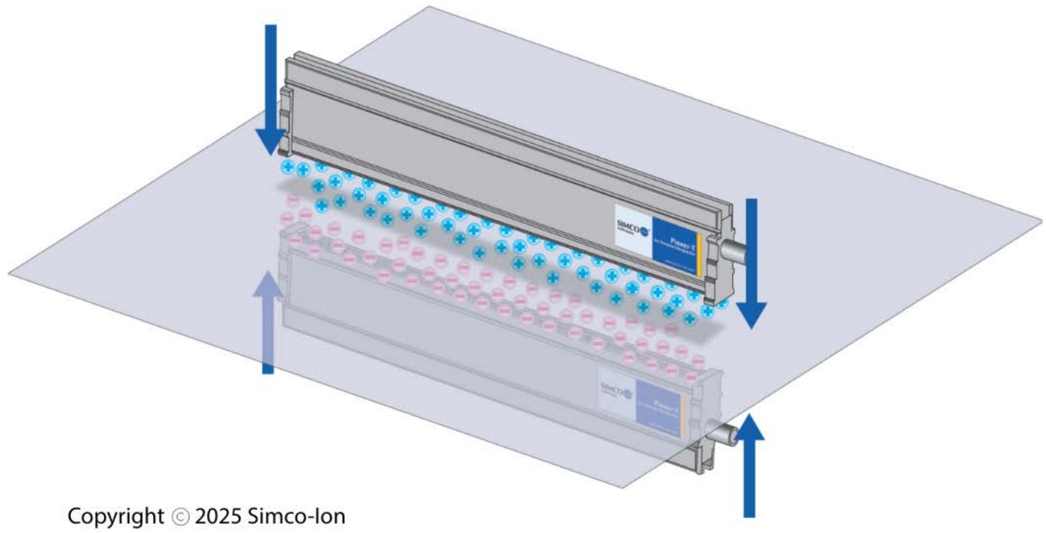


Figure 7

Extending Charging Bar Lifespan

Distribute total charging current over more pin electrodes to **reduce wear** on individual electrodes and prevent overheating Alternatively, you can set the power supply in current mode control or use current mode control to determine the efficient voltage setting and run the power supply unit in voltage mode. This will require experimentation but will extend the life of the emitter pin electrodes. (*Bars effective length should not exceed material width*).

Electrode Maintenance

Conduct routine maintenance by cleaning electrodes, the bar housing, and bar sides, and inspect for signs of wear or degradation. Accumulation of conductive or insulating contaminants on the bar can result in carbon tracking, elevated dielectric stress, and early system failure.

Controlling the Charging System

1. Current Control Mode
The operator sets a target current (in milliamps), which the charging generator regulates by dynamically adjusting its output voltage to maintain the specified current level. This constant-current control ensures consistent charging performance. It actively compensates for variations due to electrode contamination, material property changes, and environmental conditions such as humidity, temperature, and air quality. **Current control also compensates for electrode contamination over time**, reducing maintenance frequency, extends the life of the emitter pin electrode.

Ideal for:
- Catalog stacking
- Roll transfer
- Interleaving
- Continuous operations

Current Limits:
- **Single-polarity applications**: Do not exceed **1.5 mA per foot** of bar.
- **Dual-polarity applications**: Do not exceed **1.5 mA per foot** to prevent overheating.
- Avoid maximizing charging current unnecessarily to prevent premature equipment failure.
- Use minimum current necessary for desired performance. Excessively high set points can wear equipment and lead to premature equipment failure.

Do NOT Use Current Mode If:
- **A counter-electrode is absent** during parts of the cycle, as it may cause charge instability.
- **Counter-electrode distance varies** significantly, affecting charge distribution uniformity.
- **Maximum generator voltage** is needed, limiting system control.
- **Charging current is very low** (< 0.2 mA), making current control ineffective.

2. Voltage Mode Control
The voltage is set by the operator, and the charging generator locks it in, and adjusts current as needed to maintain voltage stability. The operator selects a voltage setpoint (in kV), which the charging generator maintains by automatically adjusting the output current as needed.

Ideal for:
- Absence of counter-electrode i.e. IML, requiring independent voltage stability.
- Low charging current (< 0.10 mA), needing precise control.
- Prevents instability due to fluctuating distances or material properties or non-uniformities.
- Factory presets protect against excessive charging current.

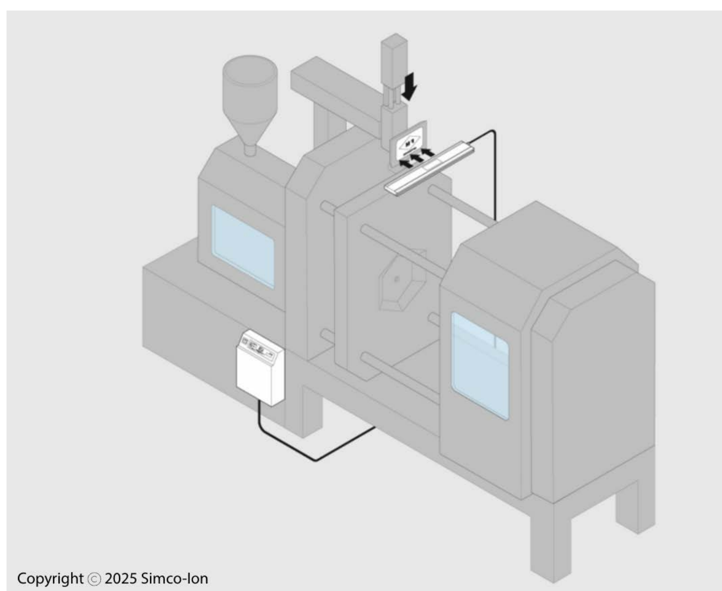


Figure 8: IML

Remote HV On/Off

- The VCM generator when invoked, can automatically activate/deactivate high voltage, improving system automation.
- **Continuous operation**: A "Machine Run" relay can be used to synchronize with production cycles.
- **Intermittent operation**: An optical detector can signal the generator, improving energy efficiency.
- Charge rise time: < **70 milliseconds**

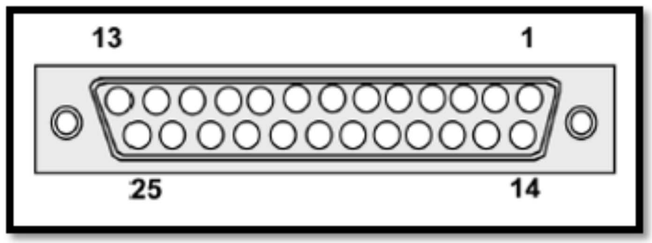


Figure 9: DB25 (See VCM instruction manual for connection details)

Attributes & Non-Idealities in Charging

Charge Transfer Affects: System Setup/Material

1. Charging applicator configuration and mounting distance
2. Operating voltage
3. Condition and cleanliness of electrode
4. Material thickness and dielectric properties
5. Material speed affecting charge retention
6. Machine configuration influencing charge stability

Charge Dissipation: Ambient Environment/Material

1. Material conductivity affecting charge retention
2. Ambient temperature & humidity impacting electrostatic properties
3. Material speed influencing charge dwell time
4. Charging generator output determines charging effects
5. Amount of charge applied by applicator

Electrostatic Holding Force Affects

1. Residual Charge Density and Sustained Holding Force
    a. Holding force is proportional to the residual electrostatic charge remaining on the surface after charging. Higher surface charge density enhances electrostatic attraction between materials. Over time, this charge decays due to factors such as ambient air conductivity, time, material contact or separation, and grounding—ultimately reducing the effective holding force.

2. Material Thickness and Charge Transfer Efficiency
    a. Thicker insulating materials can reduce charge transfer efficiency, as the electrostatic charge tends to remain closer to the surface, limiting field penetration. This results in lower electric field strength at the material interface. In contrast, thinner materials enable stronger electric field interaction with the opposing surface or electrode, enhancing charge coupling and overall system performance.

Charging Current & Performance

- **Optimal setup**: Use the required current at the lowest possible voltage for energy efficiency and emitter pin longevity.
- **Higher voltage** is required for longer distances.
- **Thicker materials** require higher surface charge for adhesion.
- Overcharging may cause inefficiency, repulsion of ions, and potential **corona discharge**, reducing performance.

Material Considerations

- **Surface resistivity >10^9 Ohm-cm, (108- 1018Ωcm),** ensures successful charge retention.
- **Low resistivity** materials may not hold a charge. (Conductors, Low resistivity, high conductivity)
- **Humidity >55%** may reduce resistivity, impacting performance.
- **Faster speeds** may require higher charging current.

Note: A Resistivity Meter is used by placing its back-mounted electrodes on a clean surface of the material being tested. The operator presses the test button, and the meter instantly calculates and displays the material resistivity, Ωcm, indicating conductive or insulative surface is determining suitability for successful charging.

Charging Bar Size

- Bar should be **~1 inch shorter** than the material or web width for efficiency.
- Overly long bars waste energy and may overheat.
- Plasma formation **(bluish glow)** signals ineffective charging—reduce charging generator output, **(voltage or current)**.

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