# 2012 EOS/ESD Symposium for Factory Issues

# CDM Risk Mitigation With Air Ionization In Hi-Temp Automated Test Handler

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# 1) Motivation

Mass volume testing of semi-conductor devices using Automated Handling Equipment (AHE) has prevailed for fast turn-around time in semi-conductor manufacturers.

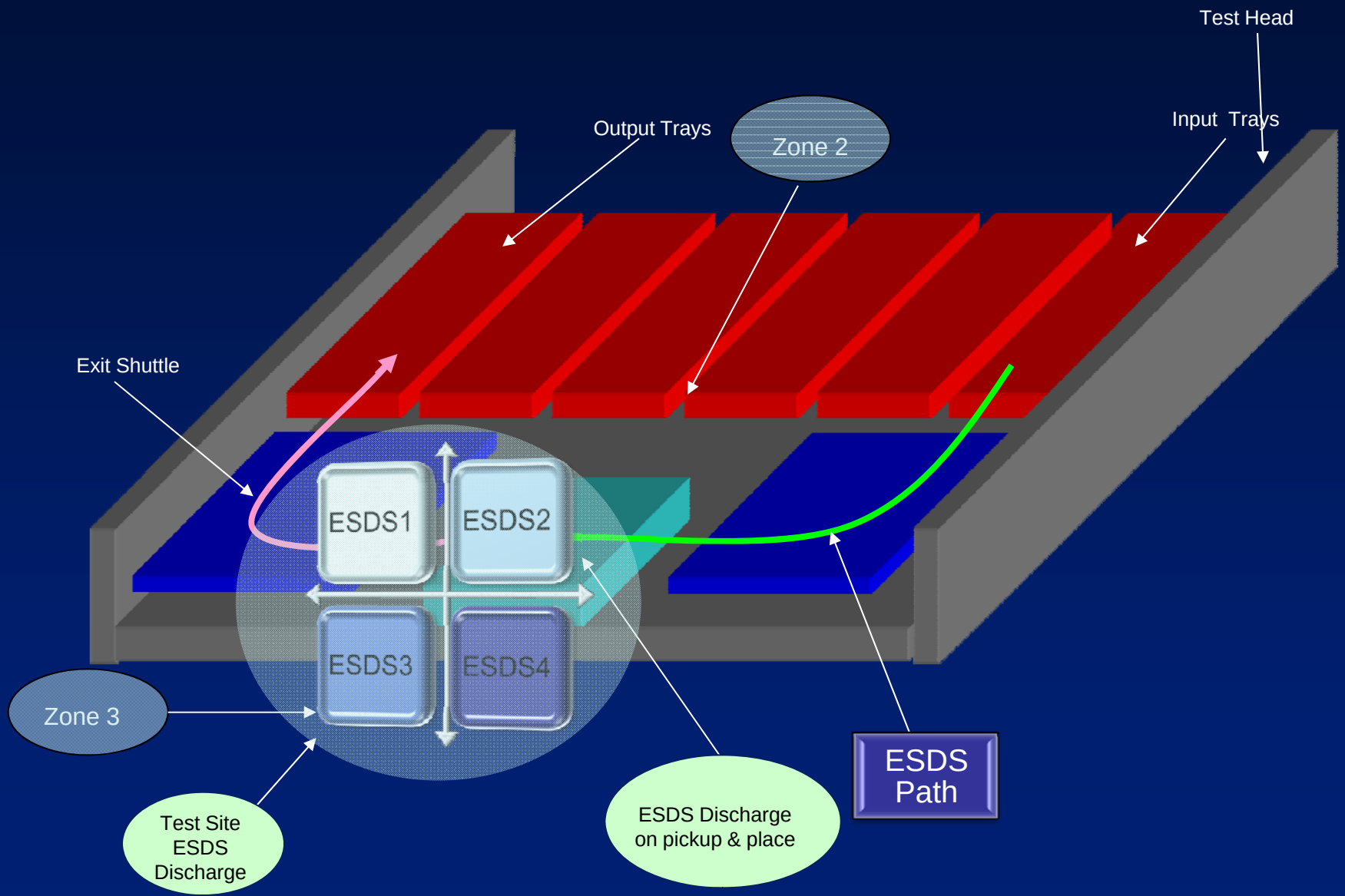
1. The underlying Charge Device Model (CDM) risks leading to catastrophic failure
2. Latency issues with testing of Electrostatic Discharge Sensitive (ESDS) Devices in AHE

- Technology scaling and the ever-increasing demand on device operating speed is a severe challenge to maintain the sensitivity of ESDS devices on-chip protection.

# 1) Motivation (Cont'd)

- Reduce risks leading to catastrophic failure
- Reduce Latency issues
- Reduce Failure rates
- Reduce Low yield

# 1) AHE PnP & Test Site Sequence



# 2) Problem Statement

- **Zone 2 – No adequate ESD Specification.**
  - Hi-Temp V-Block Ionizers in Open-loop Mode
  - Open-loop Controllers contributed to drift voltage at high temperature thus causing high offset voltage.
  - Controller no remote output interface
- **Zone 3 – No Air ionization**
  - Relied on left over ionization from Zone 2

# 3) Solution

- Customized sensors were designed for each ionizer at specific locations.
- Feedback to controller regulate offset at measurement zone and maintain long-term stability.
  - Set-up at inner loop with ion current control – offset stability despite on components aging & temperature variation.
  - Emitter pins at one microampere, offset control @+/-100V

# 3) Solution (Cont'd)

- Outer – loop control with feedback via isolated sensor feedback maintain desire offset.
  - Adjustment on CDA to assist limited distance of DC air ionization.
  - Reducing in Decay time
- Each controller was pre-configured with a failed safe relay output.

# 3) Solution (Cont'd)

- Failed safe relay output wired in series to side door interlock.
  - Pre-programmed to stop the AHE once air ionization triggered on composite signal.
- Black box with RED and GREEN LEDs displayed.
  - Distinguish between chamber air ionization mal-function and side door opening.

# 3) Solution (Cont'd)

- ESDS devices tray installed with single-fan blower.
  - Alarm output same as the relay logic wired as a composite signal for air ionization malfunctions to side door opened interlock.
  - With a black box installed with 2 LED color to differentiate tray stacking area air ionization mal-function and side door opening.

# 3) Zone 2

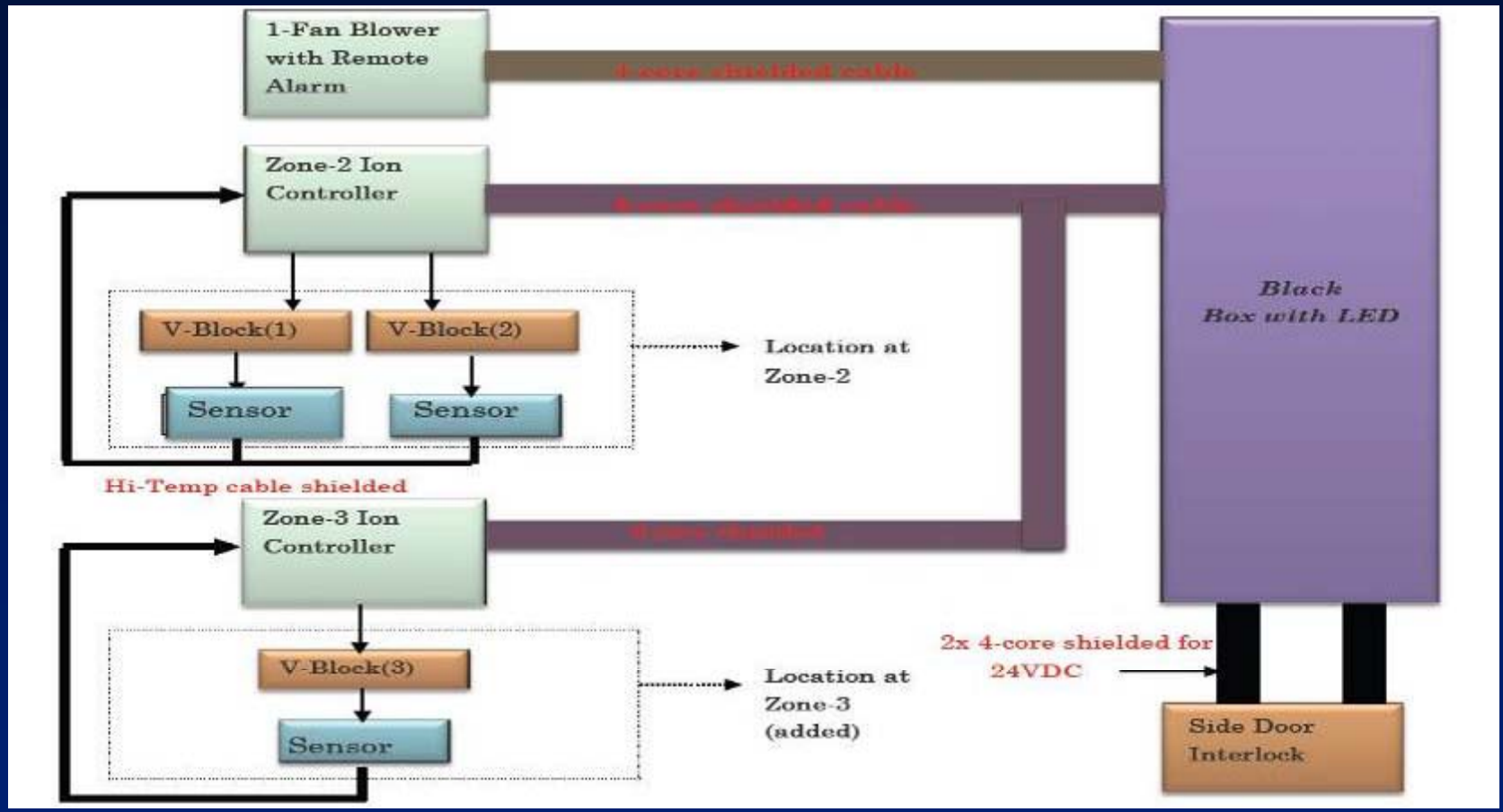
- Two open – loop DC ionizer was changed to Closed-loop isolator sensor with shielded Hi-Temp cable

- Decay time and offset performance drastically reduced.

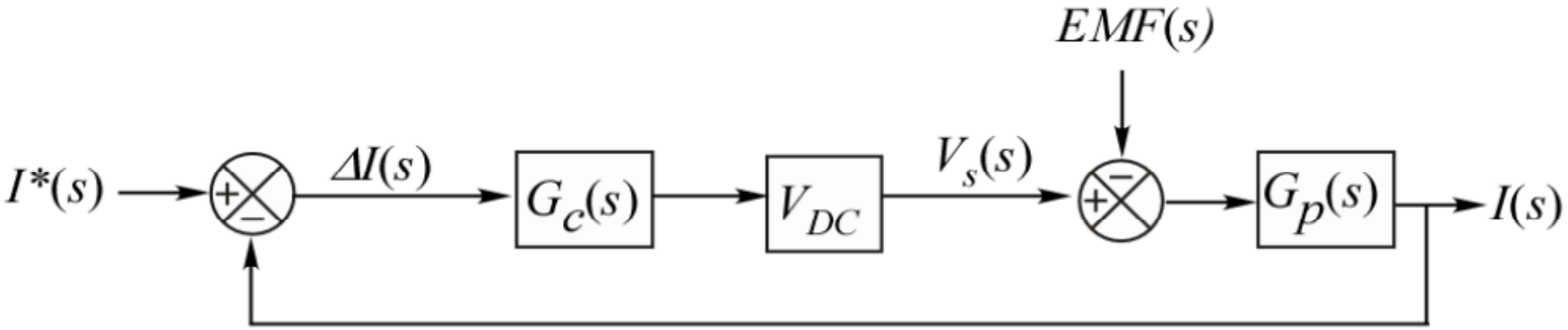
# 3) Zone 3

- As Zone 3 does not have any dedicated Ionization, A new DC ionizer with isolator sensor fixture and controlled CDA purging was introduced.

# 3) Overview


1-Fan Blower with Remote Alarm
Zone-2 Ion Controller
V-Block(1)
V-Block(2)
Sensor
Sensor
Location at Zone-2
Hi-Temp cable shielded
Zone-3 Ion Controller
V-Block(3)
Sensor
Location at Zone-3 (added)
Black Box with LED
2x 4-core shielded for 24VDC
Side Door Interlock

# 4) Modeling




Time domain:

$$V_s(t) - e(t) = Ri(t) + L\frac{di(t)}{dt}$$

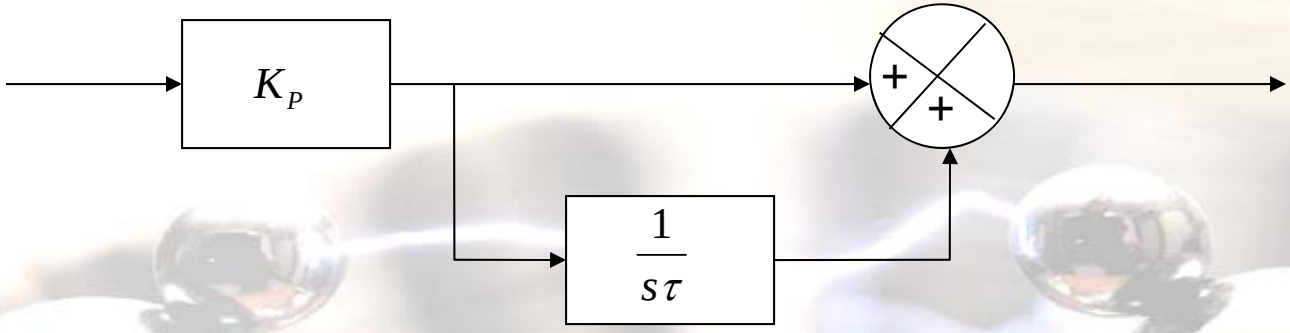
S domain:

$$I(s) = \frac{V_S(s) - E(s)}{R + sL} \Rightarrow G_p(s) = \frac{1}{R}\left(\frac{1}{1 + sT_p}\right)$$

First Order Plant

$$T_P = \frac{L}{R}$$

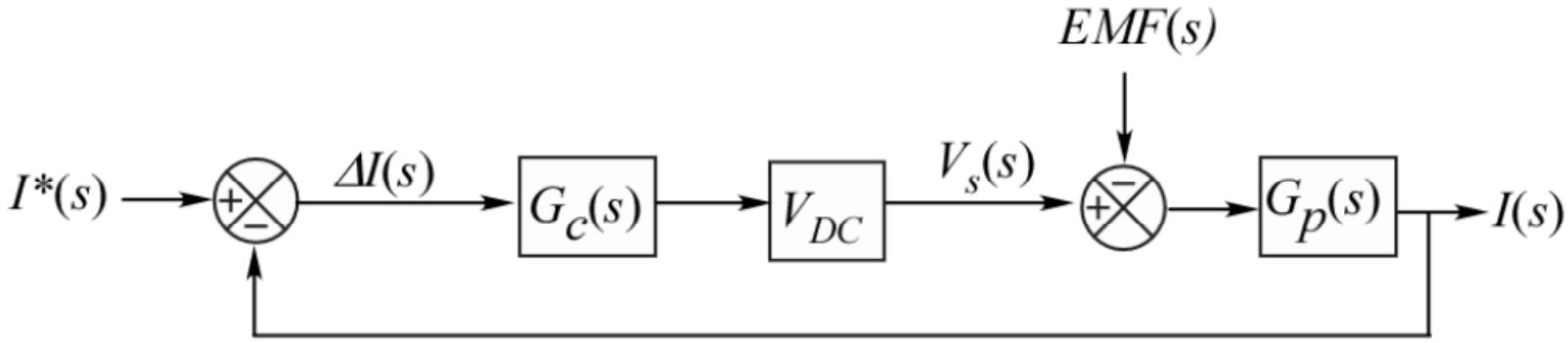
# 4) First Order Plant suggests simple PI Regulator




First Order Plant, i.e. PI Block $G_c$ Ion Controller:

$$G_c(s) = K_p\left(1+\frac{1}{s\tau}\right)$$

# 4) PI Regulator Control Blocks




Forward path transfer function with PI regulator

$$G_c(s)V_{DC}G_p(s) = \frac{K_pV_{DC}}{R}\left(\frac{1}{1+sT_p}\right)\left(\frac{1+s\tau_i}{s\tau_i}\right)$$

Using the Ion Controller $G_C(s)$ into the Control Block

$$\Delta I(s) = \frac{I^*(s) + EMF(s)G_p(s)}{1 + G_c(s)V_{DC}G_p(s)}$$

- Large PI gain make $\Delta I(s) \rightarrow 0$
- System is unconditionally stable irrespective of PI gains because forward path phase is always < 180

# 5) Results

| DESCRIPTIONS | +1000V~ +100V(sec) | -1000V~ -100V(sec) | Balance (volts) |
|---|---|---|---|
| 1-FAN BLOWER AT TRAY STORAGE | 1.0 | 1.6 | -3 |
| ZONE 2 AIR IONIZATION | 1.4 | 1.7 | -36 |
| ZONE 3 AIR IONIZATION | 1.9 | 2.6 | 45 |
| REQUIREMENTS | 5.0 | 5.0 | +/-100V |

# 6) Conclusion

- Upgrade old but functional AHE with inadequate ESD performance to handle new ESDS CDM protection, under high-temperature test

- Machine is implemented with a new design that met the new ESD specification with consistent performance for a longer period of time.