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ESD Risk Analysis using Pulsed AC Ionization Technology

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Outline

- ESD and Contamination issues in FPD industry
- Static Issues and Possible Solutions
- Early Ionization Issues and in FPD
- Pulsed AC Ionization Technology for FPD Industry
- **Ionizer Measurement** – Lack of Definition for Ionizer Standard Test Method STM3.1
- CPM Measurement Results
- **ESD Risk from Ionizers** – Discharge Current and Radiated EMI Signal Measurement Result with Test Electrodes under Pulsed AC Ionizers
- EMI Signal Measurement with TFT LCD Module

ESD and Contamination Issues in FPD Industry

- Very likely wafer process, contamination is major issue in FPD industry from the beginning
- ESD is relatively new and became an issue when advanced panel technology adopted (e.g., higher dense of pixels, COG, LTPS, oxide TFT or thin gate insulator etc.)

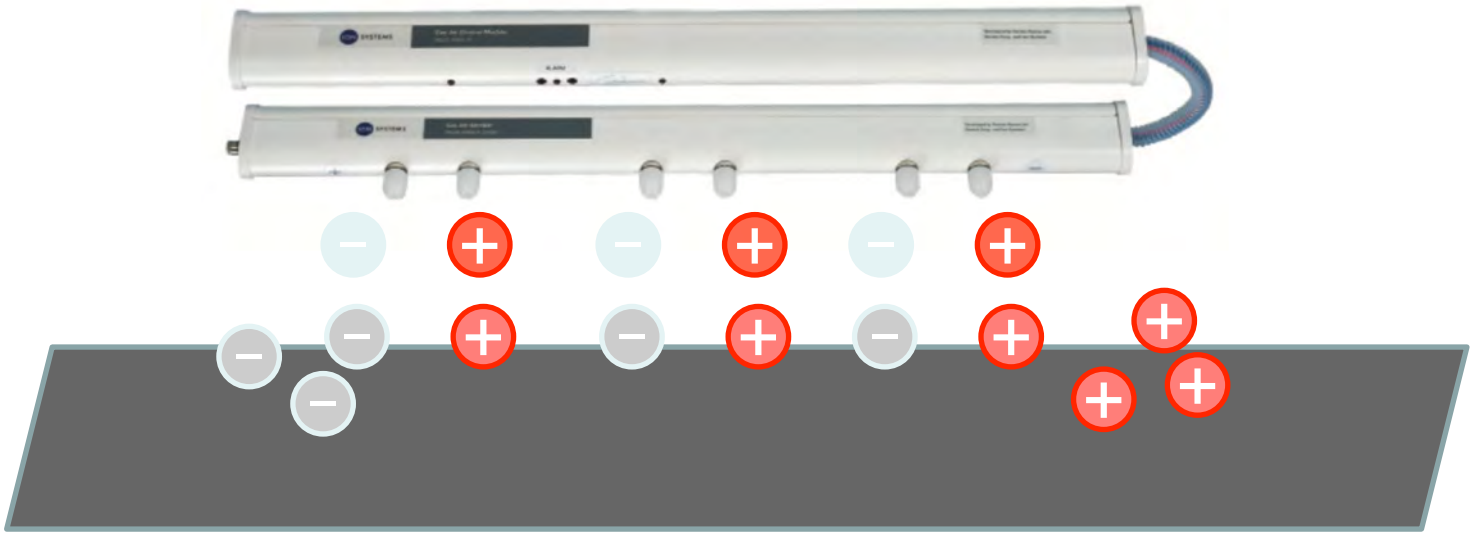
- Both contamination and ESD damages are major failures of current panel manufacturing environment

Static Issues and Possible Solutions

- Unlikely wafers, glass panel substrate are not able to use ground procedure due to their resistance high and not able to drain charge to ground
- Thus, electric field suppression method and use ionizations are possible solution to avoid contamination problem
- But, ESD event can happen when glass has sitting or placement on the conductive or even dissipative surface. So, the best solution to avoid ESD event on glass panel will be ionization

Early Ionization Issues in FPD

- In the early era of FPD industry, Steady-State DC air assist ionizers used to solve ESD and contamination issues copy from wafer process improvement experiences
- But, this type of ionizer makes another problem when they applied this in short distances
- Glass panel get polarized and ESD event occurs after ionization



Pulsed AC Ionization Technology for FPD Industry

- As experienced with DC ionization, better uniform ionization technology requires to neutralize glass substrate within FPD processes
- Pulsed AC (or fast bipolar switching) type of ionizers introduced and adopted in FPD manufacturing processes
- Due to their slim profile and various length, this type of ionization used as in-tool ionization in many places
- Until this time, there are very few ESD issues in FPD as long as panel technology wasn't much advanced
- Using with Pulsed AC ionizer is may good enough to minimize contamination issue and some ESD problems

ESD Issues Increasing

- When panel starts getting higher definition, there are several other technologies adopted on panel substrate such as Chip on Glass (COG), Low Temperature Poly-Silicon (LTPS), oxide TFT and thin gate insulator technologies
- When these type of changes made, ESD become major issues in panel manufacturing processes
- ESD event happens between TFT structures laterally discharged and dielectric breakdown through thin film layers during panel process by strong field changes on substrates
- Such technology changes, process speed increased and pulsed AC ionizer installed in short distance and they could be source of strong electric fields and switching voltages

Pulsed AC Ionizer and Testing Gap

- Pulsed AC ionizer technology constructed bipolar power supplies have joint output on emitter points with output parameter adjustable ranges compare with conventional fixed output AC ionizers
- Pulsed AC ionizer have multiple nozzles emitting ions and switching 3kV to 7kV at 10Hz to 30Hz around in use
- ANSI/ESD STM3.1 and other related documents are IC handling oriented ionization application testing methods
- Thus, it is focused offset voltage and decay time performance from ionizers for qualification and verification testing

Ionization Test Method Issues

- There are unclear or not enough definition in STM3.1 and other ionization related document from ESDA
  - Two type of testing methods are used for ionizer performance testing: Discharge Time and Balance Test
  - There is no detail explanation or justification what balance measurement means: High/Low peak or Average
- But, most of CPM manufacturers provided average balance (or offset voltage) data on their software and hardware display on LCD or LED
- ANSI/ESD S20.20 have limits that balance should be less than ±35 volts
- This balance terminology and average value could lead misinterpreting data from some type of ionizers such as Pulsed AC Ionizers

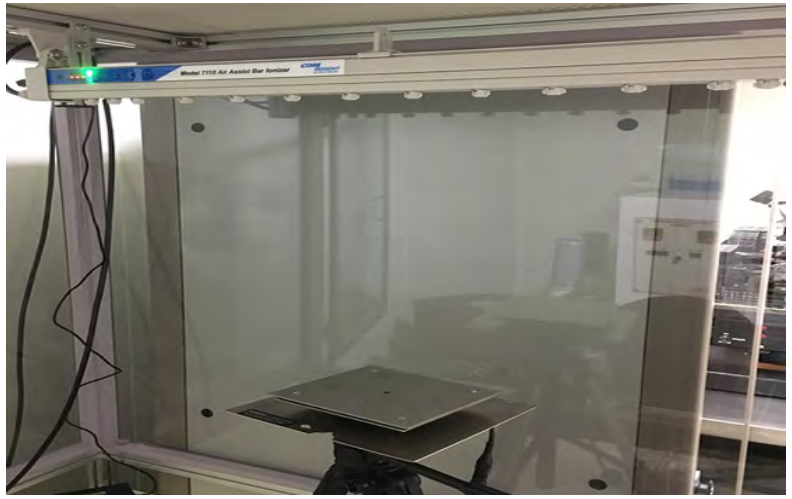
CPM Measurement Limits

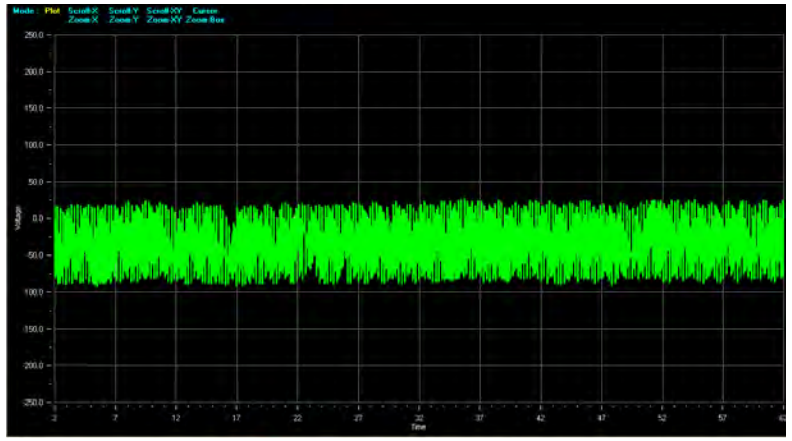
- Most of CPM operating speed is quite slow around 10Hz for full scale of 2000Vp-p.
- Fast operation speed of CPM is 1kHz for small signal which is 20Vp-p only.
- There are new type of ionizers within industry and their switching voltages are 30Hz to 70kHz

Model #	Speed of Response	Accuracy	Manufacturer
Model 300	6Hz	2%	Monroe
Model 288	1kHz 20Vp-p 10Hz 2000Vp-p	0.1% (-3dB)	Monroe
Model 156A/1	1kHz 20Vp-p 10Hz 2000Vp-p	0.1% (-3dB)	Trek
Model 157	80Hz	1% (-3dB)	Trek

Ionization Test Method Issues

- There are some suspect that conventional AC type and Pulsed AC ionizers are could give ESD impact to field sensitive devices or FPD device structures due to their voltage switching technology
- Using with various response speed of CPM, there was different switching voltages has being measured
- Using with 6Hz response speed of CPM, -87V and +24V peak and 31V in average value measured when ionizer operating 12Hz. But, it also shows a lot of switching voltage monitored in thick colors



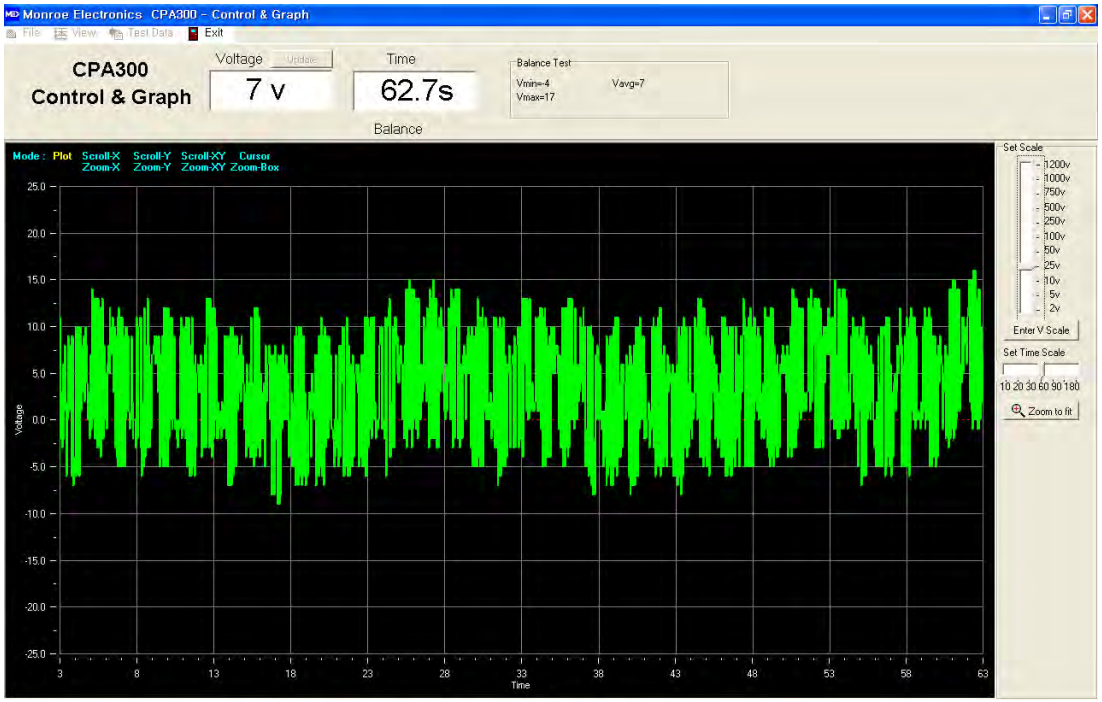


CPM Speed of Response: 6Hz

Ionizer Output: 5.5kV Pos / 4.8kV Neg with 12Hz

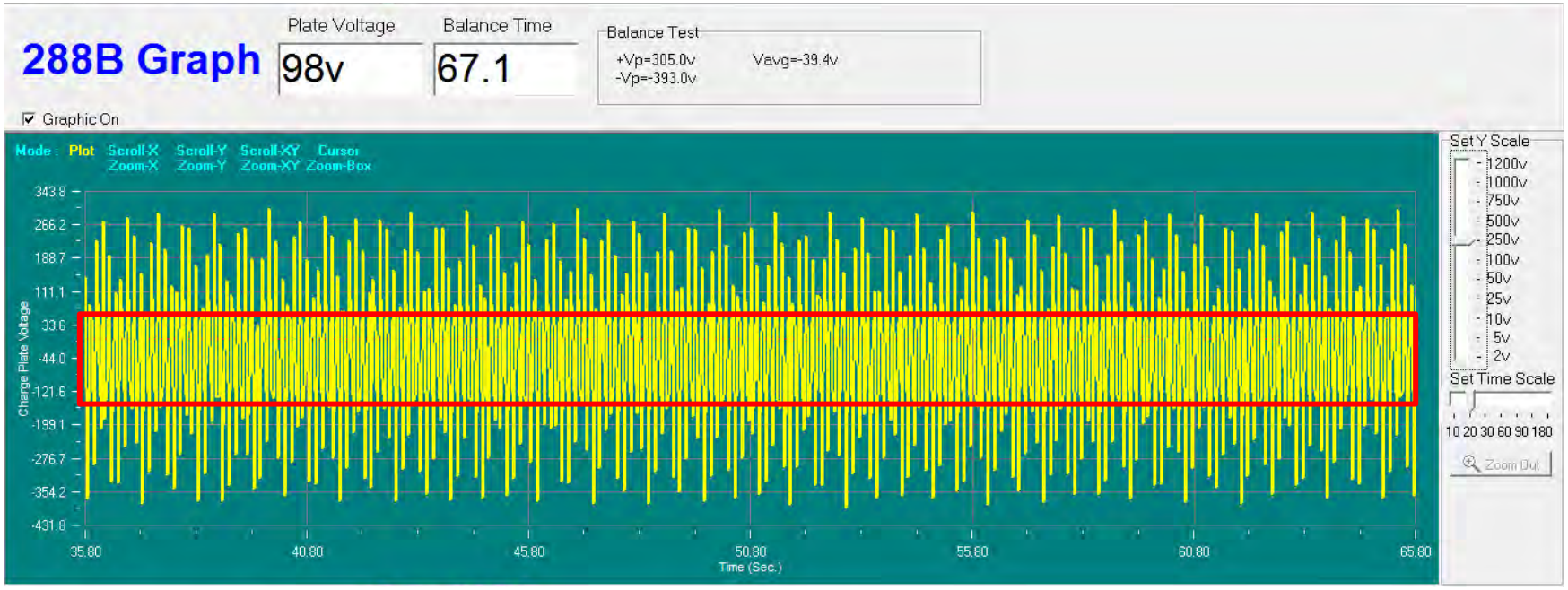
CPM Measurement Examples

- When faster switching frequency applied to ionizers from 12Hz to 30Hz, ionizer offset got much smaller such as average 7V, min -4V and max 17V only.
- CPM Speed of Response is still same at 6Hz and actual ionizer Output was 5.5kV positive and 4.8kV negative
- But, is it real voltage changes monitored?



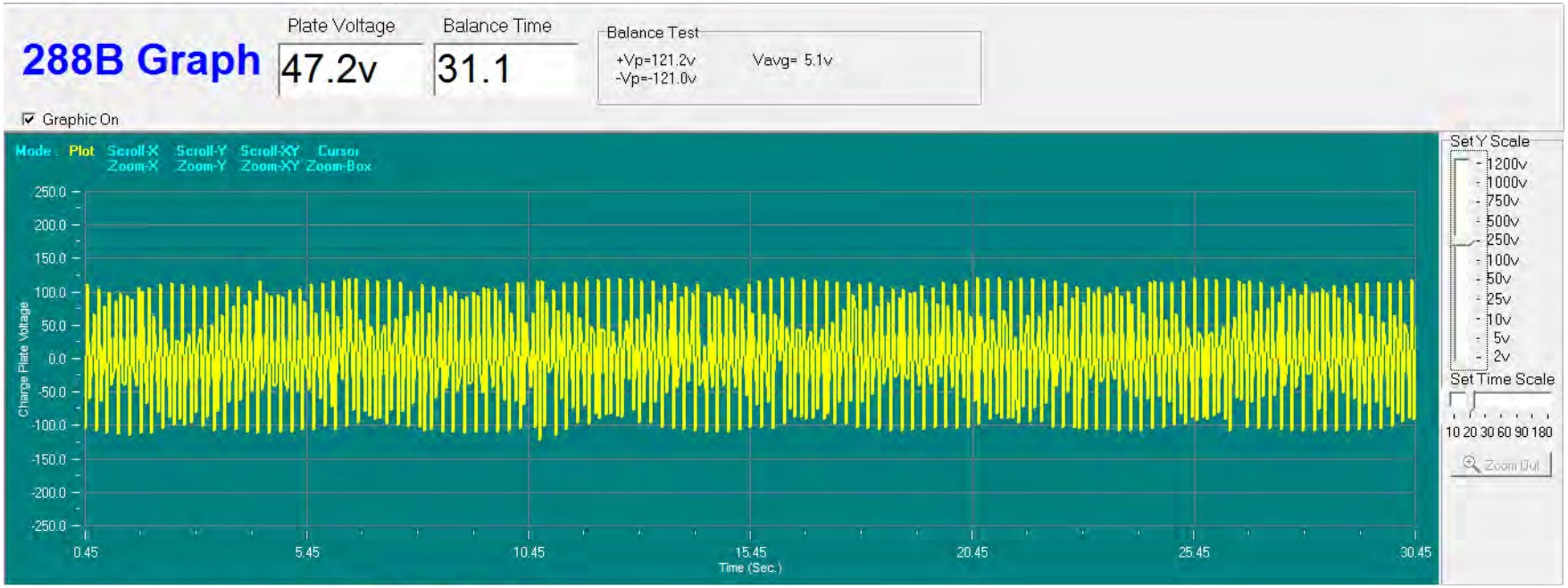
CPM Measurement Examples

- Changed CPM speed up to 10Hz Full scale and 1kHz 20Vp-p
- Ionizer Output: 5.5kV Pos and 4.8kV Neg with 12Hz as same
- The peak-to-peak value greater than 6Hz CPM measurement
- Min (V) = -393V, Max (V) = +305V, Ave (V) = -39.4V
- Then, what average balance voltage means in here?
- There are thick color area in this test which is similar represent with 6Hz CPM test result



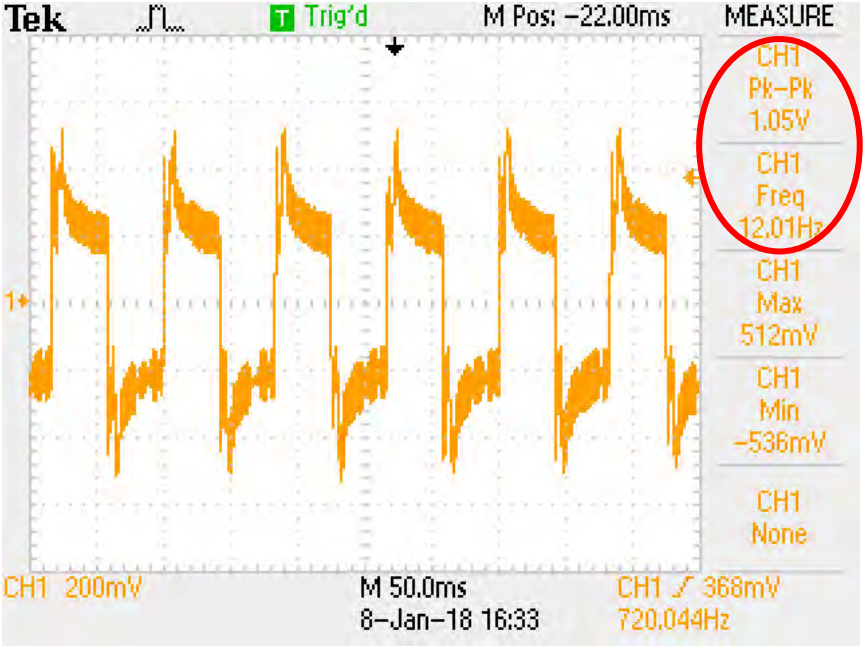
CPM Measurement Examples

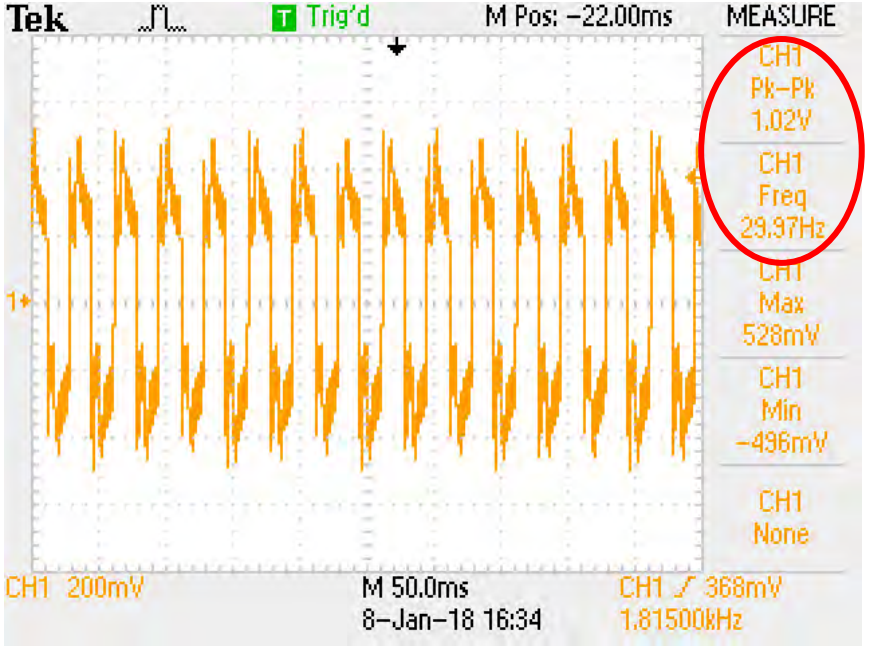
- Then, changed output frequency of ionizer at 30Hz shows peak voltage drops at all same output parameters and distance
- CPM Speed of Response: 10Hz Full / 1kHz 20Vp-p
- Ionizer Output: 5.5kV Pos and 4.8kV Neg with 30Hz
- The peak-to-peak value significantly reduced measured than 12Hz
- Min (V) = -121V, Max (V) = +121V, Ave (V) = 5.1V
- Average value looks get similar with 6Hz CPM result



CPM Plate with Oscilloscope

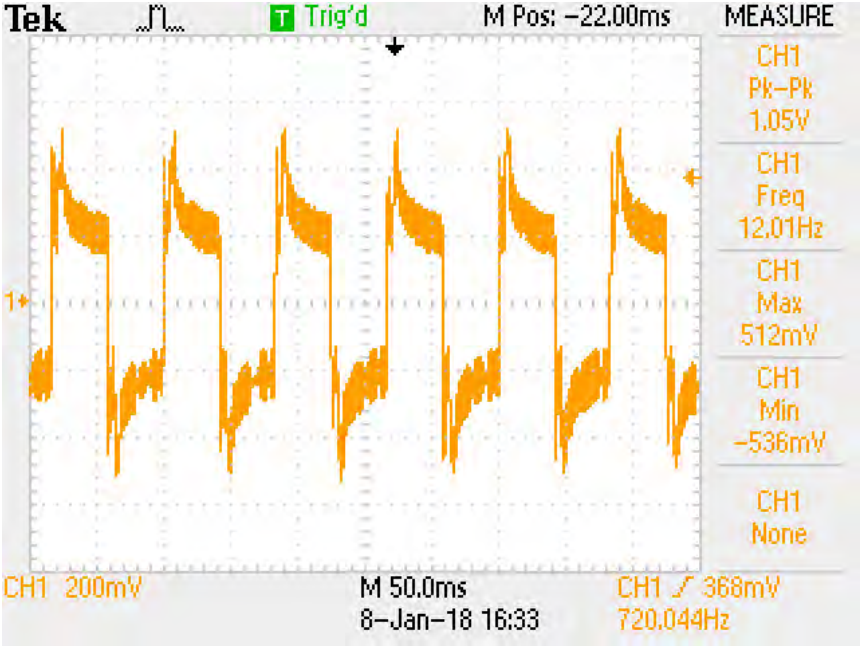
- Then connect CPM Plate to Oscilloscope
- Ionizer Output: 5.5kV Pos and 4.8kV Neg with 12Hz/30Hz
- The peak-to-peak voltage values are almost same
- Frequency also measured for each 12Hz and 30Hz
- This represent output voltage from ionizers doesn't much changes, but CPM can't read full voltage scale due to lack of response speed

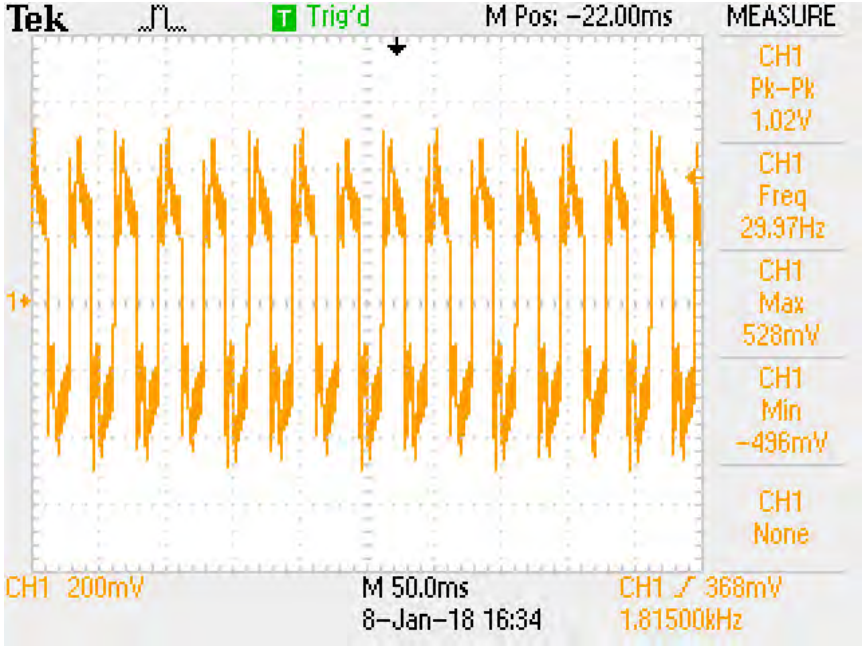




CPM Plate with Oscilloscope

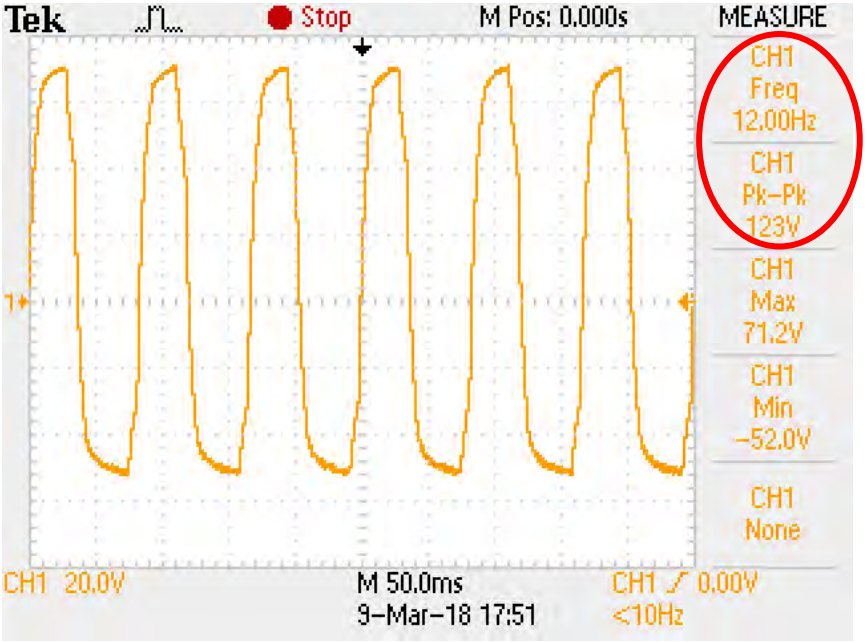
- In this result, as CPM plate sees with oscilloscope, field sensitive device or FPD will see this voltage switching as like passive sensor
- This voltage switching may lead ESD event on panel or field sensitive devices and this type of scenario has been proved in HDD industry before
- To prove this type of failure, several testing conducted

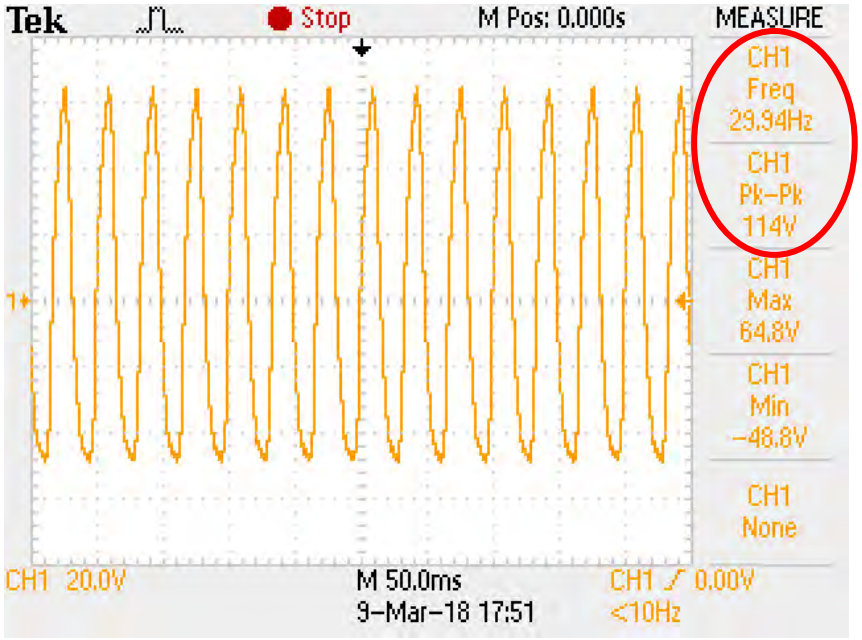




High Voltage Measurement

- It is important to measure real high voltage on emitter points and their changes based on frequency changes
- Output high voltage slightly drops from 12.3kV to 11.4kV (7%) when switching frequency changes from 12Hz to 30Hz. Tektronix TDS2022C Oscilloscope and P6015A High Voltage Divider

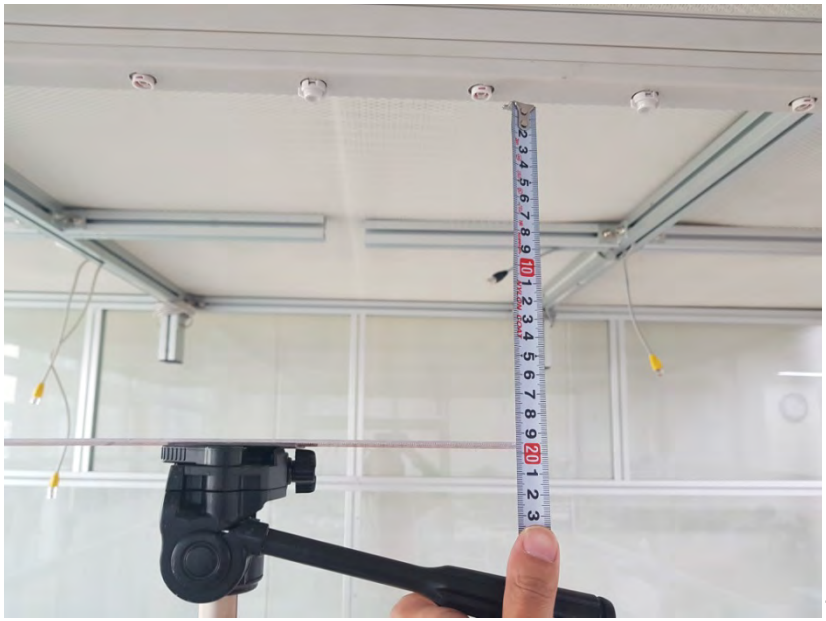




Discharge Current Measurement

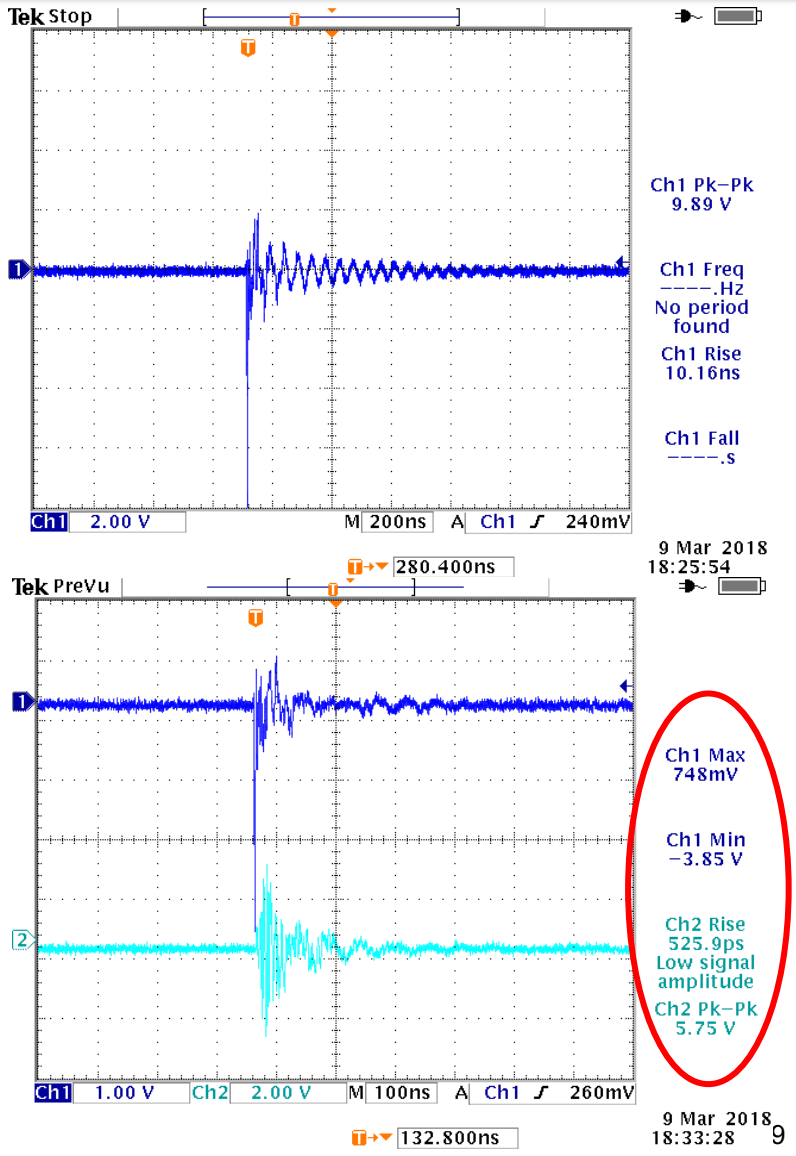
- For ESD event measurement, copper tape and micro gap apparatus prepared. CT-1 probe soldered one side to ground with TDS 3052B (500MHz) scope to measured discharge current.
- This test apparatus placed at 20cm distance from air assist ionizers and start ESD discharge current measurement
- 2GHz RF Antenna also located at 1m distance from ionizers to detect ESD event signature

D.C. Smith, System Level ESD/EMI



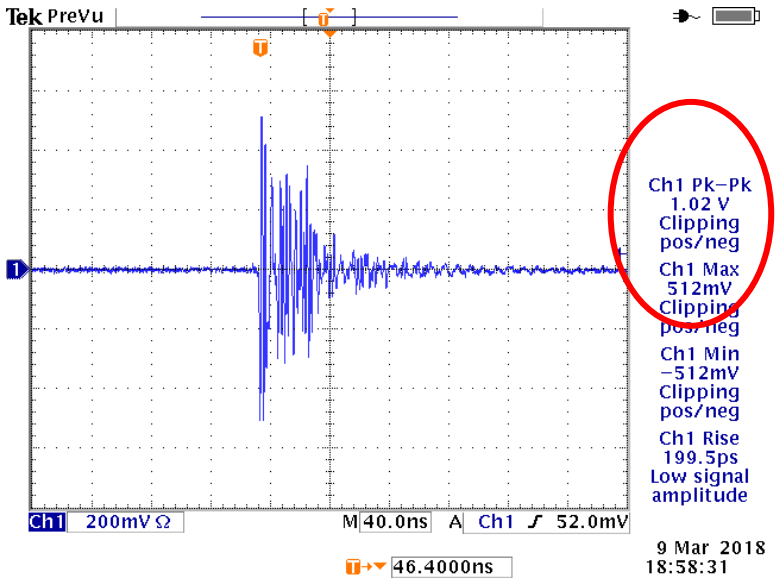
Experiments Results

- Discharge Current measured very high current through this test apparatus. This high current may caused by big capacitance of copper tape
- RF noise detected 5.75V peak-peak value at 1 meter distance to ionizer as ESD event signature with time delay
- This type of ESD event happen when test apparatus has ground through CT-1 probe and very much repeated



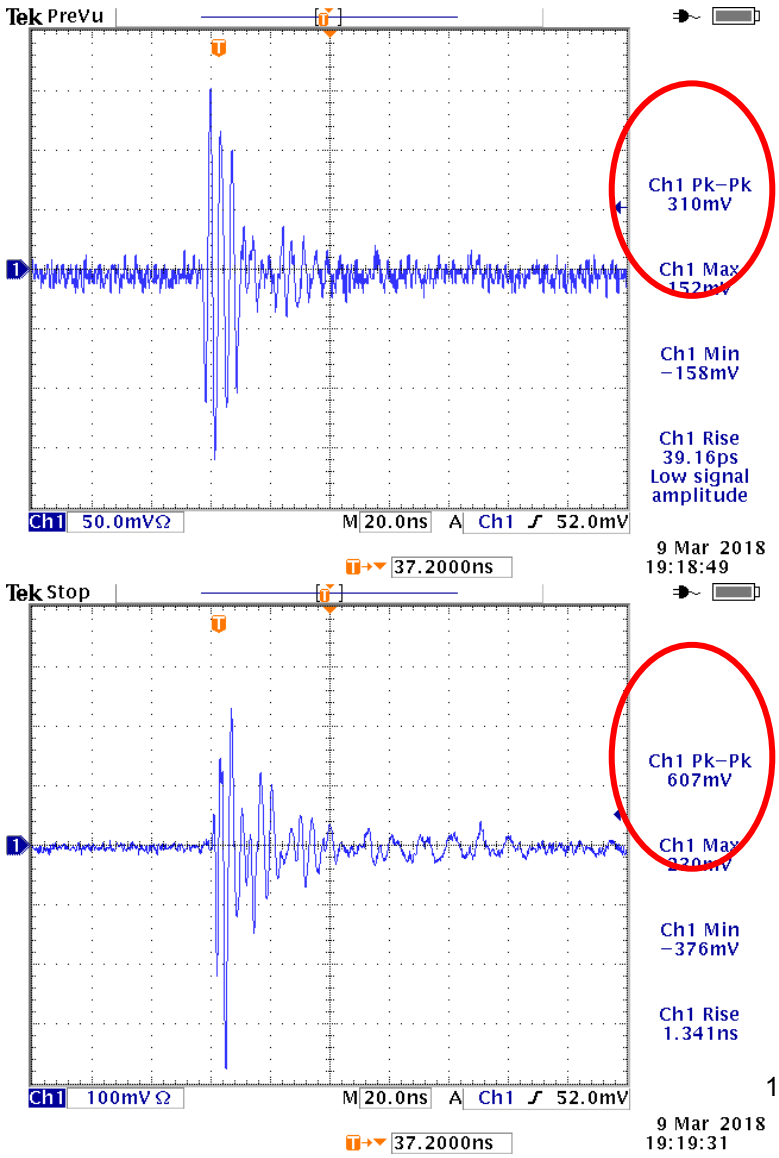
Experiments Results

- This type of ESD event also repeatedly occurs when test apparatus have no ground when apparatus movement such as conveyor system or robot handler transfer glass plates in FPD manufacturing processes
- Peak-to-peak value significantly reduced from 5.75V down to 1V
- This also can happen when ionizer output wasn't stable or when higher offset voltage



Experiments Results

- Instead of test apparatus, placed 4” smart phone TFT LCD glass at the same distance on tripod
- ESD event occurs on 4” display and measured with various peak values and repeated, but much less than test apparatus
- Measured value 310mVp-p to 607mVp-p
- It is clear that ESD event can occurs on FPD when pulsed AC ionizer operating at short distance or some level of offset voltage



Conclusion

- Pulsed AC ionizers using in many places of FPD process and many customer use it as default setting
- Ionization test standard document does not well address what balance or offset value record or collecting data during measurement especially for pulsed AC ionizer application
- CPM response speed can’t catch enough of full switching voltages from pulsed AC or high frequency ionizers
- Field sensitive device or FPD structure may see these fast switching voltage as field source and ESD event occurs
- Using pulsed AC ionizer with high switching voltage or short distance application may ESD threat in FPD processes or field sensitive devices