

TVS Failure Tests Comparison Between ESD Gun, TLP & HMM (Test set sample1 RC0531Z)

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Objective

Currently to test device failure according to test standards:

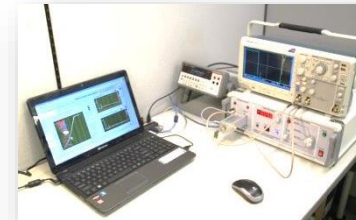
- IEC61000-4-2 (ESD Simulator – Gun type)
3 ESD simulator from different vendors are selected

- NoiseKen ESS-2000
- TESTQ NSG438
- ESD EMC ES613-20



- ANSI/ESD STM5.5.1 (TLP method, ES621-30)
Different TLP pulse width are tested :

- 100 ns TLP setup
- 400 ns TLP setup



- HMM Test Method
TLP based IEC Waveform Pulse System (HMM 100 Ohm method, ES621-90)

ESD Gun Simulator Device Setup Repeatability

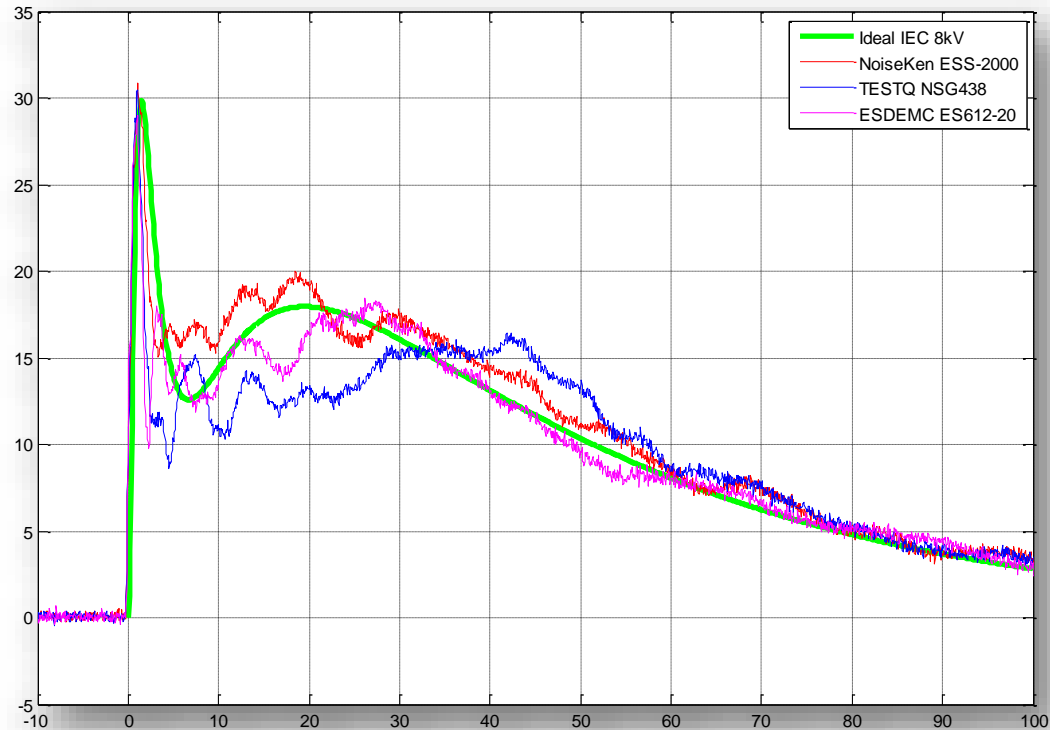
Several common repeatability issues of ESD simulator current injection test:

1. Different vendor use different waveform generator circuit, since the standard allows 15% – 30 % tolerance, which causes the total pulse energy to change a lot between each test.
2. ESD waveform first peak varies with discharge tip angle and how operator hold the simulator.
3. ESD waveform second peak varies a lot with the shape, wire gauge, position of the big ground strip.
4. When DUT is put on different test board, the impedance and parasitic of the test board change the shape of first current peak.
5. The pulse reflections between DUT and ESD simulator internal circuit will cause injection waveform change.

ESD Simulator Waveform Check

3 commercial ESD simulators are selected to do this device failure test, they are all calibrated with ESD Target up to 4 GHz and meets IEC standards:

Although IEC standard specified the simulator current waveform and tolerance requirements (according to the 2 Ohm ESD Target), there are huge variance could be exist between different vendors gun and idea IEC current waveform. The total energy of first 100 ns pulse has been calculated as below for comparison:



Gun Lev(kV)	Ideal IEC	NoiseKen ESS-2000	TestQ NSG-438	ESDEMC ES612-20
Total Energy (J)	2.90E-05	3.27E-05	2.58E-05	2.67E-05
8 kV @ 2 Ohm		(+13%)	(-11%)	(-8%)

ESD Simulator Zap & Leakage Test Result

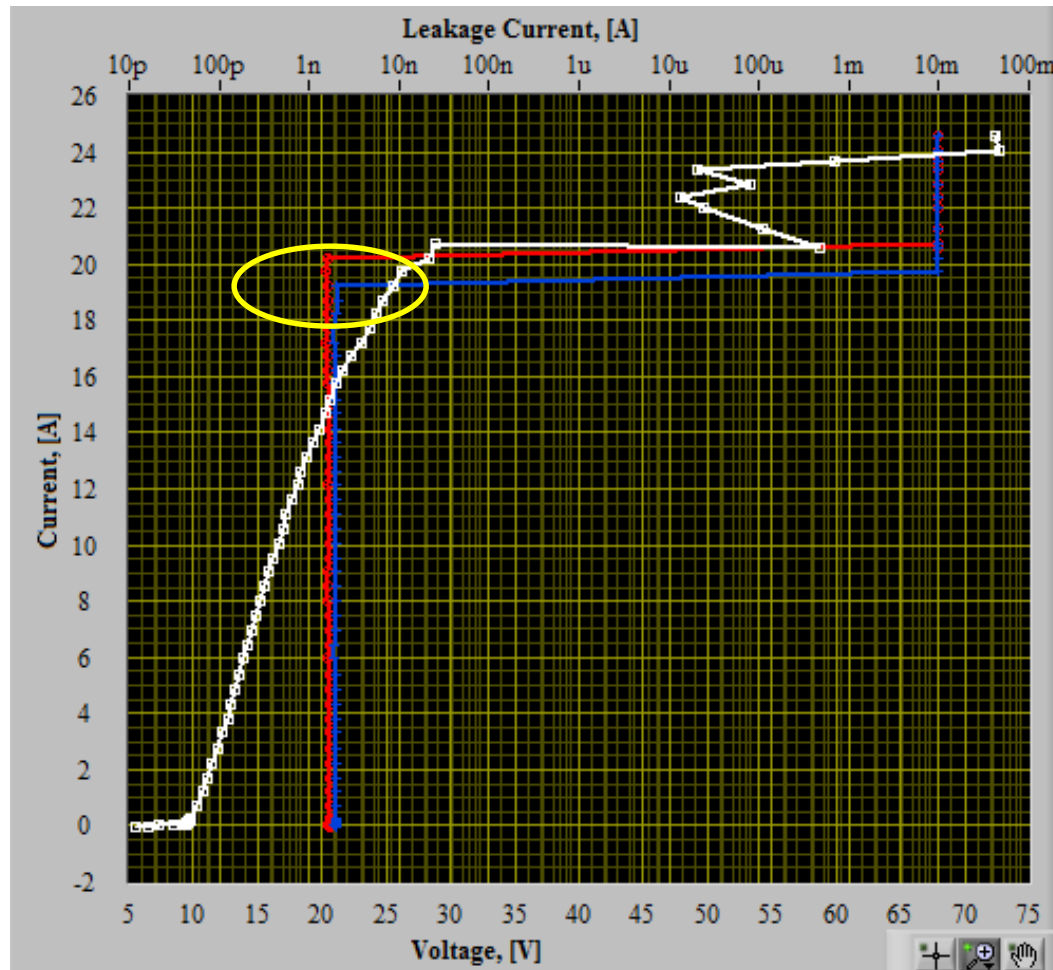
ESD Simulator Test: 1000 times Pos & Neg Zap, then 2V Leakage Test (A)									
Gun Lev(kV)	NoiseKen ESS-2000			TestQ NSG-438			ESDEMC ES612-20		
8	100n			200n					
8.5	100n			200n					
9	100n	200n	200n	200n					
9.5	100n	200n	200n	200n					
10	100n	100n	100n	200n					
10.5	100n	100n	200n	200n			200n	200n	200n
11	100n	100n	300n	300n	100n	300n	200n	200n	200n
11.5	3m	200n	200n	200n	300n	300n	200n	200n	200n
12		4.5m	4.5m	100n	200n	200n	200n	200n	200n
12.5				300n	100n	200n	200n	300n	300n
13				4.5m	100n	200n	200n	200n	200n
13.5					4.5m	4.5m	4m	200n	4m
14								4m	

Note: The leakage test setup for 0531z was Keithley2110 and has minimum resolution of 100 nA.

Tests with NoiseKen ESS-2000 does failed the device earlier due to the larger pulse energy for the test level (13% higher than standard).

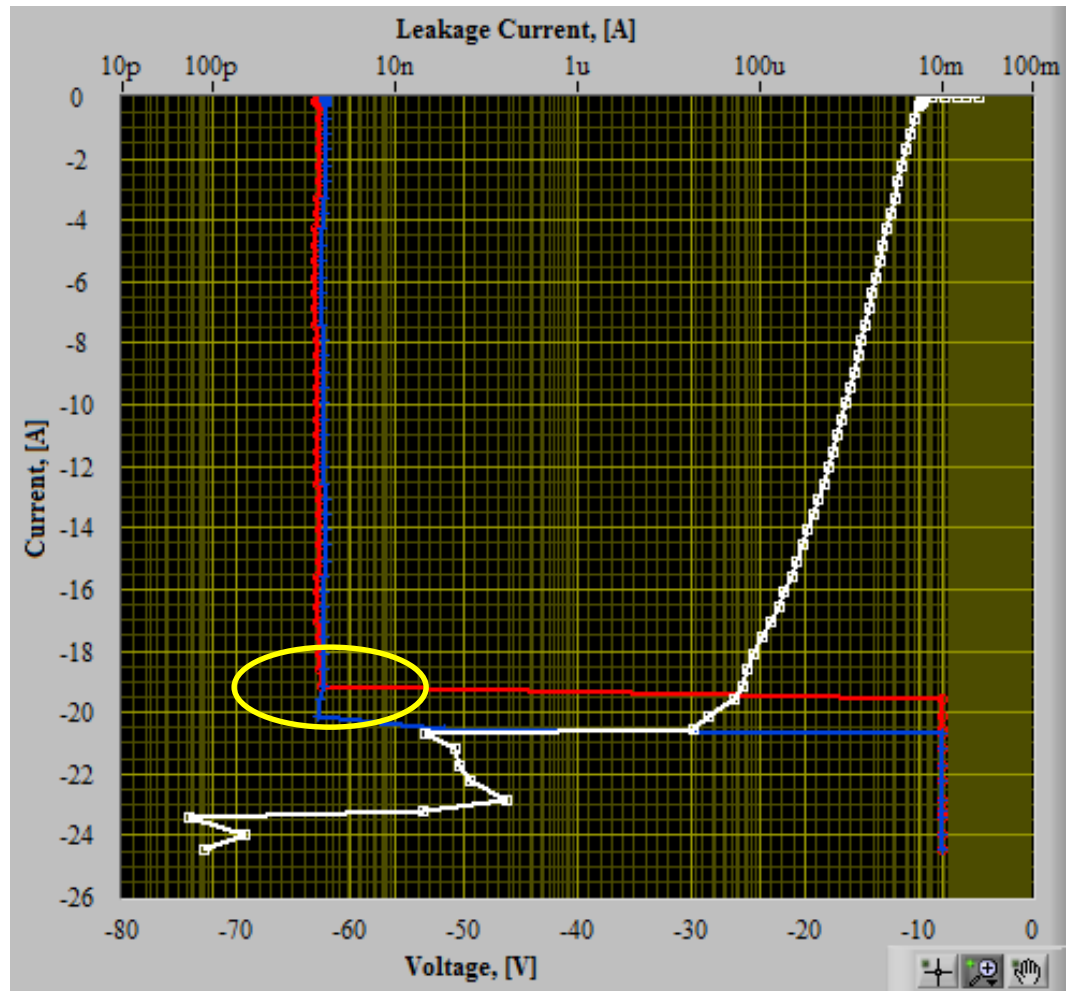
0531Z, 100 ns TLP Pulse, Positive Sweep

Failed at + 19 A



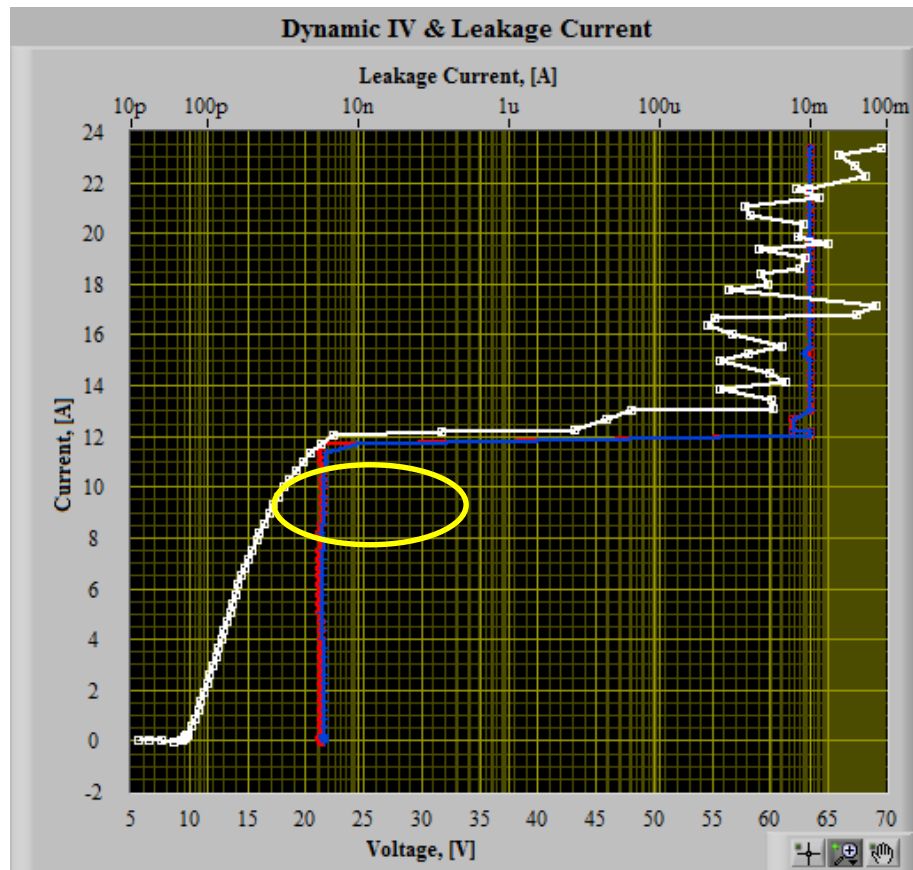
0531Z, 100 ns TLP Pulse, Negative Sweep

Failed at - 19 A



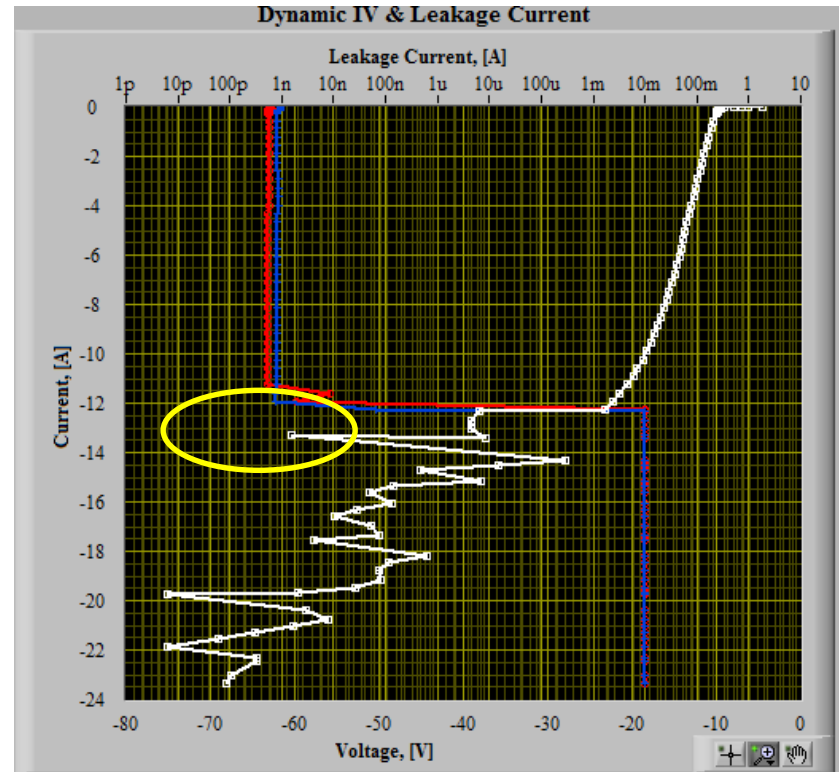
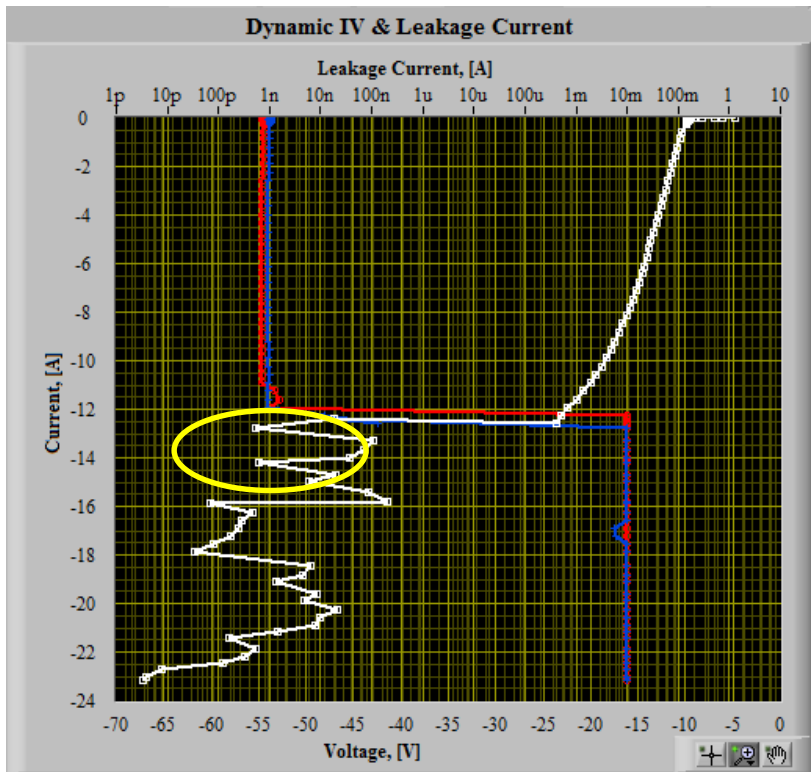
0531Z, 400 ns TLP Pulse, Positive Sweep

Failed at + 11.5 A



0531Z, 400 ns TLP Pulse, Positive Sweep

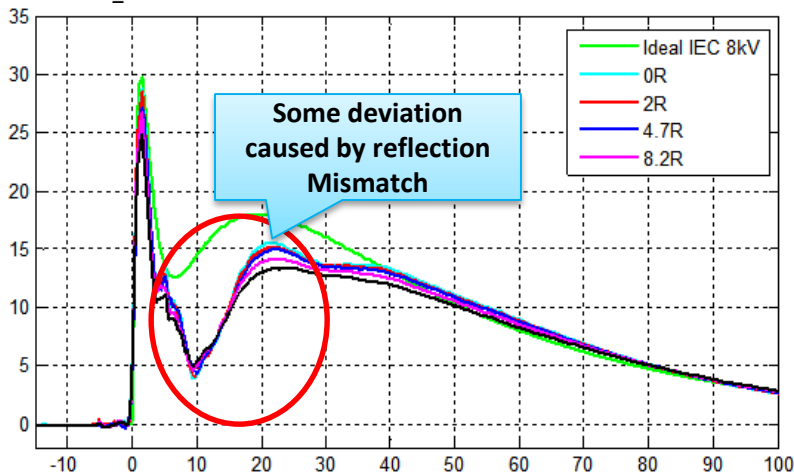
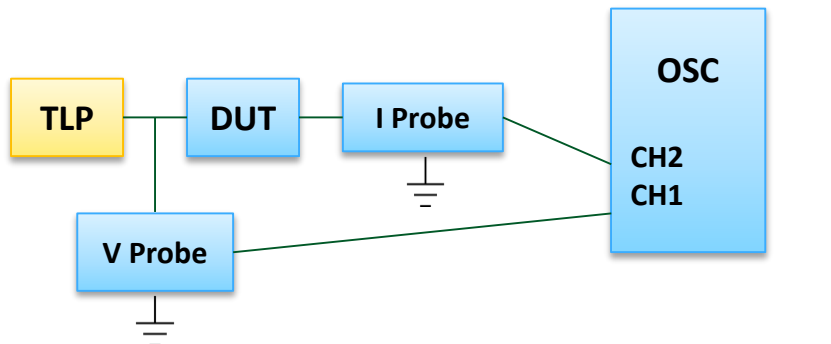
Failed at -11 A



ESDEMC HMM Pulse Concept

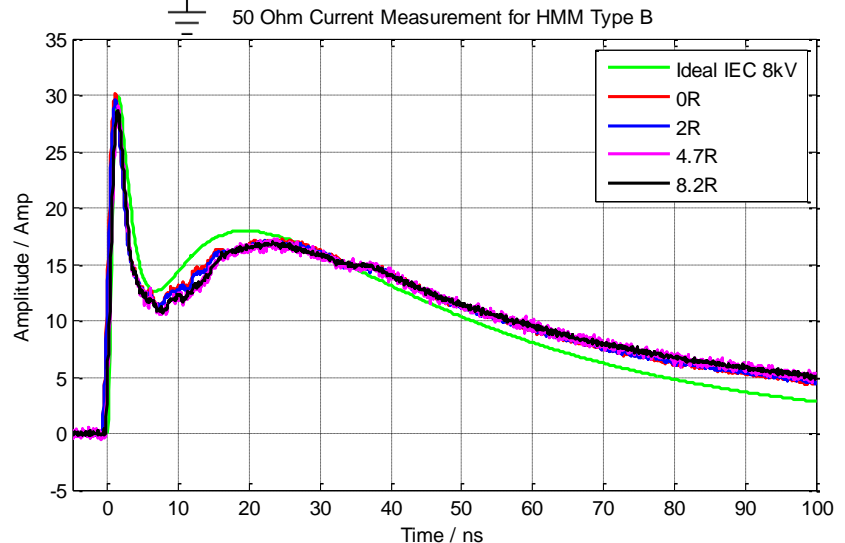
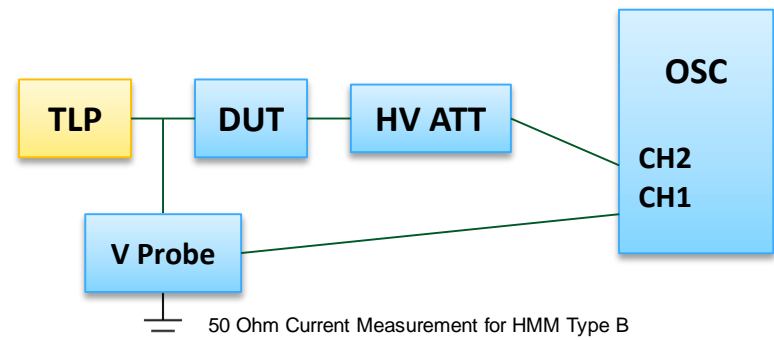
ESDEMC currently has 2 types of HMM Pulse setups:

HMM Type-A Pulsing Setup is designed to inject maximum possible current within IEC waveform standard tolerance (load reflections allowed).



ESDEMC HMM Type-A
50 Ohm matched

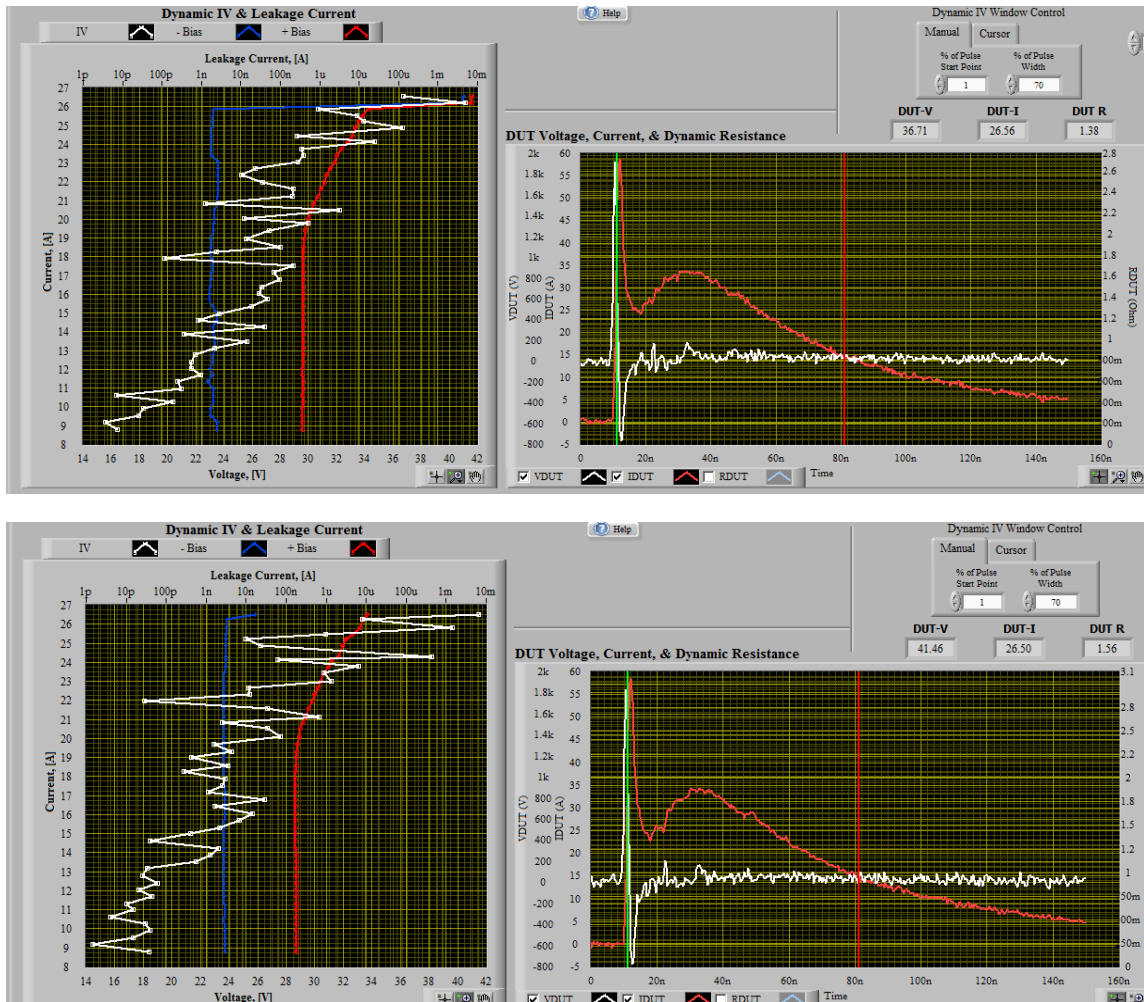
HMM Type-B Pulsing Setup is designed to inject the best waveform approaching idea IEC waveform (all reflection s are minimized by load matching)



ESDEMC HMM Type-B
50 Ohm matched

0531Z, HMM-B Pulse, 50 Ohm Matched Setup Positive Sweep

Device start to degrade at about 40A first peak, equivalent to 10.6 kV IEC Pulse
The test sweep is up to about 60 A first peak, equivalent to 15 kV IEC Pulse



Summarize 0531Z ESD Simulator, TLP 100ns, 400 ns, and HMM Tests

Overall test results show indicates both TLP & HMM setup has good prediction of failure for ESD simulator test.

ESD Simulator Test: 1000 times Pos & Neg Zap, then 2V Leakage Test									
Gun Lev(kV)	Ideal IEC	NoiseKen	ESS-2000	TestQ	NSG-438	ESDEMC ES613-20			
10.5		100n	100n	200n	200n			200n	200n
11		100n	100n	300n	300n	100n	300n	200n	200n
11.5		3m	200n	200n	200n	300n	300n	200n	200n
12			4.5m	4.5m	100n	200n	200n	200n	200n
12.5					300n	100n	200n	200n	300n
13					4.5m	100n	200n	200n	200n
13.5						4.5m	4.5m	4m	200n
14									4m

TLP Pulse 2 Times. Then 2V Leakage Test										
TLP Lev (A)	100ns TLP (A)				400ns TLP (A)				HMM First Peak Current (A)	
Failure Level	19A	19A	-19A	-19A	11.5	11.5	-11	-11	40-60A	40-60A
Predicting IEC Level (kV)	10	10	-10	-10	11.5	11.5	-11	-11	10-15 kV	10-15 kV