TN7-24-010A

TRISMAC 2024 Conference

Charge and Discharge of The Wire Harness

Hiroshi Kinoda

Reliability & Parts Engineer

Kinoda.Hiroshi@bk.MitsubishiElectric.co.jp

2024/6/26

MITSUBISHI ELECTRIC CORPORATION

Outline

MITSUBISHI ELECTRIC
Changes for the Better

1. **Introduction**
2. Methodology
3. Results

3.1 Comparison of discharge current waveforms

3.2 Measurement results of the amount of charge and the electric potential on the surface

3.3 Data acquisition of discharge current waveform

3.4 Wire Harness Discharge model

4. Conclusion

1. Introduction

- What is “Cable Oriented Electrostatic Discharge (ESD)”?
- What is the difference between Cable Oriented ESD and General ESD like HBM?
- What is the impact of Cable Oriented ESD?

➢ What is “Cable Oriented Electrostatic Discharge (ESD)”?

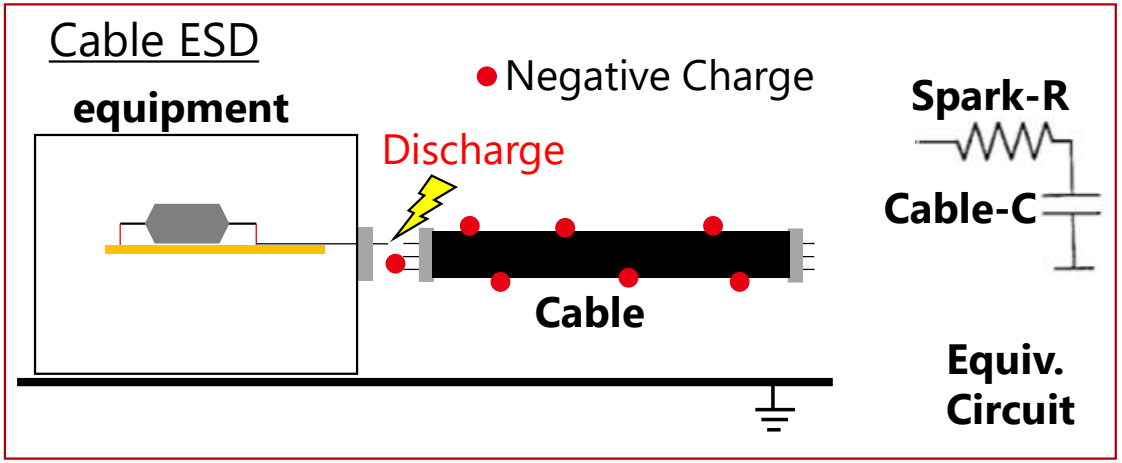
Cable Charging: Charging on a cable insulation by separation or friction between the cable and a floor and induced in cable conductor.

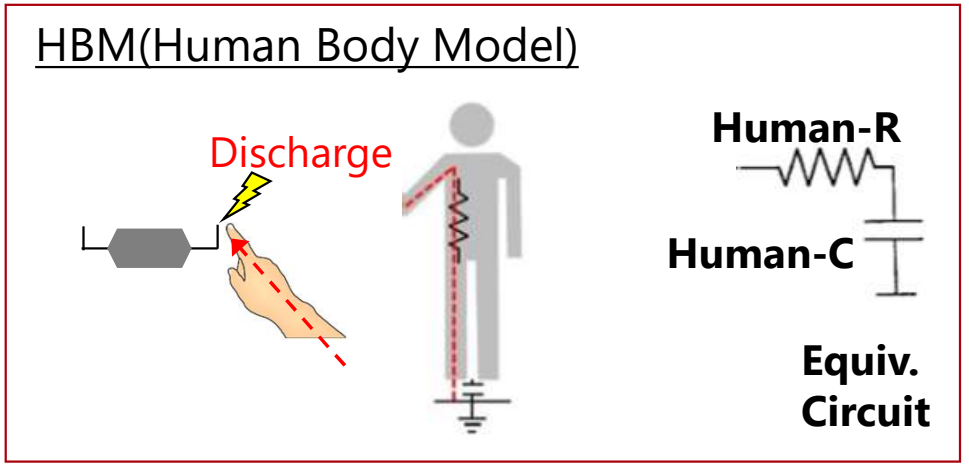
Cable Discharging: Discharging by connected to an electronic device through some connectors

Cable Oriented ESD phenomena: defined as “Cable Discharge Event” by ESD Association

ESD Open Forum Conformity—2009 Provided by the ESD Association
A Cable Discharge Event, or CDE, is a discharge that occurs when a cable is connected to a piece of electronic equipment – it occurs because there is a differential between the charge on a cable to be connected and the equipment that it’s being plugged into. It doesn’t matter if the cable is charged or if the equipment to which it will be connected is charged – same event; different polarity. It’s the differential that causes the discharge.

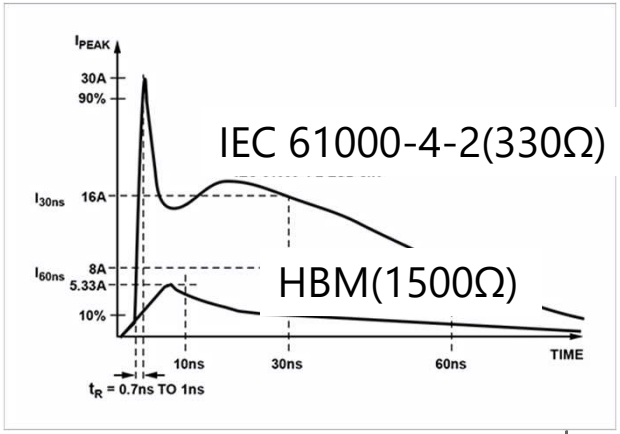
➢ What is the difference between Cable Oriented ESD and General ESD like HBM?





	Cable ESD	HBM
Resistance	several tens of ohms*	1500Ω
Capacitance	100pF～1000pF *	150pF

* Depends on cable length and type



MITSUBISHI ELECTRIC
Changes for the Better

Official ESD test standard

	ESD model	Standard	Condition	remarks
System level	HBM(Human Body Model)	IEC 61000-4-2	C=150pF R=330Ω	
	Cable ESD	None	None	
EEE parts level	HBM(Human Body Model)	MIL-STD-883 M3015	C=100pF R=1500Ω	
	CDM(Charged Device Model)	JEDEC-JS-002	Depends on the devices	During manufacturing
	MM(Machine Model)	JESD22-A115C	C=200pF R=0Ω	

➢ What is the impact of Cable Oriented ESD?

The equipment does not work because of EEE parts failure by ESD damage

Replacement work with no damage EEE parts

Behind schedule due to re-Acceptance Test of the equipment after replacement work

1. Introduction
2. **Methodology**
3. Results

3.1 Comparison of discharge current waveforms

3.2 Measurement results of the amount of charge and the electric potential on the surface

3.3 Data acquisition of discharge current waveform

3.4 Wire Harness Discharge model

4. Conclusion

MITSUBISHI ELECTRIC
Changes for the Better

Study for Charge and Discharge of the Wire Harness

Step 1: Compare cable oriented ESD and existing ESD models (HBM, MM)

Step 2: Clarify the characteristics of charging with various types of harnesses and insulations of various cables.

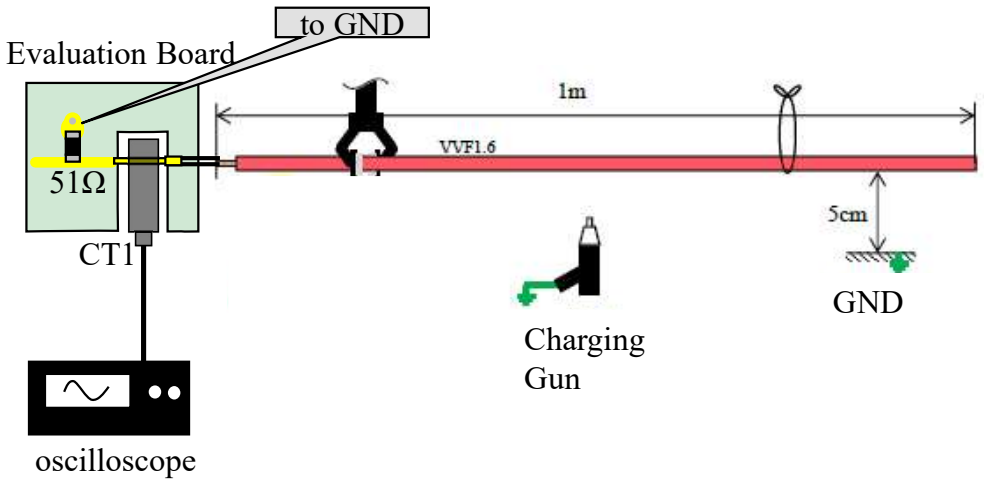
Step 3: Contact the charged cable and acquire the discharge waveform.

Step 4: Model cable conditions during discharge, simulate discharge waveforms, and validate the model.

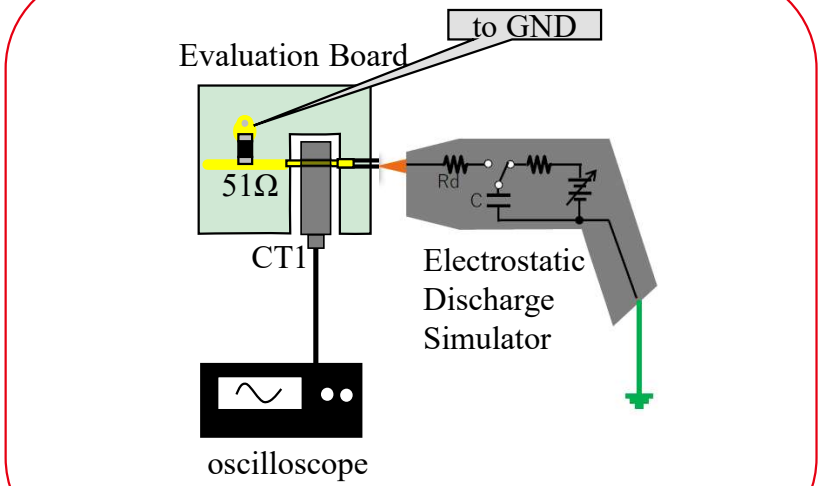
Step 1: Compare cable oriented ESD and existing ESD models

Test Configuration

cable oriented ESD



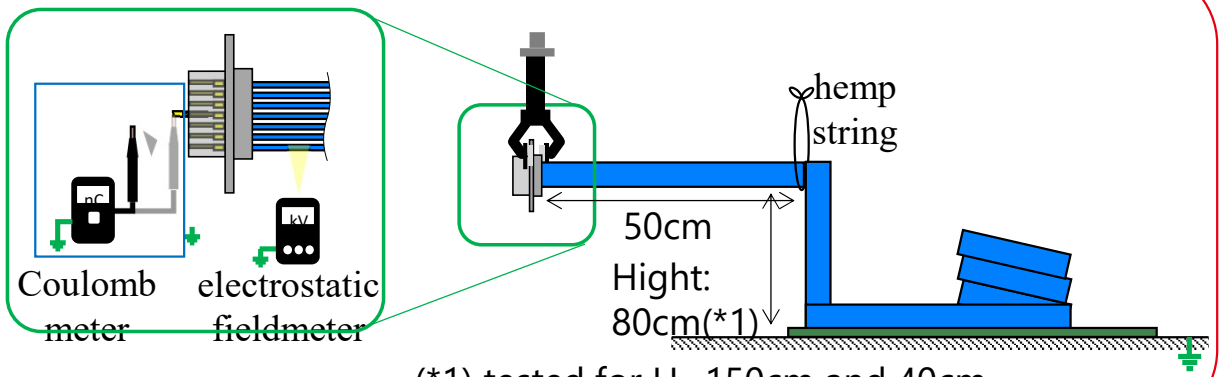
existing ESD models



MITSUBISHI ELECTRIC
Changes for the Better

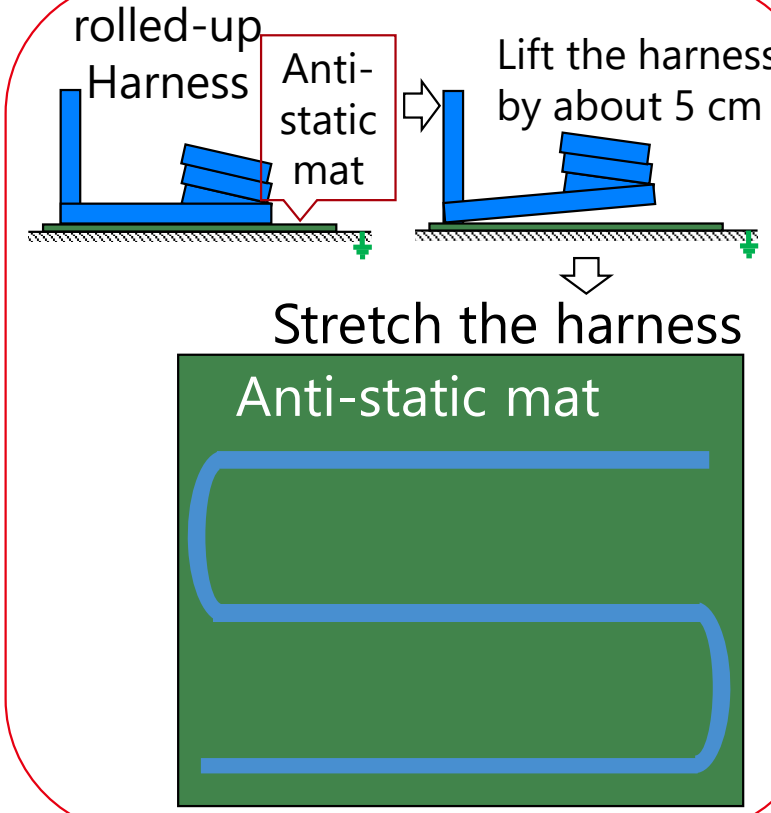
Step 2: Clarify the characteristics of charging

Test Configuration



(*1) tested for H=150cm and 40cm

Charging method

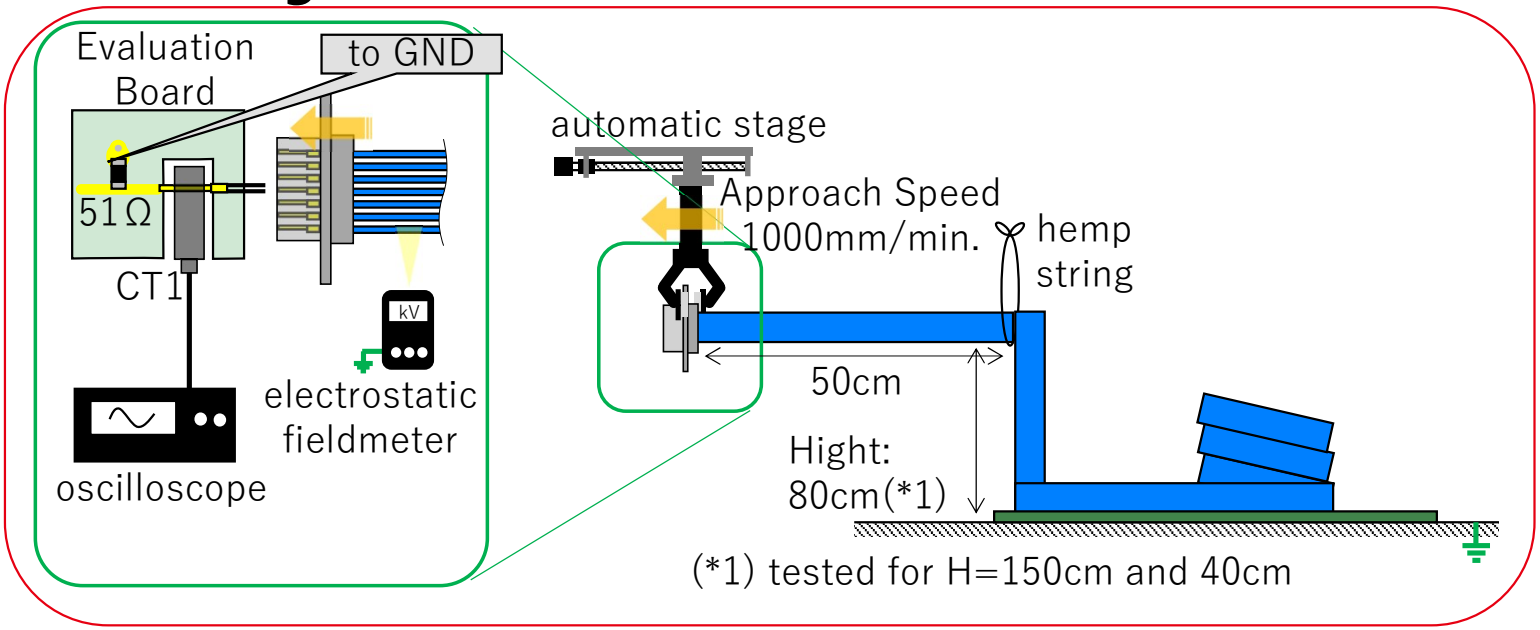


Test sample (wire harness)

Harness Type	UTP, STP, Straight
Length	10m, 20m
Bundled numbers	8, 37
Connecter Type	Dsub9, Dsub37, µDsub9, Cylindrical Connectors 8
Insulation	PVC, XETFE

Step 3: Contact the charged cable and acquire the discharge waveform

Test Configuration



Charging method

Same as Step2

Test sample (wire harness)

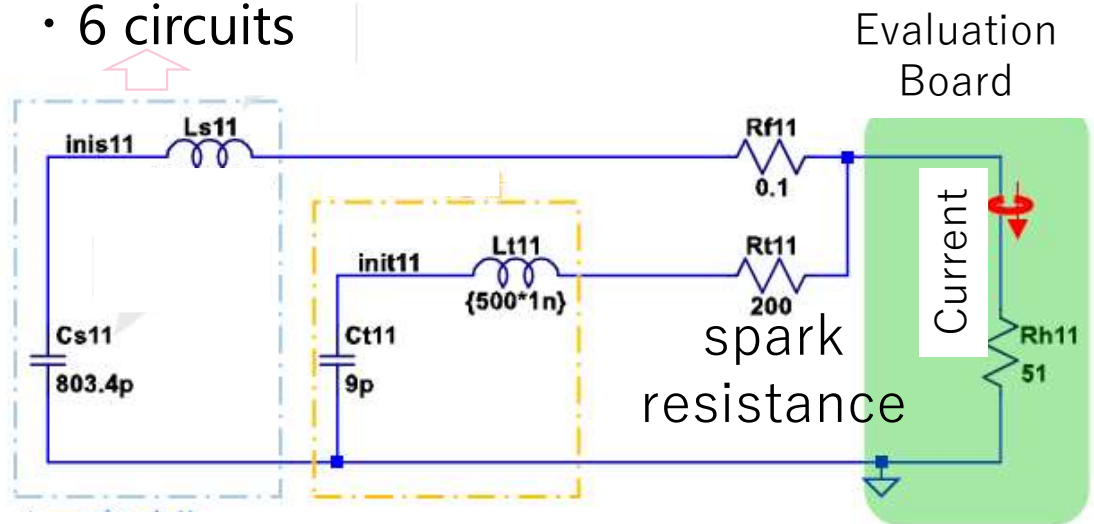
Same as Step2

Step 4: Model cable conditions during discharge, simulate discharge waveforms, and validate the model.

Simulation: LTspice®

Discharge circuit modelling of the harness

distributed constant circuit
- 3 circuits
- 6 circuits



1. Introduction
2. Methodology
3. **Results**

3.1 Comparison of discharge current waveforms

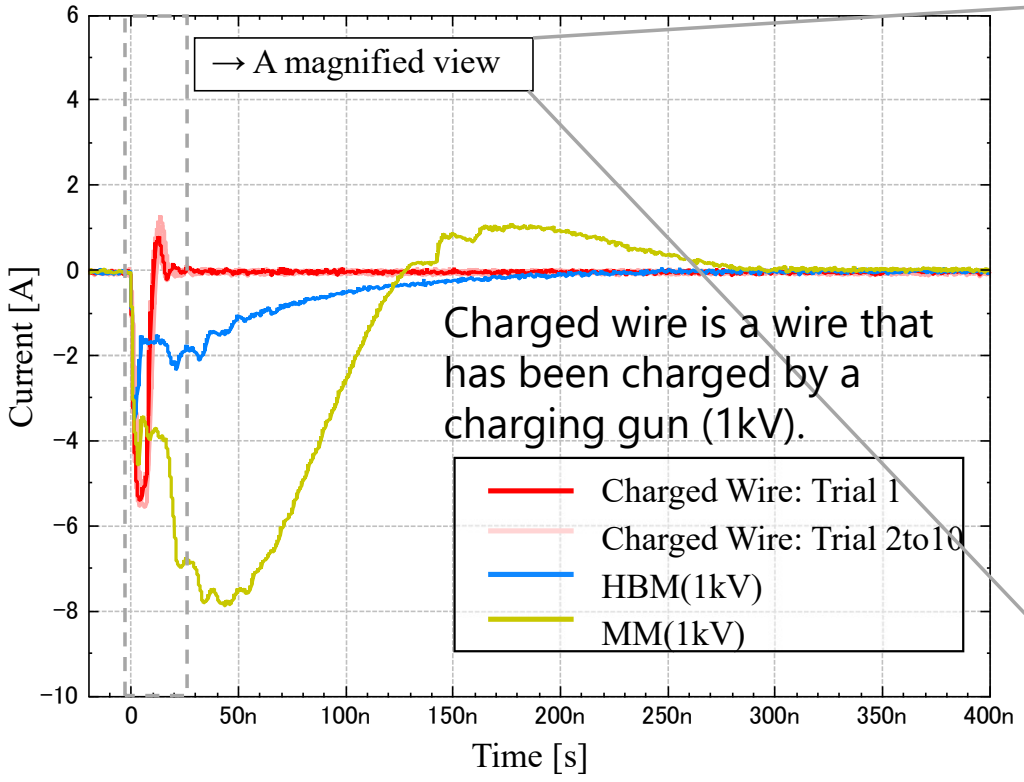
3.2 Measurement results of the amount of charge and the electric potential on the surface

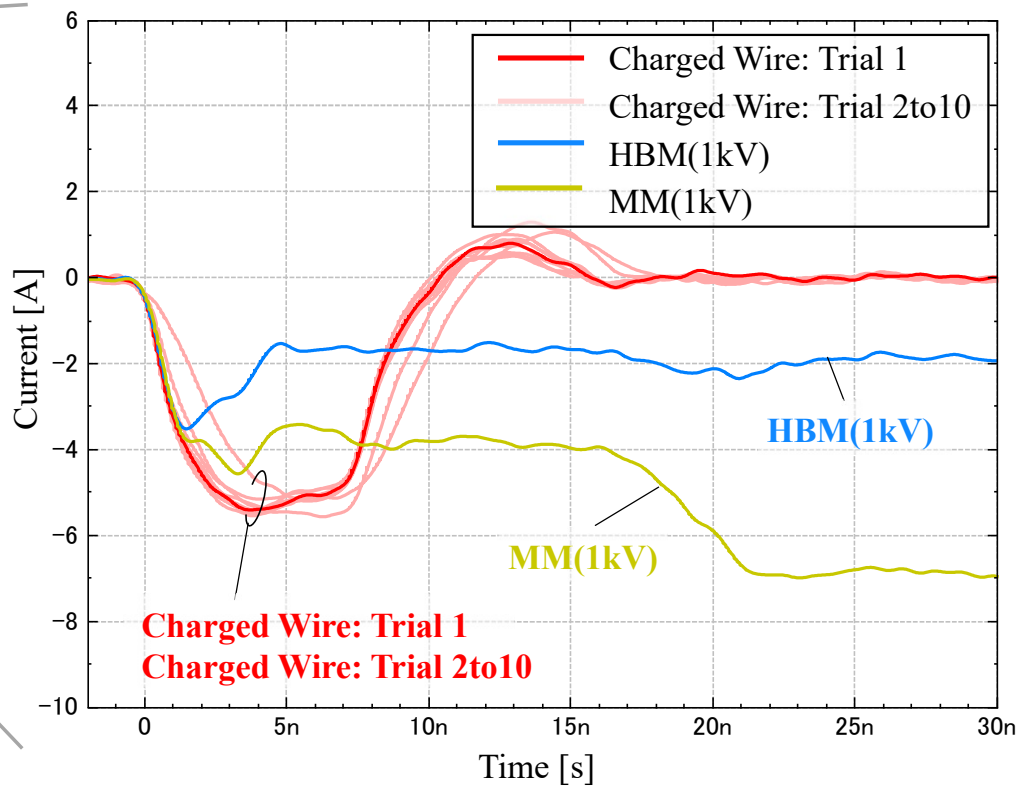
3.3 Data acquisition of discharge current waveform

3.4 Wire Harness Discharge model

4. Conclusion

3.1 Comparison of discharge current waveforms





This result suggests that **“discharges in charged wire harnesses are more severe than those in HBM."**

1. Introduction
2. Methodology
3. **Results**

3.1 Comparison of discharge current waveforms

3.2 Measurement results of the amount of charge and the electric potential on the surface

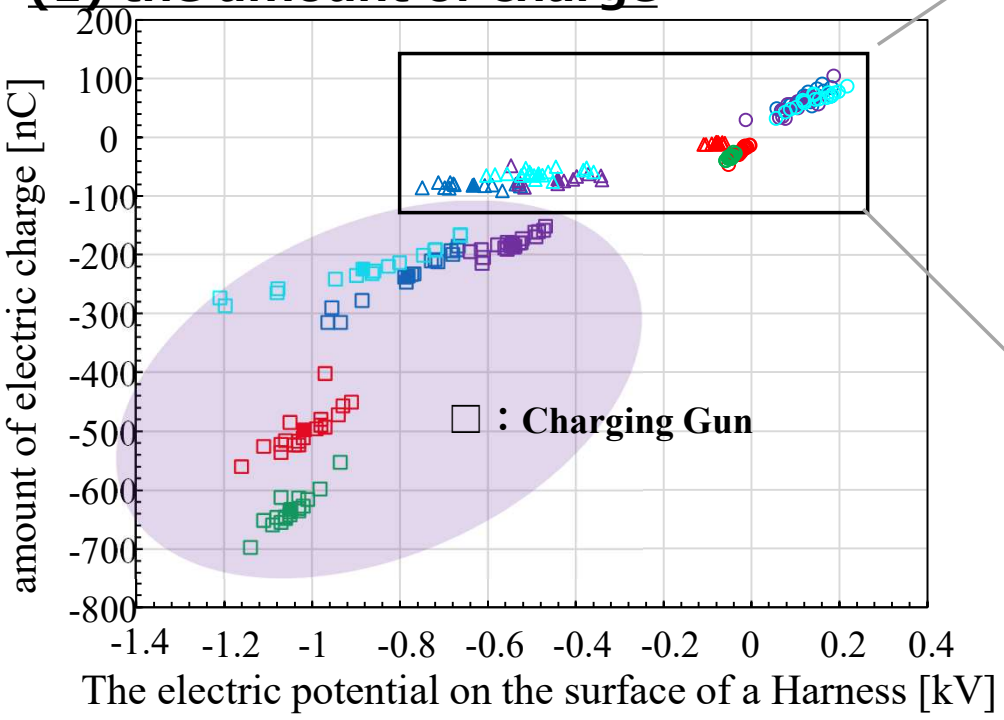
3.3 Data acquisition of discharge current waveform

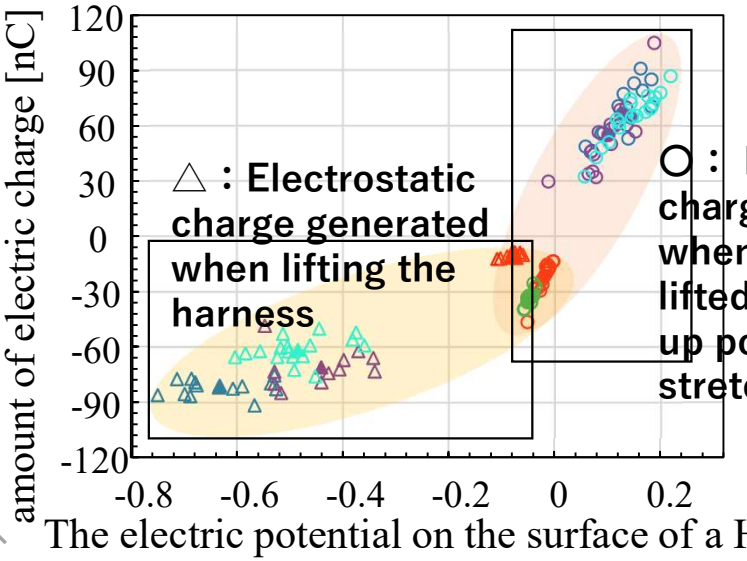
3.4 Wire Harness Discharge model

4. Conclusion

3.2 Measurement results of the amount of charge and the electric potential on the surface

(1) the amount of charge





	Harness	Insulation	Number of wires	Connector	Length	Height
Red	Straight	PVC	8	Dsub 9	10m	80cm
Green	Straight	PVC	37	Dsub 37	10m	80cm
Blue	Straight	XETFE	8	Dsub 9	10m	80cm
Purple	STP	XETFE	8	Dsub 9	10m	80cm
Light Blue	UTP	XETFE	8	Dsub 9	10m	80cm

(1) the amount of charge

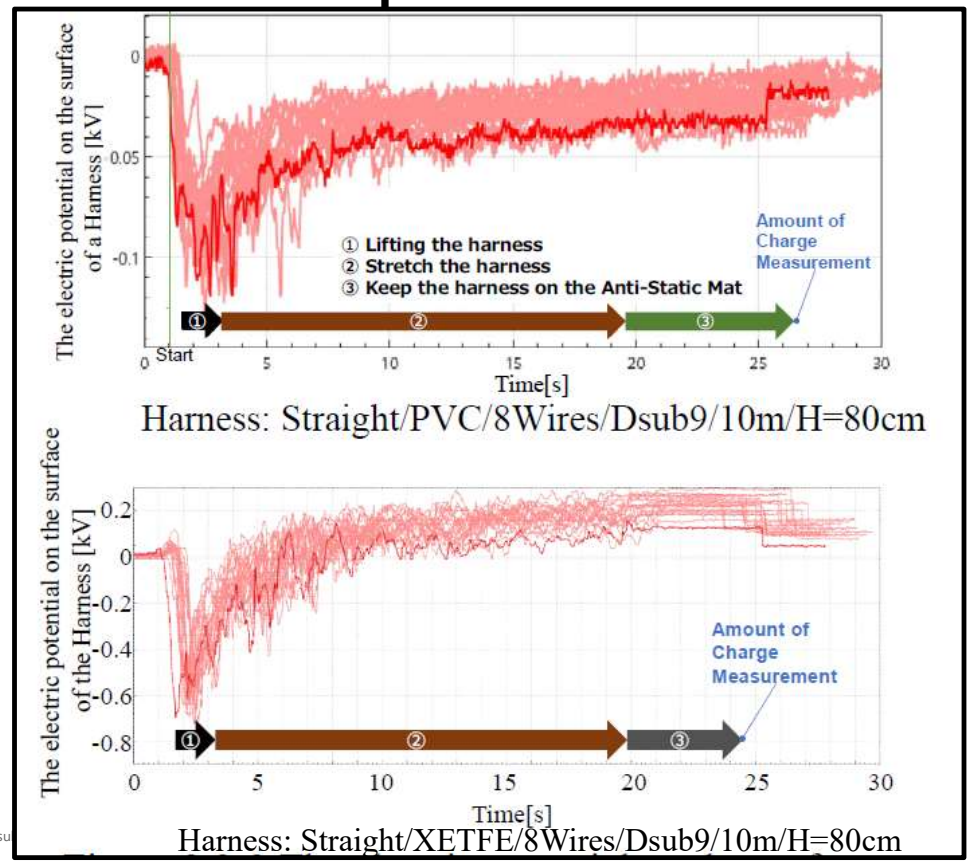
Measurement results of the amount of charge

- The amount of charge by charging gun is the largest of our three charging methods. This is because the insulation of each cable is fully charged by charging gun.
- When the harness is lifted, the core cable in the shielded twisted wire is charged as well as the core cable in the straight cable.
- When the harness is stretched it further on the static mat after lifted, the core cable in the shielded twisted wire is charged as well as the core cable in the straight cable.

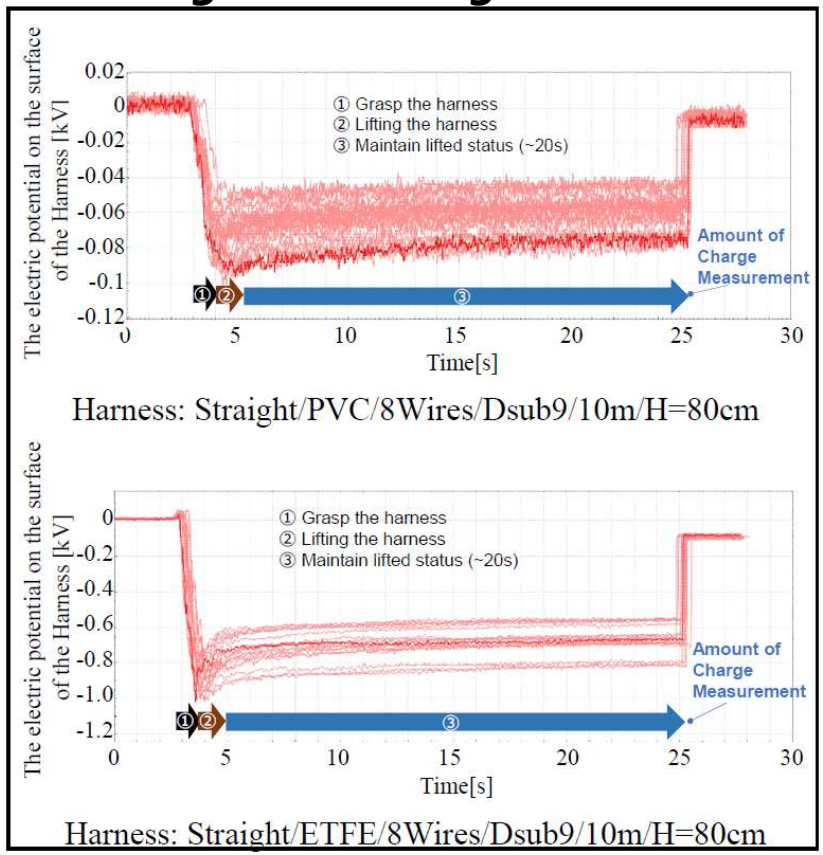
3.2 Measurement results of the amount of charge and the electric potential on the surface

(2) the electric potential

The electric potential on the surface



The electric potential on the surface During maintaining lifted status



(2) the electric potential

The charging is conducted through a series of actions
(1) Lifting the winding harness
(2) stretching the harness
(3) Lay down the harness on the anti-static mat.

The electric potential;
- The surface potential rises all at once when the harness is lifted in (1).
- The surface potential gradually decreases in (2).
- ETFE has a faster rate of decrease in surface potential than PVC.
- The surface potential of ETFE changed from negative to positive.

The charging of the core wire occurs by the action that we lift up the winding harness.

1. Introduction
2. Methodology
3. **Results**

3.1 Comparison of discharge current waveforms

3.2 Measurement results of the amount of charge and the electric potential on the surface

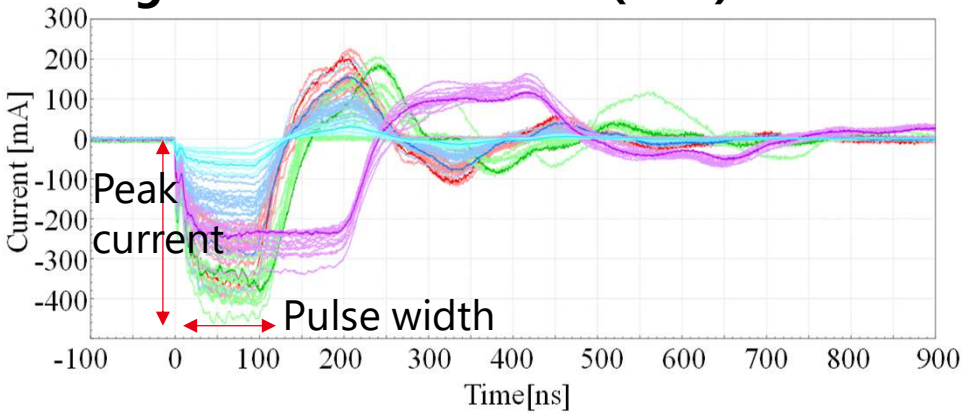
3.3 Data acquisition of discharge current waveform

3.4 Wire Harness Discharge model

4. Conclusion

3.3 Data acquisition of discharge current waveform

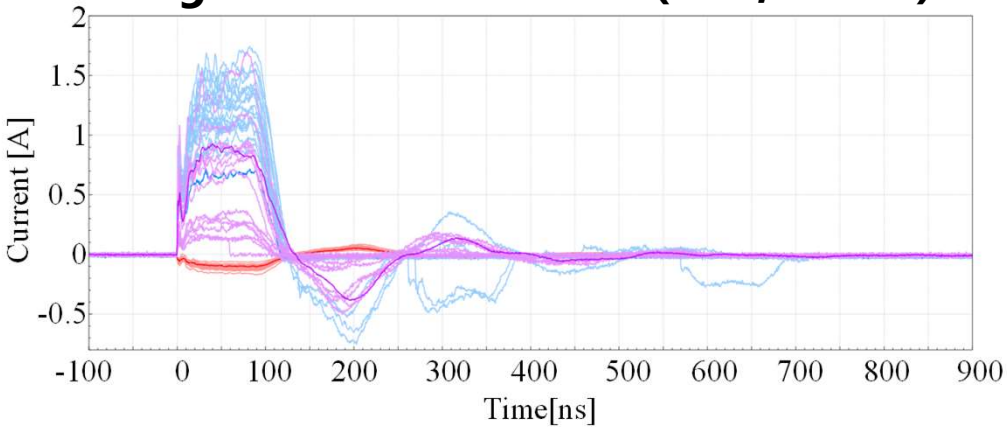
Discharge current waveform (PVC)



	Harness	Insulation	Number of wires	Connector	Length	Height	Approach speed (mm/min.)
Red	Straight	PVC	8	Dsub 9	10m	80cm	1000
Green	Straight	PVC	37	Dsub 37	10m	80cm	1000
Blue (*)	Straight	PVC	8	Dsub 9	10m	80cm	1000
Purple	Straight	PVC	8	Dsub 9	20m	80cm	1000
Light Blue	Straight	PVC	8	Dsub 9	10m	80cm	500

(*) Another pin different from Red

Discharge current waveform (PVC, XETFE)



	Harness	Insulation	Number of wires	Connector	Length	Height
Red	Straight	PVC	8	Dsub 9	10m	80cm
Blue	Straight	XETFE	8	Dsub 9	10m	80cm
Purple	STP	XETFE	8	Dsub 9	10m	80cm

3.3 Data acquisition of discharge current waveform

Summary of the results.

Pulse width: increases as the number of bundled wires increases or as the cable length increases. And it does not depend on whether PVC or XETFE cable is used.

Peak current: increases with more bundled wires or longer cable lengths. And it is slightly larger for XETFE cables than for PVC cables.

1. Introduction
2. Methodology
3. **Results**

 3.1 Comparison of discharge current waveforms

 3.2 Measurement results of the amount of charge and the electric potential on the surface

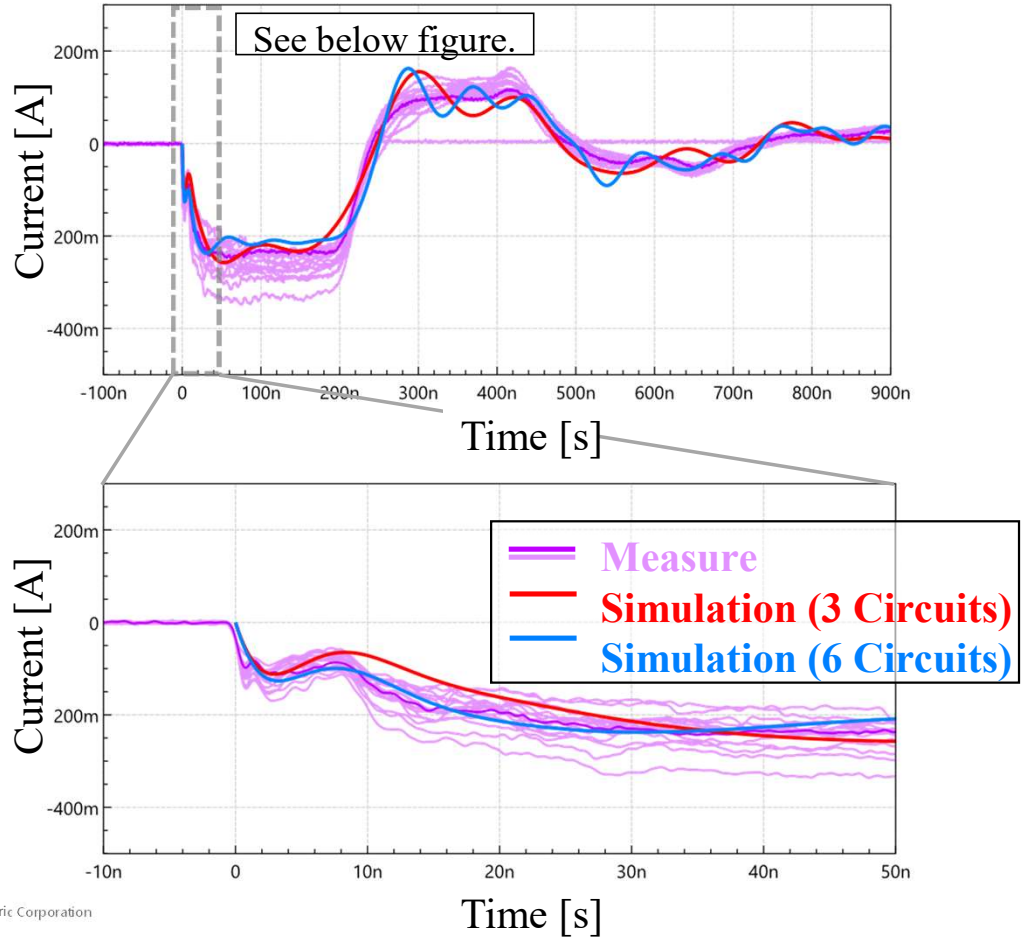
 3.3 Data acquisition of discharge current waveform

 3.4 Wire Harness Discharge model

4. Conclusion

3.4 Wire Harness Discharge model

Comparison of discharge current waveforms between simulation and measurements



The discharge current waveforms by the model were in close agreement with the measure data.

Work to resolve
The simulation model was adjusted as follows.
- Assumed inductance value: 19.5μH(*)
- Input value (adjusted value): 15μH
  (total inductance value at 6 divisions)

(*)Calculated value as 10m:10μH

1. Introduction
2. Methodology
3. Results

3.1 Comparison of discharge current waveforms

3.2 Measurement results of the amount of charge and the electric potential on the surface

3.3 Data acquisition of discharge current waveform

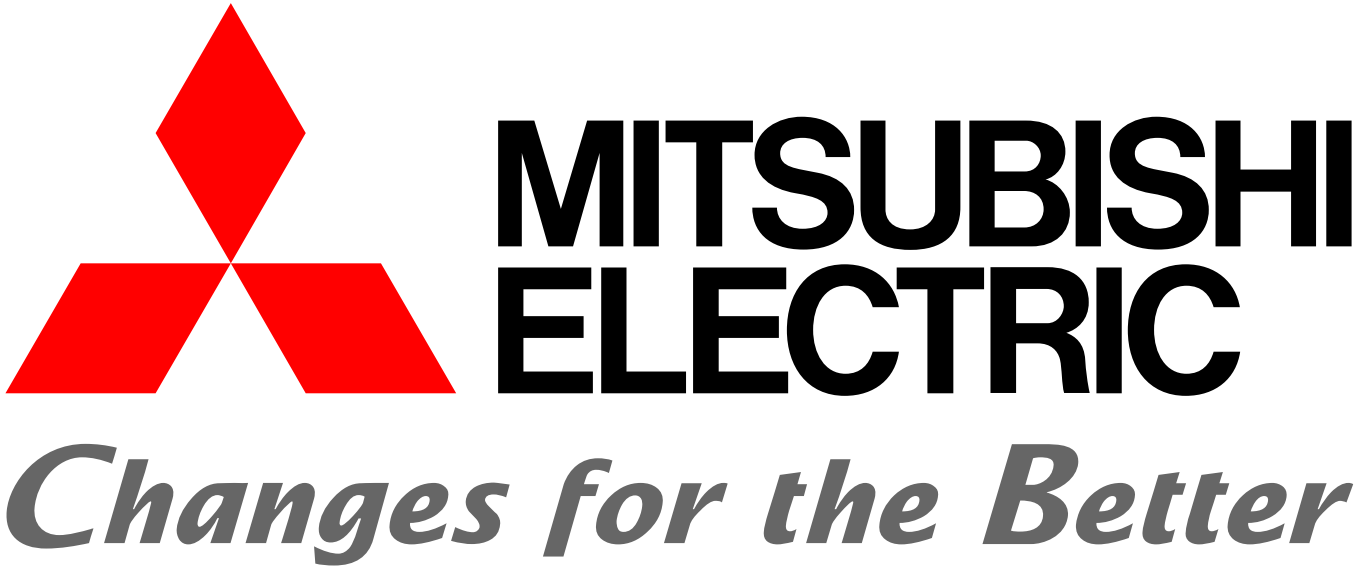
3.4 Wire Harness Discharge model

4. Conclusion

4. Conclusion

- We got the data of charging and discharging of charged harness.
- We found that the shielded twist cable was also charged by handling cable like lifting cable and laying down on the floor.
- We could know the dependance of the cable length, bundled number and so on.
- We could compare the discharge of the charged harness with the existing ESD model like HBM.
- The discharge current waveform can be simulated by the distributed constant circuit.

The results can help us make protective plans not to cause the damage to EEE components by the discharge of the charged harness.


MITSUBISHI
ELECTRIC
Changes for the Better