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DC Surge Protection of Remote Radio Units or Remote Radio Head

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ERICO

PROTECTION ENGINEERS GROUP

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DC SURGE PROTECTION OF REMOTE RADIO UNITS

- APPLICATION – LOCATION
- SIZING - CALCULATION OF RATINGS
- LAB TESTING

Background

Traditionally cellular radio antennae are connected to base station radio equipment using coaxial feeders.

The next generation of cellular equipment utilized remote radio units close to the antennae which would convert the frequencies to a intermediate frequency

Modern cellular equipment utilize remote radio unit RRU or remote radio head RRH which is fed from the base station via optical fiber. This eliminates the loss issues on feeders and allows transmission to occur at much higher frequencies and with larger bandwidth.

The snag with this method of transmission is that power cannot be transferred from the base station to RRU or RRH via the optical fiber. This power is fed separately as DC on copper cables. The copper cables are either separate to the fiber or are a composite fiber-copper cable.

The DC feed act as a source of lightning surge back into the equipment room and more precaution needs to be taken on how to control these surges, than ever before. In traditional radio, the extent of damage to equipment would normally be the radio equipment. In the modern scenario damage can occur to the rectifiers or the whole DC power system.

Scenario 1

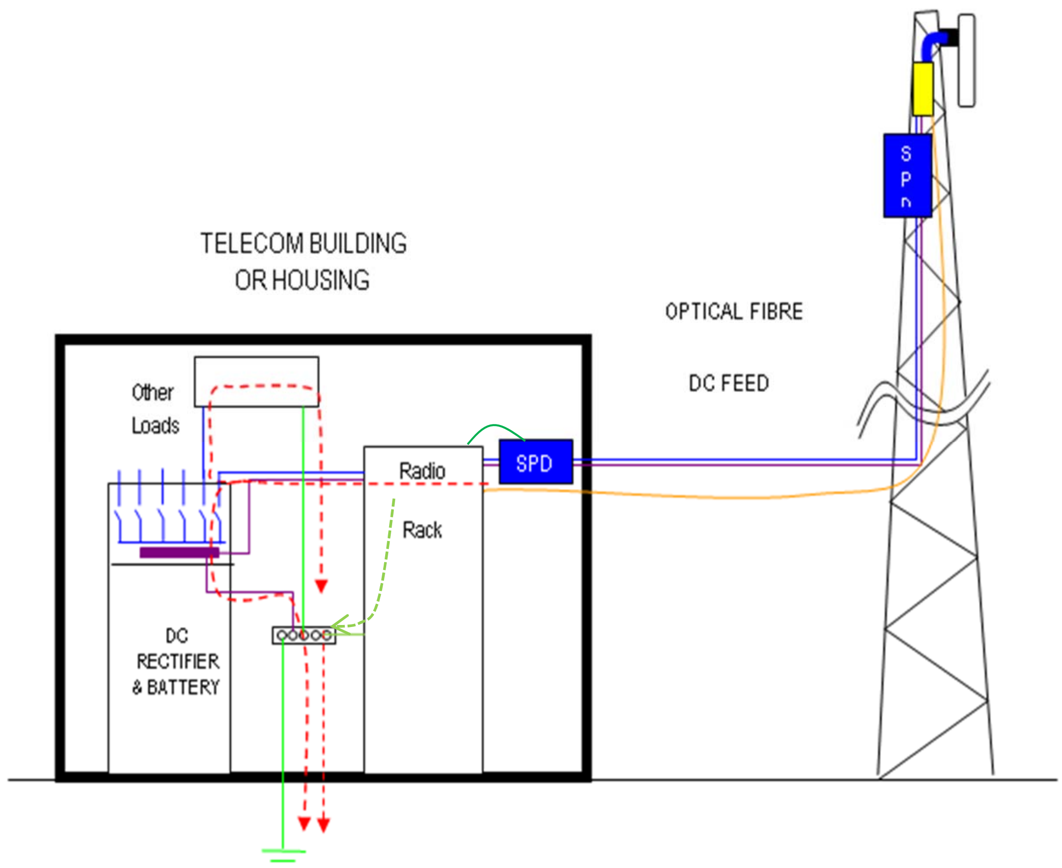
DC SPD FOR RRU APPLICATION-LOCATION

SPD is connected at each end of the DC power cable.

There is no direct grounding of SPD's to the ground bar but it is grounded via the base station equipment and racks.

The diagram depicts in a single point or star grounding arrangement

Depend on Distance of RBS rack to ground bar



DC SPD FOR RRU APPLICATION-LOCATION

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Scenario 2

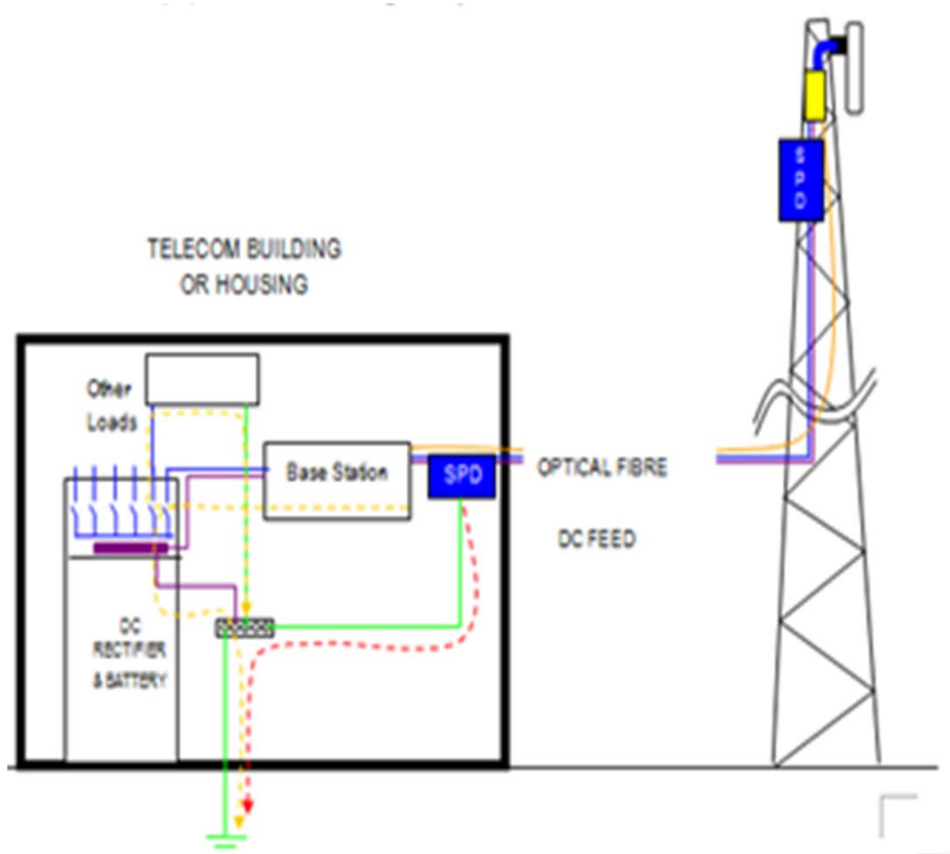
DC SPD Directly Grounded

While some or even most of the lightning surge may travel to ground as shown by the red dotted line.

Additional paths exist as shown by yellow, dotted line..

The length of the path shown by the red arrow can potentially be a long path.

The voltage drop across the cable in the order of magnitude of 20-50 V per inch



DC SPD FOR RRU APPLICATION-LOCATION

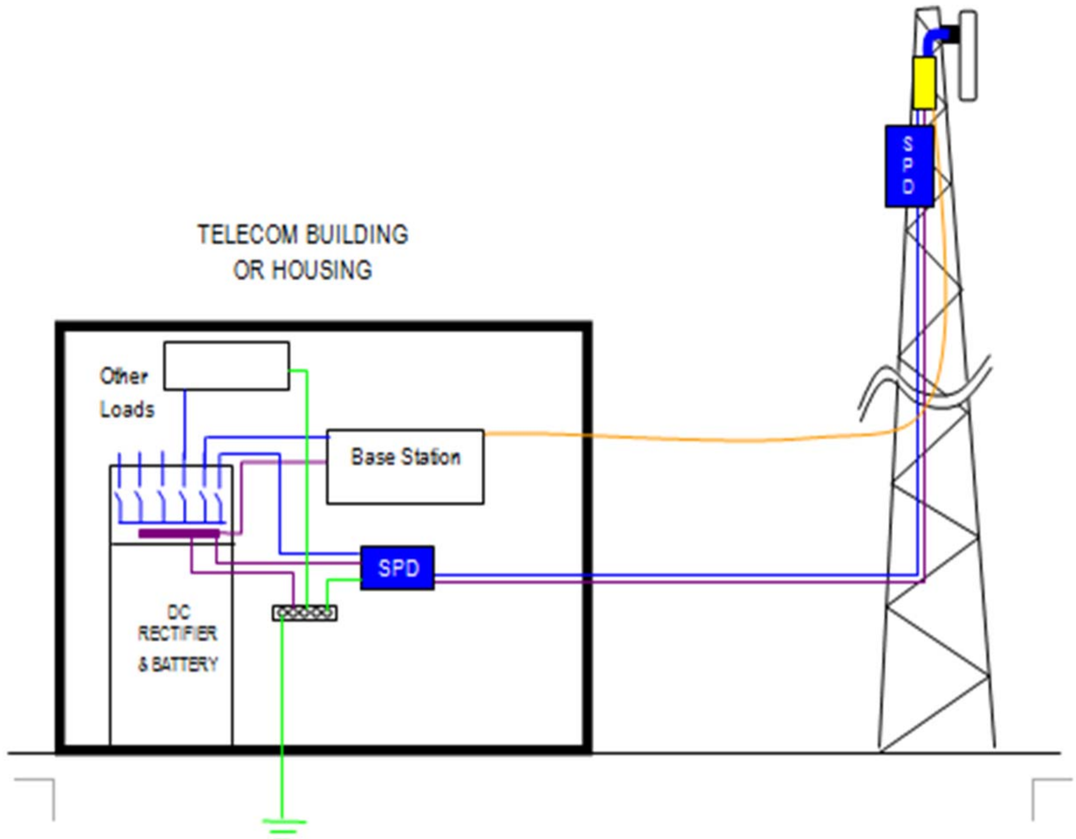
Scenario 3

SPD is mounted very close to the ground bar via a small piece of cable.

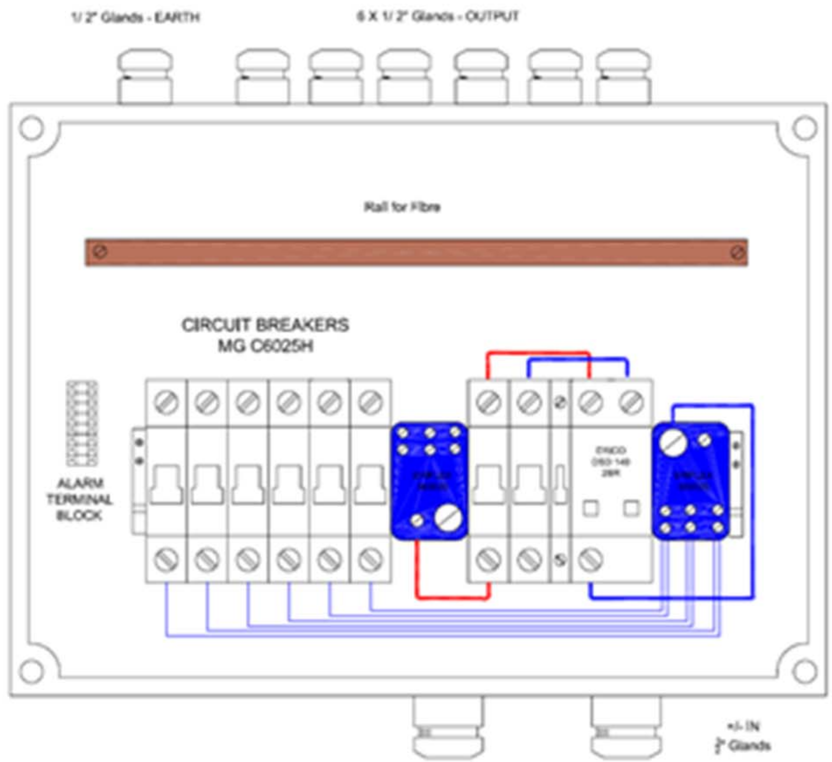
The feed to the antennae is from distribution close to SPD

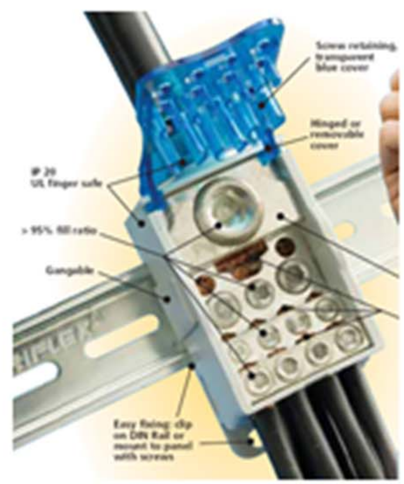
The short distance from the ground bar allows the control of the voltage at the SPD.

The non existence of paths via equipment eliminates risk of damage via ground loops.



DC SPD FOR RRU APPLICATION-LOCATION





DC SPD - SIZING

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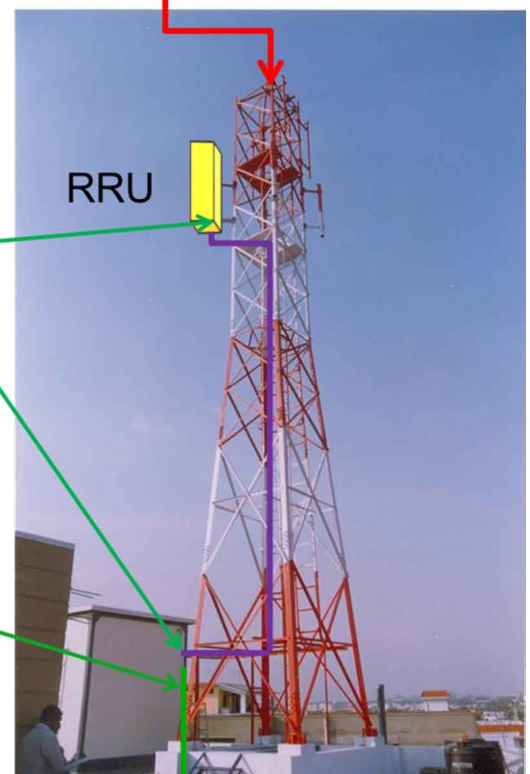
IEEE 100kA (8/20)
IEC 100-200 kA (10/350)

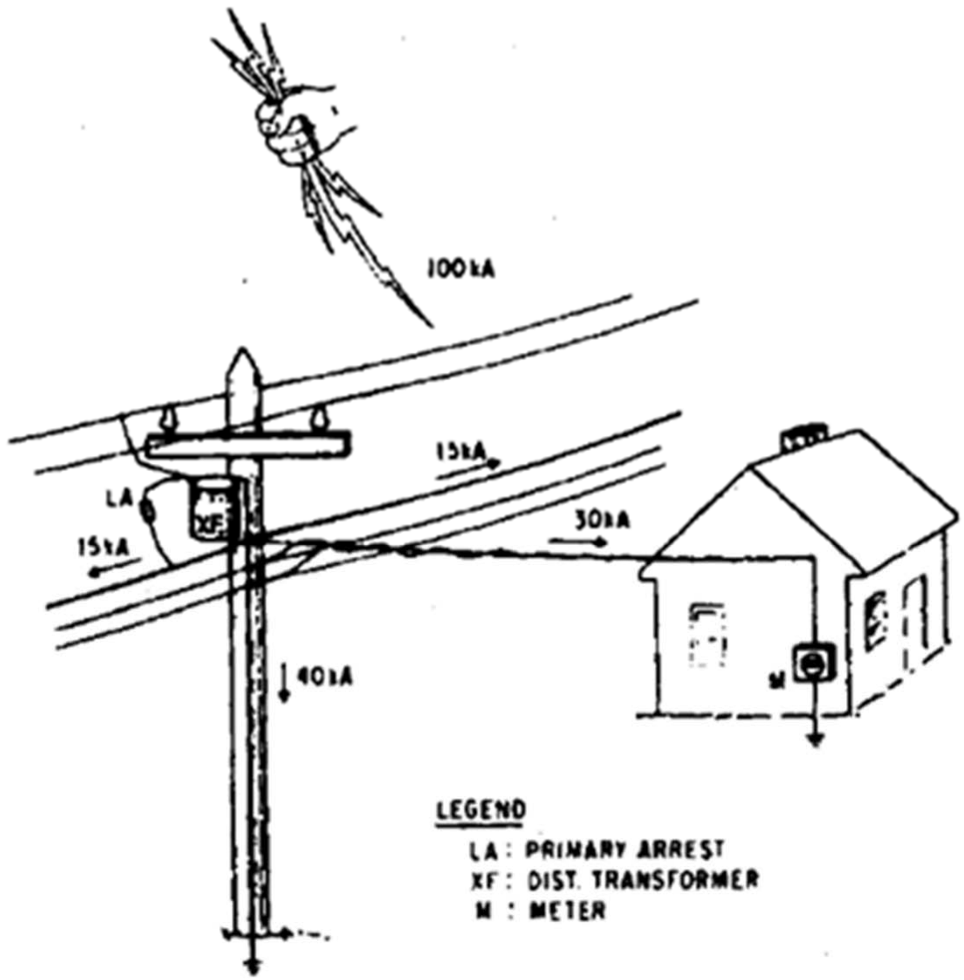
Sizing requirements on SPD here (AC fed or – 48V fed) Per cable and per wire?



Sizing requirements on SPD here as it enters the building

Any Impact on Sizing of AC SPD On Incoming Power

IEE C62.41 IEEE Guide on Surge Environment in Low Voltage AC Power Circuits.



Analysis referred to in IEEEC62.41.1 demonstrates that the highest possible surge entering a building is 30 kA across all the wires. Of course this would split across the wires and depending on the number of phases, the typical the peak current expected on a phase is 10 kA.

Source: Martzloff and Crouch 1978 [B117]

DC SPD - SIZING

Table 1 – Lightning flash parameters from [IEC 62305-1]

Parameter	Unit	LPL			
		I	II	III	IV
Maximum peak current	kA	200	150	100	100
Maximum current rate of rise	kA/µs	200	150	100	100
Radius of electro-geometric sphere	m	20	30	45	60
Probability of flash	%	99	98	95	90

NOTE – The risk assessment may indicate an LPL for the design of the LPS that is different from the LPL considered for the design of the other protection procedures.

DC SPD SIZING - K56 SPD for LIGHTS

If the conductors supplying power to the tower lights are unshielded and installed without a metallic tube, it is necessary to install SPDs close to the lighting hardware and at the point where the conductors enter the building, as described in clause 6.2.2.3. These SPDs shall comply with [IEC 61643-1] and have current rating complying with Table 4.

Table 4 – 8/20 µs single-pulse peak current of SPD for unshielded lighting cable

LPL	I	II	III – IV
Current (kA)	40	30	20

NOTE 2 – If the power to the tower lights is supplied with AC voltage from the electric board, the SPD installed at the building entrance (on the conductor supplying power to the tower lights) shall be coordinated with the SPD installed in the electric board. Refer to [IEC 61643-12] for the relevant information.

NOTE 3 – If the power to the tower lights is supplied with DC voltage from an AC/DC converter, an SPD set may be necessary at the AC/DC converter. Refer to clause 8 in order to assess the need for this SPD set.

DC SPD SIZING - IEC62305-1

Looking at table E.2 of Annex E (Next Slide) , we find that the expected value of the surge due to coupling for a line directly exposed to a partial direct lightning current, which is the case of the RRU line mounted along the tower leg

- Class III LPL would be 5kA 10/350us
- Class I-II LPL would be 10kA 10/350us

This would divide across the DC Feeds.

As a minimum for one feed with two wire it would be 10kA Divided by 2 (2 wires + and -) which is 5 kA 10/350

This is equal to a MOV device of approximately 40-50 kA 8/20us rating

E.2.1 Surges due to flashes to services (source of damage S3)

For direct lightning flashes to connected services, partitioning of the lightning current in both directions of the service and the breakdown of insulation must be taken into account.

The selection of the I_{imp} value can be based on values given in Table E.2 where the preferred values of I_{imp} are associated with the lightning protection level (LPL).

Table E.2 – Expected surge overcurrents due to lightning flashes

LPL	Low voltage systems			Telecommunication lines		
	Flash to the service	Flash near the service	Near to, or on the structure	Flash to the service	Flash near the service	Near to, or on the structure
	Source of damage S3 (direct flash) Waveform: 10/350 µs (kA)	Source of damage S4 (indirect flash) Waveform: 8/20 µs (kA)	Source of damage S1 or S2 (induced current only for S1) Waveform: 8/20 µs (kA)	Source of damage S3 (direct flash) waveform: 10/350 µs (kA)	Source of damage S4 (indirect flash) measured: 5/300 µs (estimated:8/ 20 µs) (kA)	Source of damage S2 (induced current) Waveform: 8/20 µs (kA)
III-IV	5	2,5	0,1	1	0,01 (0,05)	0,05
I-II	10	5	0,2	2	0,02 (0,1)	0,1

For shielded lines, the values of the overcurrents given in Table E.2 can be reduced by a factor of 0,5.

NOTE It is assumed that the resistance of the shield is approximately equal to the resistance of all service conductors in parallel.

DC SPD SIZING - ITU K56 APPENDIX and BARBOSA PAPER

CURRENT DISTRIBUTION IN A TELECOMMUNICATION TOWER STRUCK BY ROCKET-TRIGGERED LIGHTNING

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Fig.3 - Tower top with rocket platform

CURRENT DISTRIBUTION IN A TELECOMMUNICATION TOWER STRUCK BY ROCKET-TRIGGERED LIGHTNING

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Fig.4 - Flash triggered at 4th Feb. 2005

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6 CONCLUSION

When a metallic telecommunication tower is struck by lightning, most of the return stroke current flows through the tower's metallic elements (legs and cross-arms), and only a small fraction of the current flows through the feeder cables. In the experiments carried out with a standard radio base station complying with ITU-T Rec.56 [4], about 2% of the return stroke current flowed through each feeder cable. This value is in agreement with the theoretical value predicted by Rec.K.56, indicating that the current distribution is governed by the inductances of the conductors, instead of the resistances. The wave shape of the feeder current is influenced by the front time of the return stroke current, as a short front time (relative to the tower's transit time) leads to a pronounced peak on the feeder current, and this peak is almost absent in the case of a long front time. Apparently, the variation of the

DC SPD SIZING - K56 BARBOSA EXPERIMENT

If the worst case lightning discharge under IEC62305 was 200kA at PL 1

<u>EXPERIMENTALLY</u>

And 2% of this could flow on feeders on cable ladders then the expected surge on the DC Feeds would be 4 kA

DC SPD SIZING - K56 CALCULATIONS

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If the worst case lightning discharge under IEC62305 was 200kA at PL 1.

USING ITU K56 Calculations : Surge Current = $I_{LPL}\,\alpha_T\alpha_F$

Where :

I_{LPL} = Maximum Peak Current at a particular LPL

α_T = Shielding factor provided by tower (0.20 for 3 legged tower)

α_F = Shielding factor provided by cable trays (0.15 for Cable Tray)

Hence Surge Current at Highest Possible Peak Current = 200 x 0.20 x 0.15 = 6kA.

CONSERVATIVE COMPARED WITH EXPERIMENT

SUMMARY OF SIZING BENCHMARKS

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STANDARD	WORST CASE RATING (8/20)	COMMENTS
IEEE C62.41	30kA 2-3kA	30 kA if we said the case was same as AC 2kA (2%) If we accounted for Barbossa’s and ITU shielding
IEC62305	40 – 50 kA	Apply same analysis as on AC
ITU K56	40kA	ITU Model for Aviation Lights
ITU Barboss Experiment	40kA (4kA 10/350)	4% of 200kA
ITU K56	60kA (6kA)	Using Shielding Formulas

DC SPD – TESTING

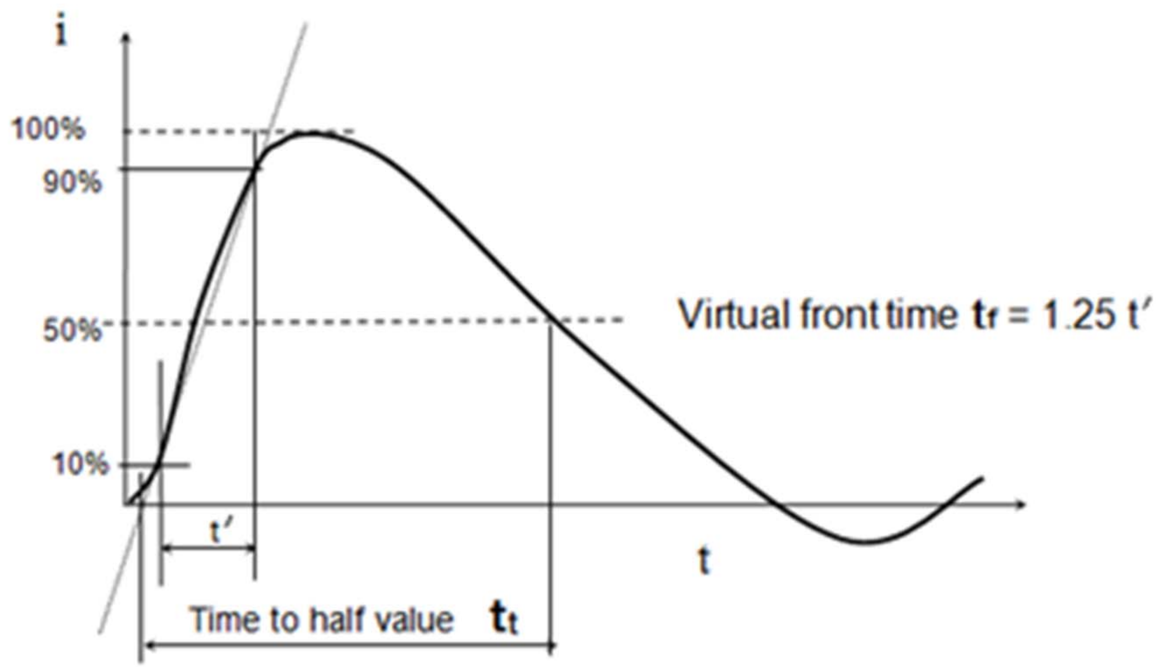
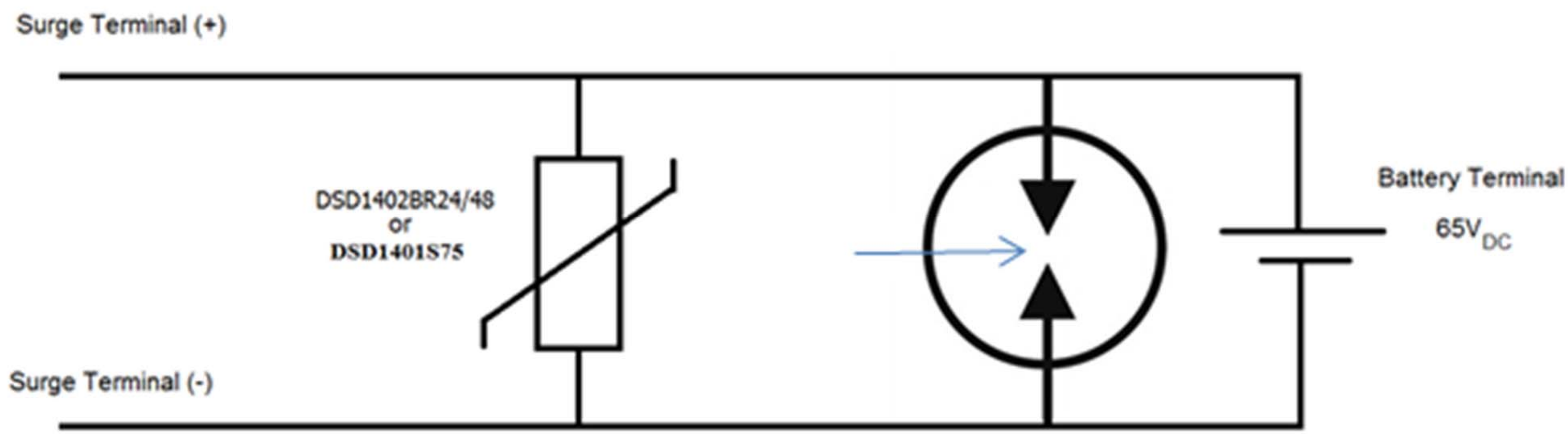
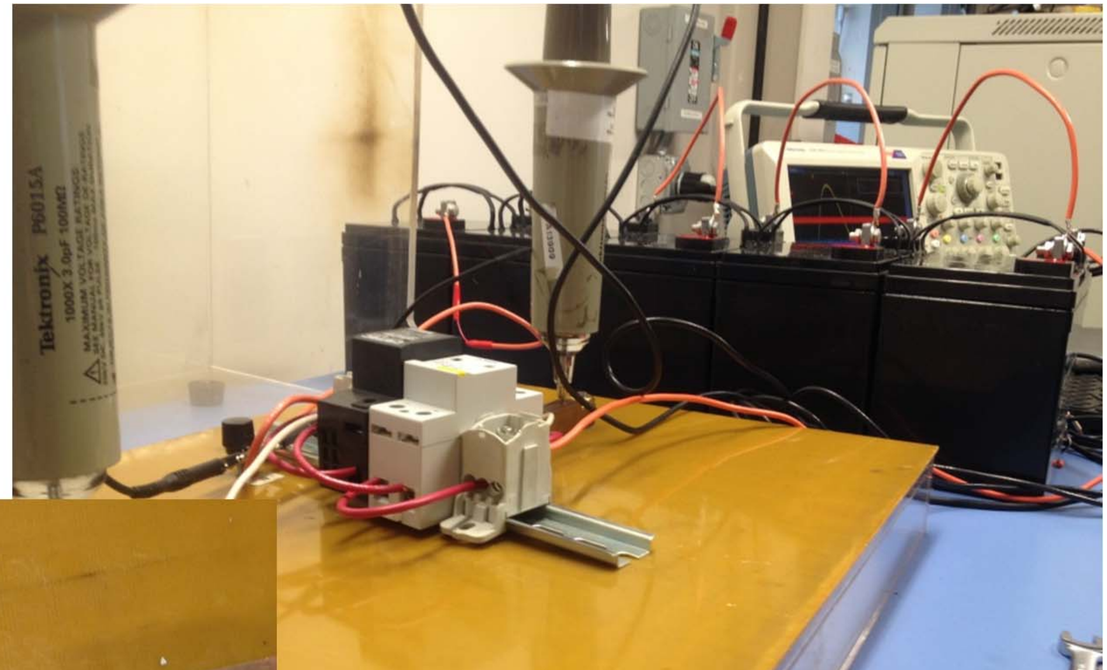


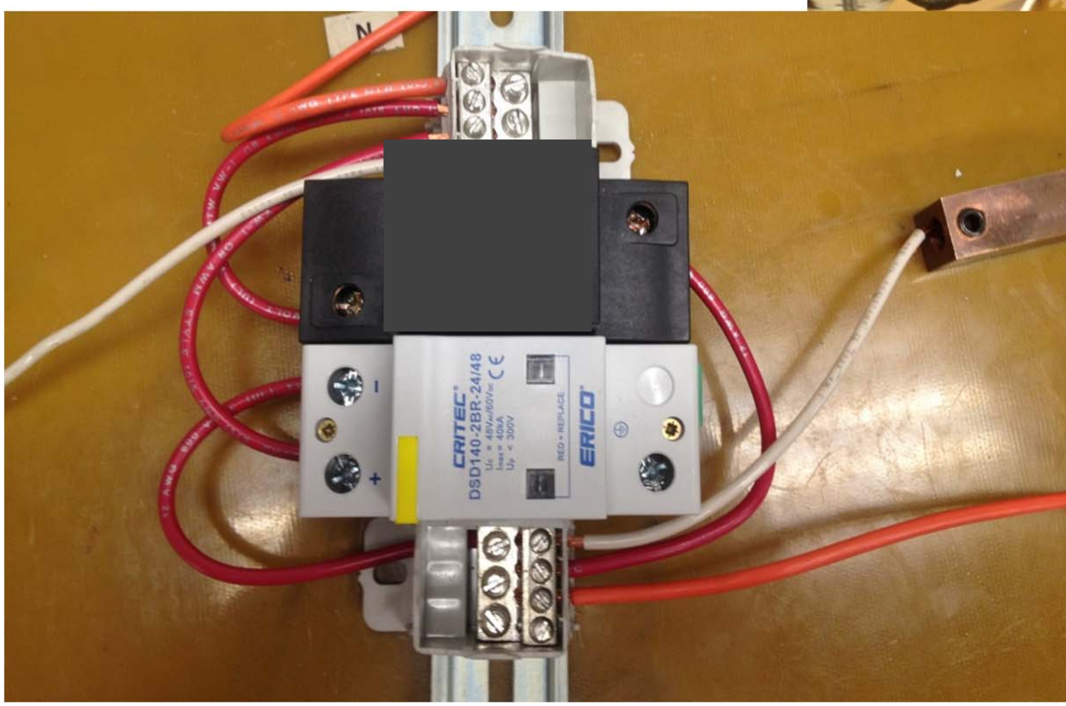
Figure 1: An 8/20 µs waveform

DC SPD – TESTING



DC SPD – TESTING





DC SPD – TESTING

	$I_{desired}$		I_{meas}		V_{LT}		Waveform	
TSG1103S2	3	kA	2.91	kA	1.380	kV	015	.wav
TSG1103S2	20	kA	20.6	kA	0.920	kV	051	.wav
DSD1401S-75	3	kA	2.91	kA	0.292	kV	024	.wav
DSD1401S-75	20	kA	20.4	kA	0.560	kV	062	.wav
DSD1402BR24/48 (+ to -)	3	kA		kA	0.280	kV		.wav
DSD1402BR24/48 (+ to -)	20	kA	20.9	kA	0.730	kV	007	.wav
DSD1402BR24/48 (+ to G)	3	kA		kA	0.870	kV		.wav
DSD1402BR24/48 (+ to G)	20	kA	19.1	kA	1.740	kV	005	.wav
DSD1402BR24/48 (- to G)	3	kA		kA	0.830	kV		.wav
DSD1402BR24/48 (- to G)	20	kA	20.1	kA	1.820	kV	006	.wav
TSG & DSD1401S-75	20	kA	20.6	kA	0.540	kV	060	.wav
TSG & DSD1402BR24/48 (+ to -)	20	kA	20.6	kA	0.440	kV	050	.wav
TSG & DSD1402BR24/48 (+ to G)	20	kA	19.8	kA	1.110	kV	063	.wav

DC SPD – TESTING CONCLUSION

- APPLICATION LOCATION OF DC SPD IS NOT TRIVIAL MATTER AND NEEDS THOUGHTS
- STANDARDS AND METHODS STILL DEVELOPING
- SOME GOOD BENCHMARK FOR SIZING EXIST BUT NOT SPECIFICALLY FOR DC SPD FOR RRU
- TESTING OF DC SPD CAN ALSO BE A TRICKY SUBJECT AND NOT TRIVIAL

VERY IMPORTANT AS IT CAN DAMAGE RECTIFIERS AND OTHER EQUIPMENT