

# Calculating the Lightning Protection System Downconductors' Grounding Resistance at Launch Complex 39B, Kennedy Space Center, Florida



Dr. Carlos T. Mata

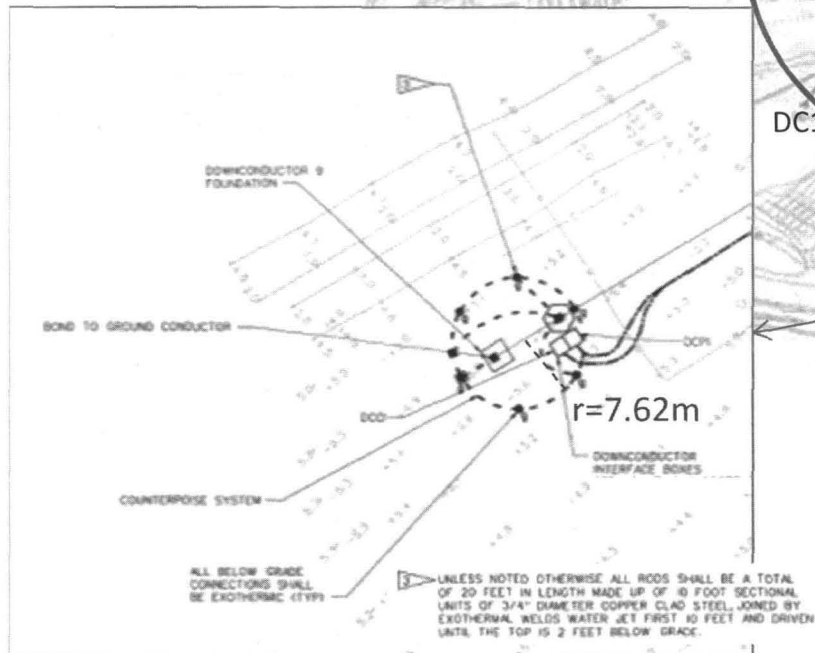
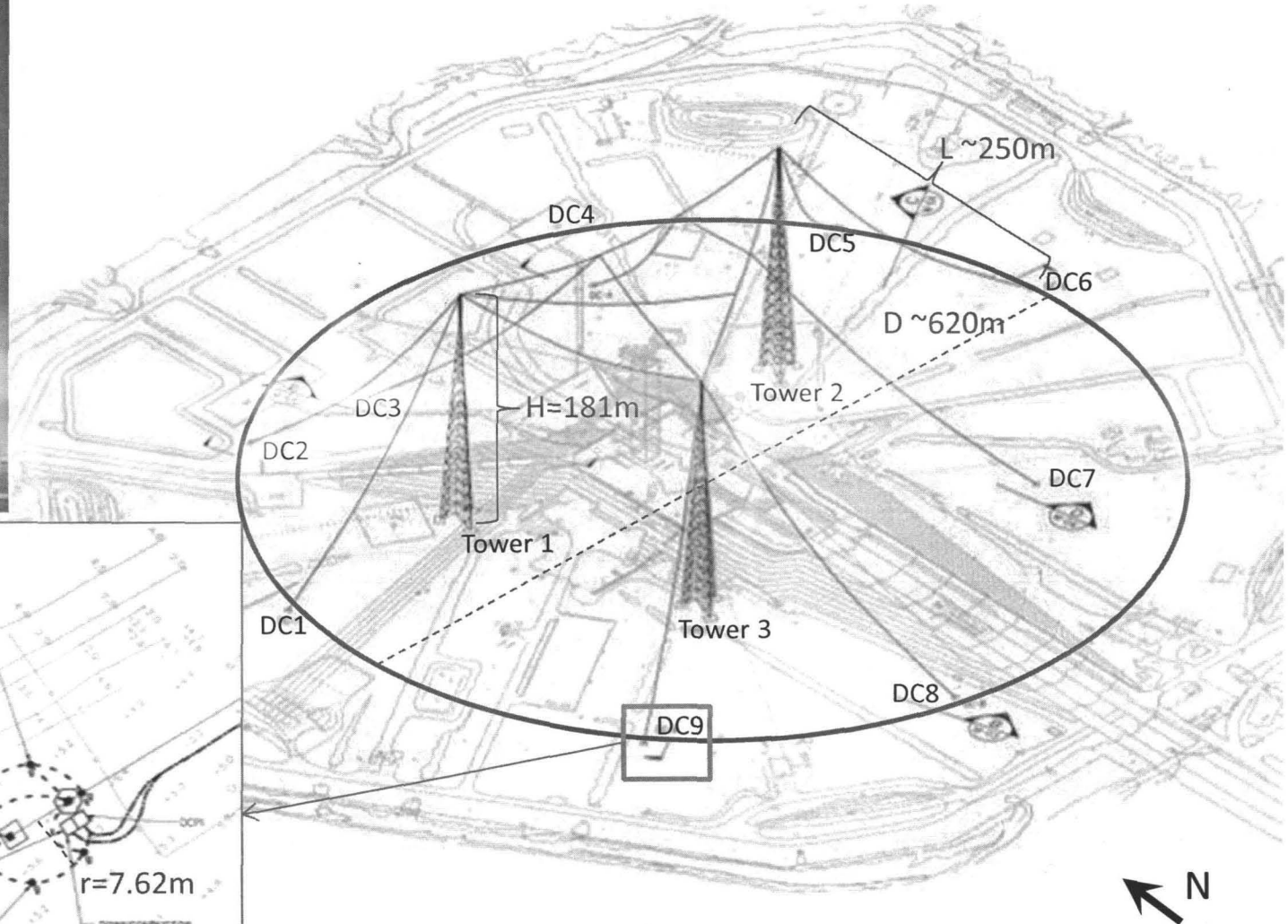
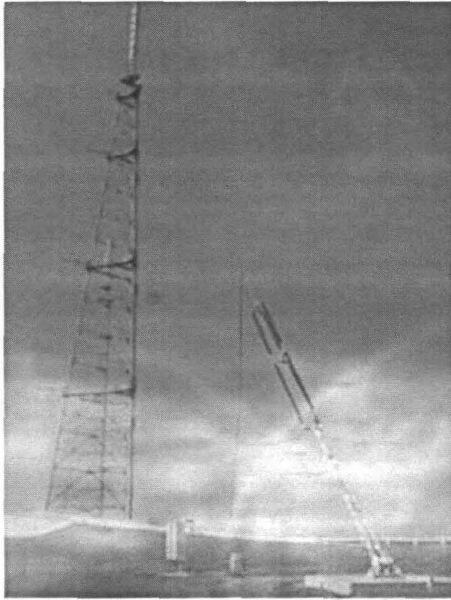
WX Lead

Angel G. Mata

WX

2012

# LC39B LPS



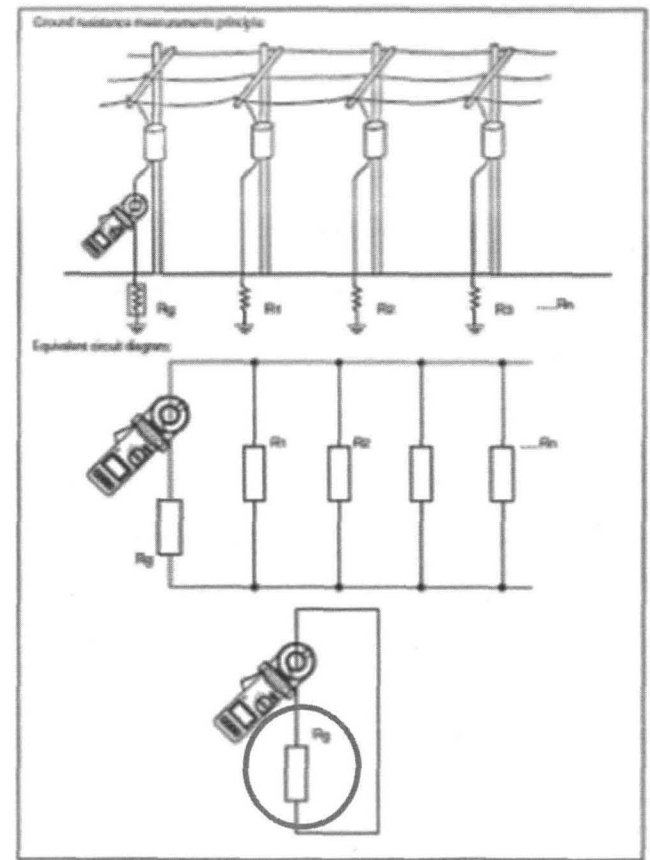
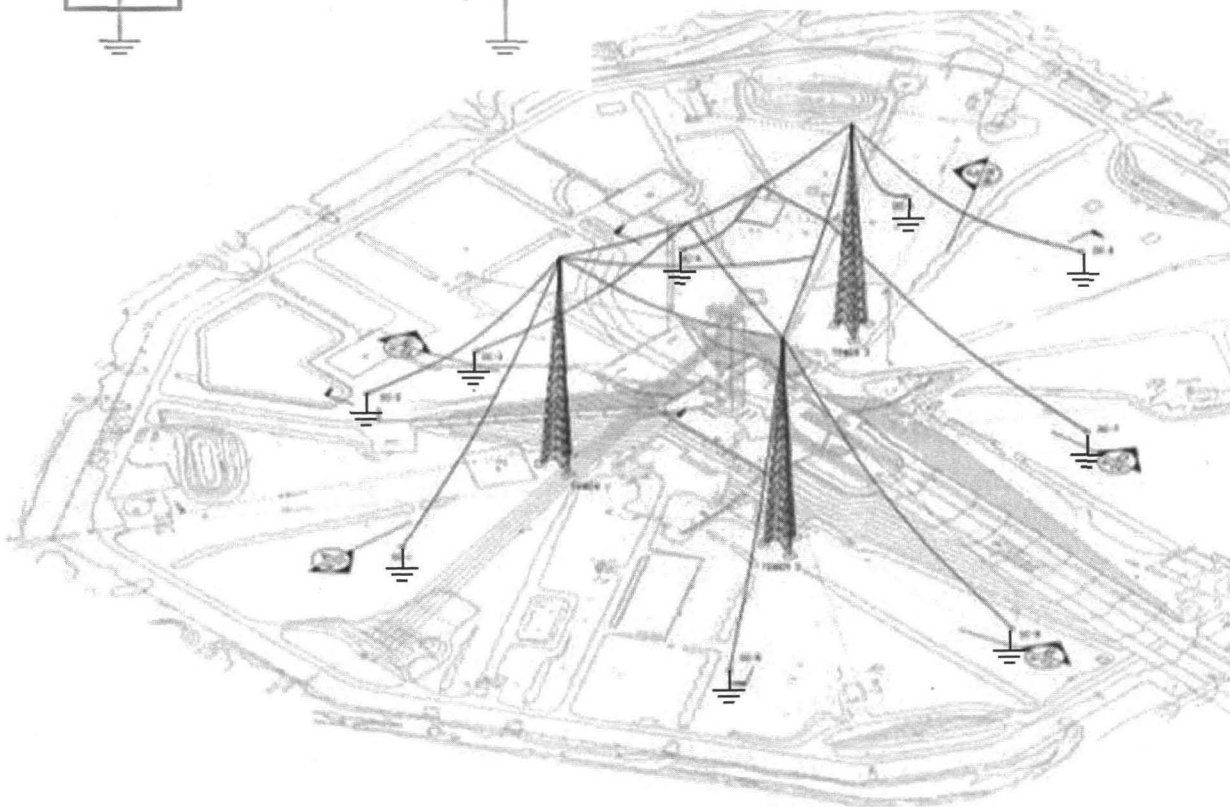
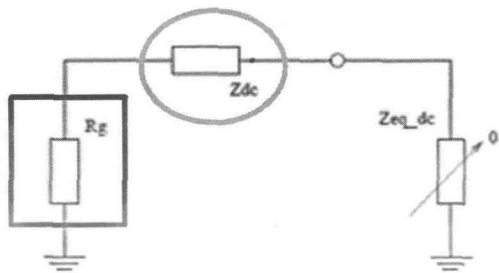
Three Towers  
Nine Downconductors

# FLUKE 1630 EGC

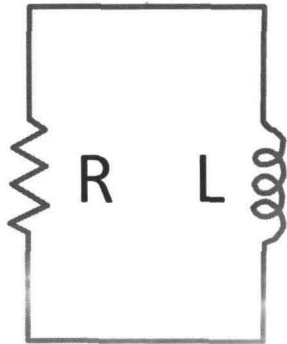


## Stakeless Ground Impedance Measurement of Ground Systems in Parallel

LC39B LPS has:  
Nine grounded downconductors  
Each about 250m long



# FLUKE 1630 EGC Measurements



RL Circuit Impedance

EGC Measurement

$$Z = 12.57 \, \Omega \angle 9.49^\circ$$

12.9  $\Omega$

$$Z = 12.68 \, \Omega \angle 50.18^\circ$$

13.5  $\Omega$

$$Z = 12.58 \, \Omega \angle 83.29^\circ$$

13.6  $\Omega$

FLUKE 1630 EGC Overestimates the loop impedance of the RL circuit by:

3%     $R \gg X$

7%     $R \approx X$

8%     $R \ll X$

# Backups – EGC Measurements



Downconductor Number	EGC Measurement, <i>ClampMeas</i> [ $\Omega$ ]						
	2010			8/25/2011 - 4/26/2012			
	<i>Aug. 27<sup>th</sup></i>	<i>Oct. 13<sup>th</sup></i>	<i>Dec. 02<sup>nd</sup></i>	<i>Average</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Std. Dev. (x100)</i>
1	12.46	12.42	12.72	12.42	12.54	12.33	4.986
2	12.26	12.21	12.53	12.26	12.36	12.16	4.884
3	12.51	12.45	12.75	12.53	12.62	12.39	5.602
4	12.37	12.28	12.53	12.26	12.39	12.15	5.887
5	12.40	12.33	12.61	12.36	12.51	12.25	6.759
6	12.19	12.15	12.37	12.14	12.28	12.01	6.681
7	13.62	13.55	13.79	13.52	13.70	13.31	8.678
8	13.62	13.47	14.26	13.77	13.94	13.60	9.306
9	13.29	13.19	13.39 <sup>a</sup>	13.26	13.36	13.15	4.931

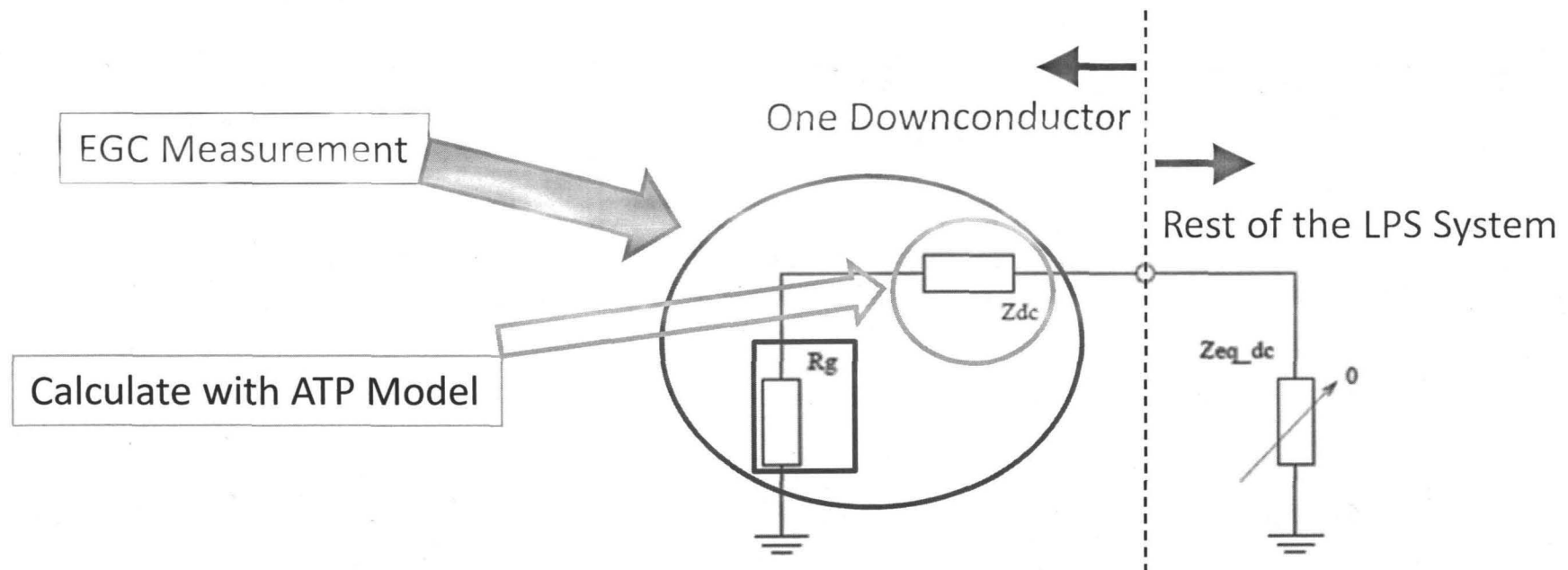
a. This measurement was taken on 11/23/2010.

# Downconductors' Ground Resistance



Calculate  $R_g$  from:

FLUKE 1630 EGC Measurements and ATP Model



$$Z_{dc} = R_{dc} + X_{dc}$$

$$\text{EGC Measurement}^2 = (R_g + R_{dc})^2 + X_{dc}^2$$



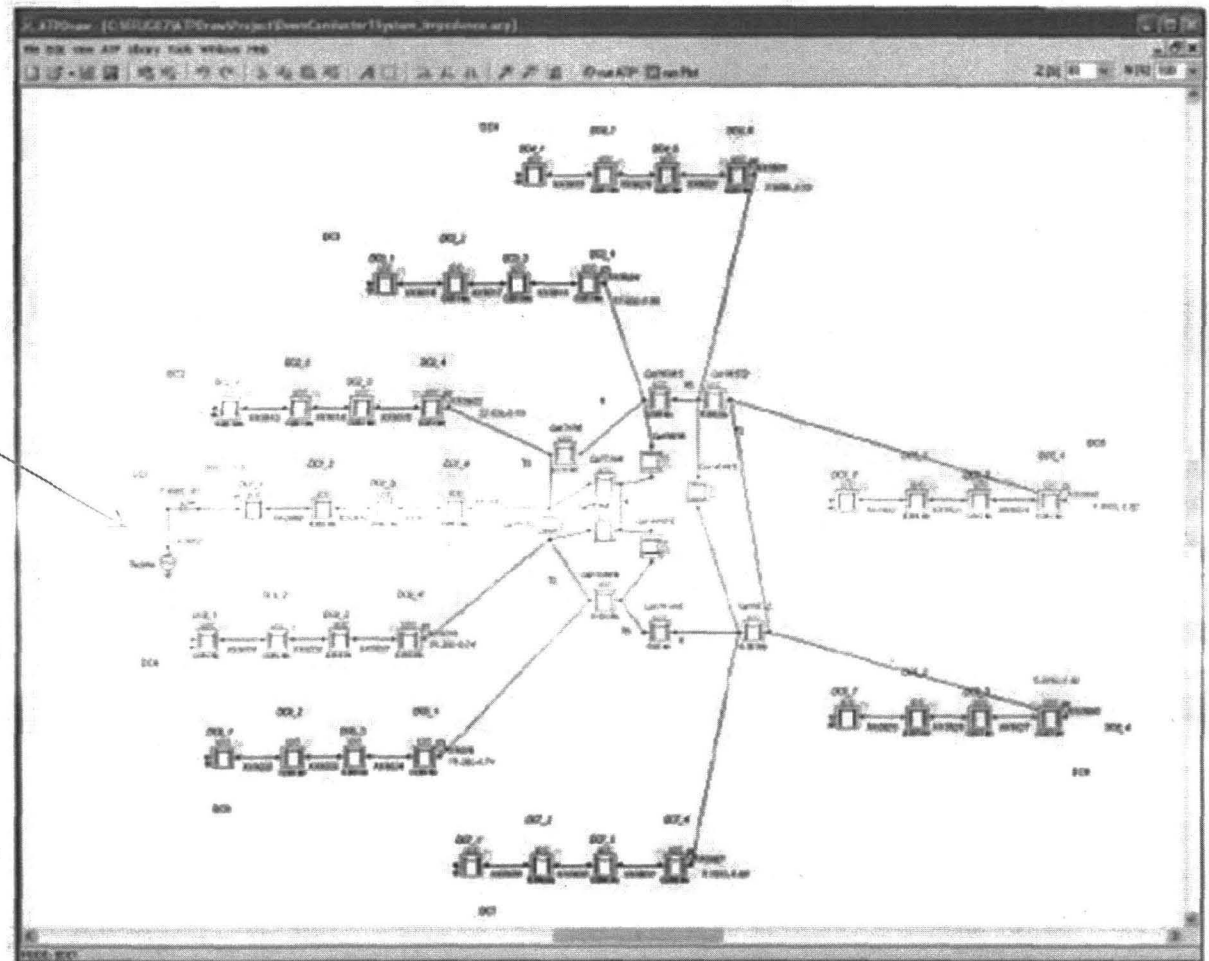
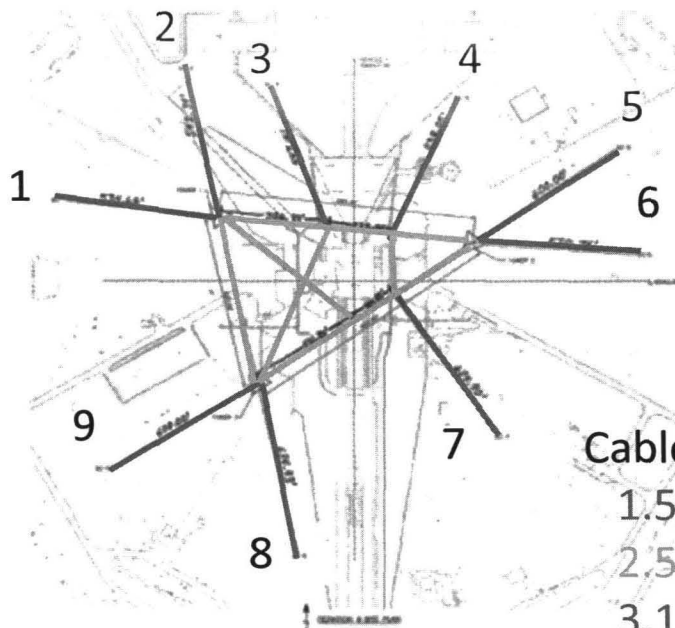
The screenshot shows a Simulink model of a multi-stage DC-DC converter. The main model window displays a power source (10 A/400 V) connected to a resistor (100000 ohms) and a series of four DC-DC converter blocks (DCDC\_1, DCDC\_2, DCDC\_3, DCDC\_4). Arrows from the caption point to these blocks. An inset window titled 'Scope' shows a plot of the output voltage 'v' over time 't' from 0 to 1.0 seconds. The plot displays a high-frequency switching waveform (blue) and a lower-frequency ripple waveform (red). A table of parameters is also visible in the bottom left corner of the screenshot.

Table	
DCDC1_converter_1_parameters	
1.750000e-04	
7.0e-05	
1.0e-14	
Initialization	

# ATP Model-LC39B LPS



Impedance calculation for  
Downconductor 1



Cables' Diameter:

1.5875 cm (5/8 inch)

2.54 cm (1 inch)

3.175 cm (1 ¼ inch)

# Downconductors' Ground Resistance



Downconductor Number	Individual Downconductor ATP Model				Full LPS System ATP Model			
	$ Z_{dc} $ [ $\Omega$ ]	$\Phi Z_{dc}$ [Degrees]	$R_g$ [ $\Omega$ ]		$ Z_{dc} $ [ $\Omega$ ]	$\Phi Z_{dc}$ [Degrees]	$R_g$ [ $\Omega$ ]	
			Approx. <sup>a</sup>	Calc. <sup>b</sup>			Approx. <sup>a</sup>	Calc. <sup>b</sup>
1	9.7276	85	7.7862	6.9844	9.7333	85.0526	7.7791	6.9848
2	9.7943	85	7.3742	6.5698	9.7953	85.0522	7.3729	6.5764
3	10.6219	81.9	6.5603	5.2289	10.6521	81.9004	6.5600	5.2287
4	10.5820	81.9	6.4061	5.0863	10.5820	81.9446	6.4060	5.0925
5	10.2754	85	6.9409	6.1029	10.2769	85.0032	6.9388	6.1011
6	10.0351	85	6.9204	6.1009	10.0354	85.0064	6.9200	6.1014
7	11.3792	81.9	7.4846	6.0511	11.3792	81.9446	7.4845	6.0579
8	10.5955	85	8.5581	7.6842	10.5954	85.0308	8.5581	7.6894
9	10.2754	85	8.4283	7.5804	10.2760	85.0320	8.4278	7.5847

$$a. R_{dc} = 0 \rightarrow R_g = \sqrt{EGC^2 - X_{dc}^2}$$

$$b. EGC^2 = (R_g + R_{dc})^2 + X_{dc}^2$$

# Conclusions

---



## **FLUKE 1630 EGC, stakeless ground resistance measurement device:**

- Measures ground loop impedances
- Overestimates the ground loop impedance by up to 8% (mostly inductive circuits)
- ATP models can be used to calculate the theoretical loop impedance and, together with the EGC measurements, obtain a better estimation of the individual ground resistances on a parallel to earth grounding system
- Loop impedance values from ATP model of the full LC39B LPS (parallel to earth grounding system) or individual ground conductors are very comparable

# Thank you



**Q  
U  
E  
S  
T  
I  
O  
N  
S**

