

# Testing Tips How to build polygonal zones in Test Universe

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#### Summary

This document will outline how to build polygonal zones in Test Universe using the Test Object's "Distance" function. The use-case will be for the SEL-T401L; but can be applied to any polygonal impedance zone shape.

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# **1** Polygonal Zones in the SEL-T401L

### 1.1 Forward Zones

For the SEL T401L, the forward "quad" zones are actually pentagons. See the instructions below from the user manual. This is relevant for both ground and phase zones.



### **1.2** Reverse Zones

The reverse zones are quadrilateral, and are configured in the following way:



# 2 Making Polygonal Zones in Test Universe

### 2.1 Settings

The following settings, taken from AcSELerator, are going to be our guide for building the zones.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Range
EZPn Enable Zone n Phase Distance	MHO v	MHO v	MHO v	MHO v	MHO v	OFF, MHO, QUAD
EZGn Enable Zone n Ground Distance	QUAD ~	QUAD ~	QUAD ~	QUAD V	QUAD ~	OFF, MHO, QUAD
ZDIRn Zone n Direction	F v	F v	R v	F v		F, R (F - Forward, R - Reverse)
Phase Distance						
ZPn Zone n Phase Distance Reach	6.02	13.52	11.99	13.52	18.90	0.05 to 64.00 (ohms, sec)
ZPnR Zone n Phase Distance Resistive Reach	7.80	7.80	7.80	7.80	7.80	0.05 to 64.00 (ohms, sec)
ZPSREV Zone 5 Phase Distance Reverse Reach					1.56	0.05 to 64.00 (ohms, sec)
ZPnTANG Zone n Phase Distance Reactance Tilt Angle	-7.0	7.0	7.0	7.0	7.0	-25.0 to 25.0 (deg)
ZPn_S0PP Zone n Phase Distance Phase-Phase Overcurrent Pickup	0.50	0.50	0.50	0.50	0.50	0.50 to 150.00 (A, sec)
Plot						
Course d Distances	Forward		Reverse			
ZSC Zero-Sequence Compensation Method [ADVS]						AUTO, MANUAL
cOMn Zone n Zero-Sequence Compensation Factor Magnitude	0.686	0.686	0.685	0.686	0.686	0.000 to 10.000
OAn Zone n Zero-Sequence Compensation Factor Angle	-4.46	-4.46	-4.46	-4.46	-4.46	-180.00 to 180.00 (deg)
ZGn Zone n Ground Distance Reach	6.02	13.52	11.99	13.52	18.90	0.05 to 64.00 (ohms, sec)
ZGnR Zone n Ground Distance Resistive Reach	22.81	51.25	41.05	51.25	64.00	0.05 to 64.00 (ohms, sec)
2GSREV Zone 5 Ground Distance Reverse Reach					1.56	0.05 to 64.00 (ohms, sec)
ZGnTANG Zone n Ground Distance Reactance Tilt Angle	-7.0	7.0	7.0	7.0	7.0	-25.0 to 25.0 (deg)
Gn_50P Zone n Ground Distance Phase Overcurrent Pickup	0.50	0.50	0.50	0.50	0.50	0.50 to 100.00 (A, sec)
ZGn_50G Zone n Ground Distance 310 Overcurrent Pickup	0.50	0.50	0.50	0.50	0.50	0.50 to 100.00 (A, sec)
	4.00	4.54		v	4.54	

The line parameters are 7.5 Ohms at 75 degrees.

- The **Forward Zone** has a reach (*ZGn*) of **6.02 Ohms** and a resistive reach (*ZGnR*) of **22.81 Ohms**. Ground distance reactance tilt angle (*ZGnTANG*) is set to **-7.0 degrees**.
- The **Reverse Zone** has a reach (*ZGn*) of **11.99 Ohms** and a resistive reach (*ZGnR*) of **41.05 Ohms**. Ground distance reactance tilt angle (*ZGnTANG*) is set to **7.0 degrees**.

### 2.2 Setup

In Test Universe, under the "Distance" function in the Test Object, navigate to the "Zone" tab. When you select "New" then "Edit," the Characteristic Editor window will appear.

Characteristic	Editor - [Z3 All]						-	•	×
- Shape Construction -		N/O							
Elements	Drawing								
		7.5 -							
Add	Mutoclose	5.0 -							
Insert	🗌 Invert all	2.5 -							
Remove									
		0.0							
	L	-2.5 -							
Predefined Shapes -		-5.0 -							
	5	-7.5 -							
$()   \phi$									
		-10.0						•	•
			-10.0	-0.0	0.0	6.0		R/Ω	
Element list:								-	
									<u>.</u>
1									V.
						ок	Car	ncel	

After Clicking "Add," change your type to Line Cartesian. This is the type we will use to make a polygon in the editor.

Element list:									
	1								
Line cart	esian		$\sim$						
R		0.0	Ω 00						
х		0.0	Ω 00						
Angle		0.	° 00						
Inverted									

>

>

- > The R value shifts the center of the line on the X-Axis
  - The X value shifts the center of the line on the Y-Axis
  - The angle changes the tilt of the line

Using this info, we can now start to add the sides of the polygon zone.

### 2.3 Building the Forward Zone

Start with the line going through origin and work counterclockwise. Be sure to set the R or X values according to the diagrams on Page 1.

#### 2.3.1 Line 1



There is no shift to the line, it goes through origin.

According to the user manual, it is set to a - **20 degree** angle.

#### 2.3.2 Line 2

Characteristic Edit	tor - [Z3 All]	- = ×
Shape Construction	Autodose Invert all	25 00
Element list:		
1 Line cartesian	2 Line cartesian	Â.
R 0.00 Ω	R 0.00 Q	
X 0.00 C	Χ -1.500 Ω	
Angle -20.00 * 7	Angle 0.00	
Inverted 🗌 I	Inverted	,
	OK	Cancel

The second line is a horizontal line shifted down on the Y-Axis by 20% of the positive sequence line impedance.

So: 7.5 x 0.2 = 1.5 Ohms down

#### 2.3.3 Line 3

Chara	d Shapes	3 Alij 2 - 2 - 0 - -2 - -4 - -8 - -10 - -12 -	2.5	5.0 7	.5 10.0 1	2.5 15.0	17.5 20.0		
Element list	:					_			
Line carte	cian v	Line carte	cian v	Line carte	3 scian				î
R	0.00 0	R	0.00 0	R		22.81 0			
X	0.00 Ω	Х	-1.500 Ω	х		0.00 Ω			
Angle	-20.00 °	Angle	0.00 °	Angle		75.00 °			
Inverted		Inverted		invertea	l				
							OK	Ci	v ancel

For the third line, shift it on the X-Axis by the "Resistive Reach" value.

So set R to 22.81 Ohms

The angle of the line is at the positive sequence line angle.

#### 2.3.4 Line 4

Chara	acteristic Ed	itor - [Z	3 All]				-	• ×
Shape Co	ts Di	awing	Ω.X					
1	Add	Autoclose	15 -					
Ir	Insert Invert all							
Re	Remove					+		
			0 -					
Predefine	ed Shapes		-5 -					
$\bigcirc$			-10 -					
				-25 -20	-15 -10 -5	0 5	10 15	R/Ω
Element list	t:							
Line carte	l	Line cart	2 esian	Line cart	3 esian	Line carte	4 esian	a î
R	0.00 (	R	0.00 Ω	R	22.81	R	1.5	58 Q
х	0.00 0	X	-1.500 Ω	Х	0.00 0	Х	5.8	15 Ω
Angle	-20.00	Angle	0.00 °	Angle	75.00	Angle	-7	.00 °
Inverted		Inverted		Inverted		inverted		_
								T
						OK	C	ancel
								.:

The line is centered around the end of the Zone 1 reach of 6.02 Ohms at 75 degrees. It is then set at an angle according to the "Reactance Tile Angle" setting.

So set Angle to -7 degrees

To find the X and Y coordinates for this point we need to do some trigonometry. Using the right triangle where the line length is the hypotenuse:

Y-Axis shift will be 6.02sin(75) = **5.815 Ohms** X-Axis shift will be 6.02cos(75) = **1.558 Ohms** 

#### 2.3.5 Line 5

Shape Cons Elements - Add Inse Remo	teristic Edi truction d rt sve	tor - [Z: wing Autoclose Invert all	3 All] XΩ 10 - 8 - 8 - 4 - 2 - 0 -					
-Predefined S	Shapes		-2 - -4 - -8 -	0.0 2.5	5.0 7.5	10.0 12.5 15.0	17.5 20.0	R/Ω
Jemerrense.	2		3		4		5	
Line cartesia	an 🗸	Line carte	sian 🗸	Line carte	esian	Line cart	esian	
R	0.00 Ω	R	22.81 Ω	R	1.5	58 🕻 R	-750	.0 mΩ
Х	-1.500 Ω	Х	0.00 Ω	Х	5.8	15 C X	(	Ω 00.0
Angle	0.00 °	Angle	75.00 °	Angle	-7	.00 Angle	9	° 00.00
Inverted		Inverted		Inverted		inverted		
4	-							

The final line is a vertical line shifted on the X-Axis by 10% of the positive sequence line impedance

So: 7.5 x 0.1 = **0.75 Ohms** 

### 2.4 Building the Reverse Zone

#### 2.4.1 Line 1

Charac	teristic Editor - [Z3 Al	]	- = ×
Shape Con Elements Ac Ins Rem	id Drawing	XimΩ 75 50 25 0 	
Predefined	Shapes	-50	50 75
Element list:			R/mΩ
	1		A
Line cartes	ian 🗸		
R	0.00 Ω		
X	0.00 Ω		
Angle	-20.00 °		
Inverted			
		OK	Cancel

The first line on the reverse zone is identical to the first line on the forward zone.

#### 2.4.2 Line 2

Charact	teristic Ed	tor - [Z	3 All]							-		×
Shape Cons	truction Dra	awing Autoclose Invert all	X/D 17.5 - 15.0 - 12.5 - 10.0 - 7.5 - 5.0 -	]								
Element list:	Shapes		2.5 - 0.02.55.0 -	-35	-30	-25	-20	-15	-10	-5	R/Ω	
Line cartesia	an 🗸	Line carte	esian									1
R	0.00 Ω	R	-41.05 Ω									
Х	0.00 Ω	Х	0.00 Ω									
Angle	-20.00	Angle	75.00 °									
Inverted		Invertea										v.
								OK		Ca	ncel	

The second line is shifted on the X-Axis by the "Ground Distance Resistive Reach" setting in the negative direction.

Set R to -41.05 Ohms

It is then shifted by the positive sequence line angle

Set Angle to 75 degrees

#### 2.4.3 Line 3

🗉 Chara	acteristic Edi	tor - [Z	3 All]				-		×
Shape Co Element Ir Re	Add ansert and Ansert	Autoclose Invert all	X/Ω 20 15 10 5 0 -5 -10 -15 -20 -25						
Element list		7		-40	-30 -20	-10 0	10	R/Ω	
	1		2		3			-	
Line carte	esian 🗸	Line carte	esian 🗸	Line cart	esian 🗸				1
R	0.00 Ω	R	-41.05 0	R	-3.103 Ω				
Х	0.00 Ω	Х	0.00 0	Х	-11.58 Ω				
Angle	-20.00 °	Angle	75.00	Angle	7.00 °				
Inverted		Inverted		Inverted					
									•
						ОК	C	ancel	

The third line is similar to the fourth line in the forward zone. It will require some trigonometry.

R value will be  $11.99\cos(75) = 3.103$  Ohms

X value will be 11.99sin(75) = **11.58 Ohms** 

The Angle will be 7 degrees per the setting.

Shape Cons Elements - Add Inse Remo	teristic Edi truction	tor - [Z wing Autoclose Invert all	3 All] X/D 10.0 7.5 5.0 0.0 -2.5 5.0		arning: shape (ele	ment 1) is	invalid!	
Element list:	Shapes		-7.5 -10.0 -12.5 -15.0 -17.5	-45	-40 -35 -30 -	25 -20	-15 -10 -5 R/C	2
Line cartesia	an v	Line cart	esian v	Line cart	esian 🗸	Line cart	esian v	
R	0.00 Ω	R	-41.05 Ω	R	-3,103 0	R	41.05 Ω	
X	0.00 Ω	Х	0.00 Ω	Х	-11.58 Ω	Х	0.00 Ω	
Angle	-20.00 °	Angle	75.00 °	Angle	7.00 °	Angle	75.00 °	
Inverted		Inverted		Inverted		invertea		
						OK	Cancel	

The fourth line in this zone brings in some additional complication, especially as it relates to the characteristic builder.

The manual says that it is a line shifted on the X-Axis according to the "resistive reach" setting. However, this value is greater than the intersection of Line 3 and Line 1, so it becomes obsolete.

If you attempt to add it to Test Universe anyways, the Characteristic Editor will give you an "Invalid" warning.

It is best (*in this case*) to not add the last side at all.

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