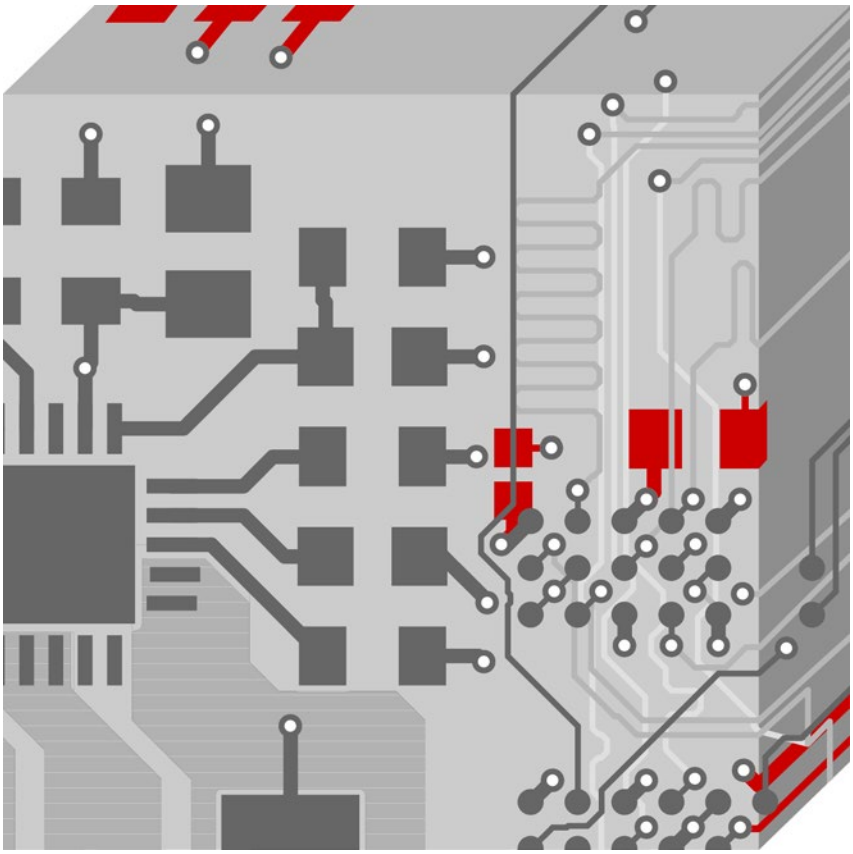
FlowCAD

Working with Differential Pairs



Allegro PCB Editor with Performance Option

Application Note | V2.0

FlowCAD

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1 Before You Start

This Application Note is based on the Application Note Start With Electrical Constraining.

For more details about electrical constraints, please check Cadence documentation and corresponding trainings like Allegro High Speed Constraint Management.

2 Definitions and Parameter

In this picture you see the differential pair section of the electrical workbook in Constraint Manager. In the following the different values for differential pairs will be explained.

diff_pairs_wiring_match_routed_done

Objects			Referenced Electrical CSet	Pin Delay		Uncoupled Length					Static Phase		
Type	S	Name		Pin 1 mm	Pin 2 mm	Gather Control	Length Ignored mm	Max mm	Actual mm	Margin mm	Tolerance mm	Actual	Margin
*	*	*	*	*	*	*	*	*	*	*	*	*	*
Dsn		diff_pairs_wiring_ma...								5.000			-0.87 mm
NGrp		BR(8)	50_OHM										
NGrp		NG1(8)	NG1										
DPr	M	DP_CLK1	DIFF			Ignore		5.000		5.000	1 mm		0.88 mm
Net		CLK1_N	DIFF			Ignore		5.000		5.000	1 mm		0.88 mm
RePP		J5.2:U8.19				Ignore	4.018	5.000	0.000	5.000	1 mm	0.12 mm	0.88 mm
Net		CLK1_P	DIFF			Ignore		5.000		5.000	1 mm		0.88 mm
RePP		J5.1:U8.20				Ignore	4.124	5.000	0.000	5.000	1 mm	0.12 mm	0.88 mm
DPr	M	DP_CLK2	DIFF			Ignore		5.000		5.000	1 mm		0.898 mm
Net		CLK2_N	DIFF			Ignore		5.000		5.000	1 mm		0.898 mm
RePP		U8.17:J5.4				Ignore	3.101	5.000	0.000	5.000	1 mm	0.102 mm	0.898 mm
Net		CLK2_P	DIFF			Ignore		5.000		5.000	1 mm		0.898 mm

2.1 Type

The field **Type** shows the type of the element. Here is a list of all possible types:

Abbreviation	Type	Abbreviation	Type
Dsn	Design	NCls	Net Class
DsnI	Design Instance	NCC	Net Class-Class
Lyr	Layer	Rgn	Region
PrtD	Part Definition	RCls	Region Class
PrtI	Part Instance	RCC	Region Class-Class
GtI	Gate Instance	Rslt	Result
Bus	Bus	PCS	Physical Constraint Set
MGrp	Match Group	SCS	Spacing Constraint Set
DPr	Differential Pair	SNSC	Same Net Spacing Constraint Set
Xnet	Extended Net	ECS	Electrical Constraint Set
Net	Net	RBnd	Ratsnest Bundle
PPr	Pin Pair	RPPr	Ratsnest Bundle pin pair Member

2.2 Objects

The **Object** field contains the name of the different objects. For example:
If the type is Design (DSN), in the object field the board file name is displayed.
Or if the type is ECS, the name of the Electrical Constraint Set is displayed.

2.3 Pin Delay

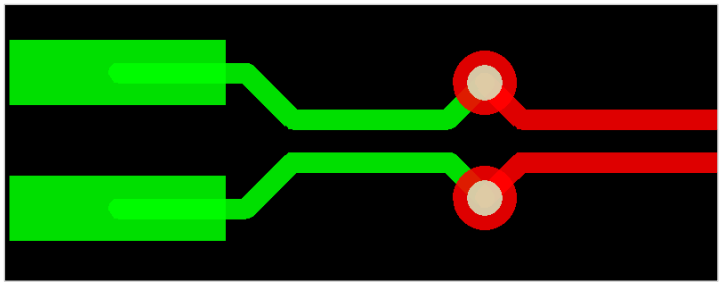
In the pin delay column, it's possible to set the delay insight the ICs on driver and also receiver side. Pin delays have to be taken from datasheets.

2.4 Uncoupled Length

Uncoupled Length contains the settings for the total etches length which is not routed using Primary or Neck Gap.

Gather Control

Gather Control defines if the last cline segments before entering a pad or via are added to the uncoupled length.



The possible settings are **Ignore** or **Include**.

Ignore	Uncoupled length for pad entry is not added (ignored) for the uncoupled length.
Include	Includes the uncoupled length for pad entry to the uncoupled length.

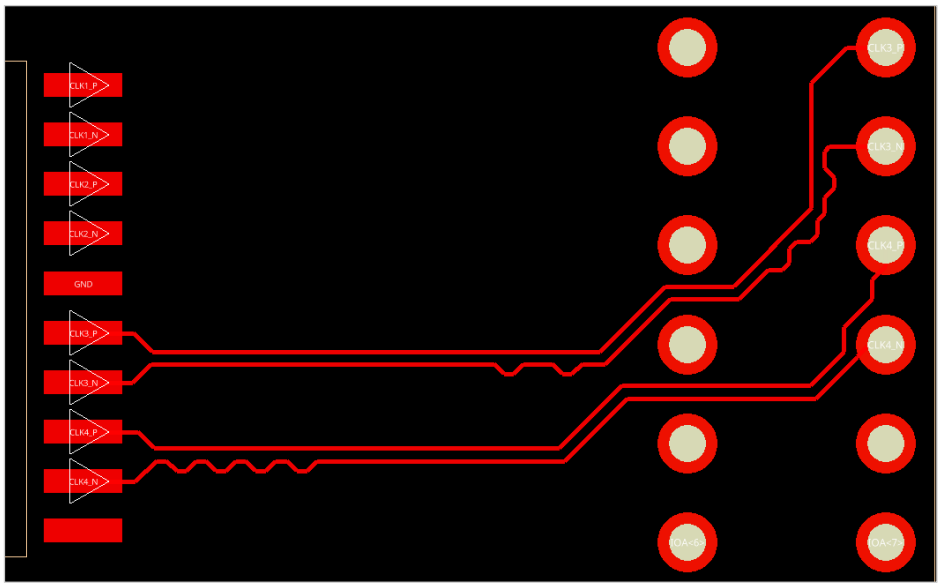
Max Uncoupled Length

Because of pad entries, it's almost impossible to route a differential pair without any uncoupled length. The max value defines the maximum total amount of uncoupled length of the differential pair.

2.5 Phase Control

2.5.1 Static Phase

The Static Phase controls the overall phase tolerance from driver to receiver. While compensation the phase difference, it does not matter where on the connect line the phase compensation is established. On both the diff pairs static phase is fulfilled.



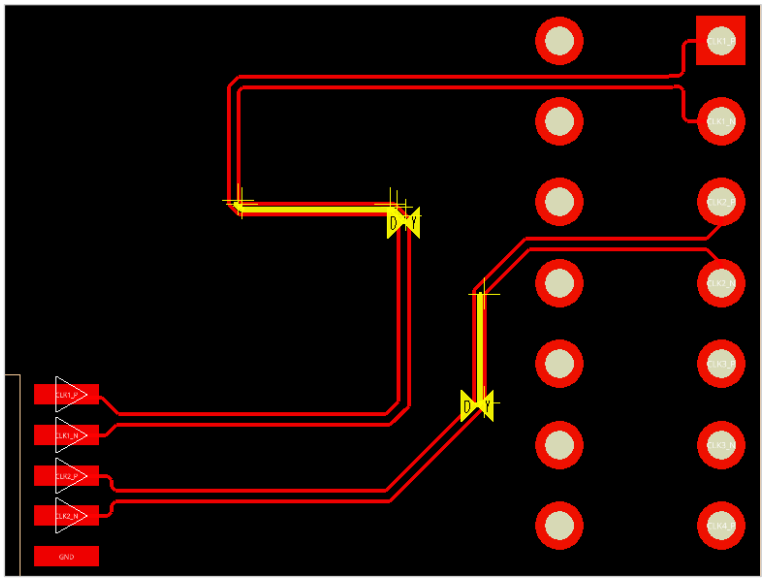
In the Constraint Manager the overall phase tolerance between the two members of the diff pair is defined and actual routed length difference and margin is displayed.

diff_pairs_wiring_match_routed_done

Objects			Static Phase		
Type	S	Name	Tolerance mm	Actual	Margin
*	*	*	*	*	*
Dsn		diff_pairs_wiring_match_routed_done			
NGrp		BR(8)			
NGrp		NG1(8)			
DPr	M	DP_CLK1	1 mm		0.88 mm
Net		CLK1_N	1 mm		0.88 mm
RePP		J5.2:U8.19	1 mm	0.12 mm	0.88 mm
Net		CLK1_P	1 mm		0.88 mm
RePP		J5.1:U8.20	1 mm	0.12 mm	0.88 mm
DPr	M	DP_CLK2	1 mm		0.898 mm
Net		CLK2_N	1 mm		0.898 mm
RePP		U8.17:J5.4	1 mm	0.102 mm	0.898 mm
Net		CLK2_P	1 mm		0.898 mm
RePP		U8.18:J5.3	1 mm	0.102 mm	0.898 mm

2.5.2 Dynamic Phase

Using dynamic phase control, the phase compensation has to be established at the position, at which the phase is violated. In the design canvas the area in which the phase is violated is marked in yellow.



In the Constraint Manager the maximal allowed phase violation (tolerance) and the length, in which it has to be compensated, is defined. Again, actual routing and margin are displayed.

diff_pairs_wiring_match_routed_done

Objects			Dynamic Phase			
Type	S	Name	Max Length mm	Tolerance mm	Actual	Margin
*	*	*	*	*	*	*
Dsn		diff_pairs_wiring_match_routed_done				-0.194 mm
NGrp		BR(8)				
NGrp		NG1(8)				
DPr	M	DP_CLK1	2.000	0.5 mm		-0.194 mm
Net		CLK1_N	2.000	0.5 mm		-0.194 mm
RePP		J5.2:U8.19	2.000	0.5 mm	0.694 mm	-0.194 mm
Net		CLK1_P	2.000	0.5 mm		-0.194 mm
RePP		J5.1:U8.20	2.000	0.5 mm	0.694 mm	-0.194 mm
DPr	M	DP_CLK2	2.000	0.5 mm		-0.041 mm
Net		CLK2_N	2.000	0.5 mm		-0.041 mm
RePP		U8.17:J5.4	2.000	0.5 mm	0.541 mm	-0.041 mm
Net		CLK2_P	2.000	0.5 mm		-0.041 mm
RePP		U8.18:J5.3	2.000	0.5 mm	0.541 mm	-0.041 mm

If constraints are fulfilled, letters are displayed in green, if no in red.

2.5.3 Min Line Spacing

The value is used as a sanity check for minimal line spacing between the members of the diff pair. If used, the value has to be smaller than the primary or neck gap minus the (-) tolerance. The smallest value has to be used.

2.5.4 Coupling Parameters

Primary Gap

Primary Gap is the primary or standard value for the distance between the 2 clines of a differential pair.

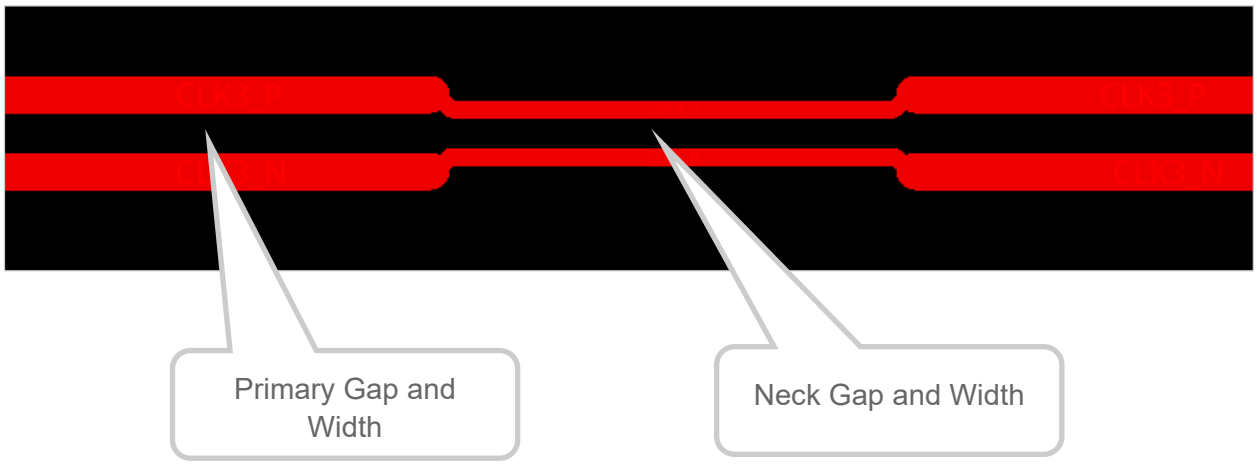
Primary Width

Primary width is the primary or standard width for the clines of a differential pair.

Neck Gap and Neck Width

If it is required to route within a tight area, e.g., inside a BGA footprint, you can use the Neck Routing Mode (select **Add Connect > right mouse button > Neck Mode**).

Neck Gap and Neck Width are the values for the Neck Routing Mode.



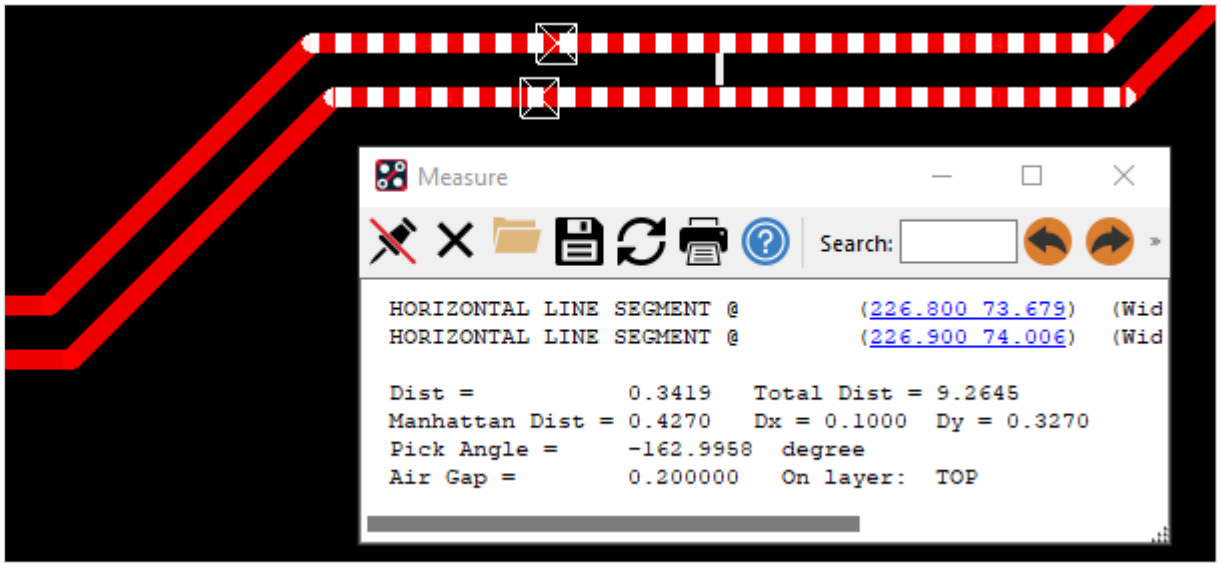
If you use Neck Mode, please remember to set Min Line Width to the right value toa void DRC violations.

Also, Min Line Spacing has to be small enough (Neck Gap minus (-) Tolerance).

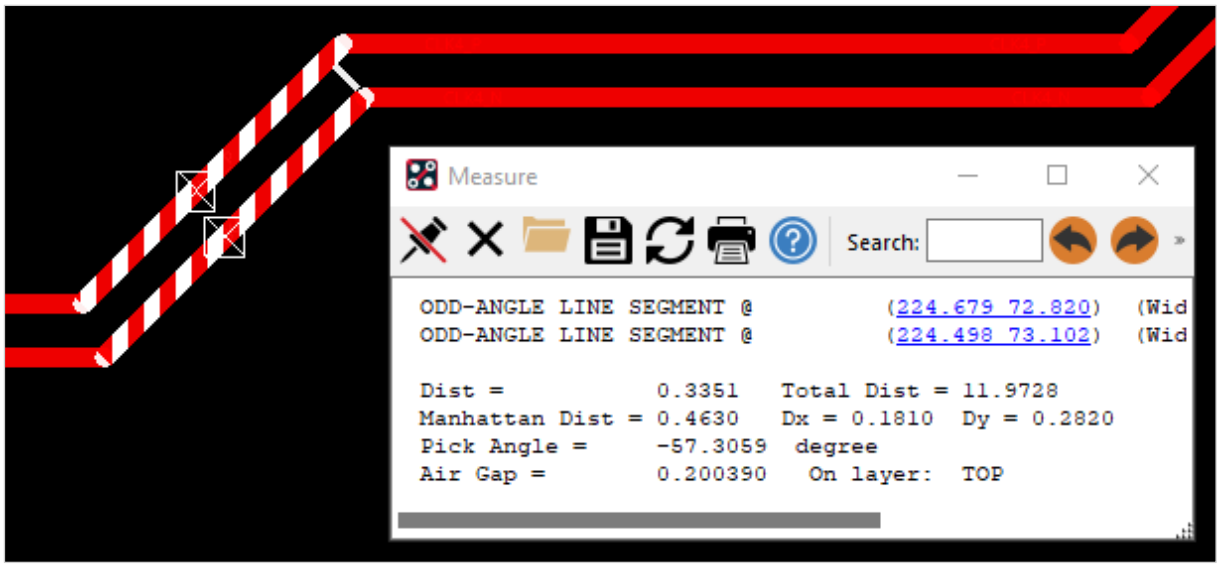
(+) and (-) Tolerance

When routing at 45 degrees or using arc clines the tool needs a tolerance for primary and neck gap.

For horizontal and vertical lines, the gap matches the gap value of 0.2 mm exactly.

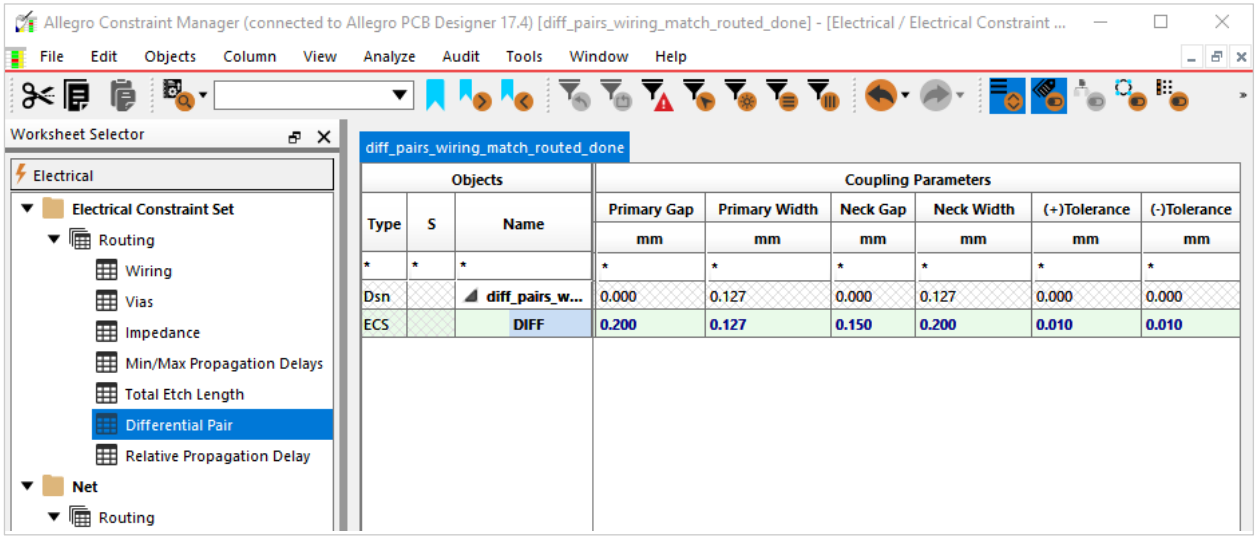


For line routed in 45 degrees or arcuated lines, the gap is slightly different due to calculation reasons. Here 0.20039 mm instead of 0.2 mm.

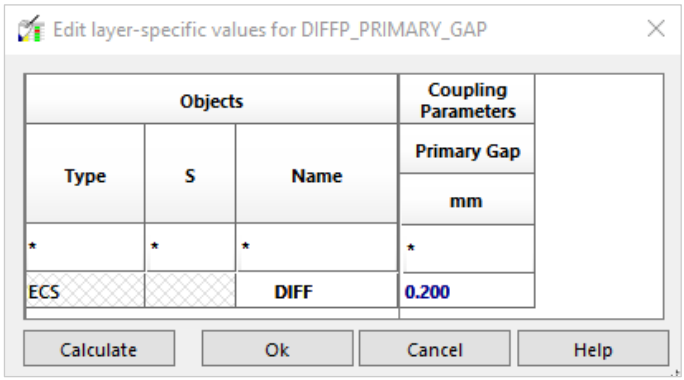


2.6 Calculating Differential Impedance

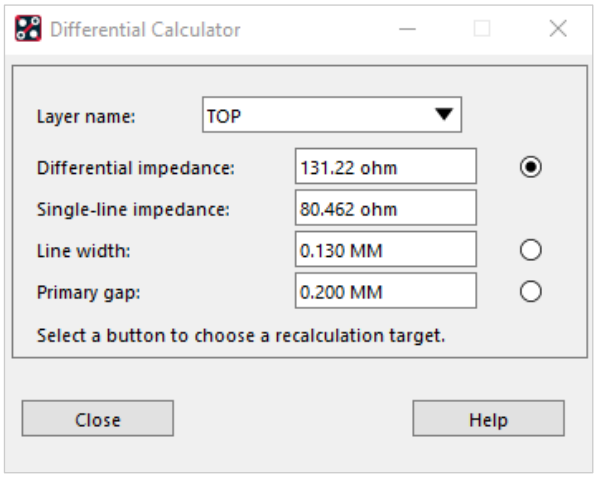
In the Constraint Manager go to **Electrical Workbook > Electrical Constraint Set > Differential Pair**.



Select **Min Line Spacing** or a **Coupling Parameter > right mouse button > change**.



Select **Calculator**. The Calculator window opens. Enable the radio button to the value you want to calculate. Change the other value followed by the tab key until you get the right result.



3 Creating an Electrical Constraint Set for Differential Pairs

3.1 Similar Settings for All Layers

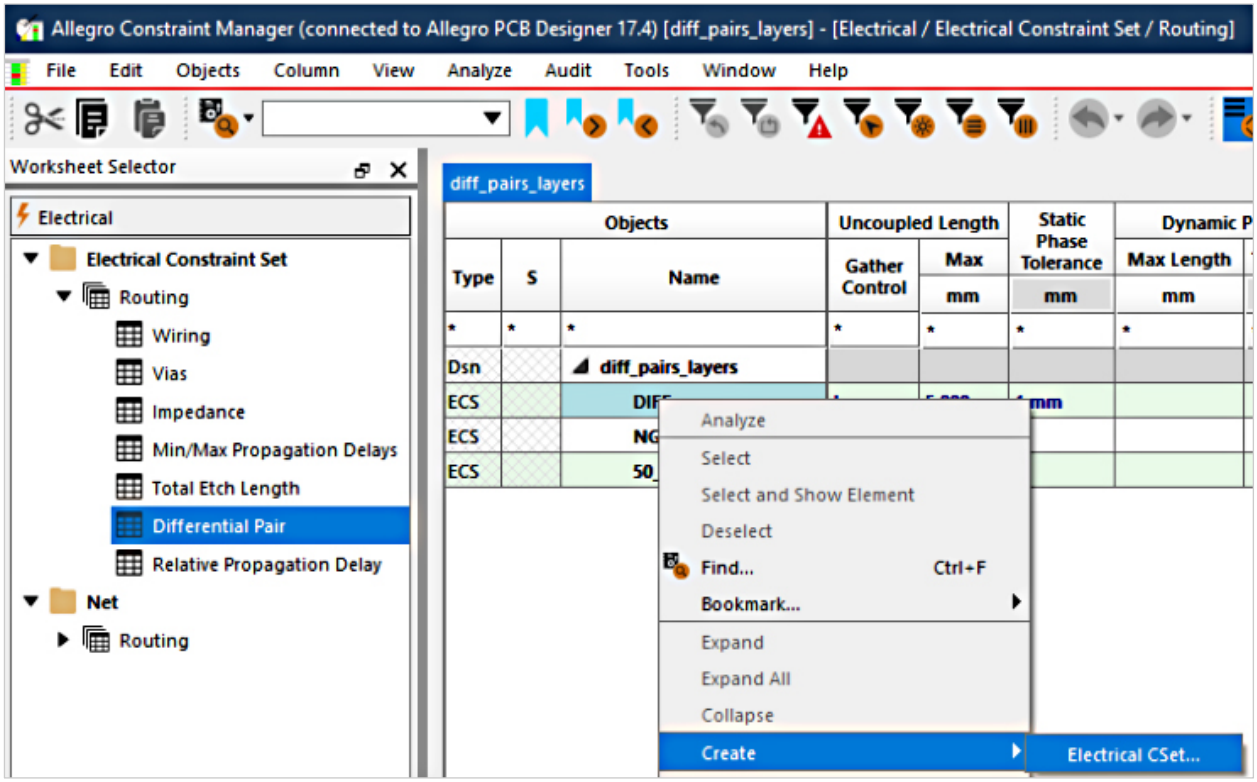
In the electrical domain of the Constraint Manager, it is only possible to use the same settings for all layers. If different settings for the different layers are required, they have to be defined in the physical domain (see chapter 3.2).

In Constraint Manager go to **Electrical Workbook > Electrical Constraint Set > Differential Pair**.

diff_pairs_wiring_match_routed_done

Objects			Min Line Spacing	Coupling Parameters					
Type	S	Name		Primary Gap	Primary Width	Neck Gap	Neck Width	(+)Tolerance	(-)Tolerance
			mm	mm	mm	mm	mm	mm	mm
*	*	*	*	*	*	*	*	*	*
Dsn		diff_pairs_w...	0.000	0.000	0.127	0.000	0.127	0.000	0.000
ECS		DIFF		0.200	0.127	0.150	0.200	0.010	0.010

Select any of the **Objects fields > right mouse button > Create > Electrical Cset**.



Type in the name of the new constraint set and select OK. Adopt the values to your needs.

3.2 Individual Settings Per Layer

When you route the differential pair on different layers, you need to use different values for Width and Gap. Otherwise, you will get different impedances on the different layers. Please see the following Cross Section:

Cross-section Editor

Export Import Edit View Filters

Primary

Objects		Thickness	Signal Integrity				
#	Name	Value	Width	Impedance	Diff Coupling Type	Diff Spacing	Diff Z0
		mm	mm	Ohm		mm	Ohm
*	*	*	*	*	*	*	*
1	TOP	0.03	0.130	79.999	Edge	0.200	130.97
		0.2					
2	GND	0.03					
		0.2					
3	INTERNAL_1	0.03	0.127	63.89	Edge	0.127	93.996
		0.2					
4	INTERNAL_2	0.03	0.127	63.89	Edge	0.127	93.996
		0.2					
5	VCC	0.03					
		0.2					
6	BOTTOM	0.03	0.130	79.999	Edge	0.200	130.97

In the next Cross Section, all impedances are the same because the values for Width and Gap have been changed.

Cross-section Editor

Export Import Edit View Filters

Primary

Objects		Thickness	Signal Integrity				
#	Name	Value	Width	Impedance	Diff Coupling Type	Diff Spacing	Diff Z0
		mm	mm	Ohm		mm	Ohm
*	*	*	*	*	*	*	*
1	TOP	0.03	0.130	79.999	Edge	0.200	130.97
		0.2					
2	GND	0.03					
		0.2					
3	INTERNAL_1	0.03	0.063	79.846	Edge	0.198	129.8
		0.2					
4	INTERNAL_2	0.03	0.063	79.846	Edge	0.198	129.8
		0.2					
5	VCC	0.03					
		0.2					
6	BOTTOM	0.03	0.130	79.999	Edge	0.200	130.97

The Width and Diff Spacing values in the Cross Section Editor are not directly used as constraint values, as the calculator here is just a help for developing the cross section.

The required constraint values have to be set up in the physical domain of the Constraint Manager.

diff_pairs_layers

Objects			Line Width		Neck		Differential Pair		
Type	S	Name	Min	Max	Min Width	Max Length	Min Line Spacing	Primary Gap	Neck Gap
			mm	mm	mm	mm	mm	mm	mm
*	*	*	*	*	*	*	*	*	*
Dsn		diff_pairs_layers	0.127	1.000	0.127	10.000	0.000	0.000	0.000
PCS		DEFAULT	0.127	1.000	0.127	10.000	0.000	0.000	0.000
PCS		DIFF_PAIR_LAYER	0.130:0...	1.000	0.100:0.127...	10.000	0.000	0.200:0.000:0.19...	0.150:0.00...
LTyp		Conductor	0.127	1.000	0.100	10.000	0.000	0.000	0.000
Lyr	1	TOP	0.130	1.000	0.100	10.000	0.000	0.200	0.150
Lyr	3	INTERNAL_1	0.063	1.000	0.050	10.000	0.000	0.198	0.150
Lyr	4	INTERNAL_2	0.063	1.000	0.050	10.000	0.000	0.198	0.150
Lyr	6	BOTTOM	0.130	1.000	0.100	10.000	0.000	0.200	0.150
LTyp		Plane	0.127	1.000	0.127	10.000	0.000	0.000	0.000
PCS		XL_SET	0.400	0.000	0.200	3.000	0.000	0.000	0.000

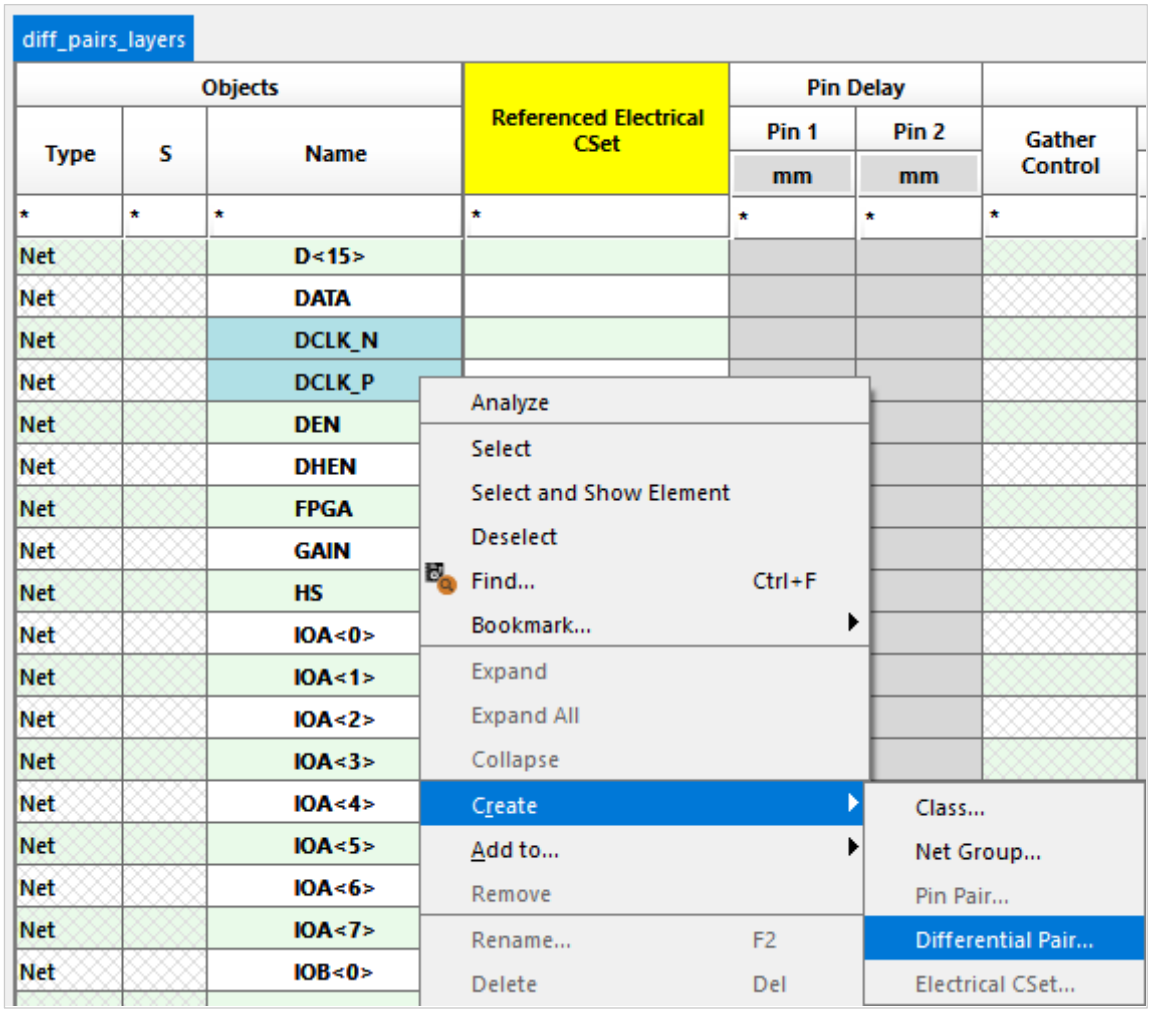
In the Cset in the **electrical domain** leave all Coupling Parameters and Min Line Width blank.

diff_pairs_layers

Objects			Coupling Parameters			
Type	S	Name	Primary Gap	Primary Width	Neck Gap	Neck Width
			mm	mm	mm	mm
*	*	*	*	*	*	*
Dsn		diff_pairs_layers	0.000	0.127	0.000	0.127
ECS		DIFF	0.200	0.127	0.150	0.200
ECS		DIFF_PAIR_LAYER				
ECS		NG1				
ECS		50_OHM				

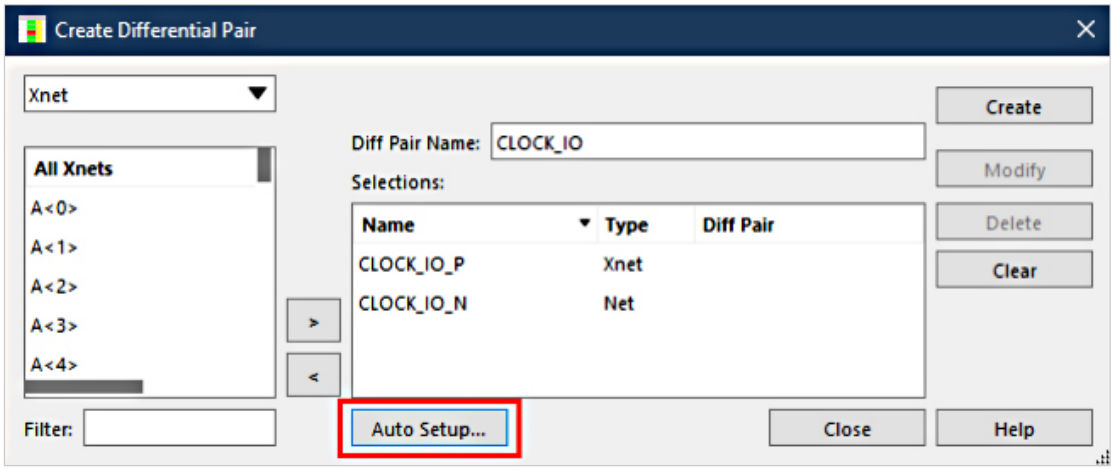
3.3 Defining Differential Pairs

In Constraint Manager go to **Electrical Workbook > Net > Differential Pair**. Select 2 single nets which you want to define as differential pair, click the **right mouse button > Create > Differential Pair**.

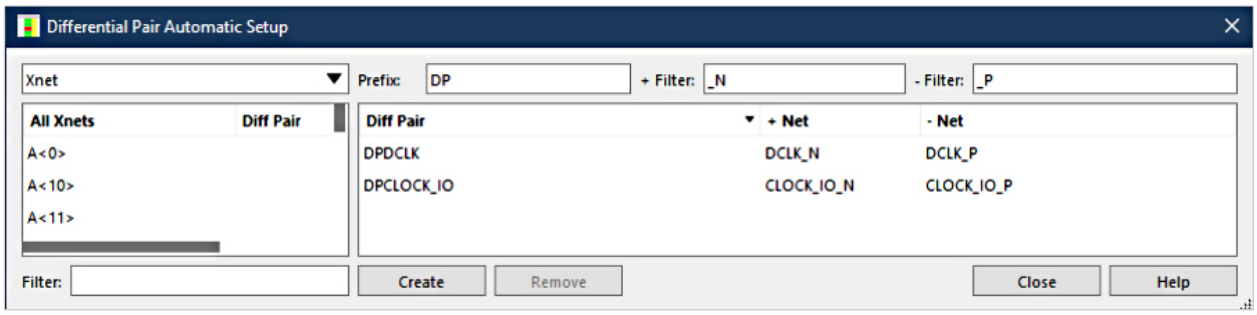


Then enter the name of the pair and select OK.

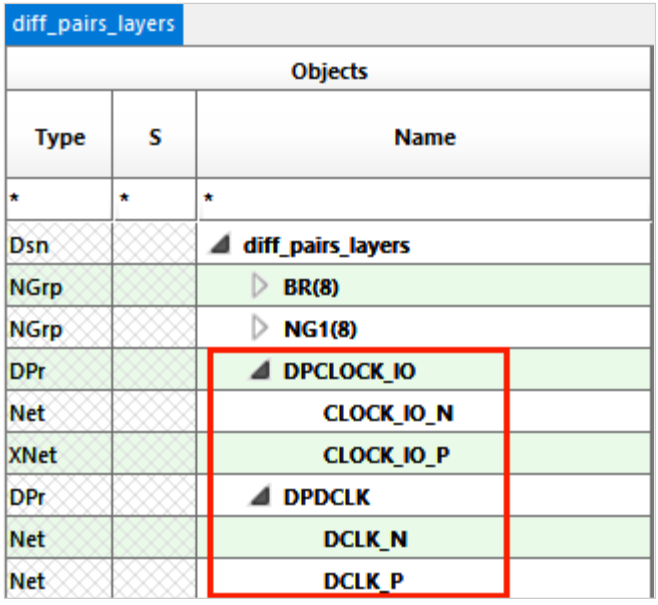
If you have several differential pairs in your design, **Auto Setup** can be used.



To filter for differential pairs, the + and – Filter can be used. It's also possible to set a prefix for the newly created diff pairs.

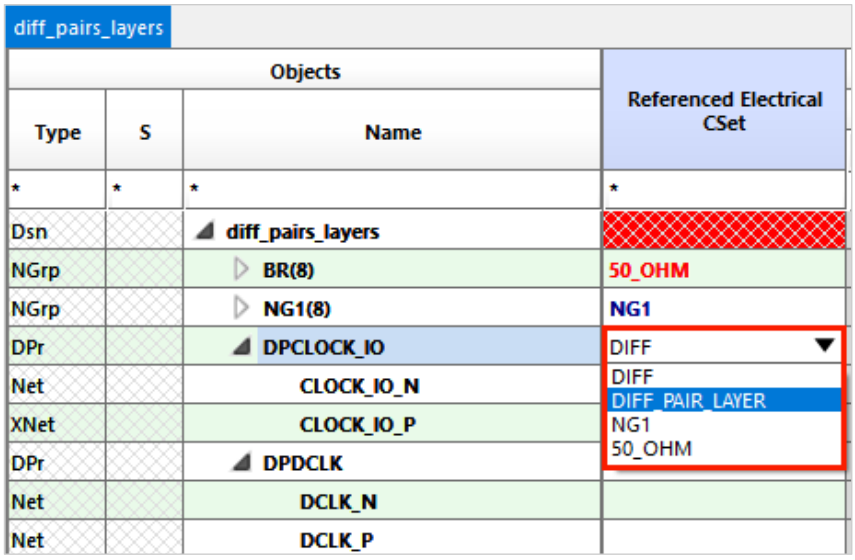


Auto Setup automatically lists all differential pairs and creates pair names. Select **Create**. Close log file, Differential Pairs Automatic Setup window and Create Differential Pair window. In Constraint Manager you will find all differential pairs:



3.4 Assigning Electrical Constraint Set to Differential Pair

In the column on the right-hand side of the Objects column with the differential pair names you can reference the differential pair Cset you created previously. To reference a single pair to a Cset, only click in the field. In the drop down, select the corresponding Csets.



4 More About

FlowCAD offers a webinar recording that takes a detailed look at electrical design rules. What is to be considered regarding net scheduling and impedance control. It informs about Min/Max/Relative Propagation delay and Diff pair Rules.

» Watch the FlowCAD Webinar in English language | in German language