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# DC Cabling Balance

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# Balanced circuit with transformer

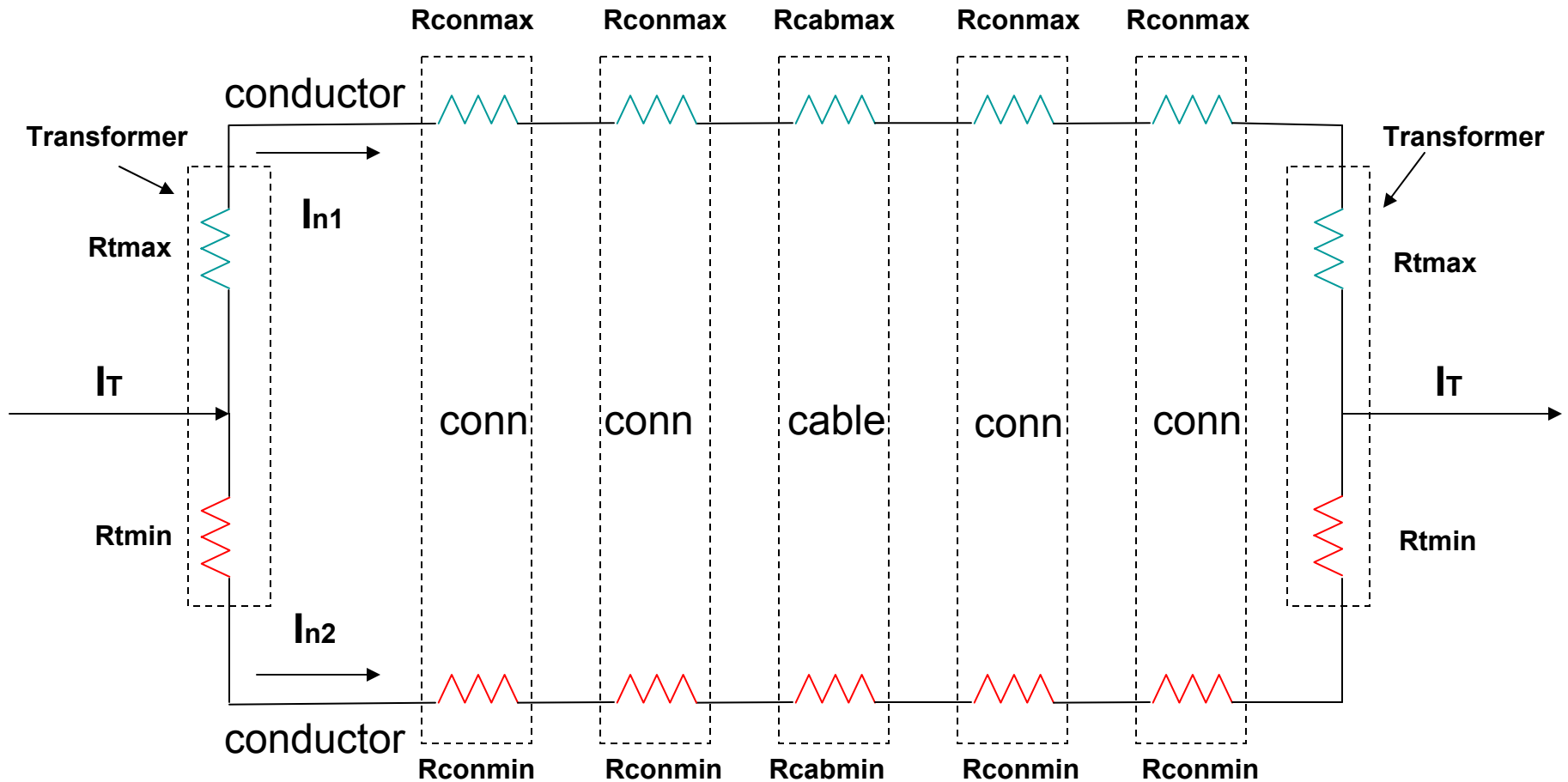


Figure 1.

Balanced Condition :  $I_{n1} = I_{n2}$

$$I_{unbalance} = I_{n1} - I_{n2}$$

# Balanced circuit without transformer

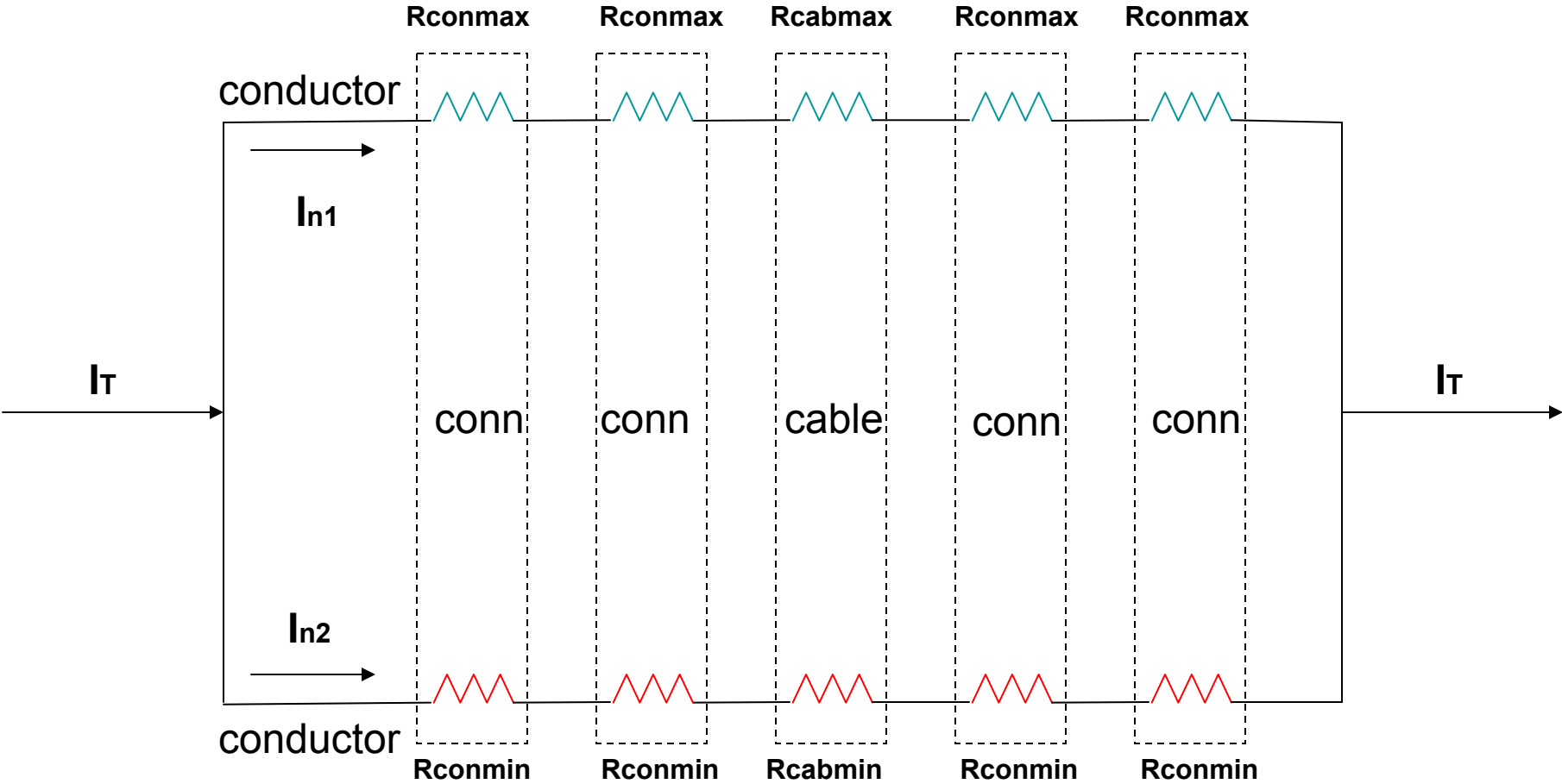


Figure 2.

Balanced Condition :  $I_{n1} = I_{n2}$

$$I_{unbalance} = I_{n1} - I_{n2}$$

# Current Unbalance

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**From Figure 1 and Figure 2:**

$$I_{\text{unbalance}} = I_{n1} - I_{n2}$$

$$I_{n1} = \frac{R_{\text{min}}}{R_{\text{max}} + R_{\text{min}}} \times I_t$$

$$I_{n2} = \frac{R_{\text{max}}}{R_{\text{max}} + R_{\text{min}}} \times I_t$$

$$R_{\text{max}} = R_{\text{cabmax}} + 4 \times R_{\text{conmax}} + 2 \times R_{\text{tmax}}$$

$$R_{\text{min}} = R_{\text{cabmin}} + 4 \times R_{\text{conmin}} + 2 \times R_{\text{tmin}}$$

## 6.4.8 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance between the two conductors within each pair of a channel shall not exceed 3 % for all classes. This shall be achieved by design.

## A.2.8 Direct current (d.c.) resistance unbalance

The d.c. resistance unbalance between the two conductors within all pairs of a Permanent link or CP link shall not exceed 3 % for all classes. This shall be achieved by design.

## IEC 61156-1

$$\% \text{ Resistance Unbalance} = \frac{\text{maximumresistance} - \text{minimumresistance}}{\text{maximumresistance} + \text{minimumresistance}} \times 100$$

## 10.2.4.3 Connecting Hardware for use in distributors and consolidation points

Table 37 – Input to output resistance unbalance

Electrical characteristics	Frequency	Requirement			Test standard
		Connector category			
		5	6	7	
Maximum input to output <sup>a</sup> resistance unbalance mΩ	d.c.	50	50	50	IEC 60512-2 Test 2a
<sup>a</sup> Input to output resistance measurements are made from cable termination to cable termination.					

# 60603-7-4:

## Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz

### 6.4.5 Input to output d.c. resistance

Conditions : IEC 60512, Test 2a  
Mated connectors  
Connection points: Cable termination to cable termination  
All types: 200 m $\Omega$  maximum

### 6.4.6 Input-to-output d.c. resistance unbalance

Conditions: IEC 60512, Test 2a  
Mated connectors  
Connection points: Cable termination to cable termination  
Among all signal conductors, maximum difference between maximum and minimum  
50 m $\Omega$  maximum

# 61156-5 Ed.1: Cable

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**11801 - Cable:** Balanced cables shall be tested according to generic specification IEC 61156-1 and shall meet the requirements of 9.2.

## **61156-5 Cable - 3.2.1 Conductor Resistance**

The maximum loop resistance shall not exceed 19.0 ohm/100m cable.

## **61156-5 Cable - 3.2.2 Resistance unbalance**

The conductor resistance unbalance shall not exceed 2 %.

## **IEC 61156-1**

$$\% \text{ Resistance Unbalance} = \frac{\text{maximumresistance} - \text{minimumresistance}}{\text{maximumresistance} + \text{minimumresistance}} \times 100$$



# ANSI/TIA/EIA-568-B.2-2001- Cable Unbalance

## 4.3.4.2 DC resistance unbalance

The resistance unbalance between the two conductors of any cable pair, measured in accordance with ASTM D 4566, shall not exceed 5% when measured at, or corrected to, a temperature of 20 °C.

## ASTM D 4566

$$\% \text{ Resistance Unbalance} = \frac{\text{maximum resistance} - \text{minimum resistance}}{\text{minimum resistance}} \times 100$$

**NOTE:** ASTM and IEC 61156-1 cable resistance unbalance are specified differently. The IEC values are less than half of those defined in ASTM D 4566.

# IEEE Std 802.3af™-2003 - unbalance

## 33.2.8.12 Current unbalance

The specification for  $I_{unb}$  in Table 33–5 shall apply to the current unbalance between the two conductors of a power pair over the current load range. The 10.5mA value is based on a simulated output current unbalance of 3%.

## 33.5.5 Cabling resistance unbalance

Resistance unbalance is a measure of the difference in resistance between the two conductors in the 100Ω balanced cabling system. The resistance unbalance shall be as specified in IEC 11801 Edition 2, Clause 6.4.8 (reference: 3 percent). The resistance unbalance as defined in IEC 61156-1 is:

$((R_{max} - R_{min}) / (R_{max} + R_{min})) \times 100$  percent, (33–7)

where  $R_{max}$  is the resistance of the conductor with the highest resistance, and  $R_{min}$  is the resistance of the conductor with the lowest resistance.

# Summary Specifications:

**Channel: 11801:** The d.c. resistance unbalance between the two conductors within each pair of a channel shall not exceed 3 % for all classes. This shall be achieved by design.

**Where:**

$$\% \text{ Resistance Unbalance} = \frac{\text{maximumresistance} - \text{minimumresistance}}{\text{maximumresistance} + \text{minimumresistance}} \times 100$$

**Cable:**

IEC conductor resistance unbalance shall not exceed 2 %.

**Where:**

$$\% \text{ Resistance Unbalance} = \frac{\text{maximumresistance} - \text{minimumresistance}}{\text{maximumresistance} + \text{minimumresistance}} \times 100$$

**Connecting Hardware:**

- Input to output d.c. resistance: 200 mΩ
- Input to output resistance unbalance: 50 mΩ

# Resistance Calculations

$$\text{conductor max resistance(L)} = \text{conductor max resistance} \times (L/100)$$

Where: conductor max resistance = 9.5  $\Omega$

$$\text{conductor min resistance} = \text{conductor max resistance(L)} \times \left( \frac{1 - \% \text{ resistance unbalance}}{1 + \% \text{ resistance unbalance}} \right)$$

Where: % resistance unbalance = 2%

$$\text{connector min resistance} = \text{connector max resistance} - \text{connector unbalance resistance}$$

Where: connector max resistance = 200 m $\Omega$

connector unbalance resistance = 50 m $\Omega$

# Channel Resistance and Unbalance

$$\text{channel max resistance(L)} = \text{conductor max resistance} \times (L / 100) + \text{connector max resistance}$$

$$\text{channel min resistance(L)} = \text{cable min resistance(L)} + \text{connector min resistance}$$

$$\% \text{ Channel unbalance(L)} = \frac{\text{channel max resistance(L)} - \text{channel minimum resistance(L)}}{\text{channel maximum resistance(L)} + \text{channel minimum resistance(L)}} \times 100$$

# Channel runb with transformer–4 connector

	Cable	Cable	Connector	Connector	Channel	Channel	Channel	Transformer	Transformer	Current
Length	Max	Min Resistance (L)	Unbalance	Resistance	Max (L)	Min (L)	Resistance	Resistance	Unbalance	Unbalance
	Resistance(L)	with 2% unbalance	4x0.05	4x.2	Resistance	Resistance	Unbalance (L)	Rt		It = 350 ma
5	0.48	0.46	0.2	0.8	1.78	1.53	7.53%	0.50	0.03	26.36
10	0.95	0.91	0.2	0.8	2.25	1.98	6.31%	0.50	0.03	22.10
15	1.43	1.37	0.2	0.8	2.73	2.44	5.54%	0.50	0.03	19.38
20	1.90	1.83	0.2	0.8	3.20	2.90	5.00%	0.50	0.03	17.48
25	2.38	2.28	0.2	0.8	3.68	3.35	4.60%	0.50	0.03	16.10
30	2.85	2.74	0.2	0.8	4.15	3.81	4.29%	0.50	0.03	15.03
35	3.33	3.19	0.2	0.8	4.63	4.26	4.05%	0.50	0.03	14.19
40	3.80	3.65	0.2	0.8	5.10	4.72	3.86%	0.50	0.03	13.51
45	4.28	4.11	0.2	0.8	5.58	5.18	3.70%	0.50	0.03	12.94
50	4.75	4.56	0.2	0.8	6.05	5.63	3.56%	0.50	0.03	12.47
55	5.23	5.02	0.2	0.8	6.53	6.09	3.45%	0.50	0.03	12.07
60	5.70	5.48	0.2	0.8	7.00	6.55	3.35%	0.50	0.03	11.72
65	6.18	5.93	0.2	0.8	7.48	7.00	3.26%	0.50	0.03	11.41
70	6.65	6.39	0.2	0.8	7.95	7.46	3.19%	0.50	0.03	11.15
75	7.13	6.85	0.2	0.8	8.43	7.92	3.12%	0.50	0.03	10.91
80	7.60	7.30	0.2	0.8	8.90	8.37	3.06%	0.50	0.03	10.70
85	8.08	7.76	0.2	0.8	9.38	8.83	3.00%	0.50	0.03	10.51
90	8.55	8.21	0.2	0.8	9.85	9.28	2.95%	0.50	0.03	10.34
95	9.03	8.67	0.2	0.8	10.33	9.74	2.91%	0.50	0.03	10.18
100	9.50	9.13	0.2	0.8	10.80	10.20	2.87%	0.50	0.03	10.04

# Channel runb without transformer–4 connector

	Cable	Cable	Connector	Connector	Channel	Channel	Channel	Transformer	Transformer	Current
Length	Max	Min Resistance (L)	Unbalance	Resistance	Max (L)	Min (L)	Resistance	Resistance	Unbalance	Unbalance
	Resistance(L)	with 2% unbalance	4x0.05	4x.2	Resistance	Resistance	Unbalance (L)	Rt		It = 350 ma
5	0.48	0.46	0.2	0.8	1.28	1.06	9.38%	0.00	0.00	32.82
10	0.95	0.91	0.2	0.8	1.75	1.51	7.27%	0.00	0.00	25.45
15	1.43	1.37	0.2	0.8	2.23	1.97	6.10%	0.00	0.00	21.35
20	1.90	1.83	0.2	0.8	2.70	2.43	5.36%	0.00	0.00	18.75
25	2.38	2.28	0.2	0.8	3.18	2.88	4.84%	0.00	0.00	16.94
30	2.85	2.74	0.2	0.8	3.65	3.34	4.46%	0.00	0.00	15.61
35	3.33	3.19	0.2	0.8	4.13	3.79	4.17%	0.00	0.00	14.60
40	3.80	3.65	0.2	0.8	4.60	4.25	3.94%	0.00	0.00	13.80
45	4.28	4.11	0.2	0.8	5.08	4.71	3.76%	0.00	0.00	13.15
50	4.75	4.56	0.2	0.8	5.55	5.16	3.61%	0.00	0.00	12.62
55	5.23	5.02	0.2	0.8	6.03	5.62	3.48%	0.00	0.00	12.17
60	5.70	5.48	0.2	0.8	6.50	6.08	3.37%	0.00	0.00	11.79
65	6.18	5.93	0.2	0.8	6.98	6.53	3.27%	0.00	0.00	11.46
70	6.65	6.39	0.2	0.8	7.45	6.99	3.19%	0.00	0.00	11.17
75	7.13	6.85	0.2	0.8	7.93	7.45	3.12%	0.00	0.00	10.92
80	7.60	7.30	0.2	0.8	8.40	7.90	3.06%	0.00	0.00	10.69
85	8.08	7.76	0.2	0.8	8.88	8.36	3.00%	0.00	0.00	10.49
90	8.55	8.21	0.2	0.8	9.35	8.81	2.95%	0.00	0.00	10.31
95	9.03	8.67	0.2	0.8	9.83	9.27	2.90%	0.00	0.00	10.15
100	9.50	9.13	0.2	0.8	10.30	9.73	2.86%	0.00	0.00	10.01

# Connector unbalance versus channel unbalance

