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AN220
Twisted Pair Cable Resistance

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Abstract

This application note discusses how the resistance of a twisted pair cable affects the impedance plot on a step TDR.

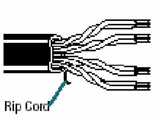
General

When using a step TDR to plot the impedance over the length of twisted pair cable, the trace or plot will be relatively horizontal on the TDR's display for short lengths of cable. As the cable length increases the resistance will cause the trace to "Dribble Up" over its length.

Normal Dribble Up – Good Cable

A normal or nominal expected amount of dribble up can be predicted by knowing the manufacturer's resistance specification for the cable being measured. Manufacturers typically specify this resistance in Ohms per 100 meters, Ohms per 1000 feet or Ohms per 1000 meters of cable depending on application. As seen in figure 1, a reprint of Belden specifications for a 24 AWG Cat 6 Network cable, the resistance is specified for 1 wire of the pair over 100 meters [Max DCR (Ω/100m)]. Additionally, the next column specifies the accuracy of that DC resistance [Max. DCR Unbal. (%)]. For the 24AWG Cat 6 cable listed the resistance is 9.0 Ω / 100m and the accuracy is ± 3% which gives us a range of 8.73 Ω to 9.27 Ω for one wire or a loop resistance of 18 Ω for the pair.

Description	Part No.	UL NEC/ C(UL) CEC Type	No. of Pairs	Standard Lengths		Standard Unit Wt.		Insulation Thickness		Nominal OD		Max. DCR (Ω/ 100m)	Max. DCR Unbal. (%)	Max. Cap. Unbal. (pF/ 100m)	Freq. (MHz)	Max. Atten. (dB/ 100m)	Min. PSUM NEXT (dB)	Min. PSUM ACR (dB/ 100m)	Min. PSUM ELFEXT (dB/ 100m)	Input Imped. (Ω)	Min. RL (dB)
				Ft.	m	Lbs.	kg	Inch	mm	Inch	mm										
23 AWG Bonded-Pairs Solid Bare Copper • Rip Cord • See Color Code Chart (below)																					
Non-Plenum • Polyolefin Insulation • PVC Jacket (Blue, Red, Yellow, Orange, Green, Gold, Violet, White, Black or Dark Gray)																					
	1872A	NEC:	4	1000	304.8	37.0	16.8	.009	.23	.365	9.27	9.0	3.0	49.2	1	1.9	72.3	70	64.8	100±12	20.0
		CMR		A-1000*	A-304.8	38.0	17.3			x	x				4	3.7	63.3	59	52.7	100±12	23.0
		CEC:								.165	4.19				8	5.3	58.8	53	46.7	100±12	24.5
		CMR FT4													10	5.9	57.3	51	44.8	100±12	25.0
															16	7.5	54.3	46	40.7	100±12	25.0
															25	9.5	51.4	42	36.8	100±15	24.3
															31.25	10.6	49.9	39	34.9	100±15	23.6
															62.5	15.4	45.4	30	28.8	100±15	21.5
															100	19.8	42.3	25	24.8	100±15	21.0
															155	25.1	39.5	14	20.9	100±15	21.0
															200	29.0	37.8	10	18.7	100±15	21.0
															250	32.8	36.3	3	16.8	100±20	18.0
															300	35.2	35.2	>0	15.2	100±20	18.0
															350	39.8	34.2	—	13.9	100±22	17.0
															400•	43.0	—	—	—	100±32	14.0
															500•	49.0	—	—	—	100±32	14.0



*A-1000 ft. put-up not available in Black.
Jacket sequentially marked at 2 ft. intervals.
U.S. Patents 5,606,151; 5,734,126; 5,821,467
Third party verified to TIA/EIA-568-B.2-1, Category 6

Figure 1

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To calculate the dribble up over the length of the twisted pair, the loop resistance should be used. Using this information we could expect to get an impedance reading at the 50 foot mark of Belden 24 AWG Cat 6, Part No. 1872A of about 109 Ω [(9.0 +9.0 = 18Ω)/2 + 100 Ω Z_0]. This assumes that the initial reading at the TDR was 100 Ω impedance and there were no connections adding resistance between the TDR and the 50 foot mark. Also note the impedance specification [Input Impedance (Ω)] for this twisted pair cable has an accuracy range from ± 12% to ± 32% depending on the frequency range applied. For calculating good or bad reading range purposes, AEA Technology recommends using the ± 15% accuracy. Hence, a 100 Ω twisted pair cable could start out reading as high as 115 Ω at the near end and adding resistance plus 3% accuracy at 50 feet, as in the example above, as high as 124.13 Ω and still be within manufacturer's tolerance.

Abnormal Dribble Up or Lossy Cable

If a twisted pair's nominal dribble up exceeds the expected resistive increases by more than 20%, it is referred to as "Lossy Cable." The plot in Figure 2 is an example of a good section and a lossy section of twisted pair cable. Note the pronounced increase in impedance dribble up in the lossy section from 50 feet to the end of the cable.

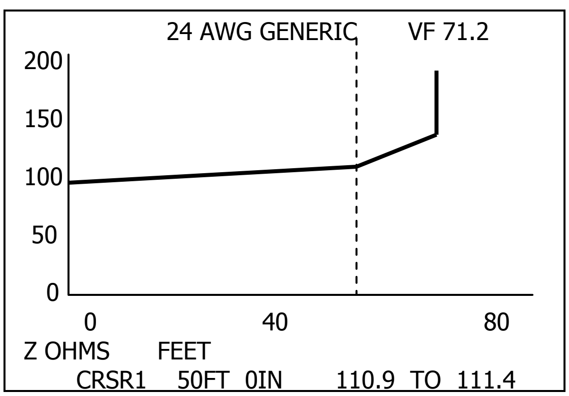

Figure 2

This would be similar to what a user would see on the 20/20 TDR display if a poor quality patch cable was connected to the end of 50 feet of good quality horizontal cable installed in a LAN network.

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Telco Twisted Pair Cable Resistance Standards

A long, long time ago, when Ma Bell was king of cable, BellCore standards were established for all telephone company cable. Despite divestiture in 1984 all the telephone companies continue to purchase cable to these standards. The resistance specifications are a bit different than for other twisted pair cables in that they specify the footage of a single wire per ohm. Below is an example table of Telco cable's resistance for their four standard sizes:

OHMS	19 AWG	22 AWG	24 AWG	26 AWG
1	125 ft	62 ft	40 ft	25 ft
2	250 ft	124 ft	80 ft	50 ft
100	12,500 ft	6,200 ft	4,000 ft	2,500 ft
500	62,500 ft	31,000 ft	20,000	12,500 ft

Resistance at 68°F, add or subtract .00218 ft X (degrees of temp. difference) to adjust

As with other twisted pair cables, always use the loop resistance for calculating the acceptable dribble up over the length of the cable. For Telco cables this can accomplished by dividing the distance in half for each ohm, hence the loop distance for 1 Ohm of 22 AWG = 31 feet, or multiplying the Ohms by 2 for each distance cited, hence, the loop resistance for 124 feet of 22 AWG = 4 Ohms.

For more information on the subject of dribble up see the related application note AN204 Impedance Shifts, which discusses the reasons behind dribble up and why some cables exhibit dribble down.

Keywords: Measuring TWP cable loss basics, TWP cable resistance, TWP cable impedance, TWP dribble up, Measuring TWP cable with TDR, TWP DCR, TWP conductor resistance, TWP shield resistance

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