

## Calculating the propagation delay of coaxial cable

The delay of a cable or velocity factor is determined by the dielectric constant of the cable. The velocity factor is the speed at which an RF signal travels through a material compared to the speed the same signal travels through a vacuum. The velocity of propagation is inversely proportional to the dielectric constant. Lowering the constant increases the velocity. Generally, the higher the velocity factor, the lower the loss through a coaxial cable. Said another way, Velocity of Propagation (VP) or velocity factor (VF) is a parameter that characterizes the speed at which an electrical signal (e.g. radio) passes through a medium. Expressed as a number between 0 and 1 (or a percentage), it is the ratio of a signal's transmission speed to the speed of light in vacuum. Thus, transmission in a vacuum would have a VP of 1 (100%). VP equals the reciprocal of the square root of the dielectric constant of the material through which the signal passes.

Here are a few definitions:

$c$  = speed of light in vacuum = speed RF travels

So if the speed of light in a vacuum is 300,000,000 meters per second then it takes 1.016 ns to go 1ft. =

$\%c$  (speed of light in a vacuum) = Velocity Factor or Velocity of Propagation

$$\text{Velocity} = \frac{100}{\sqrt{\epsilon}}$$

$$\epsilon = (\epsilon_0 \epsilon_r)$$

Where:

$\epsilon$  = Dielectric constant of the insulator.

The dielectric constant is often quoted as the relative dielectric constant  $\epsilon_r$ , referred to the dielectric constant of free space  $\epsilon_0 = 1$

$$\epsilon = \epsilon_r \epsilon_0.$$

When the insulator is a mixture of different dielectric materials (e.g., polyethylene foam is a mixture of polyethylene and air), then the term effective dielectric constant  $\epsilon_{eff}$  is often used.

Below is a table of common dielectric materials and their characteristics. Further down is another table of common coaxial types and their delays based on my calculations.

Dielectric Material	Time Delay	Propagation	Propagation Velocity	Time Delay	Speed of light in free space
	(ns/ft)	Velocity (% of c)	(formula needs single value) (% of c)	ns/ft Worst case	
Solid Polyethylene (PE)	1.54	65.9	65.9	1.5417E-09	1.016E-09
Solid Teflon (ST)	1.46	69.4	69.4	1.4640E-09	
Foam Polyethylene (FE)	1.27	80	80	1.2700E-09	
Air Space Polyethylene (ASP)	1.15-1.21	84-88	84	1.2095E-09	

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Air Space Teflon (AST)	1.13-1.20	85-90	85	1.1953E-09
Foam Polystyrene (FS)	1.12	91	91	1.1165E-09

Type (U)	MIL-W-17	Z0(Ω)	Dielectric Type	Capacitance (pF/ft)	O.D. (in.)	dB/100 ft @400 MHz	Vmax (rms)	Shield	Time Delay (ns/ft)
RG-4		50	PE	30.8	0.226	11.7	1,900	Braid	1.5417E-09
RG-5		52.5	PE	28.5	0.332	7	3,000	Braid	1.5417E-09
RG-5A/B		50	PE	30.8	0.328	6.5	3,000	Braid	1.5417E-09
RG-6	/2-RG6	76	PE	20	0.332	7.4	2,700	Braid	1.5417E-09
RG-6A	/2-RG6	75	PE	20.6	0.332	6.5	2,700	Braid	1.5417E-09
RG-8		52	PE	29.6	0.405	6	4,000	Braid	1.5417E-09
RG-8A		52	PE	29.6	0.405	6	5,000	Braid	1.5417E-09
RG-9		51	PE	30.2	0.42	5.9	4,000	Braid	1.5417E-09
RG-9A		51	PE	30.2	0.42	6.1	4,000	Braid	1.5417E-09
RG-9B		50	PE	30.8	0.42	6.1	5,000	Braid	1.5417E-09
RG-10		52	PE	29.6	0.463	6	4,000	Braid	1.5417E-09
RG-10A		52	PE	29.6	0.463	6	5,000	Braid	1.5417E-09
RG-11	/6-RG11	75	PE	20.6	0.405	5.7	4,000	Braid	1.5417E-09
RG-11A	/6-RG11	75	PE	20.6	0.405	5.2	5,000	Braid	1.5417E-09
RG-12	/6-RG12	75	PE	20.6	0.463	5.7	4,000	Braid	1.5417E-09
RG-12A	/6-RG12	75	PE	20.6	0.463	5.2	5,000	Braid	1.5417E-09
RG-17A		52	PE	29.6	0.87	2.8	11,000	Braid	1.5417E-09
RG-22	/15-RG22	95	PE	16.3	0.405	10.5	1,000	Braid	1.5417E-09
RG-22A/B	/15-RG22	95	PE	16.3	0.42	10.5	1,000	Braid	1.5417E-09
RG-23/A	/16-RG23	125	PE	12	0.65	5.2	3,000	Braid	1.5417E-09
RG-24/A	/16-RG24	125	PE	12	0.708	5.2	3,000	Braid	1.5417E-09
RG-34	/24-RG34	71	PE	21.7	0.625	5.3	5,200	Braid	1.5417E-09
RG-34A	/24-RG34	75	PE	20.6	0.63	5.3	6,500	Braid	1.5417E-09
RG-35	/64-RG35	71	PE	21.7	0.928	2.8	10,000	Braid	1.5417E-09
RG-35A/B	/64-RG35	75	PE	20.6	0.928	2.8	10,000	Braid	1.5417E-09
RG-55B		53.5	PE	28.8	0.2	11.7	1,900	Braid	1.5417E-09
RG-58	/28-RG58	53.5	PE	28.8	0.195	11.7	1,900	Braid	1.5417E-09

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RG-58A	/28- RG58	52	PE	29.6	0.195	13.2	1,900	Braid	1.5417E-09
RG-58B		53.5	PE	28.8	0.195	14	1,900	Braid	1.5417E-09
RG-58C	/28- RG58	50	PE	30.8	0.195	14	1,900	Braid	1.5417E-09
RG-59/A	/29- RG59	73	PE	21.1	0.242	10.5	2,300	Braid	1.5417E-09
RG-59B	/29- RG59	75	PE	20.6	0.242	9	2,300	Braid	1.5417E-09
RG-62/A/B	/30- RG62	93	ASP	13.5	0.242	8	750	Braid	1.2095E-09
RG-63/A/B	/31- RG63	125	ASP	10	0.405	5.5	1,000	Braid	1.2095E-09
RG-65/A	/34- RG65	950	ASP	44	0.405	16 @5MHz	1,000	Braid	1.2095E-09
RG-71/A/B	/90- RG71	93	ASP	13.5	0.245	8	750	Braid	1.2095E-09
RG-79/A/B	/31- RG79	125	ASP	10	0.436	5.5	1,000	Braid	1.2095E-09
RG-83		35	PE	44	0.405	9	2,000	Braid	1.5417E-09
RG-88		48	PE	50	0.515	0.7 @1MHz	10,000	Braid	1.5417E-09
RG-108/A	/45- RG108	78	PE	19.7	0.235	2.8 @10MHz	1,000	Braid	1.5417E-09
RG-111/A	/15- RG111	95	PE	16.3	0.478	10.5	1,000	Braid	1.5417E-09
RG-114/A	/47- RG114	185	ASP	6.5	0.405	8.5	1,000	Braid	1.2095E-09
RG-119	/52- RG119	50	ST	29.4	0.465	3.8	6,000	Braid	1.4640E-09
RG-120	/52- RG120	50	ST	29.4	0.523	3.8	6,000	Braid	1.4640E-09
RG-122	/54- RG122	50	PE	30.8	0.16	18	1,900	Braid	1.5417E-09
RG-130	/56- RG130	95	PE	17	0.625	8.8	3,000	Braid	1.5417E-09
RG-131	/56- RG131	95	PE	17	0.683	8.8	3,000	Braid	1.5417E-09
RG-133/A	/100- RG133	95	PE	16.3	0.405	5.7	4,000	Braid	1.5417E-09
RG-141/A		50	ST	29.4	0.19	9	1,900	Braid	1.4640E-09
RG-142/A/B	/60- RG142	50	ST	29.4	0.195	9	1,900	Braid	1.4640E-09
RG-144	/62- RG144	75	ST	19.5	0.41	4.5	5,000	Braid	1.4640E-09
RG-164	/64- RG164	75	ST	20.6	0.87	2.8	10,000	Braid	1.4640E-09
RG-165	/65- RG165	50	ST	29.4	0.41	5	5,000	Braid	1.4640E-09
RG-166	/65- RG166	50	ST	29.4	0.46	5	5,000	Braid	1.4640E-09
RG-174		50	PE	30.5	0.11	14.7		Braid	1.5417E-09
RG-177	/67- RG177	50	PE	30.8	0.895	2.8	11,000	Braid	1.5417E-09
RG-178/A/B	/93- RG178	50	ST	29.4	0.072	29	1,000	Braid	1.4640E-09
RG-179	/94- RG179	70	ST	20.9	0.1	21	1,200	Braid	1.4640E-09
RG-179A/B	/94- RG179	75	ST	19.5	0.1	21	1,200	Braid	1.4640E-09

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RG-180	/95- RG180	93	ST	15.4	0.14	17	1,500	Braid	1.4640E-09
RG-180A/B	/95- RG180	95	ST	15.4	0.14	17	1,500	Braid	1.4640E-09
RG-210	/97- RG210	93	ASP	13.5	0.242	8	750	Braid	1.2095E-09
RG-211/A	/72- RG211	50	ST	29.4	0.73	2.3	7,000	Braid	1.4640E-09
RG-212	/73- RG212	50	PE	29.4	0.332	6.5	3,000	Braid	1.5417E-09
RG-213	/74- RG213	50	PE	30.8	0.405	5.5	5,000	Braid	1.5417E-09
RG-214	/75- RG214	50	PE	30.8	0.425	5.5	5,000	Dbl Braid	1.5417E-09
RG-215	/74- RG215	50	PE	30.8	0.463	5.5	5,000	Braid	1.5417E-09
RG-216	/77- RG216	75	PE	20.6	0.425	5.2	5,000	Braid	1.5417E-09
RG-217	/78- RG217	50	PE	30.8	0.545	4.3	7,000	Braid	1.5417E-09
RG-218	/79- RG218	50	PE	30.8	0.87	2.5	11,000	Braid	1.5417E-09
RG-219	/79- RG219	50	PE	30.8	0.928	2.5	11,000	Braid	1.5417E-09
RG-223	/84- RG223	50	PE	19.8	0.211	8.8	1,900	Dbl Braid	1.5417E-09
RG-302	/110- RG302	75	ST	19.5	0.201	8	2,300	Braid	1.4640E-09
RG-303	/111- RG303	50	ST	29.4	0.17	9	1,900	Braid	1.4640E-09
RG-304	/112- RG304	50	ST	29.4	0.28	6	3,000	Braid	1.4640E-09
RG-307/A	/116- RG307	75	80	16.9	0.27	7.5	1,000	Braid	??
RG-316	/113- RG316	50	ST	29.4	0.102	20	1,200	Braid	1.4640E-09
RG-391	/126- RG391	72		23	0.405	15	5,000	Braid	??
RG-392	/126- RG392	72		23	0.475	15	5,000	Braid	??
RG-393	/127- RG393	50	ST	29.4	0.39	5	5,000	Braid	1.4640E-09
RG-400	/128- RG400	50	ST	29.4	0.195	9.6	1,900	Braid	1.4640E-09
RG-401	/129- RG401	50	ST	29.4	0.25	4.6	3,000	Cu. S- R	1.4640E-09
RG-402	/130- RG402	50	ST	29.4	0.141	7.2	2,500	Cu. S- R	1.4640E-09
RG-403	/131- RG403	50	ST	29.4	0.116	29	2,500	Braid	1.4640E-09
RG-405	/133- RG405	50	ST	29.4	0.086	13	1,500	Cu. S- R	1.4640E-09
9914 (Belden)		50		26	0.405	10	-----		??

(Disclaimer this is an amalgam of data from several sources I looked up on the web and massaged a little to say what I wanted. If you care if I copied your data then let me know will

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be happy to take it down give you credit or whatever you like e.g. the coaxial chart came from RF cafe I added the delay calculations per foot column. )

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