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

Velocity = $\frac{100}{\sqrt{\varepsilon}}$

$\varepsilon = (\varepsilon_0 \varepsilon_r)$

Where:

ε = Dielectric constant of the insulator.

The dielectric constant is often quoted as the relative dielectric constant ε_r referred to the dielectric constant of free space $\varepsilon_0 = 1$

$\varepsilon = \varepsilon_r \varepsilon_0$.

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 ε_{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 (ns/ft)	Propagation Velocity (% of c)	Propagation Velocity (formula needs single value) (% of c)	Time Delay ns/ft Worst case	Speed of light in free space
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	

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

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

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

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.)