

Occasionally an Audio Delay calibrated in Metres turns up. Whilst this may suit P/A applications, what if you are fixing Audio/Video sync problems? And how are Metres, Frames and milliseconds related? This paper contains a few notes and tables to help.

About the Speed of Sound.

The transmission of sound through air is rather complex. This is not unexpected when we recall that air is a gas composed of other gasses, so temperature, pressure,(etc) and the ratio of gasses all serve to change the properties of air and hence the Speed of Sound. The Speed of Sound also turns up in some very interesting places, eg. many aircraft use "Mach Meters" to display airspeed as ratio of Speed of Sound. This goes some way to explaining why the Speed of Sound is often specified in odd units, eg. Knots for aviation.

Calculating the Speed of Sound (SOS).

Although exact calculations are very messy, an "every day formula" has been derived which will work well enough for our situation.

Speed of Sound in Metres per second $\cong 20.14 \times \sqrt{273 + ^\circ\text{C}}$
 ("≅" is used above to mean "approximately equal to" which is the actual case, from this point on "=" will be used)

To use the above, simply insert the temperature.

Example: Speed of Sound at 20 °C
 Speed of Sound in Metres per second $= 20.14 \times \sqrt{273 + 20}$
 $= 20.14 \times \sqrt{293}$
 $= 20.14 \times 17.12$
 $= 344.74$

Thus at a temperature of:
 20 °C, sound will travel approx 345 Metres in 1 second.
 10 °C, sound will travel approx 339 Metres in 1 second.
 0 °C, sound will travel approx 333 Metres in 1 second.

The next few pages.

The above formula is ok if you have a calculator handy but...as this is not always the case tables are probably more helpful.

Table 1.
 Convert time delay (in tens of milliseconds) caused by speed of sound to distance in Metres at various temperatures.

Table 2.
 Convert time delay (for various values) caused by speed of sound to distance in Metres at various temperatures.
 This table may be used to calculate values not covered above reasonably simply.

Table 3.
 Convert distance in Metres to time delay (in tens of milliseconds) caused by speed of sound at various temperatures.

Table 1 - Convert time delay (in tens of milliseconds) caused by speed of sound to distance in Metres at various temperatures.

Time (ms)	Temperature in Degrees Celsius						
	5	10	15	20	25	30	35
	Equivalent distance at above temperatures						
10	3.36	3.39	3.42	3.45	3.48	3.50	3.53
20	6.71	6.77	6.83	6.89	6.95	7.01	7.07
30	10.07	10.16	10.25	10.34	10.43	10.51	10.60
40	13.43	13.55	13.67	13.79	13.90	14.02	14.13
50	16.78	16.94	17.08	17.23	17.38	17.52	17.67
60	20.14	20.32	20.50	20.68	20.85	21.03	21.20
70	23.50	23.71	23.92	24.12	24.33	24.53	24.73
80	26.86	27.10	27.33	27.57	27.80	28.04	28.27
90	30.21	30.48	30.75	31.02	31.28	31.54	31.80
100	33.57	33.87	34.17	34.46	34.76	35.05	35.33
110	36.93	37.26	37.58	37.91	38.23	38.55	38.87
120	40.28	40.64	41.00	41.36	41.71	42.06	42.40
130	43.64	44.03	44.42	44.80	45.18	45.56	45.93
140	47.00	47.42	47.84	48.25	48.66	49.07	49.47
150	50.35	50.81	51.25	51.70	52.13	52.57	53.00
160	53.71	54.19	54.67	55.14	55.61	56.07	56.54
170	57.07	57.58	58.09	58.59	59.09	59.58	60.07
180	60.43	60.97	61.50	62.03	62.56	63.08	63.60
190	63.78	64.35	64.92	65.48	66.04	66.59	67.14
200	67.14	67.74	68.34	68.93	69.51	70.09	70.67
210	70.50	71.13	71.75	72.37	72.99	73.60	74.20
220	73.85	74.51	75.17	75.82	76.46	77.10	77.74
230	77.21	77.90	78.59	79.27	79.94	80.61	81.27
240	80.57	81.29	82.00	82.71	83.41	84.11	84.80
250	83.92	84.68	85.42	86.16	86.89	87.62	88.34
260	87.28	88.06	88.84	89.60	90.37	91.12	91.87
270	90.64	91.45	92.25	93.05	93.84	94.63	95.40
280	93.99	94.84	95.67	96.50	97.32	98.13	98.94
290	97.35	98.22	99.09	99.94	100.79	101.63	102.47
300	100.71	101.61	102.50	103.39	104.27	105.14	106.00
310	104.07	105.00	105.92	106.84	107.74	108.64	109.54
320	107.42	108.38	109.34	110.28	111.22	112.15	113.07
330	110.78	111.77	112.75	113.73	114.70	115.65	116.60
340	114.14	115.16	116.17	117.18	118.17	119.16	120.14
350	117.49	118.55	119.59	120.62	121.65	122.66	123.67
360	120.85	121.93	123.00	124.07	125.12	126.17	127.20
370	124.21	125.32	126.42	127.51	128.60	129.67	130.74
380	127.56	128.71	129.84	130.96	132.07	133.18	134.27
390	130.92	132.09	133.26	134.41	135.55	136.68	137.80
400	134.28	135.48	136.67	137.85	139.02	140.19	141.34
410	137.64	138.87	140.09	141.30	142.50	143.69	144.87
420	140.99	142.25	143.51	144.75	145.98	147.20	148.40
430	144.35	145.64	146.92	148.19	149.45	150.70	151.94
440	147.71	149.03	150.34	151.64	152.93	154.20	155.47
450	151.06	152.42	153.76	155.09	156.40	157.71	159.01
460	154.42	155.80	157.17	158.53	159.88	161.21	162.54
470	157.78	159.19	160.59	161.98	163.35	164.72	166.07
480	161.13	162.58	164.01	165.42	166.83	168.22	169.61
490	164.49	165.96	167.42	168.87	170.31	171.73	173.14
500	167.85	169.35	170.84	172.32	173.78	175.23	176.67

Table 1 - continued.

Time (ms)	Temperature in Degrees Celsius						
	5	10	15	20	25	30	35
	Equivalent distance at above temperatures						
510	171.20	172.74	174.26	175.76	177.26	178.74	180.21
520	174.56	176.12	177.67	179.21	180.73	182.24	183.74
530	177.92	179.51	181.09	182.66	184.21	185.75	187.27
540	181.28	182.90	184.51	186.10	187.68	189.25	190.81
550	184.63	186.29	187.92	189.55	191.16	192.76	194.34
560	187.99	189.67	191.34	192.99	194.63	196.26	197.87
570	191.35	193.06	194.76	196.44	198.11	199.77	201.41
580	194.70	196.45	198.17	199.89	201.59	203.27	204.94
590	198.06	199.83	201.59	203.33	205.06	206.77	208.47
600	201.42	203.22	205.01	206.78	208.54	210.28	212.01
610	204.77	206.61	208.42	210.23	212.01	213.78	215.54
620	208.13	209.99	211.84	213.67	215.49	217.29	219.07
630	211.49	213.38	215.26	217.12	218.96	220.79	222.61
640	214.85	216.77	218.68	220.57	222.44	224.30	226.14
650	218.20	220.16	222.09	224.01	225.92	227.80	229.67
660	221.56	223.54	225.51	227.46	229.39	231.31	233.21
670	224.92	226.93	228.93	230.90	232.87	234.81	236.74
680	228.27	230.32	232.34	234.35	236.34	238.32	240.27
690	231.63	233.70	235.76	237.80	239.82	241.82	243.81
700	234.99	237.09	239.18	241.24	243.29	245.33	247.34
710	238.34	240.48	242.59	244.69	246.77	248.83	250.87
720	241.70	243.86	246.01	248.14	250.24	252.33	254.41
730	245.06	247.25	249.43	251.58	253.72	255.84	257.94
740	248.41	250.64	252.84	255.03	257.20	259.34	261.48
750	251.77	254.03	256.26	258.48	260.67	262.85	265.01
760	255.13	257.41	259.68	261.92	264.15	266.35	268.54
770	258.49	260.80	263.09	265.37	267.62	269.86	272.08
780	261.84	264.19	266.51	268.81	271.10	273.36	275.61
790	265.20	267.57	269.93	272.26	274.57	276.87	279.14
800	268.56	270.96	273.34	275.71	278.05	280.37	282.68
810	271.91	274.35	276.76	279.15	281.52	283.88	286.21
820	275.27	277.74	280.18	282.60	285.00	287.38	289.74
830	278.63	281.12	283.59	286.05	288.48	290.89	293.28
840	281.98	284.51	287.01	289.49	291.95	294.39	296.81
850	285.34	287.90	290.43	292.94	295.43	297.90	300.34
860	288.70	291.28	293.84	296.38	298.90	301.40	303.88
870	292.06	294.67	297.26	299.83	302.38	304.90	307.41
880	295.41	298.06	300.68	303.28	305.85	308.41	310.94
890	298.77	301.44	304.10	306.72	309.33	311.91	314.48
900	302.13	304.83	307.51	310.17	312.81	315.42	318.01
910	305.48	308.22	310.93	313.62	316.28	318.92	321.54
920	308.84	311.61	314.35	317.06	319.76	322.43	325.08
930	312.20	314.99	317.76	320.51	323.23	325.93	328.61
940	315.55	318.38	321.18	323.96	326.71	329.44	332.14
950	318.91	321.77	324.60	327.40	330.18	332.94	335.68
960	322.27	325.15	328.01	330.85	333.66	336.45	339.21
970	325.62	328.54	331.43	334.29	337.13	339.95	342.74
980	328.98	331.93	334.85	337.74	340.61	343.46	346.28
990	332.34	335.31	338.26	341.19	344.09	346.96	349.81
1000	335.70	338.70	341.68	344.63	347.56	350.47	353.34

Table 2 - Convert time delay (for various values) caused by speed of sound to distance in Metres at various temperatures.

<u>Time (ms)</u>	5	10	15	20	25	30	35
1	0.34	0.34	0.34	0.34	0.35	0.35	0.35
2	0.67	0.68	0.68	0.69	0.70	0.70	0.71
3	1.01	1.02	1.03	1.03	1.04	1.05	1.06
4	1.34	1.35	1.37	1.38	1.39	1.40	1.41
5	1.68	1.69	1.71	1.72	1.74	1.75	1.77
6	2.01	2.03	2.05	2.07	2.09	2.10	2.12
7	2.35	2.37	2.39	2.41	2.43	2.45	2.47
8	2.69	2.71	2.73	2.76	2.78	2.80	2.83
9	3.02	3.05	3.08	3.10	3.13	3.15	3.18
10	3.36	3.39	3.42	3.45	3.48	3.50	3.53
20	6.71	6.77	6.83	6.89	6.95	7.01	7.07
30	10.07	10.16	10.25	10.34	10.43	10.51	10.60
40	13.43	13.55	13.67	13.79	13.90	14.02	14.13
50	16.78	16.94	17.08	17.23	17.38	17.52	17.67
60	20.14	20.32	20.50	20.68	20.85	21.03	21.20
70	23.50	23.71	23.92	24.12	24.33	24.53	24.73
80	26.86	27.10	27.33	27.57	27.80	28.04	28.27
90	30.21	30.48	30.75	31.02	31.28	31.54	31.80
100	33.57	33.87	34.17	34.46	34.76	35.05	35.33
200	67.14	67.74	68.34	68.93	69.51	70.09	70.67
300	100.71	101.61	102.50	103.39	104.27	105.14	106.00
400	134.28	135.48	136.67	137.85	139.02	140.19	141.34
500	167.85	169.35	170.84	172.32	173.78	175.23	176.67
600	201.42	203.22	205.01	206.78	208.54	210.28	212.01
700	234.99	237.09	239.18	241.24	243.29	245.33	247.34
800	268.56	270.96	273.34	275.71	278.05	280.37	282.68
900	302.13	304.83	307.51	310.17	312.81	315.42	318.01
1000	335.70	338.70	341.68	344.63	347.56	350.47	353.34
2000	671.39	677.40	683.36	689.27	695.12	700.93	706.69
3000	1007.09	1016.10	1025.04	1033.90	1042.68	1051.40	1060.03
4000	1342.78	1354.80	1366.72	1378.53	1390.25	1401.86	1413.38
5000	1678.48	1693.51	1708.40	1723.17	1737.81	1752.33	1766.72
6000	2014.18	2032.21	2050.08	2067.80	2085.37	2102.79	2120.07
7000	2349.87	2370.91	2391.76	2412.43	2432.93	2453.26	2473.41
8000	2685.57	2709.61	2733.44	2757.07	2780.49	2803.72	2826.76
9000	3021.26	3048.31	3075.12	3101.70	3128.05	3154.19	3180.10
10000	3356.96	3387.01	3416.80	3446.33	3475.62	3504.65	3533.45

Table 3 - Convert distance in Metres to time delay (in tens of milliseconds) caused by speed of sound at various temperatures.

Metres	5	10	15	20	25	30	35
	Time delay in milliseconds at above temperatures						
1	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2	0.006	0.006	0.006	0.006	0.006	0.006	0.006
3	0.009	0.009	0.009	0.009	0.009	0.009	0.008
4	0.012	0.012	0.012	0.012	0.012	0.011	0.011
5	0.015	0.015	0.015	0.015	0.014	0.014	0.014
6	0.018	0.018	0.018	0.017	0.017	0.017	0.017
7	0.021	0.021	0.020	0.020	0.020	0.020	0.020
8	0.024	0.024	0.023	0.023	0.023	0.023	0.023
9	0.027	0.027	0.026	0.026	0.026	0.026	0.025
10	0.030	0.030	0.029	0.029	0.029	0.029	0.028
15	0.045	0.044	0.044	0.044	0.043	0.043	0.042
20	0.060	0.059	0.059	0.058	0.058	0.057	0.057
25	0.074	0.074	0.073	0.073	0.072	0.071	0.071
30	0.089	0.089	0.088	0.087	0.086	0.086	0.085
35	0.104	0.103	0.102	0.102	0.101	0.100	0.099
40	0.119	0.118	0.117	0.116	0.115	0.114	0.113
45	0.134	0.133	0.132	0.131	0.129	0.128	0.127
50	0.149	0.148	0.146	0.145	0.144	0.143	0.141
55	0.164	0.162	0.161	0.160	0.158	0.157	0.156
60	0.179	0.177	0.176	0.174	0.173	0.171	0.170
65	0.194	0.192	0.190	0.189	0.187	0.185	0.184
70	0.208	0.207	0.205	0.203	0.201	0.200	0.198
75	0.223	0.221	0.219	0.218	0.216	0.214	0.212
80	0.238	0.236	0.234	0.232	0.230	0.228	0.226
85	0.253	0.251	0.249	0.247	0.244	0.242	0.240
90	0.268	0.266	0.263	0.261	0.259	0.257	0.255
95	0.283	0.280	0.278	0.276	0.273	0.271	0.269
100	0.298	0.295	0.293	0.290	0.288	0.285	0.283
105	0.313	0.310	0.307	0.305	0.302	0.300	0.297
110	0.328	0.325	0.322	0.319	0.316	0.314	0.311
115	0.342	0.339	0.336	0.334	0.331	0.328	0.325
120	0.357	0.354	0.351	0.348	0.345	0.342	0.340
125	0.372	0.369	0.366	0.363	0.360	0.357	0.354
130	0.387	0.384	0.380	0.377	0.374	0.371	0.368
135	0.402	0.398	0.395	0.392	0.388	0.385	0.382
140	0.417	0.413	0.410	0.406	0.403	0.399	0.396
145	0.432	0.428	0.424	0.421	0.417	0.414	0.410
150	0.447	0.443	0.439	0.435	0.431	0.428	0.424
155	0.462	0.457	0.453	0.450	0.446	0.442	0.439
160	0.476	0.472	0.468	0.464	0.460	0.456	0.453
165	0.491	0.487	0.483	0.479	0.475	0.471	0.467
170	0.506	0.502	0.497	0.493	0.489	0.485	0.481
175	0.521	0.517	0.512	0.508	0.503	0.499	0.495
180	0.536	0.531	0.527	0.522	0.518	0.513	0.509
185	0.551	0.546	0.541	0.537	0.532	0.528	0.523
190	0.566	0.561	0.556	0.551	0.546	0.542	0.538
195	0.581	0.576	0.571	0.566	0.561	0.556	0.552
200	0.596	0.590	0.585	0.580	0.575	0.570	0.566
210	0.625	0.620	0.614	0.609	0.604	0.599	0.594
220	0.655	0.649	0.644	0.638	0.633	0.628	0.622
230	0.685	0.679	0.673	0.667	0.662	0.656	0.651
240	0.715	0.708	0.702	0.696	0.690	0.685	0.679
250	0.744	0.738	0.731	0.725	0.719	0.713	0.707
260	0.774	0.767	0.761	0.754	0.748	0.742	0.736
270	0.804	0.797	0.790	0.783	0.777	0.770	0.764
280	0.834	0.826	0.819	0.812	0.805	0.799	0.792
290	0.864	0.856	0.848	0.841	0.834	0.827	0.820
300	0.893	0.885	0.878	0.870	0.863	0.856	0.849

Table 3 - Continued.

Metres	5	10	15	20	25	30	35
	Time delay in milliseconds at above temperatures						
310	0.923	0.915	0.907	0.899	0.892	0.884	0.877
320	0.953	0.944	0.936	0.928	0.920	0.913	0.905
330	0.983	0.974	0.966	0.957	0.949	0.941	0.934
340	1.013	1.004	0.995	0.986	0.978	0.970	0.962
350	1.042	1.033	1.024	1.015	1.007	0.998	0.990
360	1.072	1.063	1.053	1.044	1.035	1.027	1.019
370	1.102	1.092	1.083	1.073	1.064	1.055	1.047
380	1.132	1.122	1.112	1.102	1.093	1.084	1.075
390	1.161	1.151	1.141	1.131	1.122	1.112	1.103
400	1.191	1.181	1.170	1.160	1.151	1.141	1.132
410	1.221	1.210	1.200	1.189	1.179	1.170	1.160
420	1.251	1.240	1.229	1.218	1.208	1.198	1.188
430	1.281	1.269	1.258	1.247	1.237	1.227	1.217
440	1.310	1.299	1.287	1.276	1.266	1.255	1.245
450	1.340	1.328	1.317	1.305	1.294	1.284	1.273
460	1.370	1.358	1.346	1.334	1.323	1.312	1.301
470	1.400	1.387	1.375	1.363	1.352	1.341	1.330
480	1.429	1.417	1.404	1.392	1.381	1.369	1.358
490	1.459	1.446	1.434	1.421	1.409	1.398	1.386
500	1.489	1.476	1.463	1.450	1.438	1.426	1.415
510	1.519	1.505	1.492	1.479	1.467	1.455	1.443
520	1.549	1.535	1.521	1.508	1.496	1.483	1.471
530	1.578	1.564	1.551	1.537	1.524	1.512	1.499
540	1.608	1.594	1.580	1.566	1.553	1.540	1.528
550	1.638	1.623	1.609	1.595	1.582	1.569	1.556
560	1.668	1.653	1.638	1.624	1.611	1.597	1.584
570	1.697	1.682	1.668	1.653	1.639	1.626	1.613
580	1.727	1.712	1.697	1.682	1.668	1.654	1.641
590	1.757	1.741	1.726	1.711	1.697	1.683	1.669
600	1.787	1.771	1.755	1.740	1.726	1.711	1.698
610	1.817	1.800	1.785	1.769	1.755	1.740	1.726
620	1.846	1.830	1.814	1.798	1.783	1.769	1.754
630	1.876	1.859	1.843	1.827	1.812	1.797	1.782
640	1.906	1.889	1.873	1.856	1.841	1.826	1.811
650	1.936	1.918	1.902	1.885	1.870	1.854	1.839
660	1.965	1.948	1.931	1.914	1.898	1.883	1.867
670	1.995	1.978	1.960	1.943	1.927	1.911	1.896
680	2.025	2.007	1.990	1.972	1.956	1.940	1.924
690	2.055	2.037	2.019	2.002	1.985	1.968	1.952
700	2.085	2.066	2.048	2.031	2.013	1.997	1.980
710	2.114	2.096	2.077	2.060	2.042	2.025	2.009
720	2.144	2.125	2.107	2.089	2.071	2.054	2.037
730	2.174	2.155	2.136	2.118	2.100	2.082	2.065
740	2.204	2.184	2.165	2.147	2.128	2.111	2.094
750	2.233	2.214	2.194	2.176	2.157	2.139	2.122
760	2.263	2.243	2.224	2.205	2.186	2.168	2.150
770	2.293	2.273	2.253	2.234	2.215	2.196	2.178
780	2.323	2.302	2.282	2.263	2.244	2.225	2.207
790	2.353	2.332	2.311	2.292	2.272	2.253	2.235
800	2.382	2.361	2.341	2.321	2.301	2.282	2.263

Table 3 - Continued

Metres	5	10	15	20	25	30	35
	Time delay in milliseconds at above temperatures						
810	2.412	2.391	2.370	2.350	2.330	2.310	2.292
820	2.442	2.420	2.399	2.379	2.359	2.339	2.320
830	2.472	2.450	2.428	2.408	2.387	2.368	2.348
840	2.501	2.479	2.458	2.437	2.416	2.396	2.377
850	2.531	2.509	2.487	2.466	2.445	2.425	2.405
860	2.561	2.538	2.516	2.495	2.474	2.453	2.433
870	2.591	2.568	2.545	2.524	2.502	2.482	2.461
880	2.621	2.597	2.575	2.553	2.531	2.510	2.490
890	2.650	2.627	2.604	2.582	2.560	2.539	2.518
900	2.680	2.656	2.633	2.611	2.589	2.567	2.546
910	2.710	2.686	2.662	2.640	2.617	2.596	2.575
920	2.740	2.715	2.692	2.669	2.646	2.624	2.603
930	2.769	2.745	2.721	2.698	2.675	2.653	2.631
940	2.799	2.774	2.750	2.727	2.704	2.681	2.659
950	2.829	2.804	2.780	2.756	2.732	2.710	2.688
960	2.859	2.833	2.809	2.785	2.761	2.738	2.716
970	2.889	2.863	2.838	2.814	2.790	2.767	2.744
980	2.918	2.893	2.867	2.843	2.819	2.795	2.773
990	2.948	2.922	2.897	2.872	2.848	2.824	2.801
1000	2.978	2.952	2.926	2.901	2.876	2.852	2.829