Product Data Sheet

Piezoelectric Material Specifications

	BiT	PT	BT	Lead Metaniobate			Hard PZT											Soft PZT									
Dielectric Properties	DL-10	DL-20	DL-21	DL-31	DL-32	DL-33	DL-40	DL-41	DL-42	DL-43	DL-43HD	DL-44	DL-45	DL-45HD	DL-46	DL-47	DL-48	DL-50	DL-50HD	DL-51	DL-52	DL-52HD	DL-53	DL-53HD	DL-54HD	DL-60HD	DL-61HD
ε_{33}^T (1KHz)	128	205	1150	300	750	175	350	520	750	1050	1250	1200	1350	1550	1450	1650	2650	1800	1950	2250	2750	3230	3350	3850	4600	5500	6600
ε_{33}^S (1KHz)	121	155	875	265	585	140	210	300	430	550	615	630	680	740	675	870	1550	850	890	980	1150	1265	1360	1390	1710	1900	2520
ε_{11}^T (1KHz)	140	240	1250	320	620	265	480	750	1050	1280	1510	1460	1470	1670	1530	1700	2530	1680	1780	2330	2840	3360	3170	3550	3680	4600	6020
ε_{11}^S (1KHz)	138	215	960	305	550	245	290	390	590	770	852	780	750	875	735	960	1430	900	950	1155	1370	1470	1435	1550	1660	2010	2810
$tg\delta$ (low field)	0.01	0.012	0.01	0.015	0.015	0.02	0.003	0.003	0.004	0.004	0.004	0.005	0.008	0.005	0.008	0.005	0.005	0.015	0.015	0.017	0.02	0.02	0.02	0.02	0.02	0.025	0.025
Physical Properties																											
ρ (g/cm^3)	7.1	7.6	5.6	6.1	5.7	4.6	7.7	7.7	7.7	7.6	7.9	7.6	7.6	7.8	7.6	7.8	7.7	7.7	7.9	7.7	7.7	7.9	7.6	7.9	7.9	8.2	8.2
T_c (°C)	650	380	120	480	320	280	330	320	340	320	325	330	325	310	330	285	215	360	365	290	260	270	225	230	205	170	150
V (m/s)	3850	4245	4665	2880	2910	5610	3600	3570	3420	3370	3360	3140	3180	3150	2960	3360	3460	2840	2860	2890	2940	2965	2830	2890	2890	2790	2770
Z_a (Mrayl)	27	32	26	18	17	26	28	27	26	26	27	24	24	24	22	26	26	22	23	22	23	23	21	23	23	23	23
Piezoelectric Properties																											
K_p	0.05	0.05	0.29	0.08	0.29	0.09	0.45	0.51	0.51	0.56	0.58	0.56	0.58	0.6	0.61	0.56	0.51	0.62	0.63	0.64	0.66	0.68	0.68	0.71	0.7	0.72	0.7
K_{33}	0.23	0.52	0.47	0.36	0.45	0.48	0.65	0.67	0.65	0.67	0.69	0.67	0.68	0.68	0.74	0.69	0.64	0.7	0.71	0.73	0.71	0.74	0.72	0.74	0.74	0.74	0.73
K_t	0.22	0.51	0.41	0.35	0.38	0.43	0.49	0.48	0.48	0.48	0.51	0.48	0.49	0.51	0.51	0.48	0.46	0.48	0.49	0.51	0.51	0.52	0.49	0.52	0.52	0.53	0.5
K_{31}	0.03	0.03	0.18	0.05	0.18	0.06	0.27	0.3	0.3	0.33	0.34	0.33	0.34	0.35	0.35	0.33	0.3	0.36	0.37	0.38	0.39	0.4	0.4	0.42	0.41	0.43	0.42
K_{15}	0.09	0.32	0.48	0.23	0.34	0.26	0.63	0.69	0.66	0.63	0.66	0.68	0.7	0.69	0.72	0.66	0.66	0.68	0.68	0.71	0.72	0.75	0.74	0.75	0.74	0.75	0.73
N_p (Hz-m)	2480	2750	3110	1880	1910	3620	2450	2450	2350	2320	2310	2160	2200	2180	2080	2310	2380	1970	1970	1980	2010	2040	1950	1980	1990	1900	1880
N_{33} (Hz-m)	2010	2200	2310	1380	1380	1730	1720	1680	1530	1710	1730	1580	1710	1680	1480	1730	1820	1520	1560	1410	1460	1490	1430	1460	1460	1370	1350
N_t (Hz-m)	2050	2210	2810	1490	1610	2840	2120	2150	2150	2090	2110	2130	2050	2060	2000	2130	2160	2010	2030	2000	2030	2100	1980	1910	2010	2040	1990
N_{15} (Hz-m)	1270	1420	1620	940	960	1750	1120	1150	1120	1380	1410	1290	1250	1200	1230	1250	1650	1100	1050	950	1020	1040	1020	1080	1070	980	930
N_c (Hz-m)			1450				1070	1050	1080	1120	1130	1060	1050	1030	1020	1080	1330	910	900	880	930	950	910	940	950	950	910
N_{31} (Hz-m)	1940	2180	2280	1295	1410	2450	1750	1750	1620	1550	1580	1590	1620	1620	1375	1650	1640	1350	1320	1430	1380	1430	1330	1260	1310	1400	1320
d_{33} (10^{-12}C/N)	21	72	140	90	185	62	145	170	220	245	285	290	310	360	430	320	365	400	430	460	520	580	610	680	730	750	810
d_{31} (10^{-12}C/N)	-3.2	-3.7	-51	-11.4	-66.7	-5.9	-48	-65	-81	-105	-120	-125	-131	-150	-153	-135	-150	-180	-191	-210	-235	-255	-275	-300	-320	-365	-400
d_{15} (10^{-12}C/N)	8	65	235	48	165	65	270	310	290	390	430	450	485	520	520	460	475	590	590	685	680	830	760	810	805	830	850
d_h (10^{-12}C/N)	14.6	64.6	38	67.2	51.6	50.2	49	40	58	35	45	40	48	60	124	50	65	40	48	40	50	70	60	80	90	20	10
g_{33} (10^{-3}Vm/N)	18.5	40	13.7	33.9	27.9	40	47	37	33.1	26	26	27.3	26	26	33.5	21.9	15.6	25	25	23.1	21	20.3	20.6	19.9	17.9	15.4	13.9

	g_{31} (10 Vm/N)	-2.8	-2	-5	-4.3	-10.1	-3.8	-15	-14	-12.2	-11	-11	-11.8	-11	-11	-11.9	-9.2	-6.4	-11.3	-11.1	-10.5	-9.6	-8.9	-9.3	-8.8	-7.9	-7.5	-6.8
	g_{15} (10^{-3}Vm/N)	6.4	30.6	21.2	16.9	30.1	27.7	63	46.5	31.2	34	32	34.8	37	35	38.4	30.6	21.2	40	37	33.2	27	27.9	27	25.8	24.7	20.4	15.9
	g_h (10^{-3}Vm/N)	12.9	36	3.7	25.3	7.7	32.4	17	9	8.7	4	4	3.7	4	4	9.7	3.5	2.8	2.4	2.8	2.1	1.8	2.5	2	2.3	2.1	0.4	0.3
	e_{31} (C/m^2)	-0.1	-3.3	-0.7	-0.9	-0.5	-2.5	-0.1	-1.7	-0.7	-4.2	-4.6	-3.1	-4.2	-4.9	-0.5	-4.9	-5.3	-4.8	-5.5	-5.9	-8.2	-8.4	-9.3	-12	-11.6	-13.8	-15.8
	e_{33} (C/m^2)	2.8	8.5	15.7	4.3	6.8	7.1	9	10.9	12.3	14	15.1	14.3	14.9	14.1	16.2	18.5	22.6	15.7	16.4	18.2	17.4	20.9	17.7	18.2	21.4	24	25.3
	e_{15} (C/m^2)	1.3	3.4	10.8	3.1	3.8	2.5	6.2	10.2	13.9	11.7	13.3	13.5	13.1	13.5	13.5	14.3	20.4	11.8	12.4	15.1	19	19.9	19.8	21.9	21.7	27.4	33.1
	h_{31} (10^8 V/m)	0.2	-28.3	-0.9	-4	-1.1	-22.6	-2.1	-6.5	-1.7	-8.9	-8.9	-4.9	-6.9	-7	-0.2	-5.8	-4	-6.2	-5.9	-6.5	-7.3	-6.6	-6.8	-8.8	-6.8	-7.4	-6.3
	h_{33} (10^8 V/m)	26.4	71.1	19.5	18.8	13	62.2	52.5	43.6	31.6	27.9	26.6	24.3	23.6	18.8	28	24.6	16.8	19.5	19.6	20.6	14.4	16.6	13.1	12.4	12.1	11.2	10.1
	h_{15} (10^8 V/m)	10.2	17.4	12.7	11.5	7.8	11.1	23.9	29.3	26.5	16.7	17.9	19.1	19.6	17.5	20.7	16.8	16.3	14.8	14.4	14.9	15.7	15.7	15.9	16	15.1	15.5	13.3
Mechanical Quality Factor in Planar Mode	Q_{pm}			550				1500	1300	1200	1000	1000	800	500	1000	350	1800	1500	85	90	80	80	85	75	65	60	70	65
Mechanical Quality Factor in Thickness Mode	Q_{tm} (varies with f_r)	3500	650	350	14	15	650	420	350	350	300	300	250	250	350	150	650	800	30	35	30	30	30	25	20	20	15	10

Elastic Properties

	S_{33}^E (10^{-12}m^2/N)	7.4	10.6	8.7	23.5	25.5	10.8	16	14	17.3	14.3	15.4	17.6	17.4	20.4	26.3	14.7	13.8	20.5	21.2	19.9	22	21.5	24.2	24.8	23.9	21.1	21.1
	S_{11}^E (10^{-12}m^2/N)	9.5	7.3	8.2	19.7	20.7	6.9	10	10.2	11.1	11.5	11.2	13.3	12.9	13.1	15	11.4	10.9	16.1	15.4	15.5	15	14.4	16.4	15.1	15.1	15.6	15.7
	S_{12}^E (10^{-12}m^2/N)	-1.9	-1.5	-2.1	-4.3	-4.8	-1.4	-2.9	-3.1	-3.4	-3.5	-3.5	-4.1	-4.1	-4.2	-5.1	-3.5	-3.4	-5.2	-4.8	-4.7	-4.5	-4.5	-5.1	-4.5	-4.7	-4.5	-4.4
	S_{13}^E (10^{-12}m^2/N)	-1.2	-2.7	-3	-5.9	-8.4	-2.8	-5.3	-4.8	-6.2	-5	-5.5	-6.9	-6.4	-7.6	-9.3	-5.3	-4.8	-8.2	-8.4	-7.9	-8.7	-8.5	-9.5	-9.4	-9.2	-8.8	-8.7
	S_{55}^E (10^{-12}m^2/N)	6.4	19.4	21.7	15.4	42.9	26.6	43.2	30.4	20.8	33.8	31.8	33.9	36.9	38.4	38.5	32.3	23.1	50.6	47.8	45.1	35.5	41.2	37.6	37.1	36.3	30.1	25.4
	S_{66}^E (10^{-12}m^2/N)	22.8	17.6	20.6	48	51	16.6	25.8	26.6	29	30	29.4	34.8	34	34.6	40.2	29.8	28.6	42.6	40.4	40.4	39	37.8	43	39.2	39.6	40.2	40.2
	S_{33}^D (10^{-12}m^2/N)	7	7.7	6.8	20.4	20.3	8.3	9.2	7.7	10	7.9	8.1	9.7	9.3	11	11.9	7.7	8.1	10.5	10.5	9.3	10.9	9.7	11.6	11.2	10.8	9.5	9.8
	S_{11}^D (10^{-12}m^2/N)	9.5	7.3	7.9	19.6	20	6.9	9.3	9.3	10.1	10.2	9.9	11.8	11.4	11.5	13.2	10.2	9.9	14	13.3	13.3	12.7	12.1	13.8	12.4	12.5	12.7	12.9
	S_{12}^D (10^{-12}m^2/N)	-1.9	-1.5	-2.4	-4.3	-5.5	-1.4	-3.6	-4	-4.4	-4.8	-4.8	-5.5	-5.6	-5.8	-6.9	-4.7	-4.4	-7.3	-6.9	-6.9	-6.8	-6.8	-7.7	-7.2	-7.2	-7.4	-7.2
	S_{13}^D (10^{-12}m^2/N)	-1.1	-2.6	-2.3	-5.5	-6.5	-2.6	-3.1	-2.4	-3.5	-2.2	-2.4	-3.5	-3	-3.7	-4.2	-2.4	-2.5	-3.7	-3.7	-3.1	-3.7	-3.3	-3.9	-3.4	-3.5	-3.2	-3.2
	S_{55}^D (10^{-12}m^2/N)	6.3	17.4	16.7	14.6	37.9	24.8	26	15.9	11.7	20.4	17.9	18.2	18.8	20.1	18.5	18.2	13	27.2	25.7	22.4	17.1	18	17	16.2	16.4	13.2	11.9
	S_{66}^D (10^{-12}m^2/N)	22.8	17.6	20.6	47.8	51	16.6	25.8	26.6	29	30	29.4	34.6	34	34.6	40.2	29.8	28.6	42.6	40.4	40.4	39	37.8	43	39.2	39.4	40.2	40.2
	C_{33}^E (10^{10}N/m^2)	14.2	12.4	17.4	5.3	6	12.6	12.4	13.3	13.7	12.4	13.3	13.8	12.4	13.5	11.3	13.2	13.1	12.2	12.7	12	13.2	14.5	12.1	12.3	13.1	14	13
	C_{11}^E (10^{10}N/m^2)	11.3	17	17.2	6.1	6.8	18.4	17.8	16.9	18.8	14.4	16.6	16.1	15.2	18.3	17.5	15.6	15.5	13.9	15.2	13.5	16.4	18.4	15.3	16.9	17.6	15.8	14.6
	C_{12}^E (10^{10}N/m^2)	2.5	5.6	7.5	1.9	2.9	6.3	10.1	9.3	11.9	7.8	9.8	10.3	9.3	12.6	12.6	8.9	8.5	9.2	10.2	8.6	11.2	13.1	10.7	11.8	12.5	10.8	9.6
	C_{13}^E (10^{10}N/m^2)	2.2	5.8	8.5	2	3.2	6.4	9.2	9	11	7.8	9.5	10.3	9	11.5	10.6	8.8	8.4	9.2	10	8.8	10.9	12.4	10.2	10.9	11.6	11.1	10
	C_{55}^E (10^{10}N/m^2)	15.6	5.2	4.6	6.5	2.3	3.8	2.3	3.3	4.8	3	3.1	3	2.7	2.6	2.6	3.1	4.3	2	2.1	2.2	2.8	2.4	2.6	2.7	2.7	3.3	3.9
	C_{66}^E (10^{10}N/m^2)	4.4	5.7	4.8	2.1	2	6	3.9	3.7	3.4	3.3	3.4	2.9	2.9	2.9	2.5	3.4	3.5	2.3	2.5	2.5	2.6	2.6	2.3	2.5	2.5	2.5	2.5
	C_{33}^D (10^{10}N/m^2)	14.9	18.6	20.5	6.1	6.9	17.1	17.1	18	17.5	16.4	17.1	17.2	16.1	16.1	15.9	17.8	17.2	15.6	16.1	15.9	16	17.9	15.1	14.8	16.2	17.7	16.1
	C_{11}^D (10^{10}N/m^2)	11.3	18	17.5	6.1	6.8	18.9	17.7	16.9	18.8	15.3	17	16.1	15.9	18.5	17.5	15.8	16.1	14.6	15.6	14	17.3	19	16.7	18.5	19	18.4	16.3
	C_{12}^D (10^{10}N/m^2)	2.5	6.7	7.8	2	2.9	6.9	10	9.4	11.9	8.6	10.2	10.3	10	12.7	12.5	9.1	9.1	9.9	10.7	9.1	12.2	13.7	12.1	13.4	13.9	13.4	11.4

	C_{13}^D ($10^{10}N/m^2$)	2.2	8.3	8.6	2.2	3.1	8.1	9.3	8.2	10.8	6.7	8.1	9.6	8.3	10.5	10.6	7.8	7.8	8.6	9.3	7.7	10	11.1	9.7	9.7	10.7	10.7	9
	C_{55}^D ($10^{10}N/m^2$)	15.9	5.8	6	6.8	2.6	4	3.8	6.3	8.5	4.9	5.6	5.5	5.3	5	5.4	5.5	7.7	3.7	3.9	4.5	5.8	5.6	5.9	6.2	6.1	7.6	8.4
	C_{66}^D ($10^{10}N/m^2$)	4.4	5.7	4.8	2.1	2	6	3.9	3.7	3.4	3.3	3.4	2.9	2.9	2.9	2.5	3.4	3.5	2.3	2.5	2.5	2.5	2.6	2.3	2.6	2.5	2.5	2.5
	Y_{33}^E ($10^{10}N/m^2$)	13.5	9.4	11.5	4.3	3.9	9.3	6.2	7.1	5.8	7	6.5	5.7	5.7	4.9	3.8	6.8	7.2	4.9	4.7	5	4.5	4.6	4.1	4	4.2	4.7	4.7
	Y_{11}^E ($10^{10}N/m^2$)	10.5	13.8	12.2	5	4.8	14.5	10	9.8	9	8.7	8.9	7.5	7.7	7.6	6.7	8.7	9.2	6.2	6.5	6.5	6.6	6.9	6.1	6.6	6.6	6.4	6.3
	Y_{33}^D ($10^{10}N/m^2$)	14.3	13	14.7	4.9	4.9	12.1	10.9	13	10	12.6	12.3	10.3	10.8	9.1	8.4	13	12.3	9.5	9.5	10.7	9.2	10.3	8.6	8.9	9.2	10.5	10.2
	Y_{11}^D ($10^{10}N/m^2$)	10.5	13.7	12.6	5.1	5	14.5	10.8	10.7	9.9	9.8	10.1	8.5	8.8	8.7	7.6	9.8	10.1	7.1	7.5	7.5	7.9	8.3	7.2	8.1	8	7.9	7.7
Poisson's Ratio	σ	0.2	0.2	0.26	0.22	0.23	0.2	0.29	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.34	0.31	0.31	0.32	0.31	0.3	0.3	0.31	0.31	0.3	0.31	0.29	0.28
Time Stability																												
	ε_{33}^T (% Per Decade)	-0.5	-0.8	-1.5	-1	-1.7	-1	-2.6	-2.9	-2.8	-3.1	-3.4	-3.1	-3.2	-2.5	-2.6	-2.8	-2.5	-0.8	-1.3	-1.6	-1.9	-1.9	-2	-2.2	-2.4	-2.8	-2.8
	K_p (% Per Decade)			-1.8				-1	-1.2	-1.1	-1.2	-1.3	-1.1	-1.5	-1.1	-1	-1.3	-1.2	-0.1	-0.4	-0.5	-0.5	-0.6	-0.6	-0.5	0.5	0.6	0.6
	K_t (% Per Decade)	-0.2	-0.3		0.2	0.3	0.4																					
	N_p (% Per Decade)			0.4				0.6	0.7	0.6	0.6	0.8	0.6	0.7	0.6	0.5	0.6	0.7	0.1	0.2	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.5
	N_t (% Per Decade)	0.1	0.2		0.3	0.3	0.3																					
Temperature Stability																												
Relative Dielectric Constant(-20 to 125°C)	ε_{33}^T (/°C)	1	1.8		1.6	1.8	2.2	4	5	6	7	7	6	5	7	7	8		5	4.5	8							
Relative Dielectric Constant(-20 to 85	ε_{33}^T (/°C)			3.1														9				9	10	12	14	18	21	25

Note: Electric Data Tested At Room Temperature 24 Hours After Poled.