PIEZO CERAMICS

The material characteristics of piezoceramics

●PZT−Pb(Zr·Ti)O₃／The lead zirconate titanate materials (hard ceramics)

Material No.			C-2	C-21	C-23	C-201	C-202	C-203	C-204
Use examples			Ultrasonic washing machines Underwater sonars Fish detectors Facial equipments		Gas lighter	Vehicle sensors Voltage sensors		Ultrasonic washing machines Ultrasonic welding machine	Ultrasonic humidifier
Coupling factors	$\times 10^{-2}$	k_p	63	59	59	60	56	59	63
		k_{31}	37	34	35	34	32	35	37
		k_{33}	76	71	73	71	69	71	74
		k_t	52	48	54	46	47	49	52
		k_{15}	77	74	79	74	69	70	71
Frequency constants	m・Hz	N_p	2100	2210	2210	2170	2240	2130	2110
		N_{31}	1550	1630	1650	1570	1620	1530	1530
		N_{33}	1410	1510	1480	1500	1550	1470	1450
		N_t	2020	2090	2040	2100	2120	2020	2070
		N_{15}	880	910	870	930	990	920	930
Dielectric constants		$\varepsilon_{11}{}^T/\varepsilon_0$	1970	1900	1700	2010	1700	1470	2240
		$\varepsilon_{33}{}^T/\varepsilon_0$	1460	1400	800	1550	1600	1450	2200
Piezoelectric charge constants	$\times 10^{-12}$ m/V(C/N)	d_{31}	-158	-131	-100	-145	-130	-145	-190
		d_{33}	367	288	270	330	315	325	435
		d_{15}	692	634	690	640	540	520	650
Piezoelectric voltage constants	$\times 10^{-3}$ V・m/N(m^2/C)	g_{31}	-12.7	-10.7	-14.4	-10.3	-9.4	-11.2	-9.7
		g_{33}	29.2	27.2	32.8	24.3	22.3	25.6	22.0
		g_{15}	39.7	37.7	44.9	36.0	33.6	39.6	32.7
Youngs modulus	$\times 10^{10}$ N/m^2	$Y_{11}{}^E=1/s_{11}{}^E$	7.3	8.3	8.3	7.9	8.2	7.2	7.2
		$Y_{33}{}^E=1/s_{33}{}^E$	5.3	6.4	6.1	6.4	6.8	6.0	5.7
		$Y_{55}{}^E=1/s_{55}{}^E$	2.2	2.3	2.0	2.4	2.8	2.3	2.4
Poisson's ratio		σ	0.30	0.29	0.26	0.30	0.31	0.29	0.29
Mechanical Q		Qm	1200	1400	1440	900	1200	2000	520
Dissipation factor	%	tan δ	0.25	0.30	0.27	0.29	0.20	0.30	0.25
Curie point	℃	Tc	300	307	290	290	290	350	250
Density	$\times 10^3$ kg/m^3	ρ	7.60	7.80	7.63	7.80	7.85	7.70	7.65
Temp. coefficient	frTC ppm/℃	-40～+20℃	200	110	120	400	400	240	140
		+20～+80℃	90	110	-150	30	150	240	120
	CTC ppm/℃	-40～+20℃	1820	1810	1500	500	300	1900	1900
		+20～+80℃	4120	3630	4900	4100	3000	3200	3600
Characteristics			For high power driving		High k_{33} High g_{33}	High d_{33}・ Stable temp. coefficient		High d_{33} & Qm High Tc	Middle Qm High k_{33}・d_{33}.

※Material characteristics test method, except for a part of the characteristics, comply with the standard of Japan Electronics and Information Technology Industrial Association JEITA EM-4501A.
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• PZT−Pb(Zr·Ti)O3／The lead zirconate titanate materials (hard ceramics)

Material No.			**C-205**	**C-213**	**C-213P**	**C-3**	**C-4**
Use examples			Ultrasonic washing machines, Welding machines, Medical nebulizers, Scalpels, Dental scalers, Ultrasonic motors			Ultrasonic test equipments Thickness indicators Bolt axial tension meters	
Coupling factors	$\times 10^{-2}$	k_p	58	58	60	45	36
		k_{31}	34	34	35	26	23
		k_{33}	70	70	70	64	57
		k_t	49	48	47	49	39
		k_{15}	68	70	69	64	53
Frequency constants	m・Hz	N_p	2270	2230	2210	2460	2520
		N_{31}	1660	1620	1630	1810	1840
		N_{33}	1560	1540	1540	1710	1760
		N_t	2110	2090	2070	2140	2150
		N_{15}	990	960	950	1060	1100
Dielectric constants		$\varepsilon_{11}{}^T/\varepsilon_0$	1650	1590	1750	820	560
		$\varepsilon_{33}{}^T/\varepsilon_0$	1580	1470	1470	510	330
Piezoelectric charge constants	$\times 10^{-12}$ m/V (C/N)	d_{31}	-136	-135	-139	-55	-39
		d_{33}	322	310	306	154	110
		d_{15}	492	510	542	381	201
Piezoelectric voltage constants	$\times 10^{-3}$ V·m/N (m^2/C)	g_{31}	-9.7	-10.2	-10.7	-12.0	-12.8
		g_{33}	22.7	23.4	23.5	32.4	33.7
		g_{15}	33.6	36.4	34.9	43.5	40.8
Youngs modulus	$\times 10^{10}$ N/m^2	$Y_{11}{}^E=1/s_{11}{}^E$	8.6	8.2	8.4	10.0	10.3
		$Y_{33}{}^E=1/s_{33}{}^E$	6.8	6.6	6.7	8.2	8.7
		$Y_{55}{}^E=1/s_{55}{}^E$	2.7	2.6	3.3	2.5	3.5
Poisson's ratio		σ	0.29	0.29	0.28	0.28	0.29
Mechanical Q		Qm	2140	2500	1520	1900	1700
Dissipation factor	%	tan δ	0.40	0.30	0.28	0.20	0.35
Curie point	℃	Tc	280	315	318	270	330
Density	$\times 10^3$ kg/m^3	ρ	7.80	7.80	7.90	7.60	7.60
Temp. coefficient	frTC ppm/℃	-40～+20℃	30	200	150	10	20
		+20～+80℃	200	100	20	-180	-170
	CTC ppm/℃	-40～+20℃	2490	2100	1900	2670	2250
		+20～+80℃	3230	3400	3900	5370	4360
Characteristics			High $Qm \cdot d_{33}$.		Low tan δ	Low $\varepsilon_{33}{}^T$	

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•PZT−Pb(Zr·Ti)O3／The lead zirconate titanate materials (soft ceramics)

Material No.			C-5	C-6	C-6H	C-62	C-63	C-64	C-601	C-602	C-8
Use examples			Bone mics, Acoustic sensors	Transmit-receive sensors (for cars, flowmeters, bubble sensors, level meters, etc.) Ultrasonic medical probes (for diagnostic imaging) For various actuators							Sound pickups
Coupling factors	$\times 10^{-2}$	k_p	64	66	70	68	59	63	65	53	65
		k_{31}	38	39	41	40	33	35	37	28	38
		k_{33}	73	76	77	77	68	73	76	68	77
		k_t	53	52	50	52	48	50	50	46	52
		k_{15}	78	74	76	76	66	71	73	64	70
Frequency constants	m・Hz	N_p	2060	1960	1960	1960	2130	1970	2060	2160	1980
		N_{31}	1530	1420	1420	1440	1480	1380	1460	1510	1410
		N_{33}	1400	1350	1380	1350	1500	1360	1380	1480	1350
		N_t	2050	2010	2110	2040	2060	1970	2070	2100	2050
		N_{15}	850	850	860	850	950	850	890	950	910
Dielectric constants		$\varepsilon_{11}^T/\varepsilon_0$	2140	2270	2550	2730	1850	1960	2400	1560	3100
		$\varepsilon_{33}^T/\varepsilon_0$	1170	2130	2400	2600	2000	1850	2300	1520	3480
Piezoelectric charge constants	$\times 10^{-12}$ m/V (C/N)	d_{31}	-140	-210	-240	-234	-165	-185	-210	-120	-274
		d_{33}	333	472	490	500	320	435	500	310	627
		d_{15}	764	758	800	860	530	670	730	460	779
Piezoelectric voltage constants	$\times 10^{-3}$ V·m/N (m^2/C)	g_{31}	-14.5	-11.5	-11.2	-10.6	-9.5	-11.4	-10.0	-9.0	-8.8
		g_{33}	32.1	25.0	23.2	24.4	23.0	24.4	23.0	23.0	19.7
		g_{15}	40.3	37.7	35.6	35.6	32.5	38.5	34.0	33.0	28.4
Youngs modulus	$\times 10^{10}$ N/m^2	$Y_{11}^E=1/s_{11}^E$	7.2	6.2	6.3	6.3	6.7	5.9	6.7	7.2	6.0
		$Y_{33}^E=1/s_{33}^E$	5.3	4.9	5.2	4.9	6.2	5.1	5.0	6.3	4.8
		$Y_{55}^E=1/s_{55}^E$	1.9	1.9	2.0	1.9	2.5	2.0	2.2	2.6	2.2
Poisson's ratio		σ	0.29	0.32	0.31	0.30	0.37	0.34	0.33	0.36	0.32
Mechanical Q		Qm	90	80	70	75	90	80	110	100	65
Dissipation factor	%	tan δ	1.65	1.60	2.00	1.65	1.20	1.50	0.90	1.30	1.90
Curie point	℃	Tc	305	295	290	245	295	345	285	360	193
Density	$\times 10^3$ kg/m^3	ρ	7.65	7.65	7.80	7.60	7.60	7.70	7.80	7.90	7.45
Temp. coefficient	frTC ppm/℃	-40～+20℃	-550	-330	-250	-380	-20	-180	-260	30	-340
		+20～+80℃	-680	-130	-5	170	80	180	-120	70	-20
	CTC ppm/℃	-40～+20℃	4230	3590	3400	3860	1850	3500	3300	1800	3940
		+20～+80℃	7960	4850	4000	5610	2550	3600	4000	2100	6050
Characteristics			Middle ε_{33}^T	General purpose	High k_{33}・d_{33}		Low temp. coefficient	High Tc	High k_{33}・d_{33}	Low temp. coefficient High Tc	High k_{33}

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•PZT−Pb(Zr·Ti)O_3／The lead zirconate titanate materials (soft ceramics)

Material No.			C-82	C-83H	C-84	C-85	C-9	C-91	C-91H	C-92H	C-93
Use exampls			Medical Ultrasound Probes (for diagnostic imaging) For various actuators								
Coupling factors	$\times10^{-2}$	k_p	65	73	69	69	57	60	69	72	68
		k_{31}	37	43	43	41	37	37	42	44	40
		k_{33}	75	78	79	80	69	69	74	78	77
		k_t	51	51	54	53	49	49	50	51	53
		k_{15}	70	76	76	72	58	65	68	69	71
Frequency constants	m・Hz	N_p	2030	1930	1900	1930	2040	1960	1950	1910	1890
		N_{31}	1430	1410	1400	1410	1440	1380	1410	1430	1410
		N_{33}	1390	1380	1290	1290	1390	1380	1390	1320	1300
		N_t	2090	2150	2000	2040	1950	1960	2080	2070	1970
		N_{15}	900	880	840	900	950	920	900	930	870
Dielectric constants		$\varepsilon_{11}^T/\varepsilon_0$	3090	3900	4870	3480	6050	4400	4900	4400	5600
		$\varepsilon_{33}^T/\varepsilon_0$	3650	4200	4760	3750	6640	5500	5800	5300	6050
Piezoelectric charge constants	$\times10^{-12}$ m/V (C/N)	d_{31}	-266	-335	-356	-297	-354	-330	-375	-366	-371
		d_{33}	600	670	774	695	718	640	710	770	826
		d_{15}	781	980	1140	845	827	820	920	848	1080
Piezoelectric voltage constants	$\times10^{-3}$ V·m/N (m^2/C)	g_{31}	-8.3	-9.0	-8.4	-8.9	-6.0	-7.0	-7.3	-7.8	-6.9
		g_{33}	18.5	17.9	18.4	20.9	12.2	13.5	13.9	16.4	15.4
		g_{15}	28.6	28.3	26.6	27.4	15.5	21.0	21.2	21.8	21.8
Youngs modulus	$\times10^{10}$ N/m^2	$Y_{11}^E=1/s_{11}^E$	6.2	6.1	6.0	6.3	6.5	5.9	6.4	6.6	6.3
		$Y_{33}^E=1/s_{33}^E$	5.1	5.1	4.4	4.4	5.4	5.4	5.5	4.9	4.6
		$Y_{55}^E=1/s_{55}^E$	2.2	2.1	1.9	2.3	2.6	2.4	2.4	2.6	2.5
Poisson's ratio		σ	0.34	0.29	0.30	0.29	0.36	0.38	0.32	0.28	0.27
Mechanical Q		Qm	65	65	46	58	25	30	24	28	67
Dissipation factor	%	tan δ	1.90	2.20	2.00	1.90	4.50	3.00	3.70	3.60	1.70
Curie point	℃	Tc	195	202	186	228	130	165	170	183	150
Density	$\times10^3$ kg/m^3	ρ	7.50	7.70	7.67	7.82	7.75	7.75	8.10	8.10	7.91
Temp. coefficient	frTC ppm/℃	-40～+20℃	-260	-290	-704	-540	-970	-1000	-1370	-1580	-690
		+20～+80℃	30	100	-185	-24	540	550	330	660	1360
	CTC ppm/℃	-40～+20℃	3650	3500	4360	3840	7610	6000	8400	8450	7190
		+20～+80℃	5440	5300	7590	5300	9630	4500	8800	6780	5360
Characteristics			High ε_{33}^T・d_{33}、Low Qm								

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※C-92H material is characteristic of Ni-Cr and Au sputtering electrode conditions.
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The material characteristics of piezoceramics

• PT―$PbTiO_3$ • PN―$PbNb_2O_6$. BiT―$Bi_4Ti_3O_{12}$／The lead titanate, metaniobate & bismuth titanate materials.

Material No.			PT Type			PN Type	BiT Type
			M-1	M-5	M-6	F-100	B-600
Use examples			Ultrasonic flow meters	Ultrasonic flaw detectors Ultrasonic level meters Touch sensors HIFU medical treatment devices		Ultrasonic flaw detectors Ultrasonic thickness gauges	Ultrasonic flow meters (High-temperature type)
Coupling factors	$\times 10^{-2}$	k_p	6.0	6.0	4.0	(30)	4.7
		k_{31}	6.5	6.0	2.6	(24)	2.9
		k_{33}	37	47	53	(31)	—
		k_t	38	43	51	39	20.1
		k_{15}	—	—	37	(39)	—
Frequency constants	m・Hz	N_p	2630	2800	2860	(2015)	2710
		N_{31}	2050	2150	2200	(1570)	2080
		N_{33}	2060	2150	2240	(1580)	—
		N_t	2130	2250	2230	1630	2180
		N_{15}	—	—	1450	(1030)	—
Dielectric constants		$\varepsilon_{11}{}^T/\varepsilon_0$	—	—	250	(370)	—
		$\varepsilon_{33}{}^T/\varepsilon_0$	185	220	215	300	150
Piezoelectric charge constants	$\times 10^{-12}$ m/V (C/N)	d_{31}	-4.3	-4.7	-3.7	(-55)	-2.9
		d_{33}	43.9	58.2	71.0	80	(19.0)
		d_{15}	—	—	41.0	(145)	—
Piezoelectric voltage constants	$\times 10^{-3}$ V・m/N (m^2/C)	g_{31}	-2.7	-2.4	-1.6	(-19)	-2.2
		g_{33}	25.1	30.3	37.3	(22)	(14.3)
		g_{15}	—	—	21.3	(45)	—
Youngs modulus	$\times 10^{10}$ N/m^2	$Y_{11}^E=1/s_{11}^E$	11.9	13.9	13.2	(5.4)	12.4
		$Y_{33}^E=1/s_{33}^E$	13.5	14.4	11.6	(5.5)	—
		$Y_{55}^E=1/s_{55}^E$	—	—	8.7	(2.3)	—
Poisson's ratio		σ	0.26	0.20	0.21	—	0.22
Mechanical Q		Qm	1200	1450	850	20	5980
Dissipation factor	%	$\tan\delta$	1.50	1.50	2.00	(1.00)	0.30
Curie point	℃	Tc	385	310	250	530	670
Density	$\times 10^3$ kg/m^3	ρ	7.60	7.40	6.92	5.70	7.20
Temp. coefficient	frTC ppm/℃	-40～+20℃	-70	-60	-50	(-1400)	-66
		+20～+80℃	-70	-40	-100	(-800)	-66
	CTC ppm/℃	-40～+20℃	2350	2550	3000	(950)	450
		+20～+80℃	3600	4000	4500	(1100)	820
Characteristics			Anisotropic $k_t > k_p$ High Tc	Anisotropic $k_t > k_p$ High Qm	Anisotropic $k_t > k_p$ High k_t	Low Qm High Tc Low ρ	Anisotropic $k_t > k_p$ High Qm

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※The values in parentheses are reference values. The values of the B-600 material of d_{33} and g_{33} is the values measured by d_{33}-meter.
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