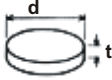
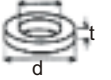
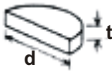
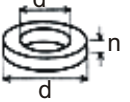
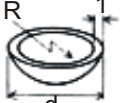


Material characteristic list (At room temp. and low signal data)

Material No.			C-1	C-2	C-21	C-22	C-3	C-4	C-5	C-6	C-62	C-7	C-8	C-82	C-9	M-1	M-5	M-6
Main use			Filter	Piezo-ignitor Ultrasonic cleaner	Ultrasonic sonar Humidifier	Ultrasonic cleaner	Ultrasonic detector Thickness gauge		Audible range microphone	Ultrasonic transmitter Medical instruments		Sound pick-up Actuator		Actuator		Ultrasonic detector Medical instruments		
Coupling factors	X 10 ⁻²	K p	50	58	55	55	42	40	58	63	63	62	63	64	56	6.0	6.0	4.0
		K 31	27	30	28	30	23	22	30	35	35	35	35	36	32	6.5	6.0	2.6
		K 33	60	65	62	55	48	50	65	70	72	65	68	72	62	37.0	47.1	53.0
		K t	43	48	46	47	45	45	45	50	52	49	50	53	43	38.0	43.0	51.0
		K 15	55	65	60	53	52	51	65	72	68	65	65	66	47	-	-	37.0
Frequency constants	m Hz	N p	2250	2100	2240	2140	2400	2450	2000	1960	2000	2050	2000	2000	2030	2630	2800	2860.
		N 31	1620	1580	1660	1530	1760	1770	1430	1400	1420	1450	1450	1430	1450	2050	2150	2200
		N 33	1600	1480	1550	1550	1660	1700	1400	1330	1350	1420	1400	1360	1400	2 60	2150	2240
		N t	2050	2000	2110	2020	2070	2100	1980	1920	2020	2000	1930	2050	1940	2130	2250	2230
		N 15	1030	910	900	940	1050	1080	860	840	870	890	890	900	960	-	-	1450
Relative Dielectric constants		$\frac{T}{\epsilon_{11}}/\epsilon_0$	1500±300	1600±350	1600±350	1600±200	800±200	520±100	1500±300	2100±300	2500±300	3600±400	2800±300	3100±400	4700±500	-	-	250±50
		$\frac{T}{\epsilon_{33}}/\epsilon_0$	1400 ± 250	1400 ± 250	1300 ± 200	1280 ± 250	570 ± 60	330 ± 50	1100 ± 150	2000 ± 300	2700 ± 300	3900 ± 400	3000 ± 300	3400 ± 400	6300 ± 630	185 ± 20	220 ± 20	215 ± 20
Piezoelectric charge constants	X10 ⁻¹² m/V (C/N)	d 31	- 120	- 120	- 130	- 140	- 57	- 42	- 120	- 195	- 210	- 250	- 230	- 260	- 300	- 4.3	- 4.7	- 3.7
		d 33	220	240	260	190	110	80	270	360	500.	460	420	540	600	43.9	58.2	71.0
		d 15	350	480	550	360	240	180	500	680	700	800	700	750	550	-	-	41.0
piezoelectric voltage constants	X10 ⁻³ V-m/N (m ² /C)	g 31	- 9.0	-10.0	-11.0	-11.0	-14.0	-14.0	-13.0	-12.0	- 8.9	- 7.5	- 9.0	- 8.7	- 5.6	- 2.7	- 2.4	- 1.6
		g 33	16.0	24.0	22.5	15.0	28.0	30.0	28.0	22.0	21.0	12.0	16.0	18.0	11.0	25.1	30.3	37.3
		g 15	27.0	35.0	37.5	31.0	42.0	45.0	38.0	37.0	29.0	25.0	25.0	27.5	13.0	-	-	21.3
Youngs modulus	X10 ¹⁰ N /m ²	Y E ₁₁	8.1	7.5	7.3	7.0	9.5	9.2	6.1	5.8	6.0	6.3	5.9	5.9	6.4	11.9	13.9	13.2
		Y E ₃₃	7.7	6.6	6.9	7.0	8.4	8.9	5.6	5.2	5.6	5.9	5.7	5.2	6.0	13.5	14.4	11.6
		Y E ₅₅	3.2	2.5	2.2	2.5	3.3	3.4	2.2	2.1	2.1	2.1	2.1	2.1	2.7	-	-	8.7
Poisson's ratio		σ	0.34	0.38	0.38	0.35	0.37	0.37	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.26	0.20	0.21
Mechanical Q		Qm	1000±300	500±200	900±300	700±250	1000±300	1100±300	75±15	75±15	75±15	45±10	70±15	70±15	20±10	1200±300	1450±400	850±250
Dissipation factor	%	tan δ	0.7	0.8	0.7	0.8	0.7	0.7	2.0	2.1	1.8	2.8	2.3	1.8	5.2	1.5	1.5	2.0
Curie point	°C	Tc	250	320	300	330	280	310	320	320	250	190	210	190	140	385	310	250
Density	X10 ³ kg/ m ³	ρ	7.5	7.5	7.6	7.5	7.5	7.5	7.4	7.4	7.5	7.3	7.4	7.4	7.7	7.6	7.4	6.9
Temperature coefficient	f r (ppm/°C)	20~20°C	50	50	- 100	190	100	- 50	- 400	- 350	- 320	- 300	- 300	- 250	- 700	- 70	- 60	- 50
		20~60°C	-150	- 200	- 200	310	- 200	- 140	- 550	- 100	- 100	- 100	- 100	-100	200	- 70	- 40	- 100
		-20~20°C	3000	3200	3000	2000	3300	2800	4200	3300	3600	4100	3800	3800	7500	2350	2550	3000
	C (ppm/°C)	20~60°C	5400	6400	5500	3700	5000	3000	6500	4500	4200	7000	4000	6000	11000	3600	4000	4500

■ Shape and dimension

Shape	Standard manufacturing range	Shape	Standard manufacturing range
Disc type	d: ø 5~ ø 100 t: 1/30 d ≤ t ≤ 1/3 d	Ring type	d: ø 10~ ø 50 d': 1/2 d ≤ d' ≤ 9/10 d t: 1/25 d ≤ t ≤ 1/5 d
			
Half disc type	d: ø 5~ ø 100 t: 1/30 d ≤ t ≤ 1/3 d	Cylindrical type	d: ø 10~ ø 50 d': 1/2 d ≤ d' ≤ 9/10 d h: 1/2 d ≤ h ≤ 2 d
			
Column type	d: ø 5~ ø 30 t: 1/2 d ≤ h ≤ 2 d	Focusing surface type	d: ø 10~ ø 50 t': 1/25 d ≤ t' ≤ 1/2 d R: d / √3 ≤ R
			
Bar plate type	ℓ: 2 ~ 30 mm t: 0.2 ~ 5 mm ω: 2 ~ 30 mm ℓ: 30 ~ 130mm t: 0.3 ~ 5 mm ω: 10 ~ 80 mm	Line focusing type	t: 0.4 ~ 1.0 mm t } 5 ≤ ø . ω ≤ 25 ω } R: ω / √3 ≤ R
			
Cubic type	a } 5 ~ 15 mm b } h: 1/2 a ≤ h ≤ 4a	Special types	We accept your consultation on the other special types.
			

● Electrode shape (For example)

Both sides		One side return	
			

■ General rated standard

- Frequency tolerance: ± 5% in nominal value
- Electrostatic capacity tolerance : ±20% in nominal value
- Dimension : In the case of the designation of frequency, the part that relates to the frequency directly is ±10% and the other dimension is ±2.5%.

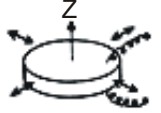
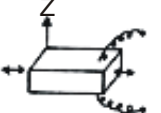
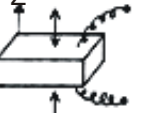
■ We accept your consultation on the other requests.

- Special dimension.
- Surface coating
- Electrode shape and lead terminal

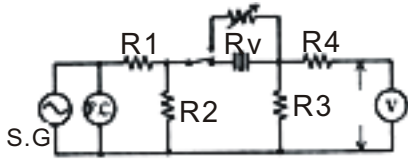
■ Please advise us the following matters in your order.

- Shape (Disc type, Bar plate type, etc.)
- Dimension (t, d, ℓ, ω)
- Material No.
- Frequency
- Electrode shape (Both sides, One side return, etc.)
- Existence of lead (Lead position in the necessary case) (These standards may be modified according to the shape, material No. and other specification. Inquire in your order.)

■ Normal vibration mode of the piezoelectric vibrator.

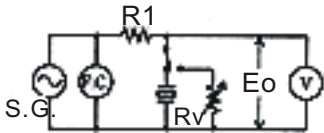
Vibration of diameter	Vibration of length	Vibration of thickness	Vibration of ring dia.	Vibration of shear
Kp Np d31 g31	K31 N31 d31 g31	K33 N33 d33 g33	K31 Nc d31 931	K15 N 15 d15 g15
				

■ Transmission measuring circuit



Constant-voltage method

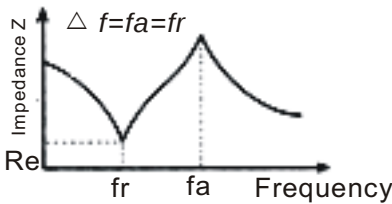
S.G. : Oscillator
F.C. : Frequency counter
V : Voltmeter



Constant-current method

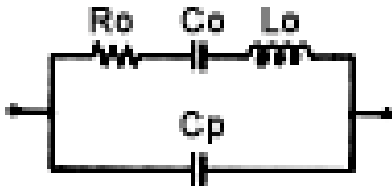
Z axis : Direction of polarization.

- Constant-voltage method
Resonant frequency (fr) : Frequency at the maximum of Eo
Antiresonant frequency (fa) : Frequency at the minimum of Eo
- Constant-current method
Resonant frequency (fr) : Frequency at the minimum of Eo
Antiresonant frequency (fa) : Frequency at the maximum of Eo
- Resonant impedance (Ro)
- Electrostatic capacity (C) : at 1KHz



Characteristics of impedance-frequency

● Equivalent electric circuit of the piezoelectric vibrator

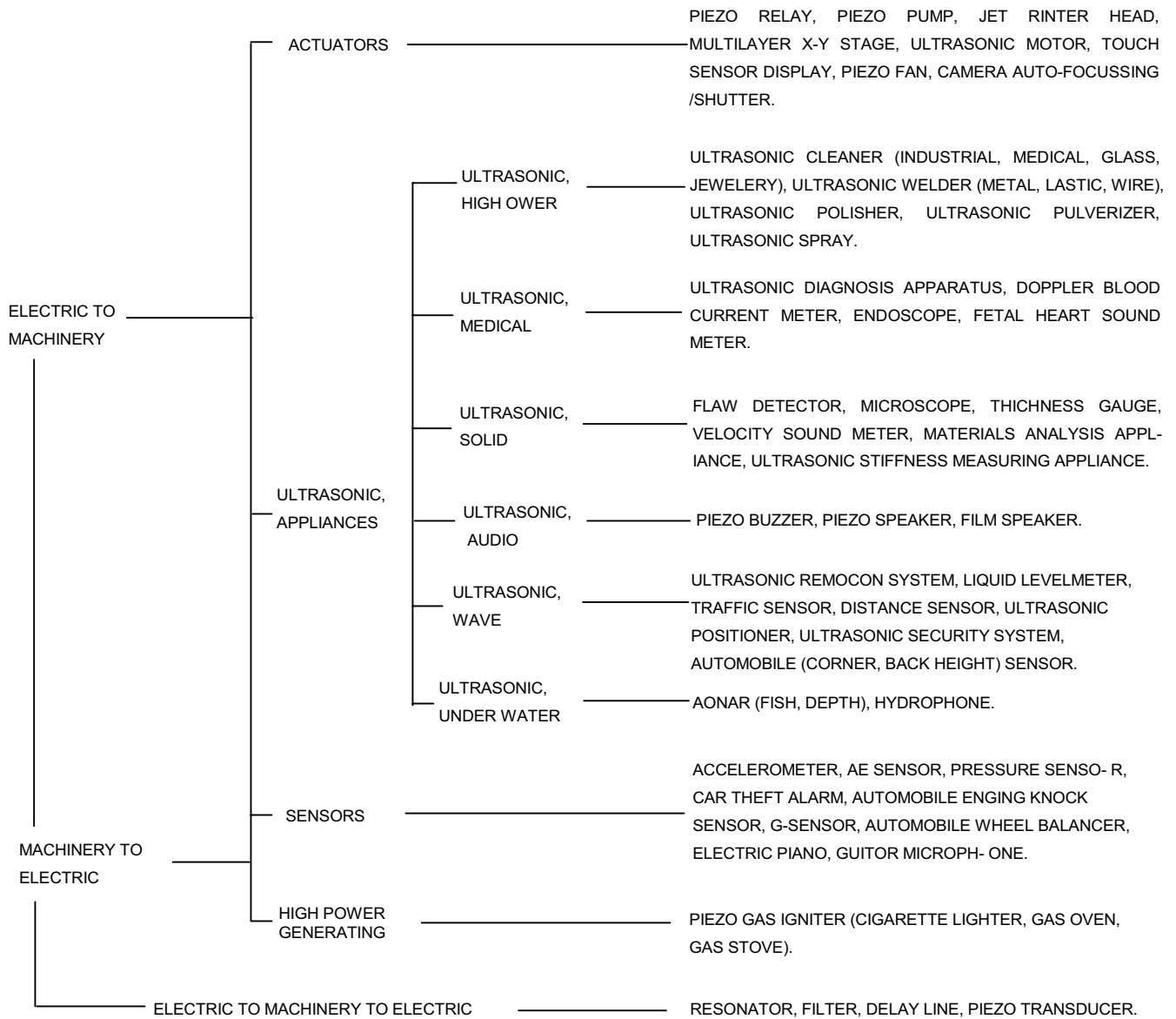


$$\begin{aligned} Co &= C(1 - fr^2 / fa^2) \\ Cp &= C \cdot fr^2 / fa^2 \\ Lo &= 1 / 4\pi^2 fr^2 Co \end{aligned}$$

$$\begin{aligned} Kp : 1 / Kp^2 &= 0.395 \cdot fr / \Delta f + 0.574 \\ K31, 1 / K31^2 &= 0.405 \cdot fr / \Delta f + 0.595 \\ K33, K15 : 1 / K33^2 &= 0.405 \cdot fr / \Delta f + 0.810 \end{aligned}$$

$$\text{Mechanical Q (Qm)} : Qm = fa^2 / 2\pi Ro Cfr (fa^2 - fr^2)$$

■ APPLICATION TABLE FOR PIEZOELECTRIC CERAMICS



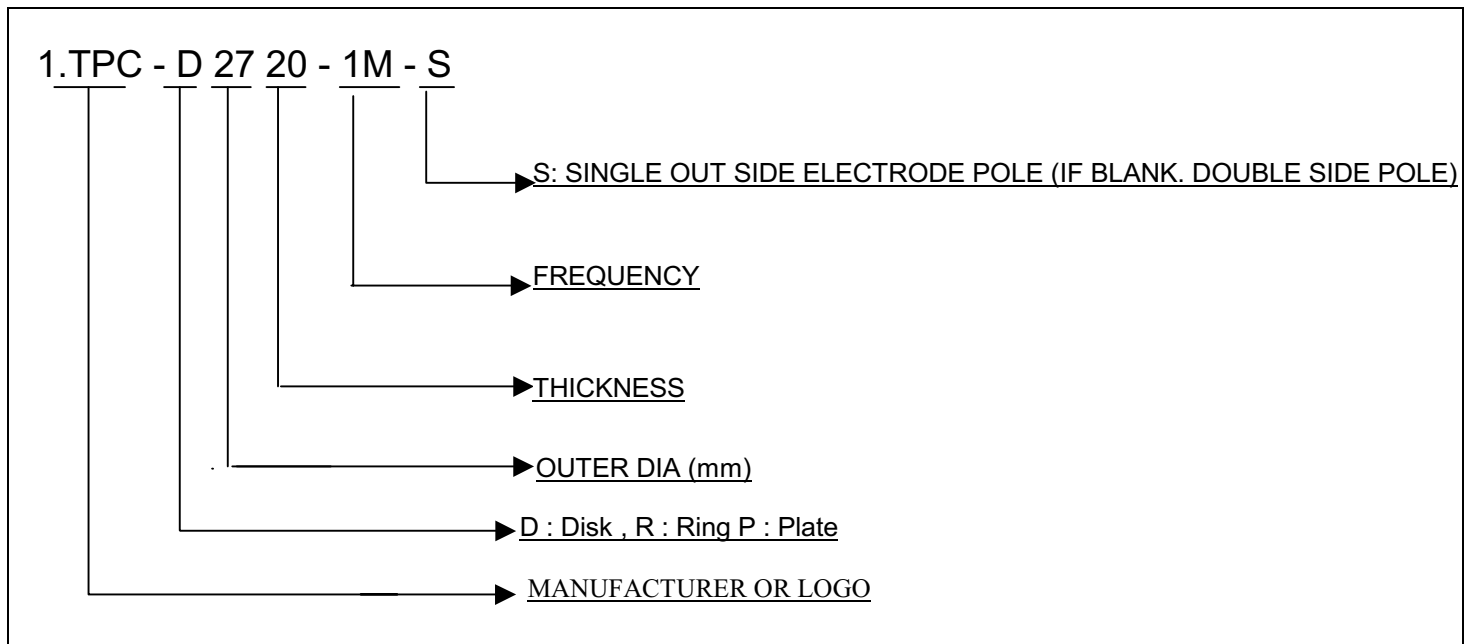
ANOTHER PRODUCTS

-CERAMIC RESONATORS :FOR REMOTE CONTROL UNITS, CLOCK OSCILATION FOR MICRO PROCESSOR.

-ACCELEROMETRIC SENSORS : FOR VIBROMETRY OF SHIPS, AIRCRAFT, AUTOMOBILES, ETC.

-AE SENSORS : FOR SAFERY MONITORING OF POWER PLANTS, PETROCHEMICAL PLANTS, ETC.

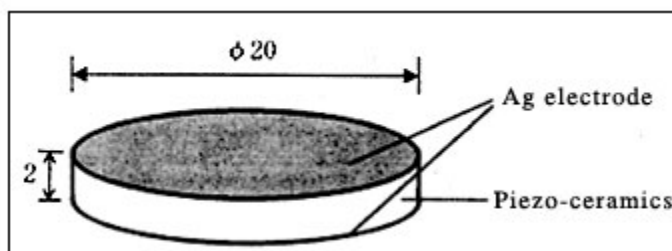
PART NUMBERING GUIDE



2. STANDARD SPECIFICATION

	NUMBER	OUTER/INTERNAL DIAMETER(mm)	THICKNESS (mm)	FREQUENCY(KHZ)	DIELECTRIC LOSS,TAN(%)	PC/N	FREE CAPACITANCE, C(pF)	APPLICATION
1	R3865-42K	38/12.7	6.5	42KHZ	<0.5	320±10%	1750±10%	ULTRASONIC CLEAN
2	R3555-42K	34.8/15	5.5	42KHZ	<0.5	320±10%	1750±10%	ULTRASONIC CLEAN
3	D5030-43K	50	3	43KHZ	< 0.5	320±10%	8000±10%	ULTRASONIC CLEAN
4	D2720-1 M	27.5	2	1 MHZ	< 0.5	320±10%	2600±10%	ULTRASONIC BEAUTY
5	D2020-1M	20	2	1MHZ	<0.5	320±10%	2600±10%	ULTRASONIC BEAUTY
6	D2513-16M	25	1.32	1.65MHZ				HUMIDIFIER
7	D2012-23M	20	1.25	2.3MHZ				HUMIDIFIER

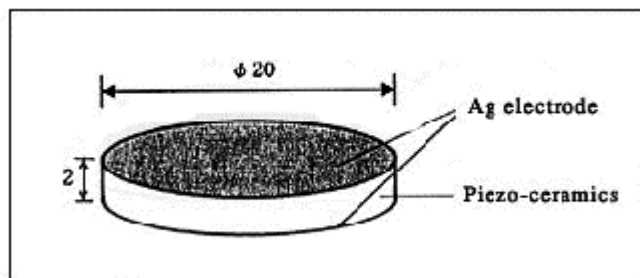
DIMENSIONS:



APPROVAL SHEET OF PIEZO-CERAMIC

TPC-D20

1.PART NUMBER : TPC-D2020-1M

2.DIMENSIONS : $\Phi 20 \times 2$ 

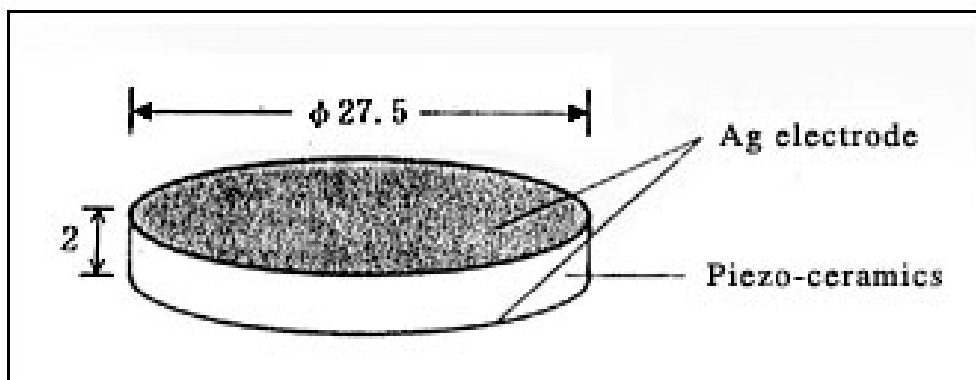
3.ELECTRICAL SPECIFICATION :

Resonant Frequency ,fr	1MHz
Piezoelectric Constant, d33(pC/N)	320±10%
Free Capacitance, C(pF)	2600±10%
Dielectric Loss ,tan δ (%)	<0.5
Application	Ultrasonic Beauty Disk

APPROVAL SHEET OF PIEZO-CERAMIC

TPC-D27

1. PART NUMBER : TPC - D2720 - 1M

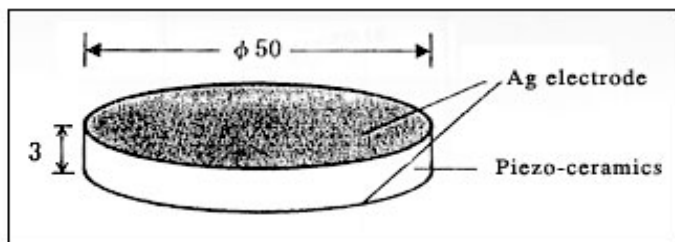
2. DIMENSIONS : $\phi 27.5 \times 2$ 

3. ELECTRICAL SPECIFICATION:

Resonant Frequency , fr	1MHz
Piezoelectric Constant ,d33(pC/N)	320±10%
Free Capacitance, C(pF)	2600±10%
Dielectric Loss ,tan δ (%)	<0.5
Application	Ultrasonic Beauty Disk

APPROVAL SHEET OF PIEZO-CERAMIC
TPC-D50

1.PART NUMBER : TPC -D5030 - 43K

2.DIMENSIONS : $\Phi 50 \times 3.0$ 

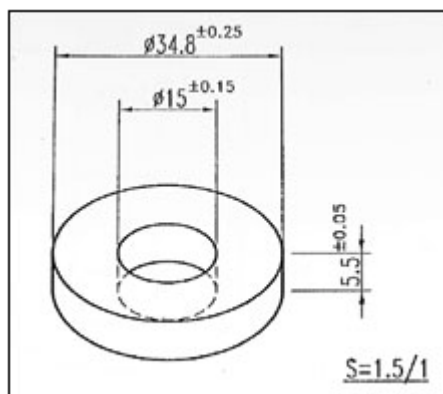
3.ELECTRICAL SPECIFICATION :

Resonant frequency ,fr(kHz)	$43 \pm 5\%$
Piezoelectric Constant ,d33(pC/N)	$320 \pm 10\%$
Free Capacitance, C(pF)	$8000 \pm 10\%$
Dielectric Loss ,tan δ (%)	<0.5
Application	Ultrasonic Clean Disk

APPROVAL SHEET OF PIEZO - CERAMIC TPC-R35

1.PART NUMBER : TPC - R3555 - 42k

2.DIMENSIONS : $\Phi 34.8 \times \Phi 15 \times 5.5$



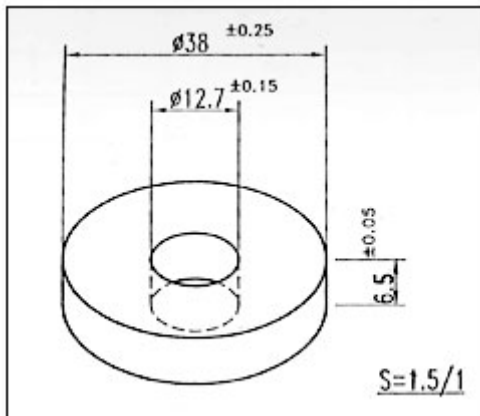
3.ELECTRICAL SPECIFICATION:

Resonant Frequency ,fr(kHz)	42±5%
Piezoelectric Constant ,d33(pC/N)	320±10%
Free Capacitance, C(pF)	1750±10%
Dielectric Loss ,tan δ (%)	<0.5
Application	Ultrasonic Clean Ring

APPROVAL SHEET OF PIEZO - CERAMIC

TPC - R38

1.PART NUMBER : TPC - R3865 - 42k

2.DIMENSIONS : $\Phi 38 \times \Phi 12.7 \times 6.5$ 

3.ELECTRICAL SPECIFICATION:

Resonant frequency ,fr(kHz)	42±5%
Piezoelectric Constant ,d33(pC/N)	320±10%
Free Capacitance, C(pF)	1750±10%
Dielectric Loss ,tan δ (%)	<0.5
Application	Ultrasonic Clean Ring