Microwave Materials

Ferrites, Dielectric & Coaxial Resonators

From Design
to Production

EXXELIA

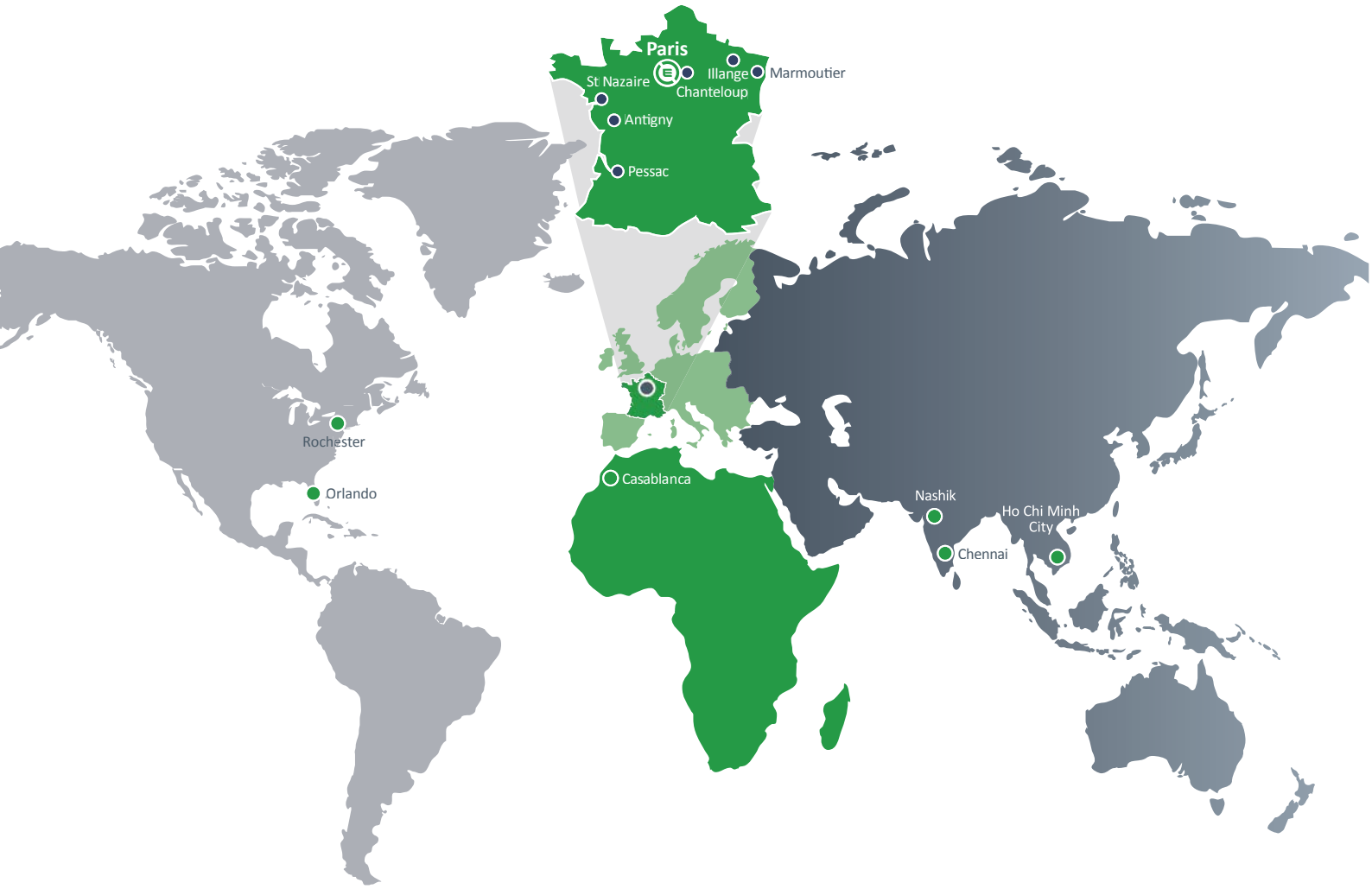
Product Catalogue 262

Microwave Materials

Ferrites, Dielectric & Coaxial Resonators

EXXELIA

A Worldwide presence



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FERRITES & FDA

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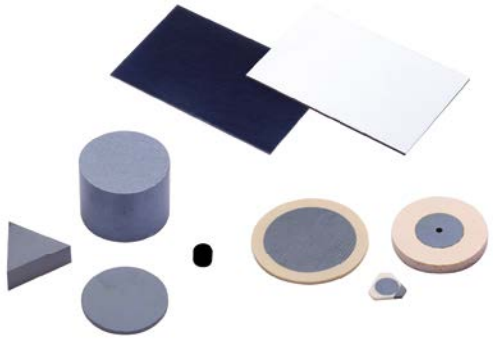
FERRITES & FDA

EXXELIA offers a wide range of ferrite materials, yttrium garnets ("Y" series or "D" series), magnesium ("U" series), nickel ("N" series) and lithium ("A" series) ferrites, as a result of their own developments on inheritage of the formerly companies CSF, LTT, Thomson. The offer covers need at frequencies from 0.1 to more than 30 GHz, high power, with temperature exigencies as well.



EXXELIA manufactures their own ferrite powders from simple oxides or carbonates raw materials, then produce pressed and fired ceramics, machine them at tight tolerances and surface finishing up to polishing.

EXXELIA also supply assemblies of ferrite surrounded with dielectric, silver thick film metalized pieces, complex shapes.

SYMBOLS / UNITS

Magnetism parameters

Great letters: time constant (DC) / Small letters: frequency, time dependent (RF)

Symbol	Parameter	MKSA system	CGS system
B **B_r** **M ($4\pi M_S$ or M_S), m**	Magnetic induction | Remnant induction Volume magnetization (saturation)	Tesla (T)	Gauss (=10^{-4} Tesla)
H, H_r, H_a, H_c **h, h_c** **ΔH** **ΔH_{eff}** **ΔH_k**	Magnetic field (magnetizing force),resonance Anisotropy field | Coercive force Magnetic wave field, c field Ferromagnetic resonance line width Effective resonance line width Spin wave line width	A/m	Oersted (Oe) (=$10^3/4\pi$ A/m)
μ_0	Vacuum permeability	$4\pi 10^{-7}$H/m $B = \mu_0 (H+M)$	1 $B = H+4\pi M$
$\mu = \mu_0 \mu_r$	Permeability	$B = \mu_0.\mu_r.H$	$B = \mu_r.H$
C	Magnetic susceptibility = M/H, m/h	-	-
μ_r	Relative permeability	$\mu_r = 1 + \chi$	$\mu_r = 1 + 4\pi c$ (or $1+\chi$)
α	Magnetization temperature coefficient: $\frac{\Delta M_s}{M_s \Delta T}$	$10^{-3}.K^{-1}$	$10^{-3}.°C^{-1}$
f	Wave frequency	MHz	MHz
γ	Gyromagnetic ratio: $f = \gamma H_r$	~35 10^{-3} MHz. m/A	~2.8 MHz/Oe
γ_{eff}	Landé g-factor ~ 2	$= \gamma/0.0176$	$= \gamma/1.4$

In the below text, CGS system is mainly used with simplified expression (without the factor 4π).

Dielectric properties

Symbol	Parameter
ε'	Relative permittivity (real part)
ε''	Relative permittivity (imaginary part)
ε_r	Relative complex permittivity
tanδ	Dielectric loss tangent: $\tan\delta = \varepsilon''/\varepsilon'$

Other

Symbol	Parameter	Unit
T, T_c	Temperature, Curie temperature	K
R_a	Surface roughness	µm

I. BASIC PROPERTIES

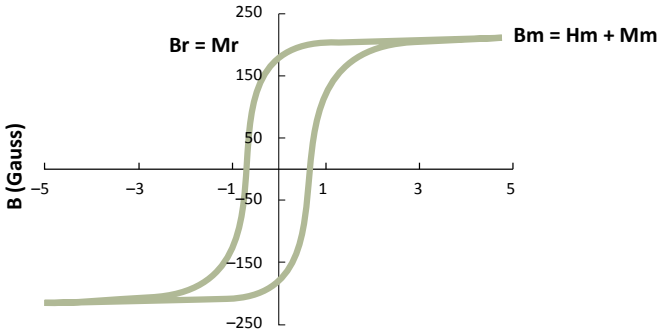
Ferrite materials are used in microwave applications to perform various non-reciprocal devices such as isolators, circulators, diplexers, filters, phase shifters etc. They have dielectric and magnetic properties due to the presence of magnetic ions such as iron within the composition.

I.1 MAGNETIC PROPERTIES

Magnetization M_S

This property is based on the alignment of the spins of electrons parallel to an applied magnetic field H. Because the material is a "soft magnetic material", a small field (close to coercive force Hc) of about 1 to few Oe is enough to get its magnetization value (Mm =Bm - Hm) close to its saturated maximum M_S (values in the range 290 to 5000 Gauss). This is shown on the curves of the hysteresis loop. However this M_S value is really obtained at much higher field, the measurement is made with a 8000 Oe magnet.

The hysteresis loop also shows, how for the null H field, the material can be in a remnant state with an induced field B_r different from zero. This is used in phase shifters to monitor phase shift through the ferromagnetic resonance at M_r.



By increasing temperature of the ferrite, the aligning of the spins parallel to the H field is more and more difficult due to thermal agitation. The magnetization becomes null at the Curie temperature Tc, which are in the range of 120 to 650°C. The evolution of the magnetization with temperature is measured by the parameter:

$$\alpha = \frac{\Delta M_s}{M_s \Delta T}$$ in the common range of T: -20 to +60°C

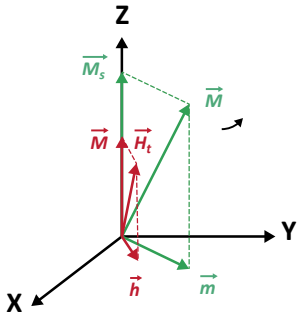
Gyromagnetic resonance - Landé g-factor γ_{eff}

The gyromagnetic resonance, and so the non-reciprocal effect, is created in ferrite devices isolators, circulators, phase shifters, switches under a static magnetic field $\vec{H}$.

In case of saturation of the ferrite to M_s, and in case of a wave propagating parallel to the z axis, the microwave field $\vec{h}$ is in a plane "x y" perpendicular to the z axis and rotating at a frequency f magnetization $\vec{M}$ discloses a precession motion about the field $\vec{H}$ at the frequency f. There is a resonance for $\|\vec{H}\| = H_r$ given by:

$$H_r = \frac{f}{\gamma}$$

- γ is the gyromagnetic ratio and is related to the effective Landé g-factor γ_{eff} as
- $\gamma = 1.4 \cdot \gamma_{eff}$.MHz/Oe. γ_{eff} is about 2 depending on the material: $2 \le \gamma_{eff} \le 2.3$



Permeability, gyro-resonance line width ΔH, non-reciprocal effect

The magnetization $\vec{m}$ is related to the microwave magnetic field $\vec{h}$ with the tensor of susceptibility $\bar{\bar{\chi}}$: $\vec{m} = \bar{\bar{\chi}} \times \vec{h}$. This tensor (named Polder tensor) owns two eigenvalues associated respectively to a positive (+) circularly polarized wave and to a negative (-) circularly polarized wave. Thus in a system of coordinates rotating about H axis at the frequency f, the magnetization $\vec{m}$ is described with two components only, m_+ and m_- :

$$\mu_+ = \chi_+ h_+ \quad \mu_- = \chi_- h_-$$

The susceptibilities χ_+ and χ_- are complex numbers. The real and the imaginary part of each of these values are noted χ_+, χ_-, χ''_+, χ''_-. The imaginary parts represent the loss. Complex permeability μ is related to susceptibility:

$$\mu_\pm = 1 + \chi_\pm, \ \mu_\pm = \mu'_\pm - j\,\mu''_\pm, \ \mu'_\pm = 1 + \chi'_\pm \mu'_\pm, \ \mu''_\pm = \chi''_\pm$$

Permeability can be expressed as a function of frequency or magnetic field H, or normalized to H_r, thus fig.1

$$\mu'_\pm = 1 + \frac{M_s}{H_r} \frac{\left(\frac{M_s}{H_r} \mp 1\right)}{\left(\frac{H}{H_r} \mp 1\right)^2 + \left(\frac{\Delta H}{2H_r}\right)^2} \qquad \mu''_\pm = \frac{M_s}{H_r} \frac{\frac{\Delta H}{2H_r}}{\left(\frac{H}{H_r} \mp 1\right)^2 + \left(\frac{\Delta H}{2H_r}\right)^2}$$

H is the internal static magnetic field
H_r is the resonance field
M_S is the saturated magnetization
H/H_r is the midpoint width of the Lorentz curve
ΔH gyromagnetic line width

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Within a given magnetic field range, it is possible to find values of H such that the permeabilities μ'_+ and μ'_- are different, while μ''_+ and μ''_- have very low values (fig 1).

This property has for consequence, the non-reciprocity of devices behavior: the greater the difference $\Delta\mu$ between μ'_+ and μ'_-, the more efficient the device. The field H can be either lower or higher than the resonant field H_r

Operation below resonance (zone B in fig 1)

The difference $\Delta\mu$ is greater than in the case of high field (B zone in fig 1) and more constant over the H field locally. Moreover the external field required is lower, and so the magnet strength too so that smaller magnets are required.

Nevertheless magnetization of the ferrite should be lower than a certain limit and is a limiting factor for the difference $\Delta\mu$ since magnetization is a multiplicative factors in all terms of the susceptibility. The limit is due to the phenomenon of natural resonance in unsaturated materials. This leads to "low magnetic field loss" (fig 2). Consequently, for a given frequency f, the material selected must have a magnetization lower than the field of resonance H_r, so lower than f/γ, unless it is to be used above the resonance.
Finally at low field H, the magnetization should be chosen according to:

$$\frac{1}{3} < \frac{\gamma M_s}{f} < \frac{3}{4}$$

Operation above resonance (zone A in fig 1)

In that case the magnetization may be greater than the limit of f/γ and so efficiency is improved as a consequence of a larger difference in $\Delta\mu$. This case should be applied as soon as magnet conditions for H field are fulfilled (strength, temperature behavior linked to the ferrite's one, etc.). Another advantage is seen in the case of power losses as indicated forward.

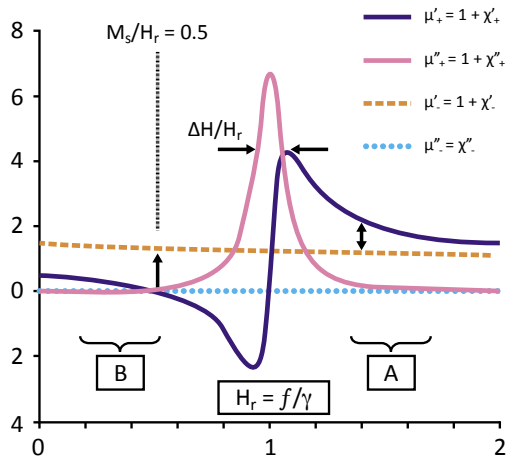

Figure 1 *μ'_+, μ'_-, μ''_+, μ''_-, as a function of H/H_r*
"B": below H_r resonance field (low field H)
"A": above H_r resonance field (high field H)

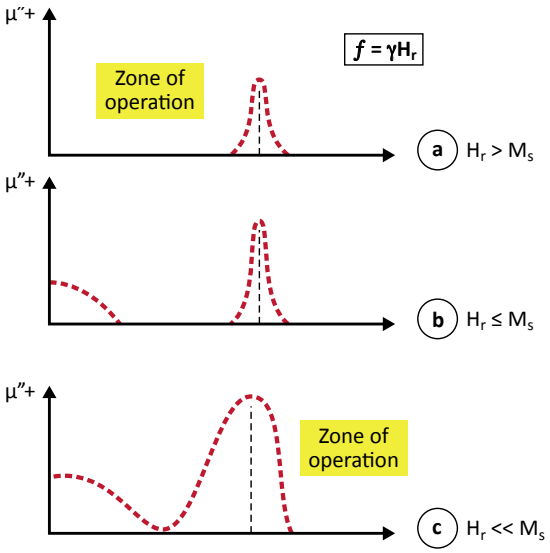

Figure 2 *: permeability μ''_+ versus static field H*

Effective line width ΔH_{eff}

The magnetic losses in the ferrites affect the insertion loss of the device. It is related to the imaginary part of the permeability of the positive polarization μ''_+, which increases with the gyromagnetic line width ΔH (fig.1).

Experiment shows that the curve μ''_+ (H) far away from the resonance is a Lorentz curve with an effective line width denoted ΔH_{eff} smaller than ΔH. Near the resonant frequency, the line width is broadening by several phenomena such as porosity, magneto crystalline anisotropy.

There is much practical interest involved in the concept of effective line width ΔH_{eff} than line width H, far from resonance.

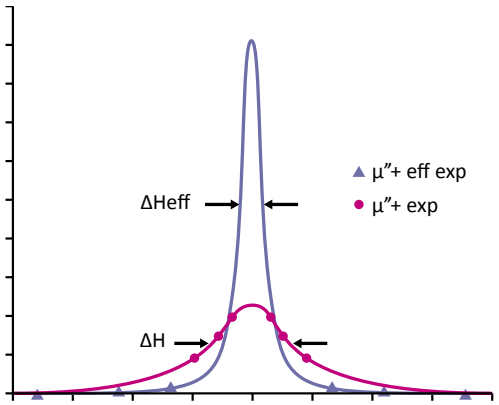

Figure 3 *: ΔH, ΔH_{eff}*

The imaginary parts of permeability μ_+ represent losses in the material:

- At the vicinity of the resonance, μ''_+ describes a Lorentz curve the half width of which, denoted ΔH

- From the values of μ''_+, far from resonance, a Lorentz curve can be extrapolated the half width of which, denoted ΔH_{eff}, corresponds to the off resonance magnetic losses.

Depending on their compositions, the ferrites have line width ΔH in the range 10 to 500 and ΔH_{eff} in the range 4 to 50.

Spin wave line width ΔH_k

Above a certain microwave power level, nonlinear phenomena take place resulting in additional magnetic loss which rapidly becomes prohibitive in the devices.

The critical magnetic microwave field hc, from which such effects appear, depends on the applied static field. The nonlinear effects are associated with the excitation of the spin waves, the attenuation of which is described by ΔH_k.

For a certain static magnetic field H denoted Hsub, there is a minimum of the microwave magnetic field hc related to ΔH_k

$$h_c \min = \frac{2f\Delta H_k}{\gamma M_S}$$

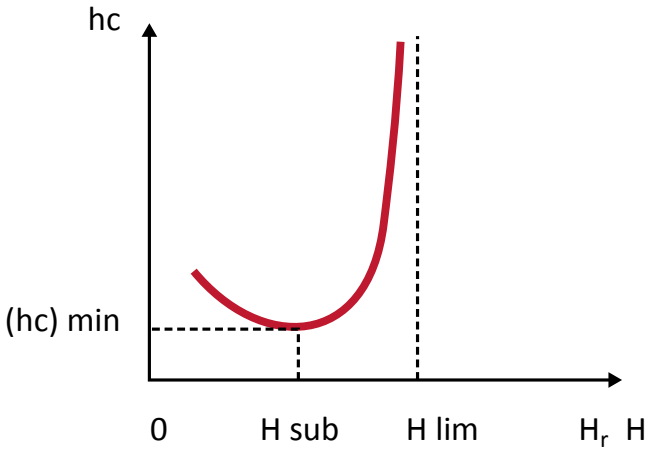

Figure 4: non-linear effect critical field hc versus static field

The higher the value of ΔH_k, the better the high power behavior.

For a static magnetic field higher than H_{lim}, there is no effect of the power on losses: this is the case for devices operating at high static field (above resonance).

The ferrites have ΔH_k from 1 to more than 20. The relation between the line widths is $\Delta H_k < \Delta H_{eff} < \Delta H$

I.2 DIELECTRIC PROPERTIES

The dielectric properties of the ferrites are also of importance in the applications. The relative real permittivity e' is within the range of about 12 to 16 and affects the wave length in the material and the impedance. The relative imaginary part of the permittivity e'' or the dielectric loss tangent $\tan\delta = \frac{\varepsilon''}{\varepsilon'}$ affects the insertion losses. Ferrites, depending on their compositions have dielectric loss tangent at 10 GHz between 10^{-4} and 10^{-3}. In this range, the insertion loss of the device is more affected by the magnetic losses.

I.3 CHARACTERIZATION

Four parameters are tested in standard production. The result of test is compared with the values in the tables at the end: Ms, ΔH, ε', tanδ

The Landé g-factor γ_{eff} and the hysteresis cycle parameters are given on request.

Other parameters such as Tc, ΔH_{eff} , ΔH_k and α are not tested but the values are given in the tables, considered as heritage.

Saturation Magnetization M_s

Saturation magnetization is measured at room temperature by the Weiss method. A sample of one gram typically is moved through the air gap of a magnet delivering a magnetic field of 8000 Oe. A flux variation is produced through Helmholtz bobbins fixed on the magnet poles and read on an integrator: the signal of a material is compared to a pure nickel's one with admitted value is 54.56 Gauss.cm^3/g

Gyromagnetic line width ΔH and effective Landé g-factor

The effective Landé g-factor γ_{eff} and line width ΔH are measured in a rectangular cavity at 9.3 GHz and at room temperature. The test sample is a sphere of about 1mm in diameter. The test complies with the IEC 60556 publication.

Relative dielectric constant ε' and dielectric loss tangent tanδ

The permittivity is measured using a rod of about 1mm in diameter in a rectangular cavity at 8.2 GHz.

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Hysteresis parameters

EXXELIA offers the possibility to perform hysteresis on request and give remnant induction B_r, coercive field H_c, temperature dependence. Values are given for the Axx families and NZ50 material.

A toroidal sample is double winded and used as a transformer. The primary winding magnetizes the sample through a 50 Hz frequency signal. The applied field H is proportional to the primary current; the signal induced in the secondary winding is proportional to the magnetic flux variation and is integrated to obtain the magnetic induction B.

The induction value B_m is obtained for an applied field of 5 H_c.

II. USER GUIDE

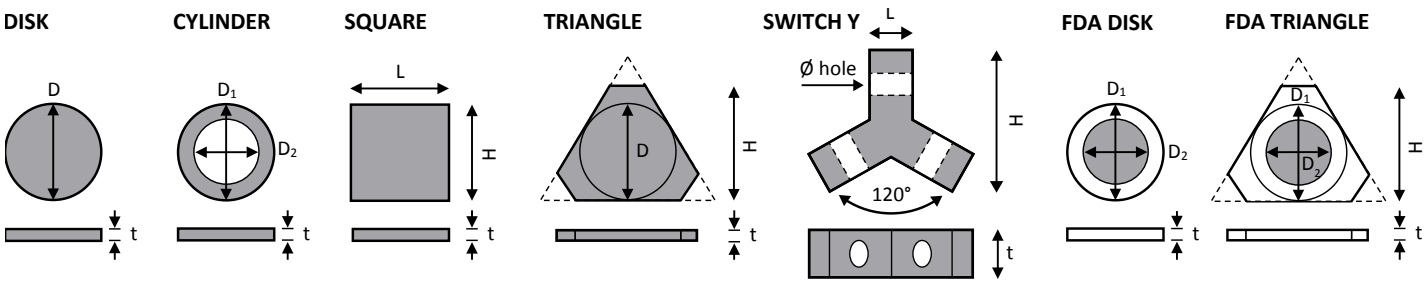
Material properties synthesis

Table below summarizes the properties of materials in term of magnetization, stability of magnetization, line widths.

Ferrite family	Chemical composition	Frequency range (GHz) (below resonance)	Magnetic losses ΔH_{eff} (Oe)	Power behaviour ΔH_k (Oe)	Temperature stability α (10^{-3}/°C)
Y1xx	Y-Gd	1.55 ~ 10.9	3 ~ 45	1.5 ~ 13	0.9~2.2
Y2xx	Ca-V-Y (CVG)	1.55 ~ 10.9	2	1	2.6~3.7
Y3xx	Y-Al	0.34 ~ 6.2	4	2	2.6 ~ 5
Y4xxx	CVG-Gd	1.55 ~ 6.2	12 ~ 18	9 ~ 12	0.8 ~ 1.4
Y7xx	Y-Gd-Al	0.34 ~ 6.2	6 ~ 15	5 ~ 10	0.5 ~ 3.4
Y9xx	Y-Gd-Al Co-doped	0.34 ~ 10.9	9 ~ 15	25 ~ 46	0.3 ~ 1.3
Dx	Y-Gd-Al Dy-doped	0.34 ~ 10.9	29 ~ 63	10 ~ 20	0.5 ~ 3
Uxx	Mn-Mg	1.55 ~ 36	6	4	2.2 ~ 3.3
Axxx	Li	6.2 ~ 40	4 ~ 9	3 ~ 10	0.9 ~ 1.6
Nxxx	Ni	1.55 ~ 40	30 ~ 50	12 ~ 25	0.7 ~ 2
YK21-xx / DK21-xx	Y-V	1.55 ~ 10.9	8 ~ 17	4 ~ 8.5	1.8 ~ 2.7

Shapes

Typical range of shapes which can be produced including single ferrite (F), assembly (FDA) with typical dielectric constant 10, 16, Other on request.



Dimensions mm (inches)

A wide range of dimensions can be made based on customer specifications

- Disks: diameter 1 (0.039) up to 60 (2.362) (typical value)
- Square: max length 50.8 (2.000) x 50.8 (2.000) / Thickness 0.5 (0.020) up to 3 (0.118) (typical value)
- Triangle: in-circle diameter up to 50 (1.969) (typical value)
- Other shapes can be considered on request.

Tolerances on dimensions mm (inches)

- Standard tolerances are ±0.05 (0.002) on both diameter and thickness.
- As-fired parts (no machining requested => lower cost) are available for ±1% tolerance.
- Smaller tolerances can be considered on request.

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	Min	Standard / Typical	Max	Typical Tolerance
Ferrite Shape				
Disk / Cylinder				
Diameter	0.6mm		70mm	± 0.05 mm
Internal diameter	1mm		65mm	± 0.05 mm
Square				
Length x Width	0.6 x 0.6mm		100 x 35mm or 50.8 x 50.8mm	± 0.05 mm
Triangle				
Incircle diameter	2.5mm		22mm	± 0.05 mm
Height	2.5mm		30mm	± 0.05 mm
Thickness	0.2mm		16.5mm	± 0.05 mm
Switch Y				
Length	On demand		On demand	
Width	On demand		On demand	
Thickness	On demand		On demand	
Hole diameter	0.5mm		On demand	
FDA				
Internal diameter	1.3mm		65mm	± 0.05 mm
External diameter	2.3mm		70mm	± 0.05 mm
Thickness	0.6mm		16.5mm	± 0.05 mm
Roughness & Metallization				
Finish Ra	0.1µm	0.8µm	As fired	
Metallization Thickness (Not for FDA)- Silver		7- 14µm		

Br value to be defined with the customer because it depends on the dimensions of the ferrite

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Surface finishing

As-fired parts can be grinded, lapped or polished.

Standard average peak-to-valley height (Ra) is specified here below.

Surface finishing	Ra (micrometer)	Ra (micro-inch)	Remarks
Standard	0.8	24	All ferrites
Lapped	0.4	16	All ferrites
Polished	0.1	4	All ferrites except A or U family

Metallization

Thick film: Silver

Thin film: on request

Chamfer

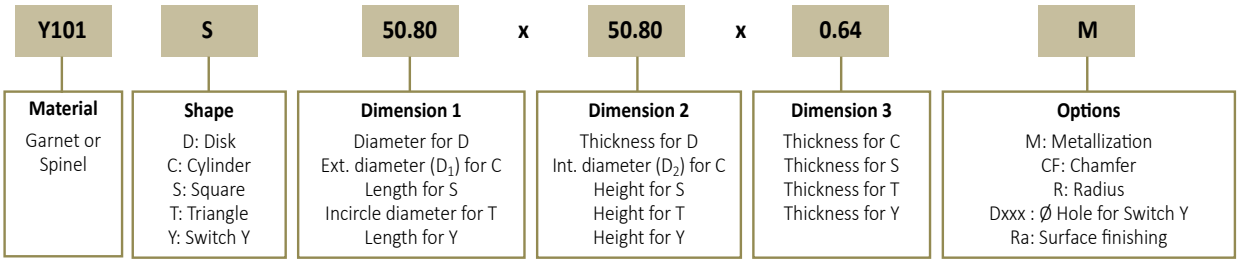
As per customer specification.

Radius

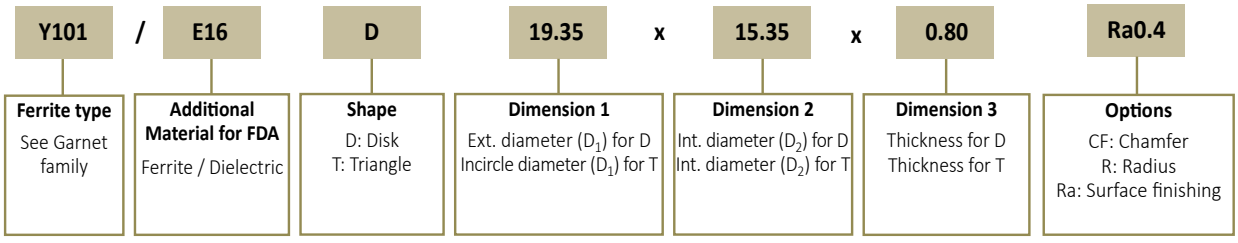
As per customer specification.

How to order

Example for ferrite: **Y101 S50.80x50.80x0.64 M**

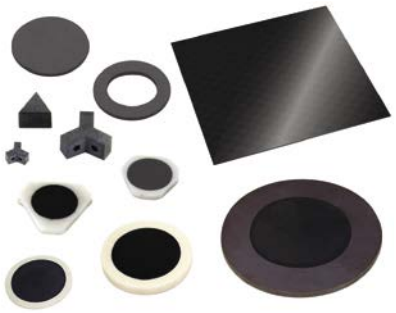


Example for FDA: **Y101/E16 D19.35x15.35x0.80 Ra0.4**



IRON GARNET
Y - Gd

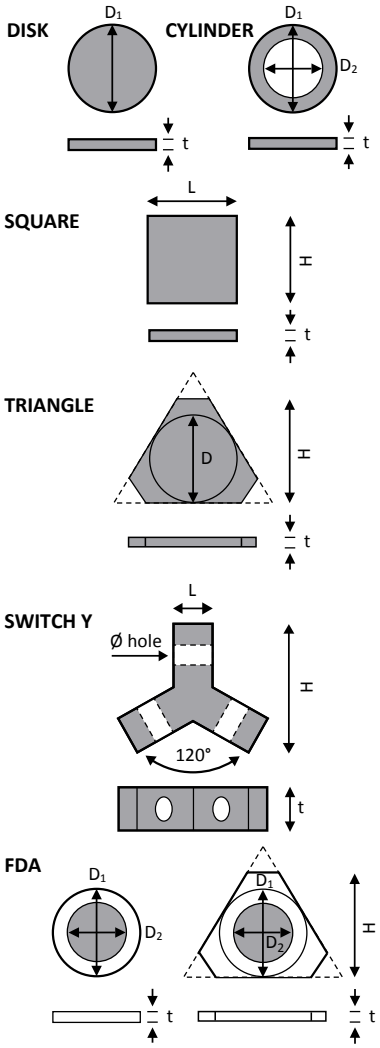
YTTRIUM - GADOLINIUM



Type	M_S (Gauss) ± 5%	Tc (°C)	γ_{eff}	ΔH (Oe) + 20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ± 5%	tanδ 10^{-4} max	α 10^{-3}/°C ± 0.2
Y101*	1820	280	2.02	18	3	1.5	15	2	2.2
Y11	1600	280	2.00	50	8	3	15.3	2	1.8
Y12	1420	280	2.01	60	14	5	15.3	2	1.5
Y13	1250	280	2.01	75	21	7	15.3	2	1
Y14	1100	280	2.02	95	28	9	15.4	2	0.5
Y15	900	280	2.03	130	36	11	15.4	2	0.7
Y16	750	280	2.02	170	45	13	15.4	2	0.9

* Pure Yttrium iron garnet

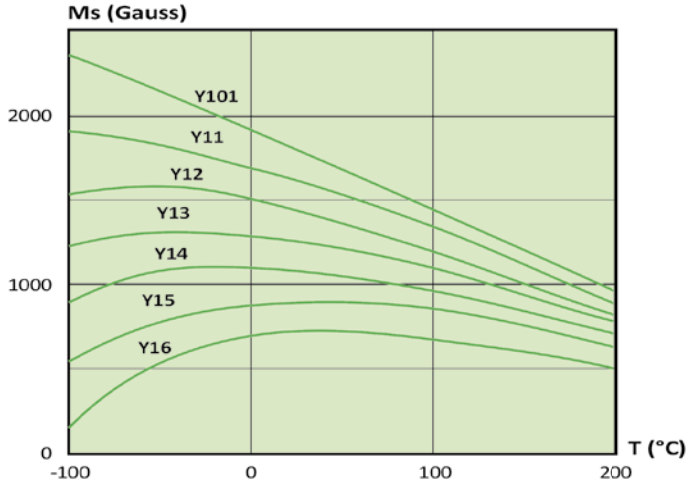
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



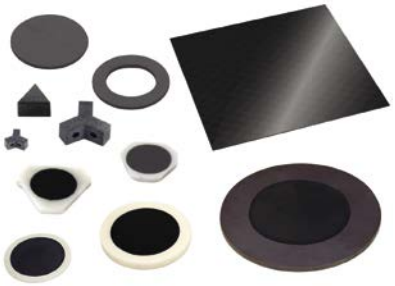
HOW TO ORDER (dimensions in mm):

Example: **Y101/E16 D19.35x15.35x0.80 Ra0.4**

Y101	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4
Ferrite type See Y-Gd family		**Additional material for FDA** Ferrite Dielectric	**Shape** D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	**Dimension 1** Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T		**Dimension 2** Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T		**Dimension 3** Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	**Options** CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

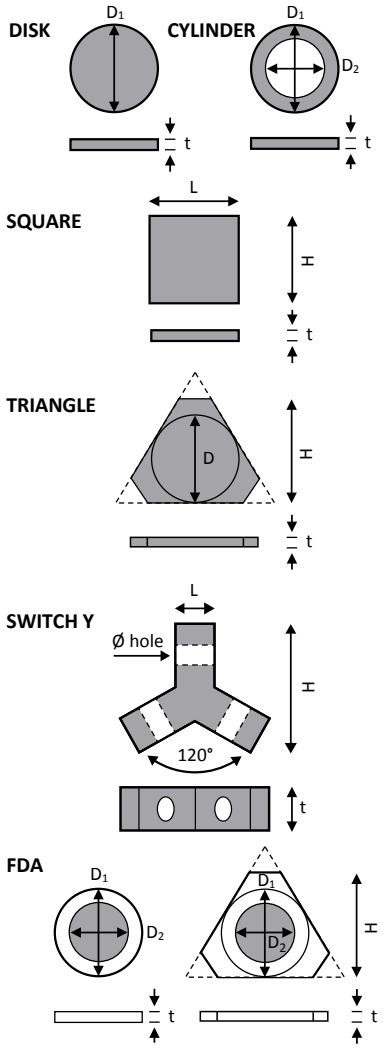
IRON GARNET
Y - Ca - V - In or Zr

YTTRIUM - CALCIUM - VANADIUM - INDIUM or ZIRCONIUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
Y220	1950	205	2.01	10	2	1	15.4	2	3.1
Y219	1900	240	2.02	15	3	1.5	15.2	2	2.6
Y218	1850	215	2.01	10	2	1	14.8	2	2.8
Y216	1600	218	2.01	10	2	1	14.8	2	2.6
Y215	1450	215	2.01	10	2	1	14.7	2	2.7
Y212	1200	209	2.01	10	2	1	14.5	2	2.9
Y211	1100	205	2.01	10	2	1	14.2	2	3
Y210	1000	200	2.01	10	2	1	14.2	2	3.3

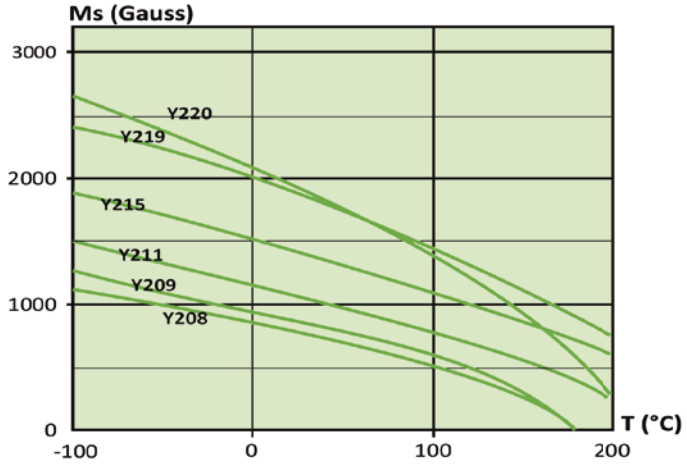
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

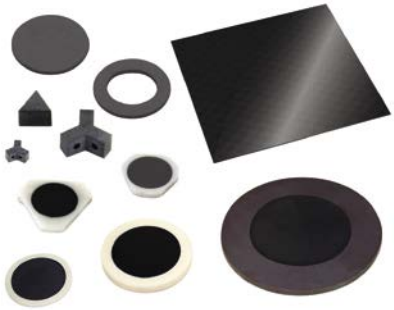
Example: **Y220/E16 D19.35x15.35x0.80 Ra0.4**

Y220	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Y- Ca- V In or Zr family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

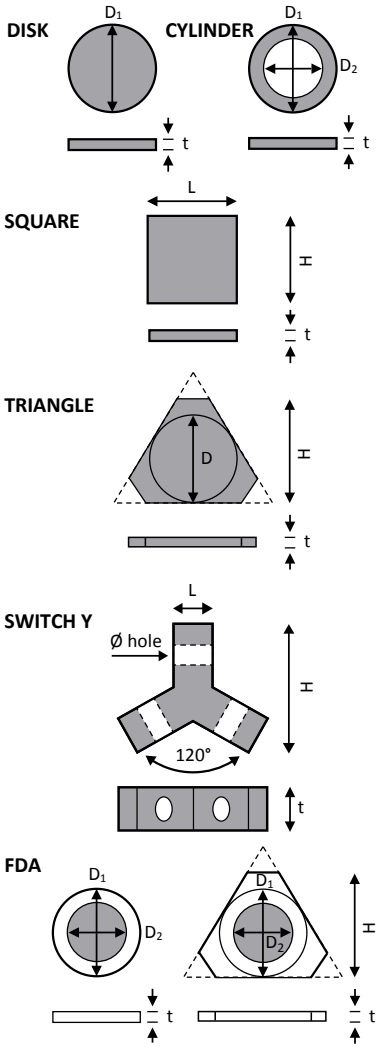
IRON GARNET
Y - Al

YTTRIUM - ALUMINUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
Y35	1200	225	2.01	40	4	2	14.9	2	2.6
Y34	1030	210	2.01	40	4	2	14.9	2	2.7
Y39	800	195	2.01	40	4	2	14.6	2	2.9
Y38	760	190	2.01	40	4	2	14.5	2	2.9
Y37	680	180	2.01	40	4	2	14.5	2	2.9
Y33	615	175	2.01	40	4	2	14.5	2	3.2
Y30	565	160	2.01	30	4	2	14.4	2	3.4
Y32	420	135	2.01	30	4	2	14.4	2	3.8
Y31	370	125	2.01	30	4	2	14.1	2	4.1
Y36	290	115	2.01	25	4	2	14	2	4.6

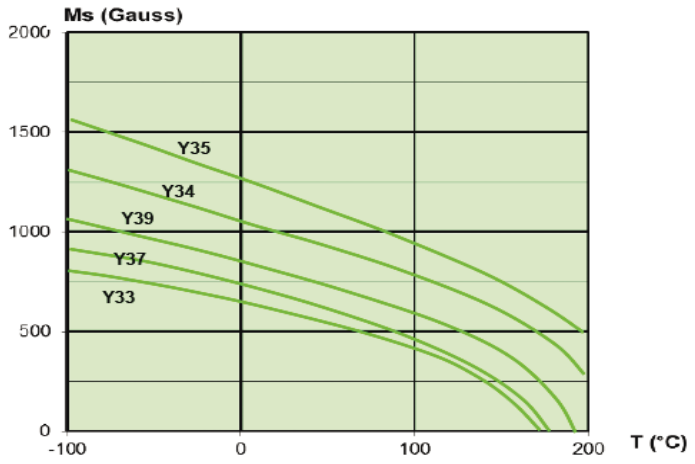
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

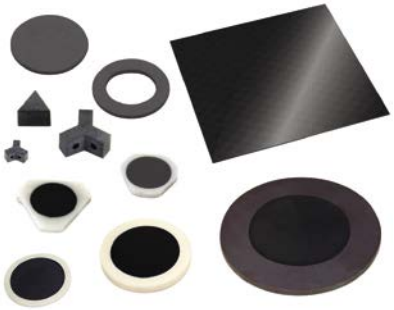
Example: **Y35/E16 D19.35x15.35x0.80 Ra0.4**

Y35	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Y- Al family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

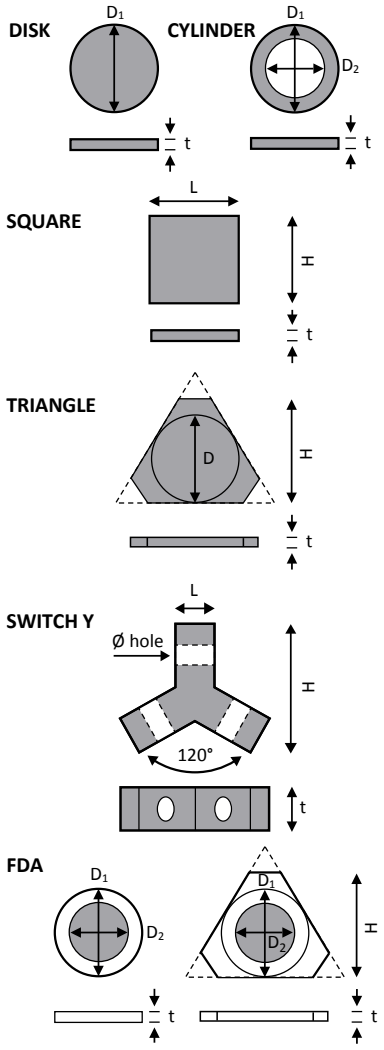
IRON GARNET
Y - Al - Gd

YTTRIUM - ALUMINUM - GADOLINIUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
Y71	1020	235	2.01	60	7	5	15	2	2.2
Y710	1020	240	2.02	75	9	7	15	2	1.7
Y77	950	230	2.01	60	6	5	14.9	2	2
Y780	830	235	2.02	60	6	5	14.8	2	1.6
Y78	800	220	2	80	8	7	15	2	1.3
Y708	800	260	2.04	140	15	10	15.2	2	0.5
Y74	670	190	2.01	60	6	5	14.9	2	2.3
Y72	540	175	2.01	60	6	5	14.6	2	2.3
Y705	470	170	2.02	65	6	5	14.3	2	2.8
Y75	400	160	2.03	65	6	5	14.3	2	2.7
Y76	390	150	2.02	50	6	5	14.2	2	3.4

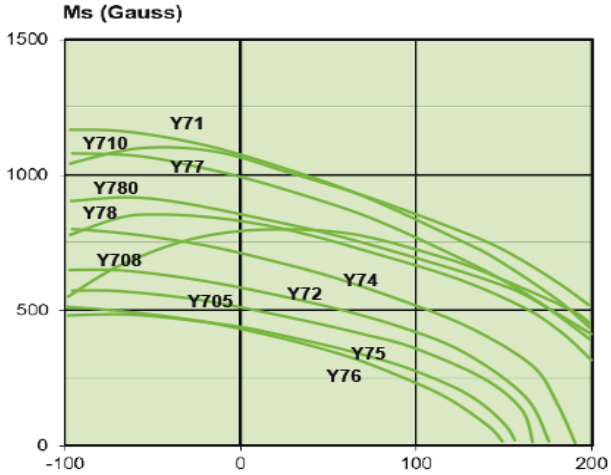
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min. mm	Min. (inches)	Standard / Typical mm	Standard / Typical (inches)	Max. mm	Max. (inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

Example: **Y71/E16 D19.35x15.35x0.80 Ra0.4**

Y71	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type
See Y- Al- Gd family

Additional material for FDA
Ferrite Dielectric

Shape
D: Disk
C: Cylinder
S: Square
T: Triangle
Y: Switch Y

Dimension 1
Diameter for D
Ext. diameter (D_1) for C
Length for S
Incircle diameter for T
Length for Y
For FDA only
Ext. diameter (D_1) for D
Incircle diameter (D_1) for T

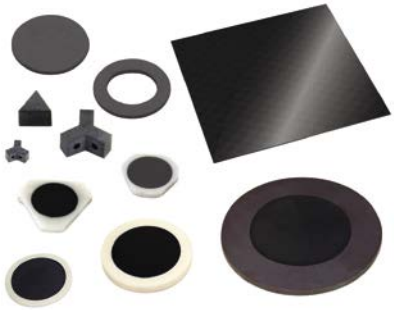
Dimension 2
Thickness for D
Int. diameter (D_2) for C
Height for S
Height for T
Height for Y
For FDA only
Int. diameter (D_2) for D
Int. diameter (D_2) for T

Dimension 3
Thickness for C
Thickness for S
Thickness for T
Thickness for Y
For FDA only
Thickness for D
Thickness for T

Options
CF: Chamfer
R: Radius
Ra: Surface finishing
Excepting FDA
M: Metallization
Dxxx : Ø Hole for Switch Y

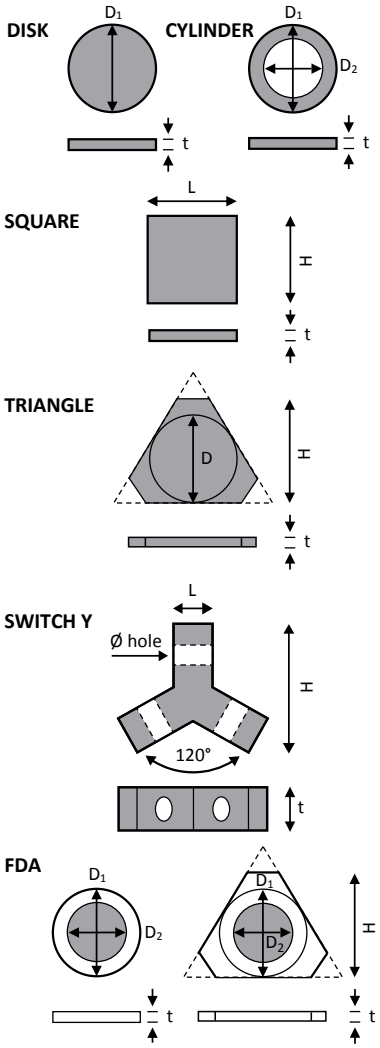
IRON GARNET
Y - Ca - V - Zr - Gd

YTTRIUM - CALCIUM - VANADIUM - ZIRCONIUM - GADOLINIUM



Type	M_S (Gauss) ± 5%	Tc (°C)	γ_{eff}	ΔH (Oe) + 20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ± 5%	tanδ 10^{-4} max	α 10^{-3}/°C ± 0.2
Y4091	960	195	2.02	35	12	9	15.2	2	1.4
Y409	920	223	2.02	50	18	12	15.2	2	0.8

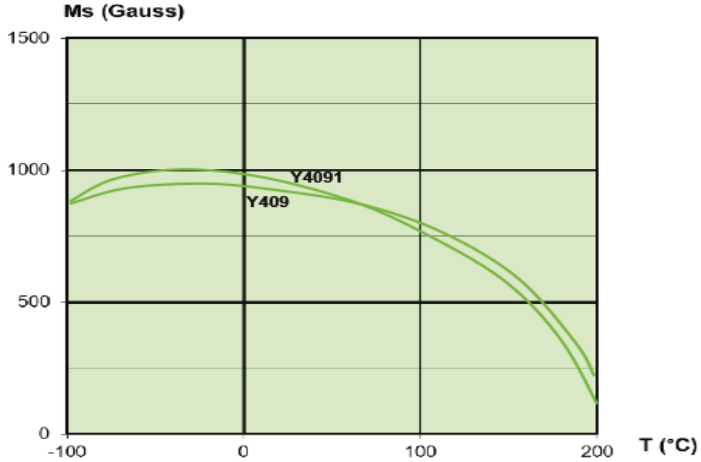
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min. mm	Min. (inches)	Standard / Typical mm	Standard / Typical (inches)	Max. mm	Max. (inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

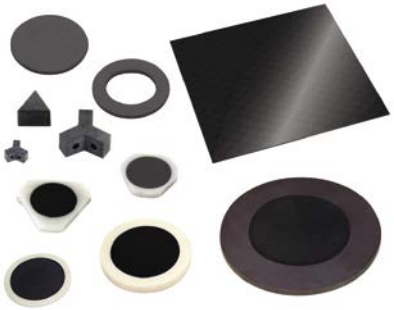
Example: **Y409/E16 D19.35x15.35x0.80 Ra0.4**

Y409	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Y- Ca- V Zr- Gd family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

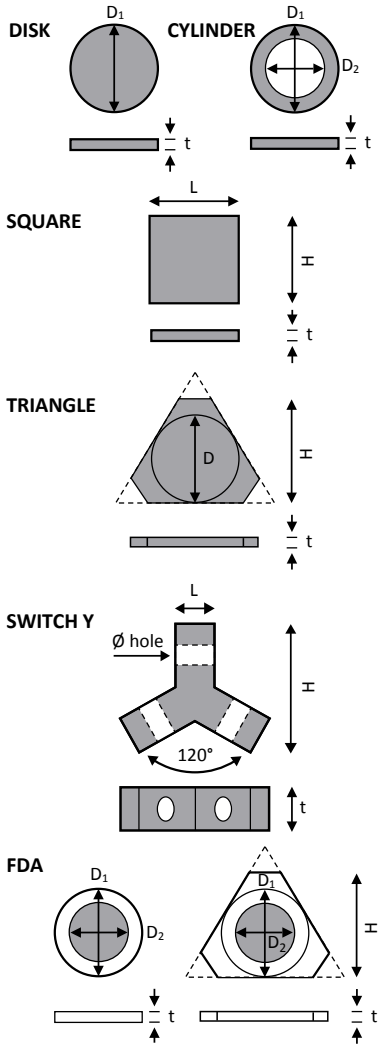
IRON GARNET
Y - Gd - Dy - Al

YTTRIUM - DYSPROSIUM or GADOLINIUM - DYSPROSIUM or ALUMINUM - DYSPROSIUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
D18	1760	280	2.02	85	54	18	15	2	2.2
D1	1400	270	2	110	41	14	15.5	2	1.4
D5	1070	270	2.02	150	55	18	15.5	2	0.5
D2	900	270	2.01	185	63	20	15.5	2	0.8
D3	590	175	2	85	29	10	14.5	2	3.5
D4	580	170	2	140	56	19	14.4	2	3

DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES

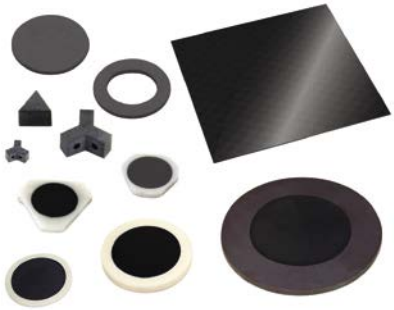
HOW TO ORDER (dimensions in mm):

Example: **D18/E16 D19.35x15.35x0.80 Ra0.4**

D18	/	**E16**	**D**	**19.35**	x	**15.35**	x	**0.80**	**Ra0.4**
Ferrite type See Y- Gd- Dy Al family		**Additional material for FDA** Ferrite Dielectric	**Shape** D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	**Dimension 1** Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T		**Dimension 2** Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T		**Dimension 3** Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	**Options** CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

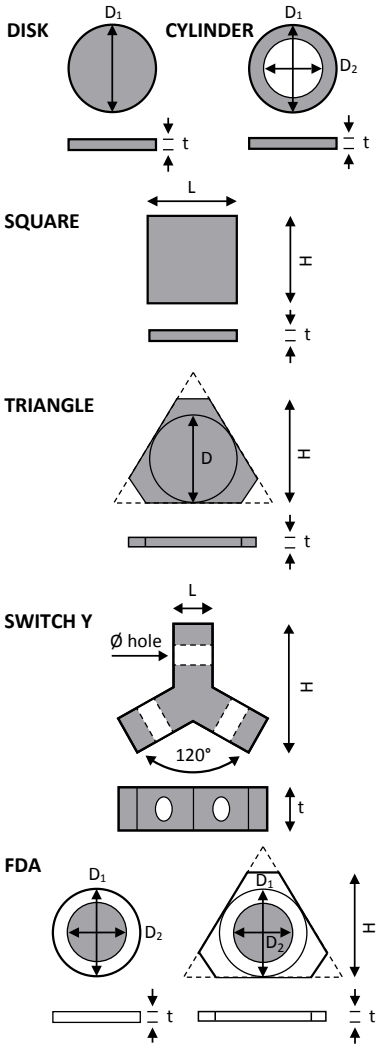
IRON GARNET
Y - Gd - Al - Co

YTTRIUM - Gadolinium - ALUMINUM - COBALT



Type	M_S (Gauss) ± 5%	Tc (°C)	γ_{eff}	ΔH (Oe) + 20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ± 5%	tanδ 10^{-4} max	α 10^{-3}/°C ± 0.2
Y91	1020	240	2.02	60	25	9	15.1	2	1.3
Y94	780	250	2.02	75	40	13	15.2	2	0.3
Y908	780	250	2.02	85	43	14	15.2	2	0.3
Y9081	780	250	2.02	120	46	15	15.2	2	0.3

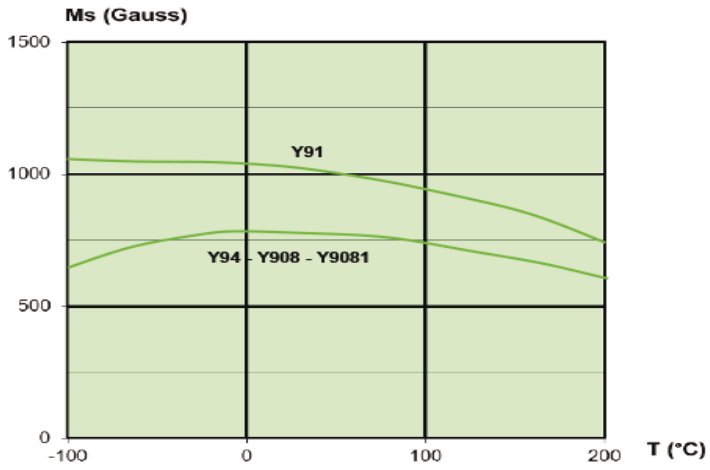
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

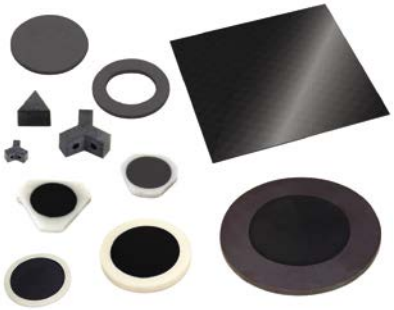
Example: **Y91/E16 D19.35x15.35x0.80 Ra0.4**

Y91	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Y- Gd- Al Co family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

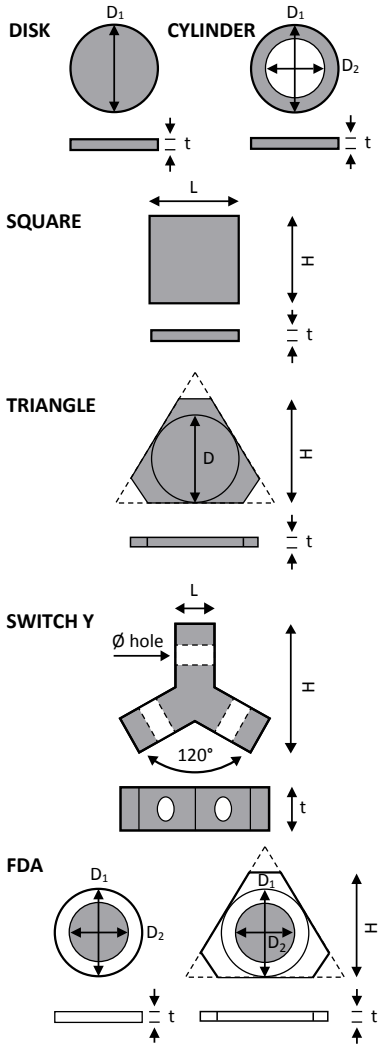
IRON GARNET
Y - Al - Gd

YTTRIUM - ALUMINUM - GADOLINIUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
Y220	1950	205	2.01	10	2	1	15.4	2	3.1
Y219	1900	240	2.02	15	3	1.5	15.2	2	2.6
Y218	1850	215	2.01	10	2	1	14.8	2	2.8
Y216	1600	218	2.01	10	2	1	14.8	2	2.6
Y215	1450	215	2.01	10	2	1	14.7	2	2.7
Y212	1200	209	2.01	10	2	1	14.5	2	2.9
Y211	1100	205	2.01	10	2	1	14.2	2	3
Y210	1000	200	2.01	10	2	1	14.2	2	3.3
Y209	900	180	2.01	10	2	1	14.1	2	3.5
Y208-1	800	177	2.01	20	2	1	14	2	3.7

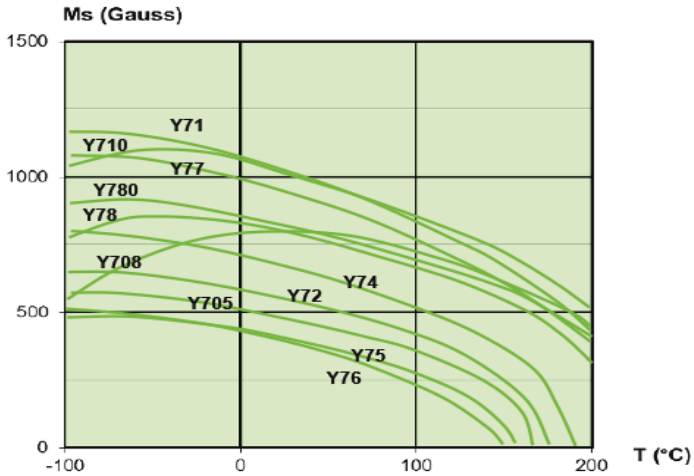
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min. mm	Min. (inches)	Standard / Typical mm	Standard / Typical (inches)	Max. mm	Max. (inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

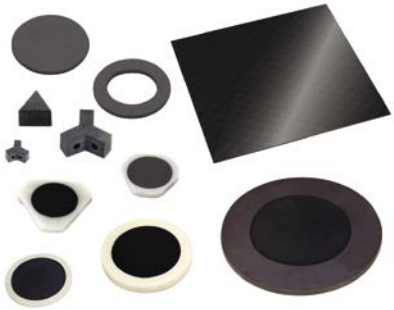
Example: **Y220/E16 D19.35x15.35x0.80 Ra0.4**

Y220	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Y- Al- Gd family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

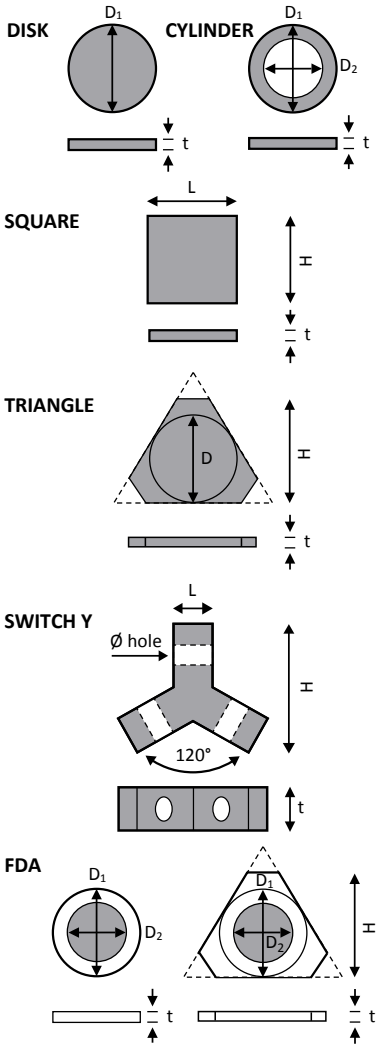
IRON SPINEL Mg - Mn - Al

MAGNESIUM - MANGANESE or MAGNESIUM - MANGANESE - ALUMINUM



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2
U21	2400	275	2.03	290	6	4	13	3	2.7
U20	2100	300	2.01	360	6	4	13	3	2.3
U19	1900	280	2.01	350	6	4	13	3	2.2
U33	1600	230	2.02	290	8	4	12.4	3	3.3

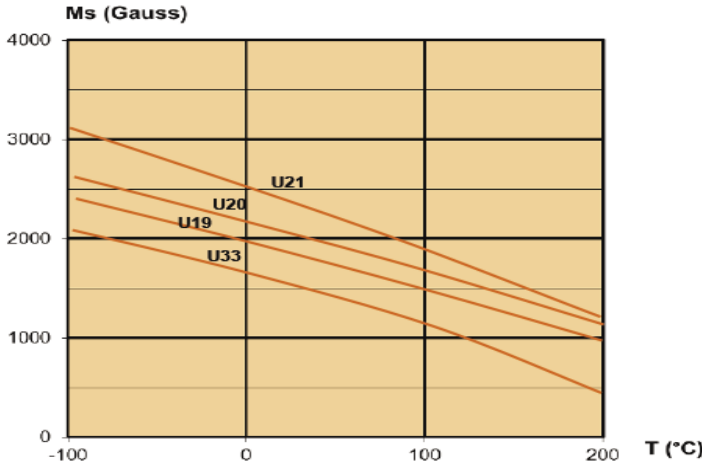
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min. mm	Min. (inches)	Standard / Typical mm	Standard / Typical (inches)	Max. mm	Max. (inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

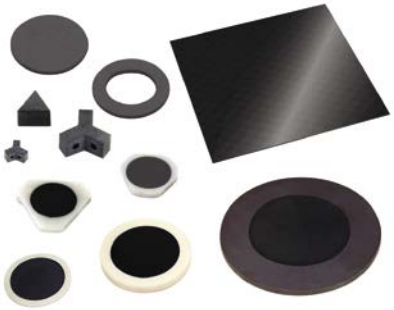
Example: **U21/E16 D19.35x15.35x0.80 Ra0.4**

U21	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Mg- Mn Al family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

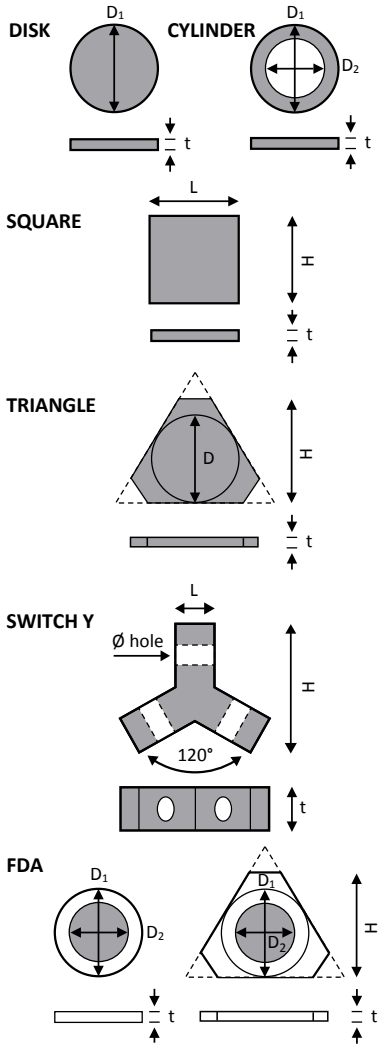
IRON SPINEL
Li - Zn - Ti - Mn - (Co)

LITHIUM - ZINC - TITANIUM - MANGANESE - (COBALT)



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2	B_r (Gauss)
A50	5000	450	2.06	170	4	3	15.3	5	1.6	3300
A500	4900	450	2.06	200	20	10	15.3	5	1.6	3200
A37	3700	565	2.08	400	4	3	16	5	1	2500
A370	3700	565	2.07	400	7	6	15.9	5	1	2500
A30	3000	555	2.08	450	4	3	16.4	5	0.8	2000
A28	2800	540	2.08	450	4	3	16.6	5	0.9	1900
A24	2450	390	2.08	250	4	3	16.8	5	1.6	1700
A23	2300	505	2.08	450	4	3	16.8	5	1.2	1600
A230	2300	505	2.08	450	9	8	16.7	5	1.2	1600

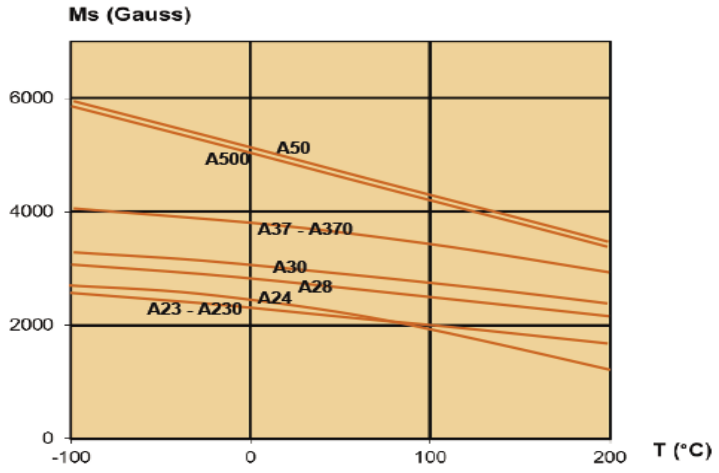
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

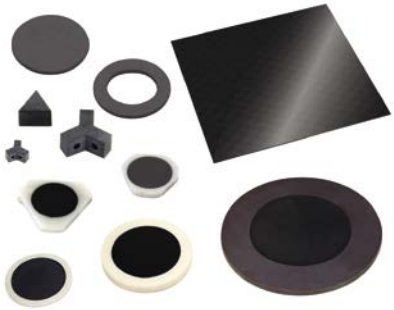
Example: **A50/E16 D19.35x15.35x0.80 Ra0.4**

A50	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Li- Zn- Ti Mn-(Co) family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

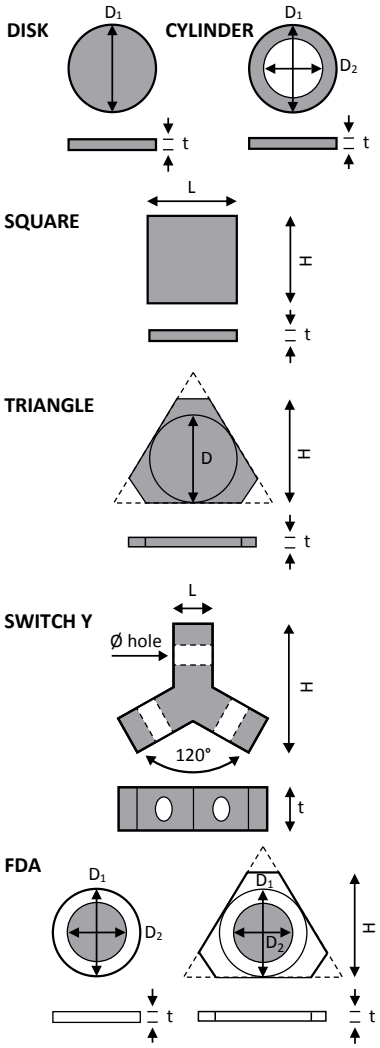
NICKEL or NICKEL - ZINC or NICKEL - ALUMINUM (WITH COBALT - MANGANESE - COPPER)

IRON SPINEL Ni - Zn - A



Type	M_s (Gauss) ±5%	Tc (°C)	γ_{eff}	ΔH (Oe) +20%	ΔH_{eff} (Oe)	ΔH_k (Oe)	ε ±5%	tanδ 10^{-4} max	α 10^{-3}/°C ±0.2	B_r (Gauss)
NZ50	5000	375	2.1	125	30	12	13.7	5	2	3650
NZ40	4000	470	2.2	200	40	15	13.4	5	1.7	-
N32	3200	560	2.3	200	50	25	13.2	6	1	-
N28	2800	550	2.3	200	50	25	13	6	0.8	-
N24	2400	520	2.3	200	50	25	12.7	6	0.7	-
N19	1900	480	2.3	200	50	25	12.4	6	0.7	-

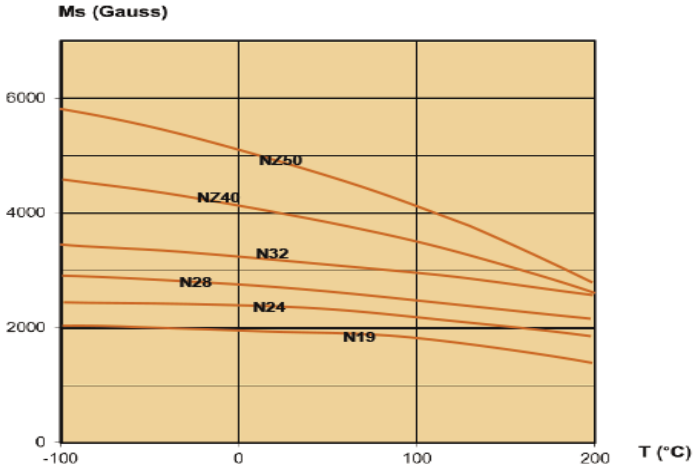
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk / Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		
Triangle	D	2.5	(0.098)	-	-	22	(0.866)
	H	2.5	(0.098)	-	-	30	(1.181)
	t	0.2	(0.079)	-	-	16.05	(0.632)
Switch Y	L	on request		-	-	on request	
	H	on request		-	-	on request	
	t	on request		-	-	on request	
	Ø hole	0.5	(0.020)	-	-	on request	
FDA	D_1	2.3	(0.091)	-	-	70	(2.756)
	D_2	1.3	(0.051)	-	-	65	(2.559)
	t	0.6	(0.024)	-	-	16.05	(0.632)
Finish Ra		0.1 µm	(0.004 µ")	0.8 µm	(0.031 µ")	As fired	
Metal. Thickness	Except FDA	-	-	7-14 µm	(0.276-0.551 µ")	-	-

Other dimensions on request

Ms vs TEMPERATURE CURVES



HOW TO ORDER (dimensions in mm):

Example: **NZ50/E16 D19.35x15.35x0.80 Ra0.4**

NZ50	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4

Ferrite type	**Additional material for FDA**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See Ni- Zn- A family	Ferrite Dielectric	D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T	Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T	Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

EPSILON 21
Y - BI - CA - ZR

NEW

YTTRIUM - BISMUTH - CALCIUM - ZIRCONIUM

Introducing our latest innovation: a new groundbreaking high epsilon microwave ferrite designed specifically for isolator and circulator applications.

With the ability to reduce the size of current circulators, it offers a compact solution without compromising performance.

Available in multiple power levels, it caters to diverse needs, ensuring versatility and adaptability in various applications of microwave ferrites.

DESCRIPTION:

Yttrium - Bismuth - Calcium - Zirconium garnet ceramic ferrite with high permittivity/dielectric constant

Also available in assembly with dielectric material (availability of several dielectric material. Example: εr = 10 ; 16 ; 20 ; 37 ; 44).

APPLICATIONS:

Circulators, isolators, phase-shifters, filters, diplexers.

FEATURES:

- High permittivity (Eps 21) ferrite for designing smaller microwave devices
- 15%* size reduction of your circulator for the same frequency (vs Eps 15 ferrites)
- Two power levels available (ΔHk = 4.5 and ΔHk = 8.5)
- Frequency applications up to X band (12GHz) below resonance

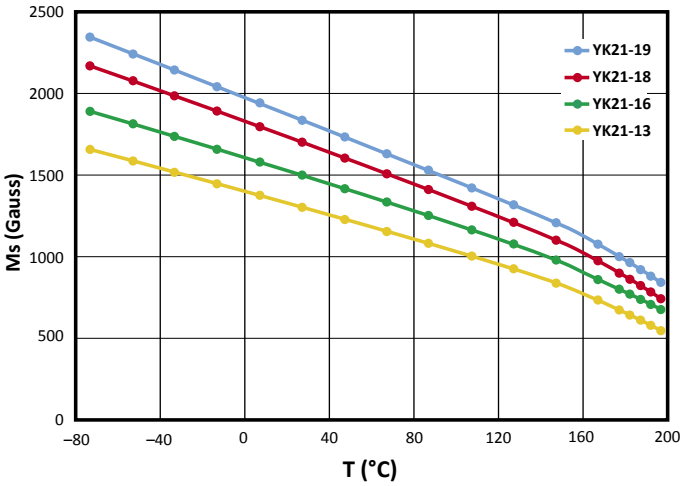
* $d = k\frac{\lambda}{2} \qquad \lambda = \frac{\lambda_0}{\sqrt{\varepsilon\mu}}$

λ = wavelength in the material
λ_0 = wavelength in the air
ε = permittivity
μ = permeability
d = dimension

SPECIFICATIONS:

Type	Ms (Gauss) ±5%	g_{eff}	ΔH (Oe) ±20%	ΔH_{eff} (Oe) ±2	ΔHk (Oe) ±0.5	ε ±5%	Tgδ 10^{-4} max.	α 10^{-3}/°C ±0.2
YK21								
19	1900	2.02	80	10	4.5	21	6	2.7
18	1800	2.02	90	14	8	21	6	2.6
16	1600	2.02	80	17	8.5	21	6	2.2
13	1300	2.02	75	8	8	21	6	1.8
DK21								
19	1850	2.04	100	16	8.5	20.5	6	2.6
16	1600	2.04	80	12	8.5	20.5	6	2.2
13	1300	2.04	80	13	8.5	20.5	6	1.8

Ms(T) under satured magnetic field of 0.5 Tesla



HOW TO ORDER (dimensions in mm):

Example: **YK21-16/E16 D19.35x15.35x0.80 Ra0.4**

YK21-16	/	E16	D	19.35	x	15.35	x	0.80	Ra0.4
Ferrite type See Y- Bi- Ca- Zr family		**Additional material for FDA** Ferrite Dielectric	**Shape** D: Disk C: Cylinder S: Square T: Triangle Y: Switch Y	**Dimension 1** Diameter for D Ext. diameter (D_1) for C Length for S Incircle diameter for T Length for Y **For FDA only** Ext. diameter (D_1) for D Incircle diameter (D_1) for T		**Dimension 2** Thickness for D Int. diameter (D_2) for C Height for S Height for T Height for Y **For FDA only** Int. diameter (D_2) for D Int. diameter (D_2) for T		**Dimension 3** Thickness for C Thickness for S Thickness for T Thickness for Y **For FDA only** Thickness for D Thickness for T	**Options** CF: Chamfer R: Radius Ra: Surface finishing **Excepting FDA** M: Metallization Dxxx : Ø Hole for Switch Y

DIELECTRIC RESONATORS

EXXELIA

DIELECTRIC RESONATORS

Operating frequencies in wireless communications have shifted towards high frequency band, and thus frequencies higher than 1 GHz are now commonly utilized. In addition, the microwave frequency spectrum becoming severely crowded and sub-divided into many different frequency bands, designers are systematically looking for resonators giving them a narrow bandwidth with smaller size. But selecting the right dielectric material for a given microwave application is a difficult challenge.

EXXELIA, being one of only a few manufacturers producing its own raw materials, is definitely the right partner to support designers at the early stage of development.

This also enables us to be independent from outside sources and flexible enough to rapidly adapt technologies to the changing needs of the market.

I. BASIC PROPERTIES

Dielectric resonators are designed to replace resonant cavities in microwave functions such as filters and oscillators. The use of dielectric resonator inside these functions allows designers to get at low cost more compact devices with higher Q factor and temperature stability.

Dielectric resonators are generally fully "customized" and dedicated to very specific applications requiring **EXXELIA** early involvement in the design. The choice of the appropriate structure depends on various parameters which are listed below.

Resonance effect origins

The most commonly used mode in many applications is the TE_{01d} (Transverse Electric Field).

Dielectric resonator traps microwave energy in an extremely small band of frequencies within the confines of the resonator volume. This energy is reflected back into the resonator due to the big gap in permittivity at the boundary of the resonator (air with $\varepsilon = 1$).

Nevertheless, a small part of this energy is distributed in the air around the resonator. These leakage magnetic fields do extend beyond the resonator structure and then can be used to provide coupling or adjusting the frequency with a loop or a stripline (Figure 1).

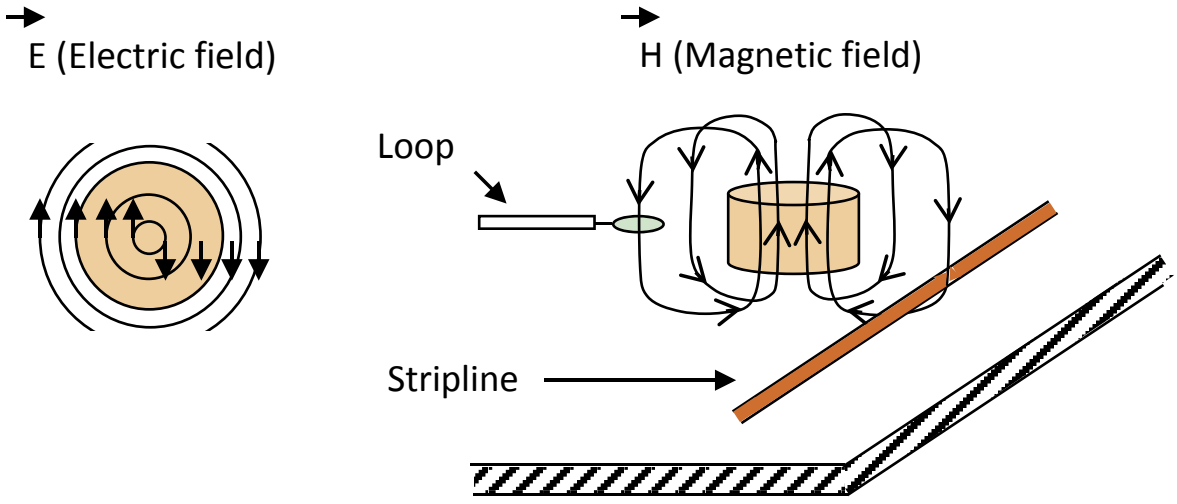


Figure 1

DIELECTRIC RESONATORS

Resonant frequency: f

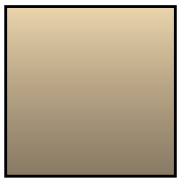
An isolated dielectric resonator is characterized by its resonant frequency which corresponds to a minimum of dielectric losses. This frequency f is primarily determined by the material dielectric constant (ε_r) and the volume V (mm^3) of the resonator and can be approximated by:

$$f \approx \frac{233}{\sqrt{\varepsilon_r}.V^{1/3}}$$

This formula can be used to give a preliminary determination (within 5 to 10%) of the size. Nevertheless, it is worth to point that a frequency correlation between the customer's test jig and the **EXXELIA** one has to be made according to the former sampling results.

Dielectric constant: ε_r

The key reason for choosing a dielectric resonator is the size reduction afforded by a high ε_r compared to a cavity air filter. It indeed appears according to the above formula, that the dielectric constant determines the resonator dimension at a given frequency. The higher the dielectric constant, the smaller the space within which the fields are concentrated, the lower the dimension at a defined frequency.



Air (ε_r = 1)

E2000 (ε_r = 37)

E5000 (ε_r = 78)

Quality Factor: Q

The Q value of a dielectric resonator is the ratio between the energy stored within the resonator to the energy dissipated in the air per cycle. It defines the losses in the material which are represented by :

$$tg(\delta) = \frac{\varepsilon''}{\varepsilon'}$$

where δ is the loss angle, ε' the dielectric constant and ε'' the dielectric losses.

The Q factor equals to: $Q = \frac{1}{tg(\delta)} = \frac{\varepsilon'}{\varepsilon''}$

The higher the Q factor, the better the material.

A common way for expressing losses, as they are linear with the frequency, is to use the "Q times frequency" factor, also specified by Q x f where f is the measurement frequency.

Typical values for E4000 family: $\left.\begin{matrix} Q = 15\,000 \\ f = 10\ \text{GHz} \end{matrix}\right\} Q \times f = 150\,000\ \text{GHz}$

DIELECTRIC RESONATORS

Temperature coefficient: τ_f

The resultant frequency of a microwave system typically decreases as temperature increases. This system is then said having a negative temperature coefficient. But usually, a system is required to be stable with temperature in the whole operating range of temperature (-55°C/+125°C for example). Then this frequency shift with temperature can be compensated using a dielectric resonator with a positive temperature coefficient.

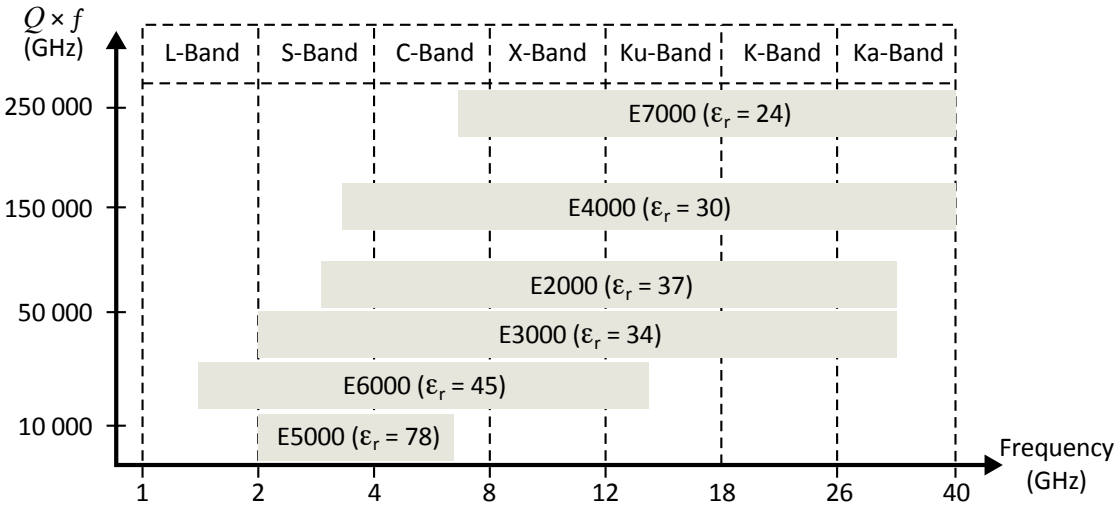
The temperature coefficient of a resonator is defined by: $\tau_f = \frac{\Delta f}{f} \cdot \frac{1}{\Delta T}$

where f is the resonant frequency (MHz) at ambient temperature, Δf the frequency variation (MHz) among the ΔT temperature range (°C) (measured here between 0°C and 40°C).

II. USER GUIDE

Materials and applications

Dielectric resonator applications are wide and the right material choice has to be done taking into account the size and Q factor requirements. Below figures and tables are useful to identify the right candidates. The frequency range from 1.5 up to 40 GHz is covered through different materials.

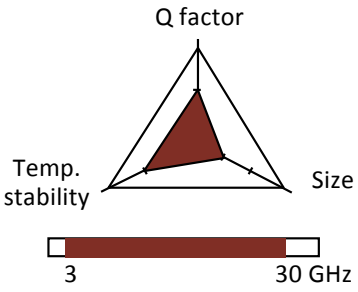


	PROPERTIES	APPLICATIONS
E2000 serie	High Q factor for high stability DRO designs. Mass-production capacity	- Alarm-detection systems, door openers - Anti-collision radar for automotive - Communication equipments - Low Noise Block (LNB) converters for DBS
E3000 serie	High linearity of frequency with temperature	- DRO for military and space applications
E4000 serie	Very high Q factor for filter designst	- Satellite multiplexing filter devices - Radio-links for communication systems (LMDS) - Anti-collision radar for automotive - Military radars
E5000 serie	High dielectric constant for reduced dimension systems	- Duplexers, filters - Cellular base stations
E6000 serie	High Q factor for low frequency applications	- Low Noise Block (LNB) converters for DBS - Security systems, detectors - Filters
E7000 serie	Ultra High Q factor for filter designs	- Satellite multiplexing filter devices - Radio-links for communication systems (LMDS) - Military radars

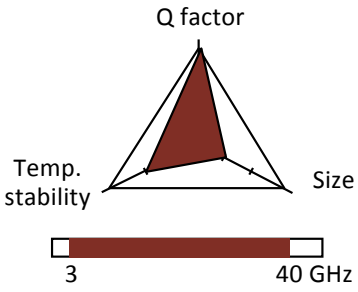
DIELECTRIC RESONATORS

Electrical and physical characteristics are listed in below table.

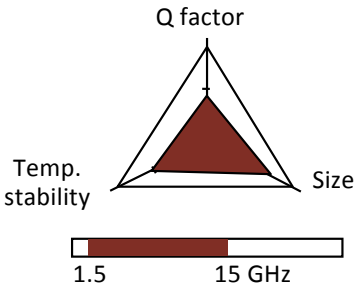
	E2000	E3000	E4000	E5000	E6000	E7000
Dielectric constant	37	34	30	78	45	24
Typical Q factor	5000 @ 10 GHz	4000 @ 10 GHz	15000 @ 10 GHz	1600 @ 5 GHz	8000 @ 5 GHz	25000 @ 10 GHz
Recommended frequency range (GHz)	3 to 30	2 to 30	3 to 40	2 to 5	1.5 to 15	10 to 24
Available τ_f (ppm/°C)	-3 to 50	-4 to 10	0 to 10	0	-6 to 12	0 to 6
Thermal expansion (ppm/°C)	6	5	10	8	6.5	10
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}	10^{15}	10^{15}	10^{14}	10^{15}	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	2.1	1.7	2.5	2.9	2.1	3.2
Water absorption (%)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Density	5.2	5.3	7.6	5.6	4.9	7.5
Oxide composition	Zr Sn Ti	Zr Sn Ti	Ba Zn Ta	Ba Sm Ti	Ti Zr Nb Zn	Ba Mg Ta



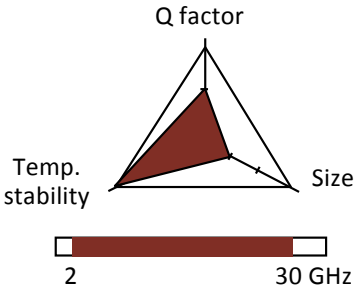
E2000



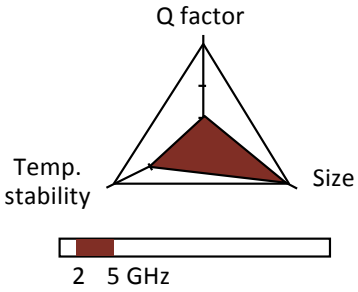
E4000



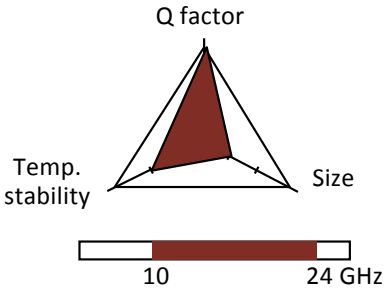
E6000



E3000



E5000

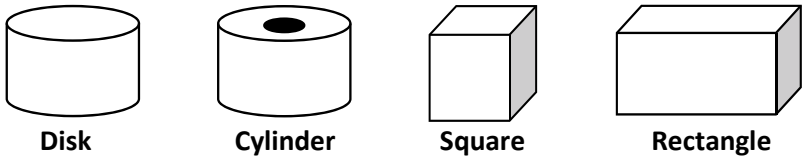


E7000

DIELECTRIC RESONATORS

Shape and Metallization

Various shapes and Metallization are available (custom shape on request).



Dimensioning mm (inches)

A wide range of dimensions can be made based on customer specifications:

Disk: diameter 1 (0.039) up to 55 (2.165) (typical value)

Cylinder: diameter 1 (0.039) up to 55 (2.165) (typical value)

Square / Rectangle: max length 50.8 (2.000) x 50.8 (2.000) / Thickness 0.5 (0.020) up to 3 (0.118) (typical value)

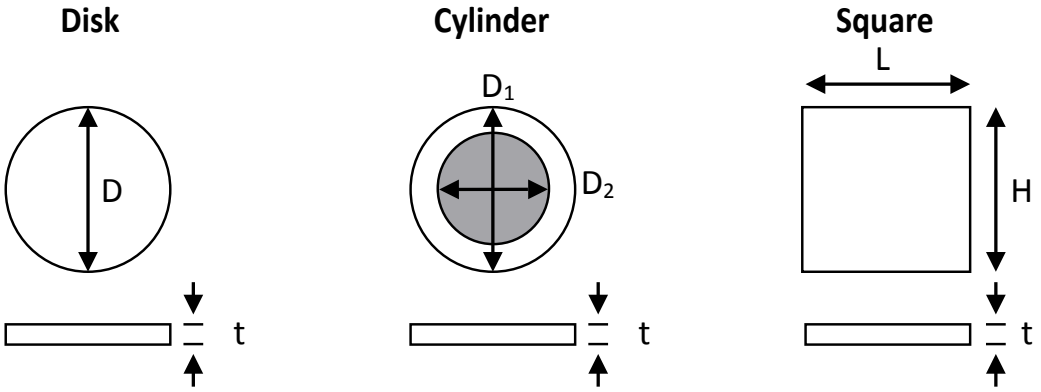
Remarks:

Rods can be delivered as well

Standard tolerances are ±0.05 (0.002) on both diameter and thickness.

As-fired parts (no machining requested => lower cost) are available for ±1% tolerance.

Smaller tolerances can be considered on request



Spacer:

In some specific designs, customers might require spacers.

In filters, there are metal sidewalls and the dielectric resonator is usually placed on the bottom of the cavity, directly on the metal. This one is then dependent upon not just the ceramic, but also on its surroundings. The nominal frequency as well as the Q factor, are then affected. A common practice for achieving a higher Q factor is to glue a spacer with low dielectric loss (made of Alumina AL_2O_3) to our dielectric resonator. Thus magnetic fields are taken away from the metal wall (Figure 1).

In a microstrip circuit, the resonator is coupled by being located near a microstrip line. This magnetic coupling is adjusted by varying the distance between the resonator and the line. A better coupling can be achieved by adding a spacer so that the resonator can overhang the line (Figure 2).

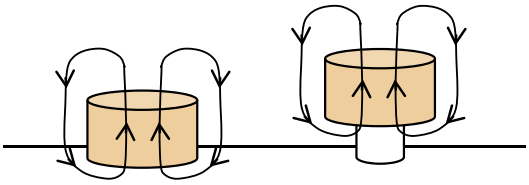


Figure 1

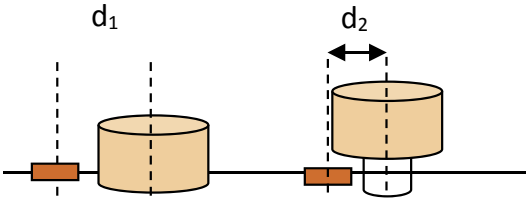


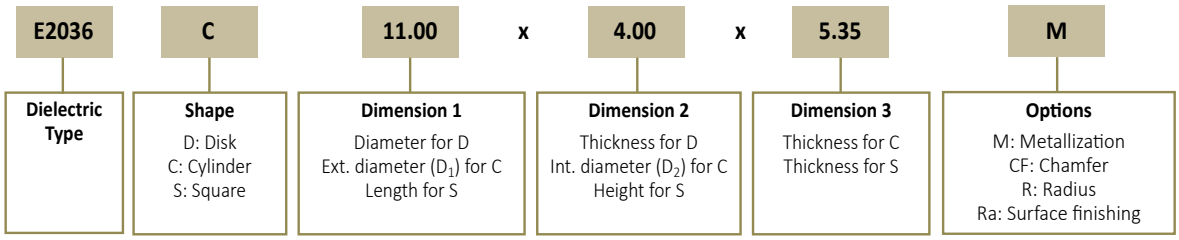
Figure 2

DIELECTRIC RESONATORS

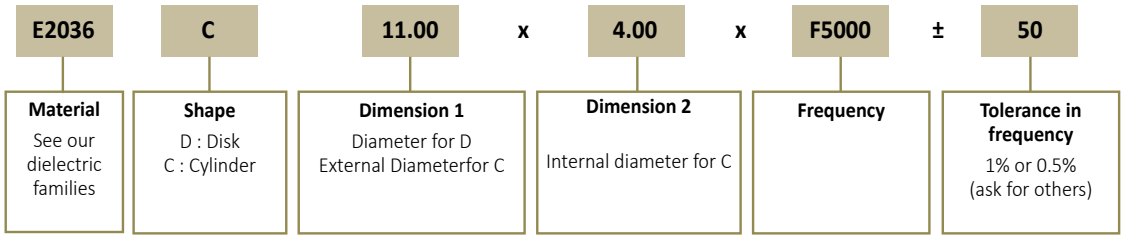
	Min	Standard / Typical	Max	Typical Tolerance
Dielectric Resonator Shape				
Disk / Cylinder				
Diameter	0.6mm		70mm (30mm for E4000 and E7000)	± 0.05mm
Internal diameter	1mm		65mm (25mm for E4000 and E7000)	± 0.05mm
Square				
Length x Width	0.6 x 0.6mm		100 x 35mm or 50.8 x 50.8mm	
Thickness	0.2mm		16.5mm	± 0.02mm
Finish Ra	0.1µm	0.8µm	As fired	
Tolerance in Frequency	0.5% to 1%			
Metallization Thickness		7- 14µm		

How to order

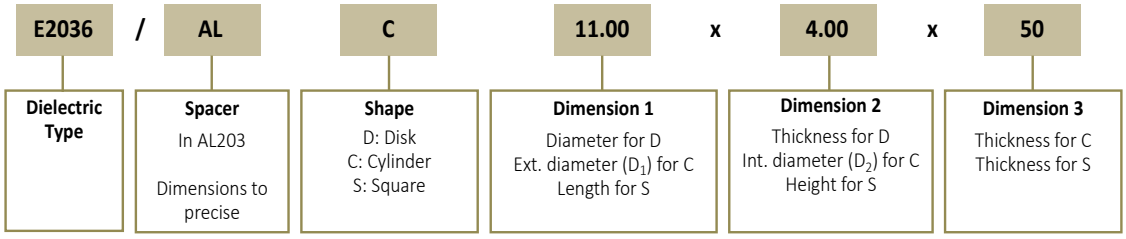
Example for dielectric resonator in dimension: **E2036 C11.00x4.00x5.35M**



Example for dielectric resonator in frequency: **E2036 C11.00 x 4.00 F5000 ±50**



Example for dielectric resonator with spacer in dimension: **E2036/AL C11.00 x 4.00 x 50**



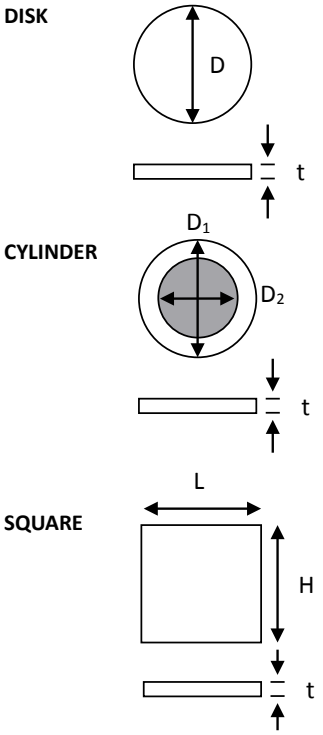
E2000 SERIES

ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E2000
Dielectric constant	37
Typical Q factor	5000 @ 10 GHz
Recommended frequency range (GHz)	3 to 30
Available tr (ppm/°C)	-3 to 50
Thermal expansion (ppm/°C)	6
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	2.1
Water absorption (%)	< 0.01
Density	5.2
Oxide composition	Zr Sn Ti

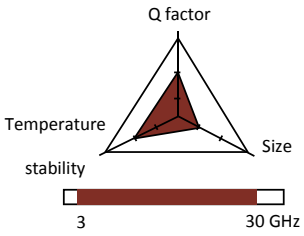
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E2336N	-3	5 000	37.1
E2036	0	5 000	37.2
E2336	+3	5 000	37.3
E2636	+6	5 000	37.4
E2936	+9	5 000	37.4
E21236	+12	5 000	37.6
E21536	+15	5 000	37.6
E21836	+18	5 000	37.6
E25036	+50	4 400	40

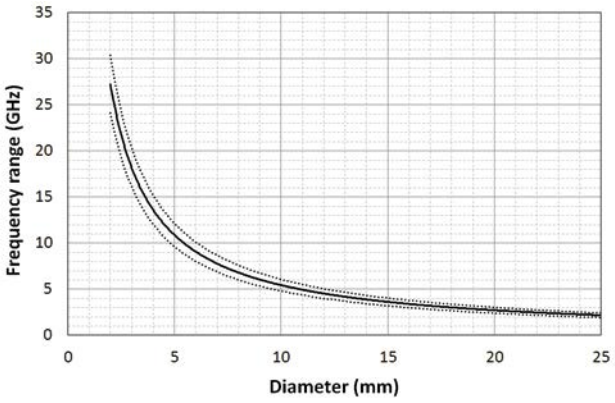
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
1930 ≤ ≤ 30350	$D_{min} = \frac{48200}{F}$ $D_{typ} = \frac{54400}{F}$ $D_{max} = \frac{60700}{F}$
	2 ≤ D ≤ 25

HOW TO ORDER (dimensions in mm):

Example: **E2036/AL C11.25x4.25x5.35M or E2036/AL C11.25x4.25 F6000±50**

E2036	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M

Material	**Spacer**	**Shape**	**Dimension 1**	**Dimension 2**	**Dimension 3**	**Options**
See E2000 family	In AL2O3 Optional	D: Disk C: Cylinder S: Square	Diameter for D External diameter for C Length for S	Height for S Internal diameter for C	Thickness for D Thickness for S Thickness for C or **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max	M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

E3000 SERIES

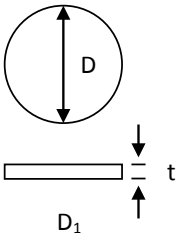
ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E3000
Dielectric constant	34
Typical Q factor	4000 @ 10 GHz
Recommended frequency range (GHz)	2 to 30
Available tr (ppm/°C)	-4 to 10
Thermal expansion (ppm/°C)	5
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	1.7
Water absorption (%)	< 0.01
Density	5.3
Oxide composition	Zr Sn Ti

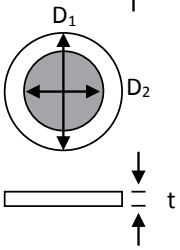
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E3434N	-4	4 000	33.5
E3234N	-2	4 000	33.8
E3034	0	4 000	34.0
E3234	+2	4 000	34.2
E3434	+4	4 000	34.4
E3634	+6	4 000	34.7
E3834	+8	4 000	35.0
E31034	+10	4 000	35.3

DIMENSIONS mm (inches)

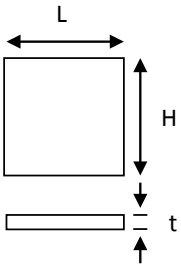
DISK



CYLINDER

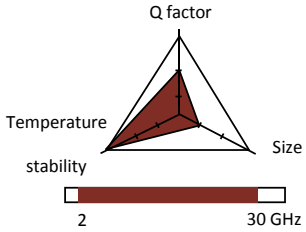


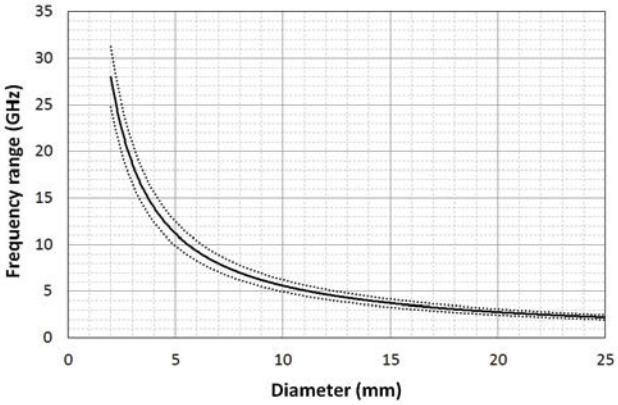
SQUARE



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
1930 ≤ F ≤ 31230	$D_{min} = \frac{49500}{F}$ $D_{typ} = \frac{56000}{F}$ $D_{max} = \frac{62500}{F}$
	2 ≤ D ≤ 25

HOW TO ORDER (dimensions in mm):

Example: **E3034/AL C11.25x4.25x5.35M or E3034/AL C11.25x4.25 F6000±50**

E3034	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M
Material See E3000 family		**Spacer** In AL2O3 Optional	**Shape** D: Disk C: Cylinder S: Square	**Dimension 1** Diameter for D External diameter for C Length for S		**Dimension 2** Height for S Internal diameter for C		**Dimension 3** Thickness for D Thickness for S Thickness for C **or** **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max			**Options** M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

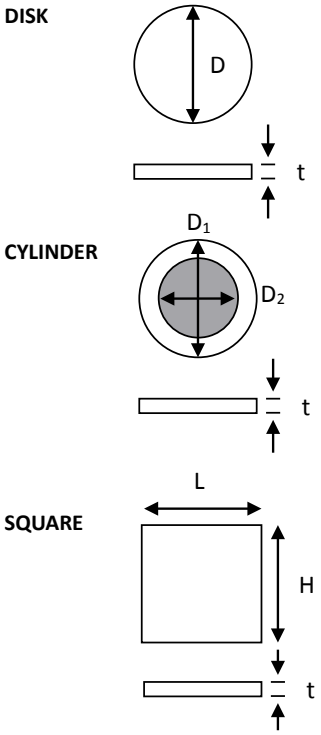
E4000 SERIES

ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E4000
Dielectric constant	30
Typical Q factor	15000 @ 10 GHz
Recommended frequency range (GHz)	3 to 40
Available tr (ppm/°C)	0 to 10
Thermal expansion (ppm/°C)	10
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	2.5
Water absorption (%)	< 0.01
Density	7.6
Oxide composition	Ba Zn Ta

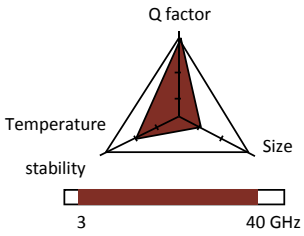
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E4030	0	15 000	29.5
E4230	+2	15 000	30.0
E4330	+3	15 000	30.3
E4430	+4	15 000	30.5
E4630	+6	15 000	31.0
E4830	+8	15 000	31.5
E41030	+10	15 000	32.0

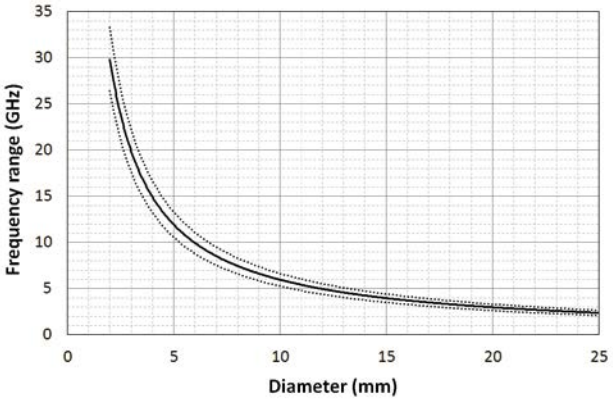
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
2110 ≤ F ≤ 33250	$D_{min} = \frac{52800}{F}$ $D_{typ} = \frac{59600}{F}$ $D_{max} = \frac{66500}{F}$
	2 ≤ D ≤ 25

HOW TO ORDER (dimensions in mm):

Example: **E4030/AL C11.25x4.25x5.35M or E4030/AL C11.25x4.25 F6000±50**

E4030	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M
Material See E4000 family		**Spacer** In AL2O3 Optional	**Shape** D: Disk C: Cylinder S: Square	**Dimension 1** Diameter for D External diameter for C Length for S		**Dimension 2** Height for S Internal diameter for C		**Dimension 3** Thickness for D Thickness for S Thickness for C **or** **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max			**Options** M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

E5000 SERIES

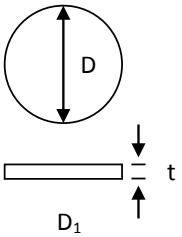
ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E5000
Dielectric constant	78
Typical Q factor	1600 @ 5 GHz
Recommended frequency range (GHz)	2 to 5
Available tr (ppm/°C)	0
Thermal expansion (ppm/°C)	8
Insulation resistivity (Wm^{-1}) (25°C)	10^{14}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	2.9
Water absorption (%)	< 0.01
Density	5.6
Oxide composition	Ba Sm Ti

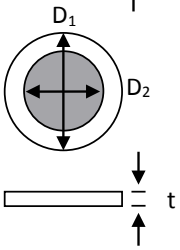
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E5080	0	1 600	78.0
E5380	+3	1 600	78.0
E5680	+6	1 600	78.0
E5980	+9	1 600	78.0

DIMENSIONS mm (inches)

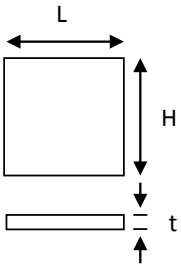
DISK



CYLINDER

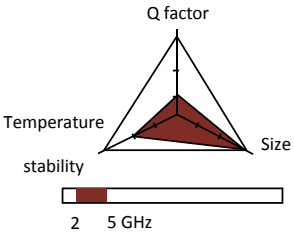


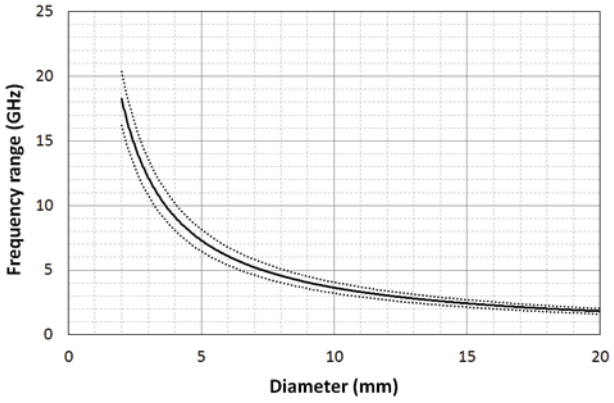
SQUARE



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
1620 ≤ F ≤ 20360	$D_{min} = \frac{32300}{F}$ $D_{typ} = \frac{36500}{F}$ $D_{max} = \frac{40700}{F}$
	2 ≤ D ≤ 20

HOW TO ORDER (dimensions in mm):

Example: **E5080/AL C11.25x4.25x5.35M or E5080/AL C11.25x4.25 F6000±50**

E5080	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M

Material	Spacer	Shape	Dimension 1	Dimension 2	Dimension 3	Options
See E5000 family	In AL2O3 Optional	D: Disk C: Cylinder S: Square	Diameter for D External diameter for C Length for S	Height for S Internal diameter for C	Thickness for D Thickness for S Thickness for C **or** **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max	M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

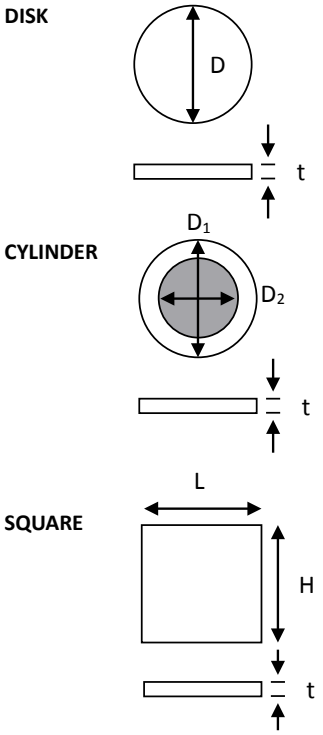
E6000 SERIES

ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E6000
Dielectric constant	45
Typical Q factor	8000 @ 5 GHz
Recommended frequency range (GHz)	1.5 to 15
Available tr (ppm/°C)	-6 to 12
Thermal expansion (ppm/°C)	6.5
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	2.1
Water absorption (%)	< 0.01
Density	4.9
Oxide composition	Ti Zr Nb Zn

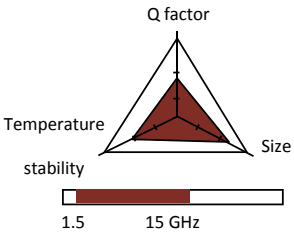
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E6645N	-6	8 000	43.9
E6345N	-3	8 000	44.3
E6045	0	8 000	44.5
E6345	3	8 000	45.0
E6645	6	8 000	45.3
E6945	9	8 000	45.5
E61245	12	8 000	46.0

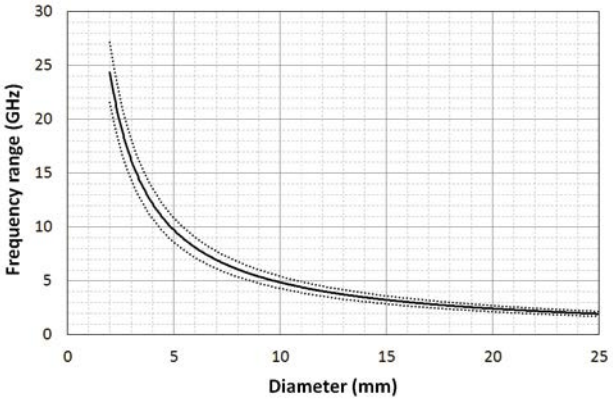
DIMENSIONS mm (inches)



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
1720 ≤ F ≤ 27150	$D_{min} = \frac{43100}{F}$ $D_{typ} = \frac{48700}{F}$ $D_{max} = \frac{54300}{F}$
	2 ≤ D ≤ 25

HOW TO ORDER (dimensions in mm):

Example: **E6045/AL C11.25x4.25x5.35M or E6045/AL C11.25x4.25 F6000±50**

E6045	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M

Material	Spacer	Shape	Dimension 1	Dimension 2	Dimension 3	Options
See E6000 family	In AL2O3 Optional	D: Disk C: Cylinder S: Square	Diameter for D External diameter for C Length for S	Height for S Internal diameter for C	Thickness for D Thickness for S Thickness for C **or** **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max	M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

E7000 SERIES

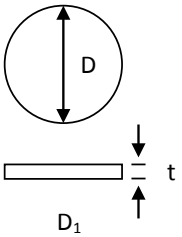
ELECTRICAL AND PHYSICAL CHARACTERISTICS

	E3000
Dielectric constant	24
Typical Q factor	25000 @ 10 GHz
Recommended frequency range (GHz)	10 to 24
Available tr (ppm/°C)	0 to 6
Thermal expansion (ppm/°C)	10
Insulation resistivity (Wm^{-1}) (25°C)	10^{15}
Thermal conductivity ($Wm^{-1}°K^{-1}$) (25°C)	3.2
Water absorption (%)	< 0.01
Density	7.5
Oxide composition	Ba Mg Ta

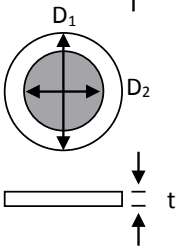
Material	t_f (ppm/°C) ±2ppm/°C	Typical Q factor @ 10GHz	Dielectric Constant ε_r ±1
E7024	0	20 000	24.3
E7224	+2	21 000	24.4
E7424	+4	22 000	24.4
E7624	+6	22 000	24.5

DIMENSIONS mm (inches)

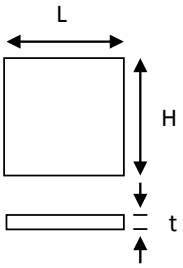
DISK



CYLINDER

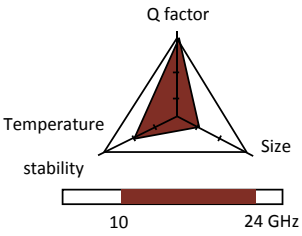


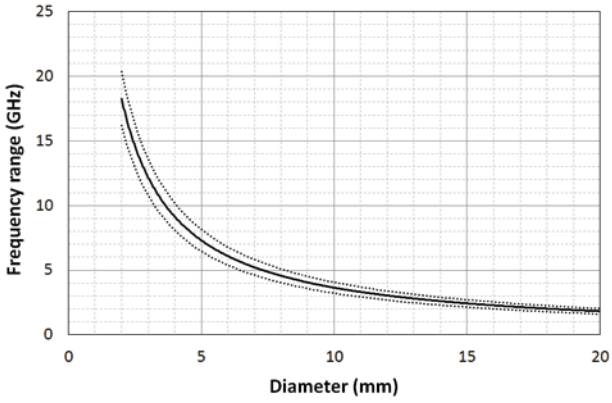
SQUARE



Model	Dimensions D,H,L ±0.05 (0.002) t ±0.02 (0.001)	Min.		Standard / Typical		Max.	
		mm	(inches)	mm	(inches)	mm	(inches)
Disk	D	1	(0.039)	-	-	70	(2.756)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Cylinder	D_1	1	(0.039)	-	-	70	(2.756)
	D_2	0.6	(0.024)	-	-	65	(2.559)
	t	0.2	(0.008)	-	-	16.05	(0.632)
Square	L	0.6	(0.024)	-	-	50.80 or 100	(2.000 or 3.937)
	H	0.6	(0.024)	-	-	50.80 or 35	(2.000 or 1.378)
	t	0.2	(0.008)	-	-		

Other dimensions on request





Frequency (MHz)	Diameter range (mm)
5900 ≤ F ≤ 37150	$D_{min} = \frac{59000}{F}$ $D_{typ} = \frac{66700}{F}$ $D_{max} = \frac{74400}{F}$
	2 ≤ D ≤ 10

HOW TO ORDER (dimensions in mm):

Example: **E7024/AL C11.25x4.25x5.35M or E7024/AL C11.25x4.25 F6000±50**

E7024	/	AL	C	11.25	x	4.25	x	5.35	or	F6000±50	M

Material	Spacer	Shape	Dimension 1	Dimension 2	Dimension 3	Options
See E7000 family	In AL2O3 Optional	D: Disk C: Cylinder S: Square	Diameter for D External diameter for C Length for S	Height for S Internal diameter for C	Thickness for D Thickness for C Thickness for S **or** **Frequency (in MHz)** Frequency ± tolerance 0.5% to 1% max	M: Metallization CF: Chamfer R: Radius Ra: Surface finishing

DIELECTRIC RESONATORS

IV. Hi-REL PRODUCTS

Being involved with all key worldwide space customers, **EXXELIA** has definitely a strong space heritage with its dielectric resonators on this market segments.

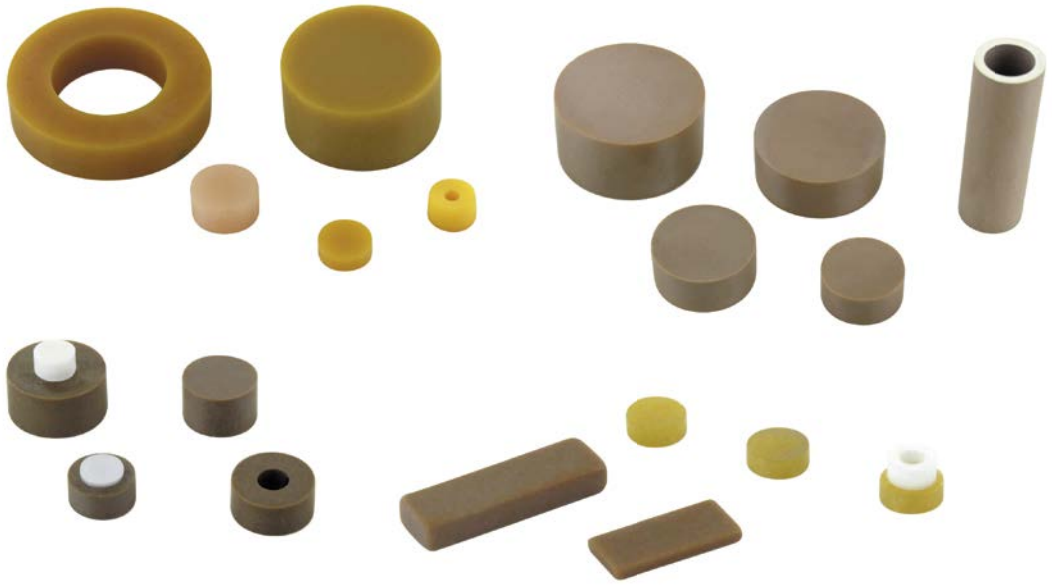
Several dielectric materials providing High Q characteristics are available for high-end communication devices (sitcom filters).

E7000 → *Qxf 250 000 @ 10GHz*

E4000 → *Qxf 150 000 @ 10GHz*

LAT tests available for Hi-rel models

Withstand strong environmental conditions
Thermal cycling: 50 cycles -55°C/+125°C
Life test: 1000 hours at 125°C



COAXIAL RESONATORS

EXXELIA

COAXIAL RESONATORS

Thanks to its high know-how in ceramic material manufacturing, **EXXELIA** has developed its own coaxial resonator product line. These products are the poles of filter, oscillator and duplexer functions for Telecom, Military & Space, Industrial and Wireless applications

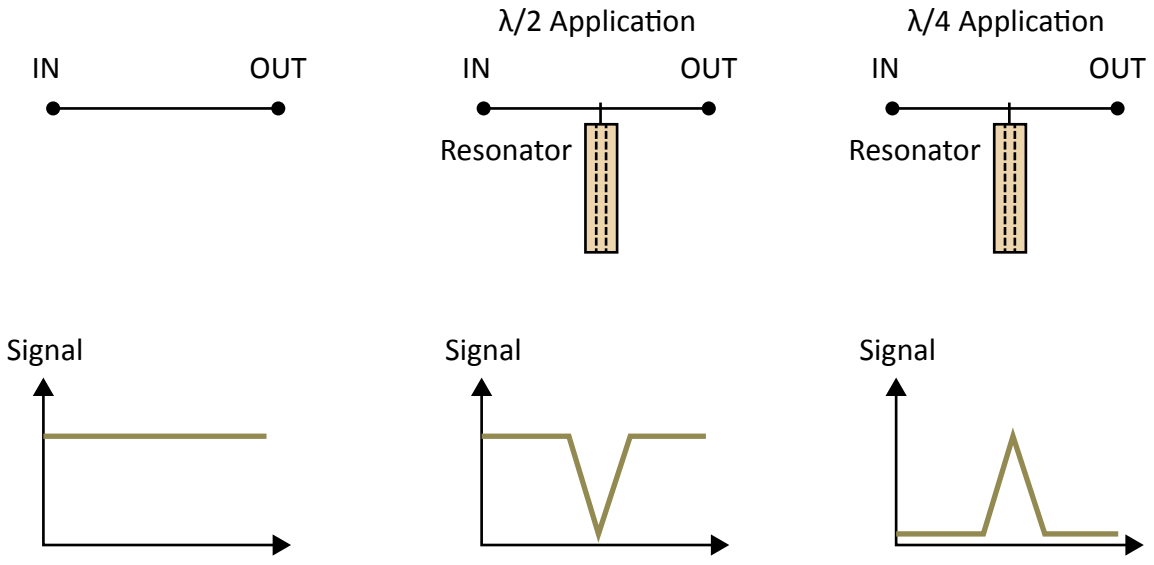
Coaxial resonators are designed to use the size-reducing effect of high dielectric constant materials in microwave functions such as VCOs (Voltage Controlled Oscillators), CROs (Coaxial Resonator Oscillators) and filters. Their use allows designers to get more compact devices.

I. BASIC PROPERTIES

Resonance effect origins

The most commonly used mode in many applications is the TEM (Transverse Electro-Magnetic) mode. Such mode has neither electric nor magnetic field in the direction of propagation. They are contained primarily within the metalized ceramic.

Let's consider a line in which a signal is sent through "IN" and received in "OUT". When a coaxial resonator is connected, this one allows or blocks (whether it is λ/2 or λ/4 configurations) microwave energy corresponding to its resonant frequency (see Figure 1).



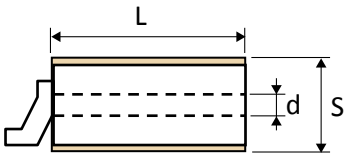
COAXIAL RESONATORS

Resonant frequency: f

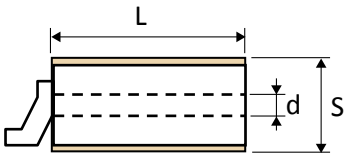
The frequency is governed by the length of the coaxial resonator. This length is usually close to a quarter or half wavelength of the required frequency. Resonators are then defined as either quarter or half wavelength type.

Quarter wavelength resonators have only one end metalized to "short-circuit" the center conductor to the external diameter conductor, whereas both ends are non-metalized on half wavelength types. Frequency is given by:

- λ/2 applications : $f = \frac{300}{2L\sqrt{e_r}}$



- λ/4 applications : $f = \frac{300}{4L\sqrt{e_r}}$



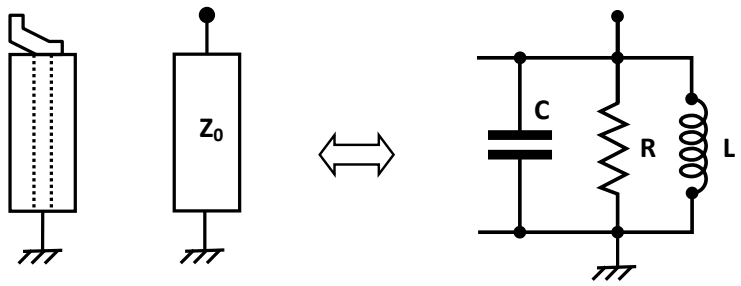
Where f is the resonant frequency (GHz), l the resonator length (mm) and εr the dielectric constant.

Useful simplified formulas are given in below table to determine the resonator length.

	λ/4 application	λ/2 application
εr = 21	$l = \frac{16.37}{f}$	$l = \frac{32.73}{f}$
εr = 38.5	$l = \frac{12.09}{f}$	$l = \frac{24.17}{f}$
εr = 45	$l = \frac{11.18}{f}$	$l = \frac{22.36}{f}$
εr = 55	$l = \frac{10.11}{f}$	$l = \frac{20.23}{f}$
εr = 90	$l = \frac{7.91}{f}$	$l = \frac{15.81}{f}$

Impedance: Z_0

The coaxial resonator impedance is directly linked to the section, the inner hole diameter and the dielectric constant of the material. An equivalent circuit is given by a common RLC circuit.



COAXIAL RESONATORS

For a λ/4 coaxial resonator, having a nominal frequency ƒ (MHz), a section S (mm), an inner hole diameter d (mm) and a dielectric constant **ε**r, the lumped elements are given by:

$$l = \frac{2Z_0}{\pi^2 f} \qquad C = \frac{1}{8Z_0 f} \qquad R = \frac{4Z_0 Q}{\pi}$$

with

$$\begin{cases} Z_0 = \dfrac{60}{\sqrt{\varepsilon_r}} \cdot Ln\left(1.079.\dfrac{S}{d}\right) \\ Q = 60.\dfrac{S\sqrt{f}}{25.4} \end{cases}$$

Quality factor: Q

What is essentially required by designers is the lowest bandwidth at 3dB giving a more selective frequency. This performance is directly given by the Q factor which is essentially determined by the Metallization. A thick film silver coating is then realized for excellent Q. Let's note that a low loss dielectric material does not influence at the first order the Q factor.

$$Q = 60.\frac{S\sqrt{f}}{25.4}$$

II. USER GUIDE

How to order "Commercial Models"

CRS	06	T	Q	1500	F	S	1	E	RoHS
Type Coaxial resonator	**Size** See table	**Material** V (ε_r 21) T (ε_r 38.5) K (ε_r 45) W (ε_r 55) N (ε_r 90)	**Application** Q : λ/4 H : λ/2	**Frequency (MHz)** See range in table	**Frequency tolerance** F = ±1% D = ±0.5% 5 = ±5 MHz 1 = ±1 MHz	**Metallization** S : Silver	**Connection** 0 : none 1 : one 2 : wire 4 : ribbon	**Tape & Reel** E : T&R Blank : none	**RoHs compliant**

How to order "Flight Models"

CRS	06	T	Q	1500	F	S	1	TRFxxx	RoHS
Type Coaxial resonator	**Size** See table	**Material** V (ε_r 21) T (ε_r 38.5) K (ε_r 45) W (ε_r 55) N (ε_r 90)	**Application** Q : λ/4 H : λ/2	**Frequency (MHz)** See range in table	**Frequency tolerance** F = ±1% D = ±0.5% 5 = ±5 MHz 1 = ±1 MHz	**Metallization** S : Silver	**Connection** 0 : none	**Hi-Rel**	**RoHs compliant**

Note: flight models are delivered with tab separately

Materials and applications

Our portfolio is designed to offer the highest degree of freedom to electronic engineers. Several dielectric constants are available (21/38.5/45/55/90) allowing the best trade-off between impedance, Q factor and resonant frequency.

Operating temperature range: -40°C / +85°C

COAXIAL RESONATORS

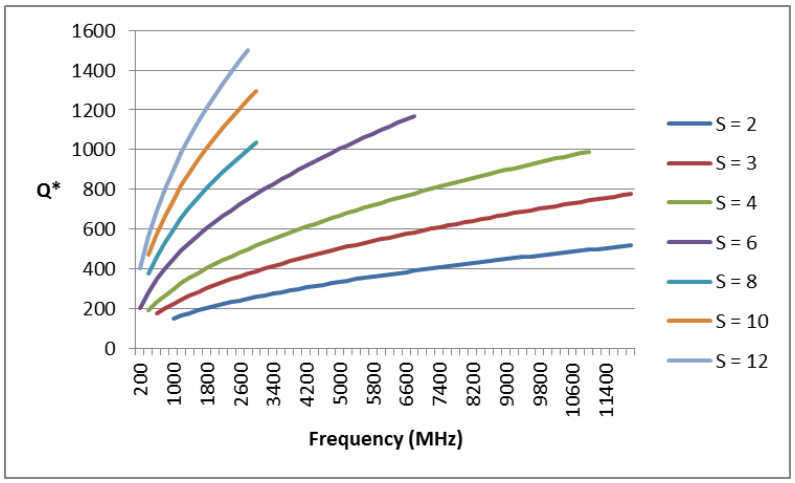
Frequency range and general characteristics

Dielectric constant	Temperature coefficient (ppm/°C)	Section		Frequency range (MHz) λ/4	Frequency range (MHz) λ/2	Q min
		(mm)	(inches)			
21	0 ± 15	2	(0.079)	2135-6000	4305-12000	200,0
		3	(0.118)	1335-6000	2730-12000	300,0
		4	(0.157)	870-5520	1735-11000	400,0
		6	(0.236)	650-3310	1365-6625	550,0
		8	(0.315)	915-3000	1890-3000	700,0
		10	(0.394)	915-3000	1890-3000	800,0
		12	(0.472)	670-2500	1365-3000	850,0
38.5	0 ± 15	2	(0.079)	1575-6000	3100-12000	200,0
		3	(0.118)	1005-4560	2050-9130	300,0
		4	(0.157)	660-4140	1315-8280	350,0
		6	(0.236)	490-2430	1000-4965	400,0
		8	(0.315)	690-3000	1420-3000	680,0
		10	(0.394)	690-3000	1420-3000	760,0
		12	(0.472)	505-2500	1050-2500	800,0
45	0 ± 15	2	(0.079)	1500-5500	3000-11000	180,0
		3	(0.118)	870-4000	1740-8000	280,0
		4	(0.157)	750-3500	1500-7000	300,0
		6	(0.236)	500-2200	1000-4400	350,0
		8	(0.315)	600-2500	1200-5000	550,0
		10	(0.394)	600-2500	1200-5000	650,0
		12	(0.472)	600-2500	1200-5000	750,0
55	0 ± 15	2	(0.079)	1400-5000	2800-10000	160,0
		3	(0.118)	800-3700	1600-7400	250,0
		4	(0.157)	700-3300	1400-6600	280,0
		6	(0.236)	450-2000	900-4000	350,0
		8	(0.315)	500-2400	1000-4800	500,0
		10	(0.394)	500-2400	1000-4800	620,0
		12	(0.472)	520-2000	1040-4000	700,0
90	0 ± 15	2	(0.079)	1040-3970	2100-7940	160,0
		3	(0.118)	650-2940	1315-5880	230,0
		4	(0.157)	410-2650	840-5300	250,0
		6	(0.236)	305-1590	630-3180	350,0
		8	(0.315)	410-1800	840-3000	460,0
		10	(0.394)	445-1800	895-3000	580,0
		12	(0.472)	330-1500	685-2500	640,0

Other frequencies on request

COAXIAL RESONATORS

Q factor



* Typical values

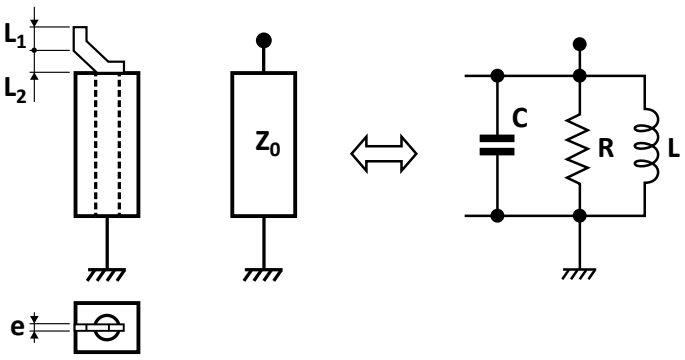
Dimensions and impedance

Section		Inner hole diameter		Impedance (Ω)					EXXELIA Reference
(± 0.2 mm)	(± 0.008")	(± 0.1 mm)	(± 0.004")	Er = 21	Er = 38.5	Er = 45	Er = 55	Er = 90	
2	(0.079)	0.65	(0.026)	15.7	11.6	10.7	9.7	7.6	CRS02
		0.80	(0.031)	13.0	9.6	8.9	8.0	6.3	CRS22
3	(0.118)	0.95	(0.037)	16.1	11.9	11.0	9.9	7.6	CRS03
4	(0.157)	1.20	(0.047)	16.8	12.4	11.4	10.4	8.1	CRS14
		1.50	(0.059)	13.8	10.2	9.5	8.6	6.7	CRS04
		2.00	(0.079)	10.1	7.4	6.9	6.2	4.9	CRS24
6	(0.236)	2.00	(0.079)	15.4	11.4	10.5	9.5	7.4	CRS06
		2.20	(0.087)	14.1	10.4	9.7	8.7	6.8	CRS16
		2.40	(0.094)	13.0	9.6	8.9	8.0	6.3	CRS26
		2.50 *	(0.098)*	12.5	9.2	8.5	7.7	6.0	CRS36
8	(0.315)	2.80	(0.110)	14.7	10.9	10.1	9.1	7.1	CRS08
10	(0.394)	3.50 *	(0.138)*	14.7	10.9	10.1	9.1	7.1	CRS10
12	(0.472)	3.50	(0.138)	17.1	12.6	11.7	10.6	8.3	CRS12
		4.00 *	(0.157)*	15.4	11.4	10.5	9.5	7.4	CRS412

* Connection not available

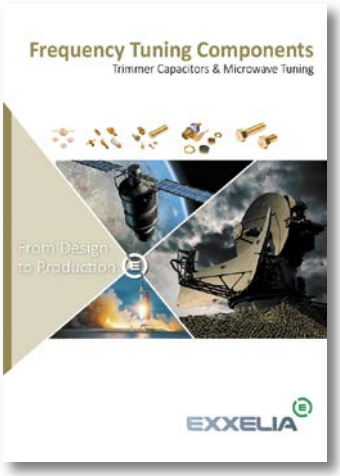
Connection dimensions

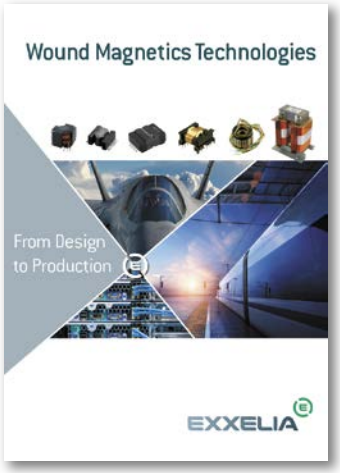
Section	2	3	4	6	8	10	12
L1 (± 0.1 mm)	0.65	0.70	0.80	1.20	1.50	N/A	2.00
L1 (± 0.004")	(0.026)	(0.028)	(0.031)	(0.047)	(0.059)	N/A	(0.079)
L2 (± 0.2 mm)	1.00	1.30	1.30	1.80	1.80	N/A	2.50
L2 (± 0.008")	(0.039)	(0.051)	(0.051)	(0.071)	(0.071)	N/A	(0.098)
e (± 0.1 mm)	0.40	0.50	0.60	0.80	0.80	N/A	1.00
e (± 0.004")	(0.016)	(0.020)	(0.024)	(0.031)	(0.031)	N/A	(0.039)



NOTES

EXXELIA Components Portfolio





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