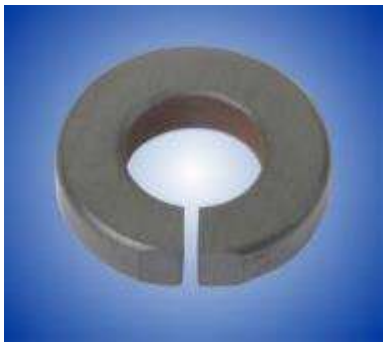
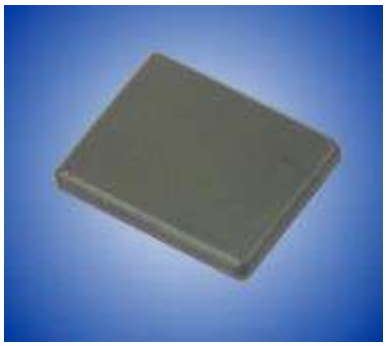
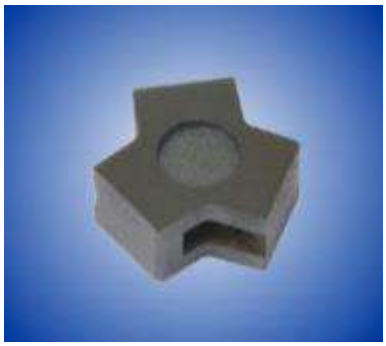
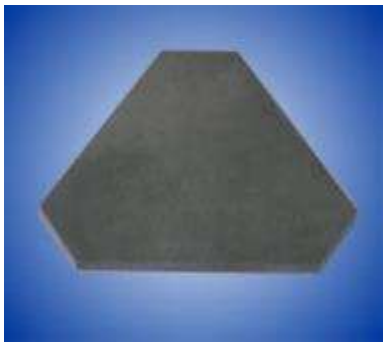
Garnets, Ferrite spinel and Hexaferrites



FERRITE DOMEN Co.
Since 1959

The company performing R&D and production of all kind of microwave garnets, spinels, hexaferrites, and absorbing ferrites used in various components of broad spectrum of radio engineering facilities such as radar antennas, telecommunication complexes including mobile satellite stations, electronic countermeasure systems, high power devices of particle accelerators, different contactless measuring/sensor instruments, the list can go on-and-on.

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SYMBOLS

$4\pi M_s$	Saturation magnetization	**Gauss**
ΔH	Resonance linewidth (@-3 dB)	**Oe**
ε'	Dielectric constant	**—**
$tg\delta_\varepsilon$	Dielectric loss tangent	**—**
g_{eff}	Landé factor	**—**
Tc	Curie temperature	**°C**
ΔH_k	Spin wave linewidth	**Oe**
Hc	Coercive force	**Oe**
H_{Aeff}	Effective anizotropy field	**Oe**
Br	Remanent flux density	**Gauss**
ρ	Balk density	**g/cm^3**

Note. ΔH, ΔH_k, ε', $tg\delta_\varepsilon$ measured @ 9.4 GHz

1. Microwave Garnets

1.1 Yttrium-Iron Garnets

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal
NG-178	1780	35	15.1	2	280	1
NG-178-1	1780	25	15.1	2	280	1
Notes!	Landé factor (g_{eff}) is 2.00±3% for all garnets.					

Pure Yttrium garnets are the basic ferromagnetic materials for the whole series of YIG - doped compositions, see example grade.

1.2 Yttrium-Iron Garnets - Al Doped

Material grade	$4\pi M_s$ G	ΔH (-3dB) Oe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal
GA-150	1500±5%	45	14.9	2	250	1.5
GA-150-1	1500±5%	25	14.9	2	250	1.5
GA-140	1400±5%	45	14.8	2	245	1.5
GA-140-1	1400±5%	25	14.8	2	245	1.5
GA-120	1200±5%	45	14.6	2	230	1.5
GA-120-1	1200±5%	25	14.6	2	230	1.5
GA-110	1100±5%	45	14.5	2	220	1.5
GA-110-1	1100±5%	25	14.5	2	220	1.5
GA-100	1000±5%	45	14.5	2	210	1.5
GA-100-1	1000±5%	25	14.5	2	210	1.5
GA-90	900±5%	45	14.4	2	200	1.5
GA-90-1	900±5%	25	14.4	2	200	1.5
GA-80	800±5%	45	14.2	2	195	1.5
GA-80-1	800±5%	25	14.2	2	195	1.5
GA-65	650±5%	45	14.2	2	175	1.5
GA-65-1	650±5%	25	14.2	2	175	1.5
GA-58	580±5%	45	14.1	2	165	1.5
GA-58-1	580±5%	25	14.1	2	165	1.5
GA-48	480±5%	45	14.0	2	150	1.5
GA-48-1	480±5%	25	14.0	2	150	1.5
GA-40	400±25 G	40	13.9	2	130	2
GA-32	320±25 G	40	13.8	2	120	2
GA-20	200±25 G	40	13.7	2	100	2
Notes!	Landé factor (g_{eff}) is 2.00±3% for all garnets.					

That series of microwave garnets is presented as the richest product mix by saturation magnetization values. They are most widely used in low power m-, dm-, and cm-wave devices.

1.3 Narrow Line Width Yttrium-Iron Garnets - Ca Doped

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal
NG-195	1950	15	15.0	2	235	1
NG-190	1900	15	15.0	2	215	1
NG-185	1850	15	14.8	2	215	1
NG-160	1600	12	14.8	2	220	1
NG-140	1400	10	14.5	2	215	1
NG-120	1200	10	14.5	2	180	1
NG-100	1000	10	14.2	2	170	1
NG-80	800	10	14.1	2	160	1
NG-52	520	10	13.9	2	120	1
Notes!	Landé factor (g_{eff}) is 2.00±3% for all garnets.					

1.4 Narrow Line Width Yttrium-Iron Garnets - Ca, V doped

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal
NGV-190	1900	15	14.8	2	215	1
NGV-160	1600	12	14.6	2	220	1
NGV-140	1400	10	14.5	2	215	1
NGV-120	1200	10	14.5	2	208	1
NGV-100	1000	10	14.2	2	200	1
NGV-80	800	10	14.0	2	190	1
Notes!	Landé factor (g_{eff}) is 2.00±3% for all garnets.					

Yttrium-Iron Garnets with Ca and Ca, V doped feature the narrowest FMR linewidth of all YIG series. They are especially suitable for application in microwave devices (including cryogenic ones) having low losses and efficient in wide frequency and temperature ranges.

1.5 Yttrium-Iron Garnets - Gd, Al Doped

Material grade	4πMs G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	Hc Oe nominal	Br G nominal	ΔH_k Oe nominal	g_{eff} ±3%
GG-178	1780	42	15.0	2	280	0.55	1240	2	2.00
GG-160	1600	45	14.9	2	280	0.75	1120	4	2.00
GG-120	1200	75	15.2	2	280	0.60	820	8	2.01
GG-95	940	95	15.1	2	255	0.70	660	10	2.01
GG-80	800	85	14.7	2	240	0.55	525	9	2.01
GG-55	550	65	14.5	2	180	0.55	385	8	2.01
GG-50	490	200	14.5	2	205	0.65	325	21	2.03

The prime features of these garnets are high temperature stability of their parameters, good squareness of hysteresis loop and raised threshold power. They find wide application in average and high power non-reciprocal as well as controlled microwave devices (phase shifters, switches, filter etc.).

1.6 Yttrium-Iron Garnets - Gd, In Doped

Material grade	$4\pi M_s$ G	ΔH (-3dB) Oe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal	g_{eff} ±3%
GI-138	1380±5%	20	15.0	2	240	5	2.00
GI-130	1300±5%	42	15.1	2	225	6	2.00
GI-122	1220±5%	20	14.9	2	220	3	2.00
GI-120	1200±5%	35	15.0	2	220	10	2.01
GI-115	1150±5%	35	15.1	2	230	7	2.00
GI-85	850±5%	55	15.0	2	210	10	2.01
GI-63	630±5%	48	14.6	2	150	14	2.01
GI-59	590±30 G	90	14.0	2	210	2	2.01
GI-45	450±25 G	48	14.5	2	135	13	2.02
GI-40	400±25 G	95	14.5	2	160	13	2.03

The garnets of this group have low losses with rather high thermal stability of saturation magnetization and good threshold characteristics. They were developed for use in non-reciprocal average power devices.

1.7 Yttrium-Iron Garnets - Gd, Rare Earth Elements Doped

Material grade	$4\pi M_s$ G	ΔH (-3dB) Oe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe max.	g_{eff} ±3%
GGH 180	1800±5%	45	15.0	2	280	12	1.99
GGH-128	1280±5%	60	15.1	2	225	16	2.00
GGH 120-1	1200±5%	140	15.0	2	270	25	2.00
GGH-90	900±5%	140	15.5	2	280	14	2.01
GGH-65-1	650±5%	45	14.7	2	150	16	2.01
GGH-47	470±25 G	45	14.5	2	130	19	2.00

The garnets of this group feature extremely good threshold characteristics. They are used in devices that must operate at high peak power levels.

2. Spinel Microwave Ferrites

2.1 Nickel Ferrites

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	Hc Oe nominal	Br G nominal
SN-500	5000	150	13.4	6	2.11	345	1.5	3500
SN-475	4750	205	13.2	4	2.14	400	2.0	3150
SN-475-1	4750	170	13.7	5	2.11	325	1.0	2850
SN-475-2	4750	250	13.2	2.5	2.14	390	2.0	$\geq$ 2800
SN-450	4500	215	13.5	6	2.13	430	1.0	3100
SN-450-1	4500	100	14.5	5	2.05	280	$\leq$ 0.4	$\geq$ 2800
SN-400	4000	240	13.6	4	2.12	480	1.9	2400
SN-350	3500	360	13.2	6	2.21	540	3.8	2340
SN-315	3150	300	13.7	4	2.17	560	3.0	2000
SN-285	2850	300	13.7	5	2.20	550	3.0	1200
SN-250	2500	265	13.7	5	2.20	530	3.5	1100
SN-230	2300	205	13.2	6	2.20	500	3.5	900

The spinels of this group feature high Curie temperature. They are widely used in resonance devices operating at cm- and mm- wave ranges.

2.2 Nickel Ferrites for High Power Applications

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe nominal	g_{eff} ±3%
SNH-500-1	5000	200	13.5	5	400	20	2.10
SNH-230-1	2300	250	13.0	5	500	25	2.20

2.3 Lithium Ferrites

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	Hc Oe nominal	Br G nominal
SL-475	4750	300	14.4	6	2.06	450	1.1	3250
SL-470	4700	200	14.7	5	2.06	440	≤ 0.6	≥ 3000
SL-450	4500	335	15.1	5	2.02	520	1.1	2900
SL-450-1	4500	400	15.0	2	2.02	500	1.1	≥ 3000
SL-420	4200	150	14.6	5	2.05	310	≤ 0.4	≥ 2800
SL-400	4000	480	15.0	6	2.06	570	1.4	2600
SL-340	3400	600	15.0	5	1.98	580	2.4	2400
SL-320	3200	360	15.6	6	2.01	560	1.0	2000
SL-315	3150	505	15.5	4	2.05	560	1.5	2150
SL-250	2500	500	15.4	5	1.98	550	1.91	1750
SL-225	2250	350	16.3	5	2.04	430	1.1	1650
SL-210	2100	335	16.3	7	2.00	430	1.2	1500
SL-200	2000	430	16.2	5	2.02	440	1.3	1450
SL-187	1870	340	16.0	8	2.04	300	≤ 1.4	≥ 1200
SL-155	1550	420	16.6	5	2.05	390	1.1	1100

Spinels of this group feature low non-resonant magnetic losses, high remanent flux density, and high Curie temperature. They are mostly used in non-resonant controlled devices of low power levels at cm- and mm- wave ranges (phase shifters, switches etc.).

2.4 Lithium Ferrites with Excellent Square Loop Properties

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	Hc Oe nominal	Br G min.
SL-475-1	4750	200	14.7	3	2.06	450	0.7…0.9	3000
SL-450-2	4500	280	14.7	3	2.08	540	1.0…1.5	3000
SL-450-3	4500	280	14.7	3	2.08	480	2.0…3.0	3000

Notes! Rectangularity ratio of hysteresis loop is 0,95 min, squareness ratio is 0.75 min.

2.5 Manganese Ferrites

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	Hc Oe nominal	Br G nominal
SM-210	2100	320	13.0	8	2.06	360	2.0	—
SM-190	1900	530	11.7	4	—	300	4.0	—
SM-170	1700	330	12.3	6	—	260	5.5	1030
SM-160	1600	570	12.5	2.5	2.10	350	4.5	—
SM-145	1450	150	12.0	4	2.02	140	1.0	250
SM-105	1050	360	10.5	2.5	1.98	330	1.0	—
SM-88	880	90	10.2	20	—	90	0.9	400
SM-78	780	210	10.0	4.0	—	160	2.0	—
SM-70	700	185	9.5	2.5	—	140	2.0	560

These materials are applied where it is necessary to have low magnetic and dielectric losses.

3. Hot-Pressed Microwave Garnets & Spinel Ferrites for High Power Applications

3.1 Hot-Pressed Yttrium-Iron Garnets

Material grade	$4\pi M_s$ G	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	ΔH_k Oe max.	g_{eff} ±3%
GHP-178	1780±5%	40	15.1	2	280	6	1.99
GHP-120	1200±5%	140	15.0	2	275	18	2.01
GHP-90-1	650±5%	45	14.8	2	165	12	2.01
GHP-65	650±5%	80	14.7	2	150	16	2.01
GHP-33	330±25 G	160	14.2	2	160	26	2.02

The garnets of this group feature extremely good threshold characteristics. They are used in devices that must operate at high peak power levels.

3.2 Hot-Pressed Nickel Ferrites

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	Hc Oe nominal	Br G nominal	ΔH_k Oe nominal
SNHP-520	5200	95	14,3	2	2.08	355	1.0	3200	> 6
SNHP-520-1	5200	115	14.2	4	2.10	365	1.0	3200	6
SNHP-500	5000	130	14.0	4	2.10	345	1.4	3000	12.5
SNHP-495	4950	170	13.9	4	2.09	420	1.9	3200	12.5
SNHP-495-1	4950	90	14.4	2	2.08	385	1.1	3400	> 9
SNHP-435	4350	140	13.9	6	2.10	440	4.0	2300	—
SNHP-315	3150	220	13.7	3	2.17	560	4.0	1350	—
SNHP-295	2950	250	13.9	5	2.17	550	3.2	1600	20
SNHP-230	2300	140	13.5	5	2.26	500	10.8	900	20

The hot-pressed Nickel spinels are characterized by very low porosity and high thermal conductivity of ferrite article body. They are recommended for use in microstrip microwave devices as well as high power waveguide ones.

3.3 Hot-Pressed Manganese Ferrites

Material grade	$4\pi M_s$ G ±5%	ΔH (-3dB) Oe max.	ε' ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	g_{eff} ±3%	Tc °C nominal	ΔH_k Oe nominal
SMHP-215	2150	240	13.6	6	2.01	400	6
SMHP-65	650	200	9.5	6	-	165	12

4. Microwave Hexaferrite

Hexaferrites occupy a special place among the microwave magnetic materials. They feature high magnetic anisotropy (17 kOe) and are recommended for the use in millimeter wave isolators and circulators workable at frequencies 10 GHz through 100 GHz. Hexaferrites permit to create miniaturized yet discrete microwave devices that do not require a permanent biasing magnets in the component package.
High-density hexaferrites are ideal for MIC application and microstrip mm-wave devices.

4.1 Hexaferrites

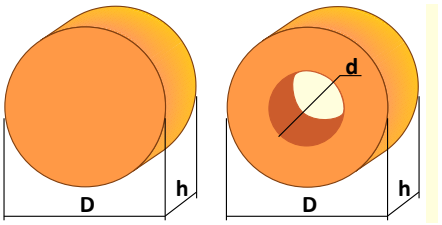
Material grade	H_{aeff} kOe ±5%	$4\pi M_s$ G ±5%	ΔH (-3dB) kOe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	Hc kOe nominal	ρ g/cm³
H6	6	2850	3.0	13	10	450	0.07	4.10
H9	9	3000	3.5	13	8	475	0.15	4.10
H12	12	3150	3.5	13	8	520	0.4	4.10
H15	15	2900	3.5	13	8	400	1.5	4.10
H18	18	2200	3.5	13	10	435	2.5	4.10
H22	22	1800	3.5	14	9	400	2.8	4.10
H23	23	1900	3.5	14	10	310	3.0	4.10
H25	25	1700	3.5	14	10	300	3.0	4.10
H28	28	1400	3.5	14	10	270	3.0	4.10
H31	31	1500	3.0	15	20	255	3.0	4.40
H33	33	1600	3.0	15	20	237	3.0	4.40
H35	35	1400	3.5	15	20	215	3.0	4.40

4.2 High density hexaferrites

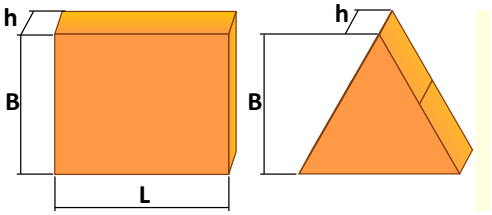
Material grade	H_{aeff} kOe ±5%	$4\pi M_s$ G ±5%	ΔH (-3dB) kOe max.	ε′ ±5%	$tg\delta_\varepsilon$ [10^{-4}] max.	Tc °C nominal	Hc kOe nominal	ρ g/cm³
HD6	6	3400	2.5	17	10	450	0.05	4.90
HD11	11	3700	2.5	17	10	507	0.1	4.90
HD16	16	3300	2.0	17	10	465	1.5	4.90
HD17	16	4300	2.0	20	8	470	0.6	5.20
HD19	19	3500	2.0	18	6	400	2.5	4.95
HD20	20	2400	2.0	16	6	400	0.6	4.95
HD22	22	2800	1.5	18	7	340	3.0	4.95
HD28	28	2300	1.5	17	10	270	3.0	4.95
HD30	30	2200	1.5	17	10	260	3.0	4.95
HD32	32	2000	1.5	17	10	250	3.0	4.95
HD33	33	1900	1.5	17	10	240	3.0	4.95

Standard form factors of microwave material parts

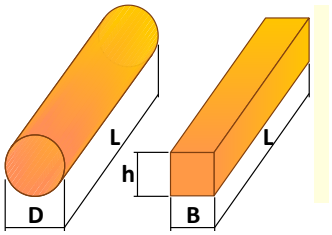
Disks and Rings



Plates and triangles



Rods and bars



The maximum dimensions of garnet & spinel parts, mm

	D	L	B	h	H	d
Disks	120	—	—	10	—	—
Rings	100	—	—	15	—	70
Plates	—	100	60	10	—	—
Triangles	—	—	—	10	90	—
Rods	40	120	—	—	—	—
Bars	—	120	30	—	10	—

The maximum dimensions of hexaferrites and hot-pressed ferrites, mm

	D	L	B	h
Disks	45	—	—	4
Plates	—	40	35	4

Standard tolerances of parts: ± 0.05 mm
Standard surface roughness: Ra ≥ 0.8 µm
Custom sizes and tolerances available on request

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