功率材料性能因子 PERFORMANCE FACTOR OF POWER MATERIALS

性能因子（Performance Factor，PF = B×f）为依频率选材之相对指标：于既定磁芯损耗密度（本图 Pv = 500 kW/m³、100 ℃）下，取各频率所允许之磁通密度峰值 B 与频率 f 之乘积。PF 愈高，表示该频率下于同一损耗预算内可用之磁通摆幅愈大，亦即同一功率所需之磁芯体积愈小。

PF 仅为相对优值：曲线高低反映材料于各频率之相对适用性，实际可用磁通密度仍须依磁芯尺寸、散热条件与样品温升验证。各材料之取样磁芯不同（T25×15×8、T22×14×8 或 T12.5×7.5×7 环形试片），小环之高频损耗低于大截面磁芯，跨图比较须以实件验证。传统低频与高 Bs 特殊类（T2 T2M TB2 TM71 TM82）以直流偏磁能力（IDC）比对，不列入 PF。

The performance factor (PF = B × f) is a relative index for frequency-based material selection: at a fixed core-loss density (here Pv = 500 kW/m³ at 100 °C) it is the product of the permissible peak flux density B and the frequency f. A higher PF indicates a larger usable flux swing within the same loss budget at that frequency, i.e. a smaller core volume for a given power.

PF is a relative figure of merit only: the curves rank the grades at each frequency, while the usable flux density must be verified against core size, cooling and measured sample temperature rise. The test cores differ between grades (T25×15×8, T22×14×8 or T12.5×7.5×7 toroids); small toroids show lower high-frequency loss than large-section cores, so cross-panel comparison must be confirmed on actual parts. The conventional low-frequency and high-Bs special classes (T2 T2M TB2 TM71 TM82) are compared by DC-bias capability (IDC) and are not included in PF.

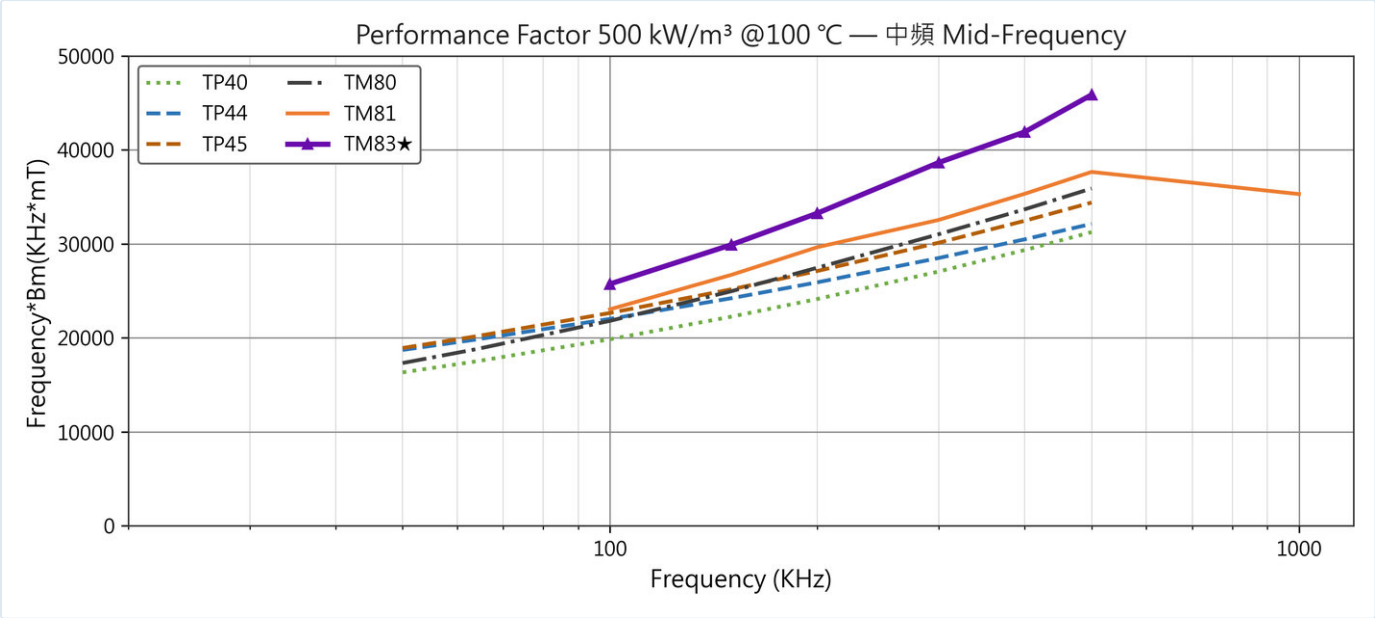


图 A　中频功率材料（TP40 TP44 TP45 TM80 TM81 TM83★）　Panel A — mid-frequency power ferrites

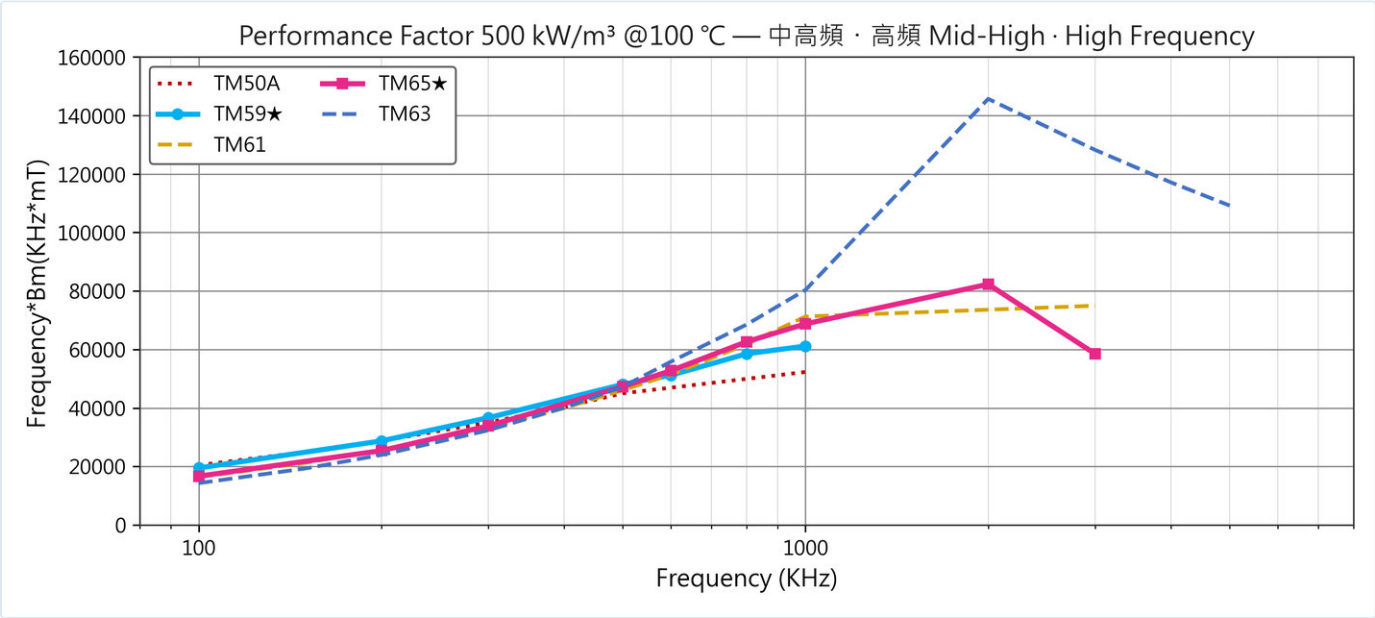


图 B　中高频 · 高频功率材料（TM50A TM59★ TM61 TM65★ TM63）　Panel B — mid-high- and high-frequency power ferrites

功率材料特性比较 POWER GRADE COMPARISON

鐵研 TAK

传统低频功率材料 CONVENTIONAL LOW-FREQUENCY POWER · 3 GRADES

特性 CHARACTERISTIC	条件·单位 CONDITION/UNIT	T2	T2M	TB2
建议频率	MHz	≤0.1	≤0.1	≤0.1
初始磁导率 25 ℃	100 kHz · <0.2 mT	2800±25%	2000±25%	1500±25%
增幅磁导率 25 ℃	25 kHz / 400 mT	> 1000	> 500	> 900
饱和磁通密度 25 / 100 ℃	1200 A/m mT	510 / 390	510 / 410	580 / 460
残留磁通密度 25 / 100 ℃	1200 A/m mT	135 / 110	130 / 130	420 / 330
矫顽力 25 / 100 ℃	1200 A/m A/m	15 / 10	10 / 10	30 / 25
相对损耗因子 25 ℃	100 kHz · <0.2 mT 10^{-6}	< 12	< 25	< 40
居里温度	℃	>180	> 220	>220
功率损耗 25 / 100 ℃	25 kHz/200 mT kW/m³	110 / 200	270 / 330	310 / 430
功率损耗 25 / 100 ℃	100 kHz/100 mT kW/m³	110 / 240	360 / 520	440 / 760

中频功率材料 MID-FREQUENCY POWER · 6 GRADES

特性 CHARACTERISTIC	条件·单位 CONDITION/UNIT	TP40	TP44	TP45	TM80	TM81	TM83
建议频率	MHz	0.1–0.3	0.1–0.3	0.1–0.3	0.1–0.3	0.1–0.3	0.1–0.3
初始磁导率 25 ℃	100 kHz · <0.2 mT	2000±25%	2000±25%	2500±25%	3000±25%	3000±25%	3000 ±25%
增幅磁导率 25 ℃	25 kHz / 400 mT	> 3000	> 3000	> 4000	> 4000	> 4000	>4000
饱和磁通密度 25 / 100 ℃	1200 A/m mT	480 / 390	500 / 400	500 / 400	520 / 420	520 / 420	545 / 425
残留磁通密度 25 / 100 ℃	1200 A/m mT	150 / 60	150 / 80	130 / 70	80 / 60	70 / 50	70 / 60
矫顽力 25 / 100 ℃	1200 A/m A/m	12 / 6.5	12 / 8	10 / 7	10 / 7	10 / 7	15 / 10
相对损耗因子 25 ℃	100 kHz · <0.2 mT 10^{-6}	<10	< 5	<10	<6	<5	
居里温度	℃	>220	>220	>210	>230	>220	≥240
功率损耗 25 / 100 ℃	25 kHz/200 mT kW/m³	110 / 60	120 / 50	81 / 41†	47 / 45†	53 / 62†	43 / 45†
功率损耗 25 / 100 ℃	100 kHz/200 mT kW/m³	720 / 480	600 / 330	600 / 300	350 / 330	340 / 400	240 / 250
功率损耗 25 / 100 ℃	200 kHz/125 mT kW/m³	580 / 350†	640 / 400†	500 / 340†	310 / 290†	230 / 270	180 / 210†
功率损耗 25 / 100 ℃	300 kHz/100 mT kW/m³	660 / 400	800 / 500	620 / 420	380 / 360	260 / 310	190 / 220
功率损耗 25 / 100 ℃	400 kHz/125 mT kW/m³	1900 / 1100†	2500 / 1500†	2400 / 1600†	1500 / 1400†	730 / 870†	630 / 820
功率损耗 25 / 100 ℃	500 kHz/50 mT kW/m³	300 / 180†	490 / 310†	270 / 200	200 / 200	100 / 120†	150 / 190†

† 估计值：由本目录该材质之特性曲线内插，或依该频段 Steinmetz 指数自最接近之实测条件换算，非材质表实测值。

† Estimated value — interpolated from the grade's characteristic curves in this catalogue or scaled from the nearest measured condition with the Steinmetz exponents of that band; not a material-sheet measurement.

功率材料特性比较（续） POWER GRADE COMPARISON (CONT.)

鐵研 TAK

中高频功率材料 MID-HIGH-FREQUENCY POWER · 2 GRADES

特性 CHARACTERISTIC	条件·单位 CONDITION/UNIT	TM50A	TM59
建议频率	MHz	≤1	0.3–1
初始磁导率 25 ℃	100 kHz · <0.2 mT	2500±25%	1900±25%
增幅磁导率 25 ℃	25 kHz / 400 mT	> 3500	> 3000
饱和磁通密度 25 / 100 ℃	1200 A/m mT	550 / 450	530 / 430
残留磁通密度 25 / 100 ℃	1200 A/m mT	90 / 70	55 / 35
矫顽力 25 / 100 ℃	1200 A/m A/m	18 / 8	15 / 10
相对损耗因子 25 ℃	100 kHz · <0.2 mT 10^{-6}	<5	<5
居里温度	℃	>240	>260
功率损耗 25 / 100 ℃	300 kHz/100 mT kW/m³	350 / 280	250 / 230
功率损耗 25 / 100 ℃	500 kHz/50 mT kW/m³	120 / 100	80 / 50
功率损耗 25 / 100 ℃	500 kHz/100 mT kW/m³	800 / 700	600 / 550
功率损耗 25 / 100 ℃	800 kHz/60 mT kW/m³	510 / 430†	330 / 250
功率损耗 25 / 100 ℃	1 MHz/30 mT kW/m³	210 / 150	100 / 70
功率损耗 25 / 100 ℃	1 MHz/50 mT kW/m³	710 / 510†	350 / 250

† 估计值：由本目录该材质之特性曲线内插，或依该频段 Steinmetz 指数自最接近之实测条件换算，非材质表实测值。

† Estimated value — interpolated from the grade's characteristic curves in this catalogue or scaled from the nearest measured condition with the Steinmetz exponents of that band; not a material-sheet measurement.

高频功率材料 HIGH-FREQUENCY POWER · 3 GRADES

特性 CHARACTERISTIC	条件·单位 CONDITION/UNIT	TM61	TM65	TM63
建议频率	MHz	≤3	≤3	≤5
初始磁导率 25 ℃	100 kHz · <0.2 mT	1000±25%	1300±25%	700±25%
增幅磁导率 25 ℃	25 kHz / 400 mT	> 2200	> 2400	> 1400
饱和磁通密度 25 / 100 ℃	1200 A/m mT	540 / 440	540 / 440	540 / 450
残留磁通密度 25 / 100 ℃	1200 A/m mT	90 / 50	70 / 50	100 / 90
矫顽力 25 / 100 ℃	1200 A/m A/m	20 / 15	15 / 20	20 / 15
相对损耗因子 25 ℃	100 kHz · <0.2 mT 10^{-6}	<5	<15	<6
居里温度	℃	>260	>240	>290
功率损耗 25 / 100 ℃	500 kHz/50 mT kW/m³	48 / 61†	70 / 50	
功率损耗 25 / 100 ℃	500 kHz/100 mT kW/m³	550 / 700	600 / 630	400 / 600
功率损耗 25 / 100 ℃	800 kHz/60 mT kW/m³	250 / 200†	300 / 220	
功率损耗 25 / 100 ℃	800 kHz/80 mT kW/m³	590 / 550†	650 / 600	
功率损耗 25 / 100 ℃	1 MHz/30 mT kW/m³	44 / 36†	70 / 50	
功率损耗 25 / 100 ℃	1 MHz/50 mT kW/m³	190 / 155	250 / 180	70 / 80
功率损耗 25 / 100 ℃	2 MHz/50 mT kW/m³			200 / 250
功率损耗 25 / 100 ℃	3 MHz/10 mT kW/m³	100 / 90		
功率损耗 25 / 100 ℃	3 MHz/30 mT kW/m³			140 / 180

† 估计值：由本目录该材质之特性曲线内插，或依该频段 Steinmetz 指数自最接近之实测条件换算，非材质表实测值。

† Estimated value — interpolated from the grade's characteristic curves in this catalogue or scaled from the nearest measured condition with the Steinmetz exponents of that band; not a material-sheet measurement.

功率材料特性比较（续） POWER GRADE COMPARISON (CONT.)

高 Bs 特殊功率材料 HIGH-BS SPECIAL POWER · 2 GRADES

特性 CHARACTERISTIC	条件·单位 CONDITION/UNIT	TM71	TM82
建议频率	MHz	≤0.5	≤0.2
初始磁导率 25 ℃	100 kHz · <0.2 mT	3800±25%	1200±25%
增幅磁导率 25 ℃	25 kHz / 400 mT	> 4000	> 4000
饱和磁通密度 25 / 100 ℃	1200 A/m mT	550 / 425	600 / 500
残留磁通密度 25 / 100 ℃	1200 A/m mT	80 / 150	80 / 100
矫顽力 25 / 100 ℃	1200 A/m A/m	6 / 2.5	12 / 10
相对损耗因子 25 ℃	100 kHz · <0.2 mT 10^{-6}	< 4	< 15
居里温度	℃	> 255	> 300
功率损耗 25 / 100 ℃	25 kHz/200 mT kW/m³	64 / 180†	200 / 330
功率损耗 25 / 100 ℃	100 kHz/200 mT kW/m³	400 / 1100	900 / 1600
功率损耗 25 / 100 ℃	300 kHz/50 mT kW/m³	50 / 170	170 / 300†
功率损耗 25 / 100 ℃	500 kHz/50 mT kW/m³	190 / 525	380 / 680†

† 估计值：由本目录该材质之特性曲线内插，或依该频段 Steinmetz 指数自最接近之实测条件换算，非材质表实测值。

† Estimated value — interpolated from the grade's characteristic curves in this catalogue or scaled from the nearest measured condition with the Steinmetz exponents of that band; not a material-sheet measurement.

Pcv 各格为 25 ℃ / 100 ℃ 之典型值（kW/m³）；空格 = 该条件无实测亦无可靠换算（3 MHz）。建议频率为选型起点，实际上限依磁通摆幅与温升而定。

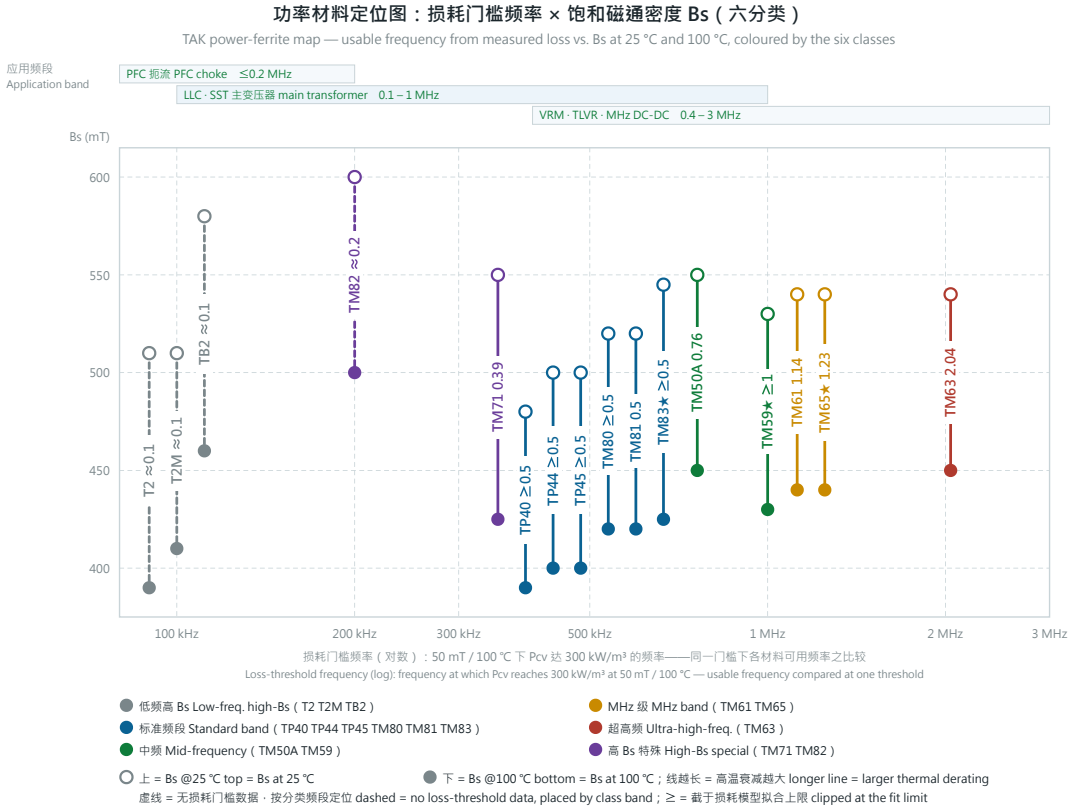
Pcv cells give typical values at 25 °C / 100 °C (kW/m³); blank = neither measured nor reliably derivable (3 MHz). Recommended frequency is a starting point; the practical limit depends on flux swing and temperature rise.

功率材料定位图 POWER-FERRITE MAP — LOSS-THRESHOLD F VS. BS

材料定位图 LOSS-THRESHOLD FREQUENCY × SATURATION FLUX DENSITY

前页比较表列出各材料之典型值；本图将全部功率材料置于同一座标系以呈现其相对位置：横轴为损耗门槛频率（50 mT / 100 ℃ 下 Pcv 达 300 kW/m³ 之频率），纵轴为饱和磁通密度 Bs（线段上端为 25 ℃、下端为 100 ℃）。

The preceding tables list typical values per grade; this map places all power grades in one coordinate system to show their relative position: the horizontal axis is the loss-threshold frequency (the frequency at which Pcv reaches 300 kW/m³ at 50 mT / 100 °C), the vertical axis the saturation flux density Bs (upper end of each line at 25 °C, lower end at 100 °C).



判读方式
How to read

位置愈右，表示于同一损耗门槛下之可用频率愈高；位置愈上，表示直流偏磁裕度愈大；线段愈长，表示 Bs 随温度之衰减愈大。高频 DC-DC（VRM / TLVR）应用要求门槛频率高且 100 ℃ 端点之 Bs 充足；PFC 与主变压器应用则以 Bs 及低频损耗为优先。

Further right = higher usable frequency at the same loss threshold; higher up = larger DC-bias margin; a longer line = larger Bs derating with temperature. High-frequency DC-DC (VRM / TLVR) requires a high threshold frequency and sufficient Bs at the 100 °C end; PFC and main transformers prioritise Bs and low-frequency loss.

六分类之对应
The six classes

由左至右依序为六分类之频段：低频高 Bs（约 0.1 MHz）→ 标准频段（TP 系三种与宽温三种，门槛 0.5–1 MHz）→ 中频 TM50A / TM59★ → MHz 级 TM61 / TM65★ → 超高频 TM63（2 MHz）；高 Bs 特殊之 TM71 / TM82 以 Bs 见长，门槛频率不高。★ 为《VRM / TLVR 选型手册》之建议材料。

From left to right the six classes follow their bands: low-frequency high-Bs (≈0.1 MHz) → standard band (three TP and three wide-temperature grades, threshold 0.5–1 MHz) → mid-frequency TM50A / TM59★ → MHz band TM61 / TM65★ → ultra-high-frequency TM63 (2 MHz); the high-Bs special grades TM71 / TM82 excel in Bs, not threshold frequency. ★ = recommended in the VRM / TLVR selection guide.

不予外推
No extrapolation

标“≥”者其门槛已超出该材料损耗模型之拟合频段，本图一律截于拟合上限而不外推，实际能力可能更高；虚线者无 50 mT 损耗数据，依分类频段定位，其能力以 IDC 比对评估。

Grades marked “≥” have a threshold beyond the fitted range of their loss model; the map clips at the fit limit instead of extrapolating, so the real capability may be higher. Dashed lines have no 50 mT loss data and are placed by class band; their capability is assessed by the IDC comparison.

本图为同一磁通摆幅与损耗门槛下之相对比较，非应用频率上限；工作磁通低于 50 mT 时可用频率更高。Bs 条件 1200 A/m；门槛频率由各材质之 Steinmetz 模型或同磁密实测点推得。

Relative comparison at one flux swing and loss threshold, not an application limit; below 50 mT the usable frequency is higher. Bs at 1200 A/m; thresholds from each grade's Steinmetz model or measured points at the same flux density.

八材料偏流能力一览 MEASURED DC-BIAS — EIGHT GRADES AT A GLANCE

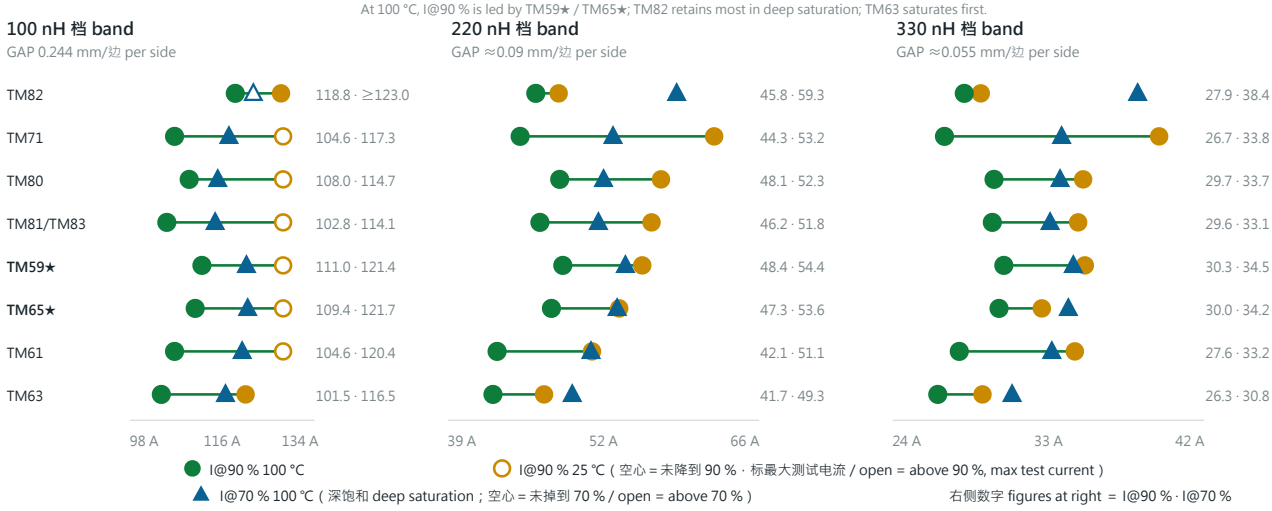
八材料 IDC 实测一览 THREE INDUCTANCE BANDS SIDE BY SIDE

定位图呈现材料层级之相对位置；实际可用与否取决于同一磁芯、同一电感值下之直流偏磁能力。下图为八种材料于同一 UD 机种、三个电感值档之 IDC 实测结果。

The map shows relative position at material level; actual usability is decided by the DC-bias capability on the same core at the same inductance. The figure below gives the measured IDC of eight grades on one UD core type in three inductance bands.

实测佐证：同一 UD 机种、八种材料的偏流能力 Measured DC bias — eight grades on one UD core

100 ℃ 下 I@90 % 以 TM59★ / TM65★ 领先；深饱和保持率以 TM82 最高 · TM63 最早进入饱和。
At 100 °C, I@90 % is led by TM59★ / TM65★; TM82 retains most in deep saturation; TM63 saturates first.



取样磁芯 UD11.75×10.45×2.8C test core；测量条件 measured at 100 kHz / 1 V。
I@90 % / I@70 % = 电感降至 90 % / 70 % 时的直流电流 DC current at which L falls to 90 % / 70 %.

100 ℃ 之判读
Reading the 100 °C data

25 ℃ 与 100 ℃ 之差距即为高温衰减：多数材料于 100 nH 档之 25 ℃ 测量范围内电感尚未降至 90 %（空心记号 = 标示最大测试电流 "≥"）· 100 ℃ 下则已降至 101–119 A。

The gap between 25 °C and 100 °C is the thermal derating: in the 100 nH band most grades had not fallen to 90 % within the 25 °C test range (open marker = max test current, "≥"), whereas at 100 °C they fall to 101–119 A.

两项指标分别判读
Two separate indices

I@90 % 为尚未进入软饱和之电流，决定稳态裕度；I@70 % 为深饱和后之保持率，决定暂态与短时过电流能力。TM82 之 I@90 % 不突出，I@70 % 则为最高。

I@90 % is the current before soft saturation and sets the steady-state margin; I@70 % is the retention in deep saturation and sets the transient / short-overload capability. TM82 is unremarkable at I@90 % but highest at I@70 %.

结果
Result

100 ℃ 下之 I@90 % 以 TM59★ / TM65★ 领先（三档皆然），此为 VRM / TLVR 依开关频率分段选材之实测依据：0.3 MHz 以下 TM80、0.3–0.5 MHz TM71、0.5–0.7 MHz TM59★、0.7–1 MHz TM65★；TM61 / TM63 供效率优先或更高频场合参考。TM63 最早进入饱和。

At 100 °C, I@90 % is led by TM59★ / TM65★ in all three bands — the measured basis for the VRM / TLVR band rule: TM80 below 0.3 MHz, TM71 0.3–0.5 MHz, TM59★ 0.5–0.7 MHz, TM65★ 0.7–1 MHz; TM61 / TM63 for efficiency-first or higher-frequency cases. TM63 saturates first.

1 匝 · I@x % 由 L(I) 线性内插。电感与偏磁测量条件 100 kHz / 1 V。取样磁芯为实件 UD11.75 · 非环形试片 · 故本表可跨材料直接比较。 "≥" 表示测量范围内电感未降至该保持率 · 标示最大测试电流；同一档内各材料之垫片微调至同一电感值 · 故 GAP 为约值。★ 为《VRM / TLVR 选型手册》之建议材料。

Single turn; I@x % interpolated from L(I). Measured at 100 kHz / 1 V on a real UD11.75 core (not a toroid sample), so grades compare directly. "≥" = inductance did not fall to that retention within the test range (max test current shown); shims within a band are trimmed to the same inductance, so GAP is approximate. ★ = recommended in the VRM / TLVR selection guide.