Introduction of New PHD by Bull Will

A New Hybrid Component Era!

Reported by

R&D Engineering

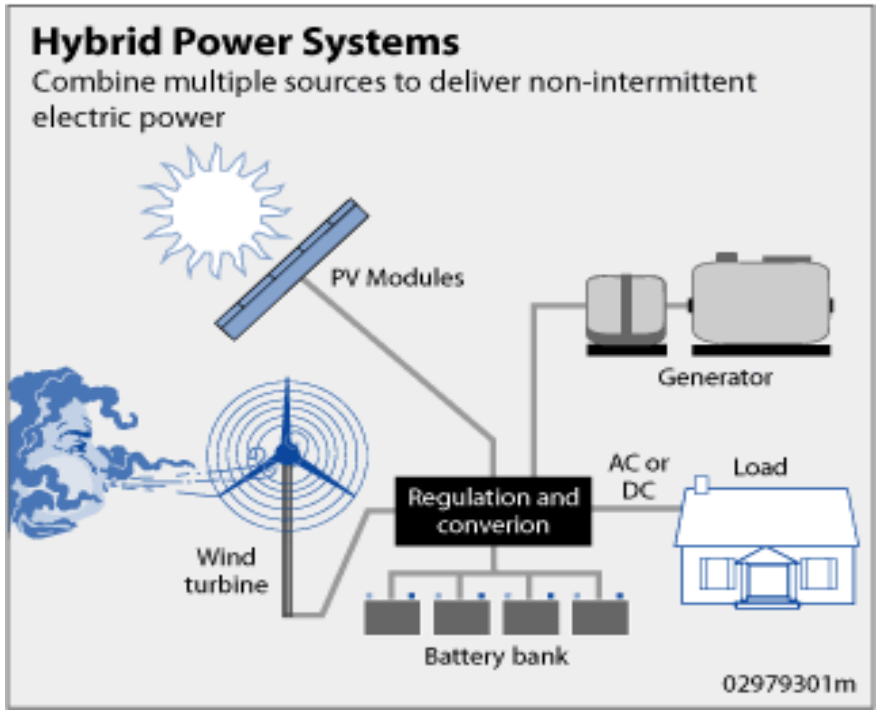
Date: July 2014

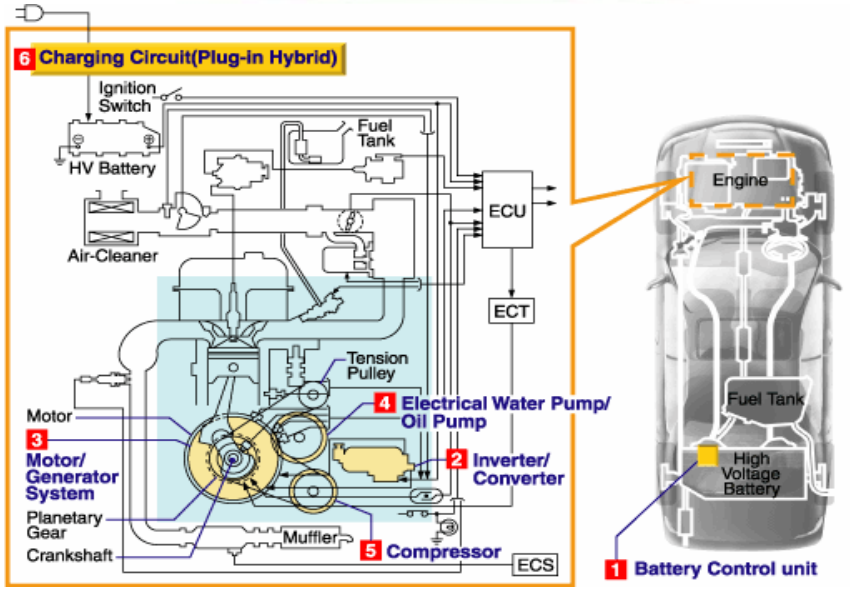
Outline –

- The Evolution of Hybrid
- Overview of Conventional Choke Design
- What “Powerful Hybrid Design” ?
- Case Study
- The Features & Advantages of the PHD
- PHD Summary

• The Evolution of Hybrid….

For the concern of energy saving and efficiency:





Bull Will is not absent under the responsibility ~

Here comes out a new component design called PHD…

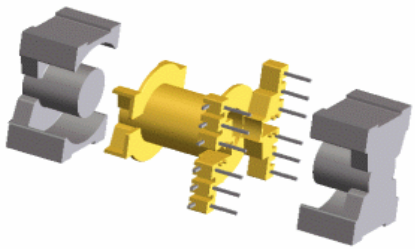
PHD: Powerful Hybrid Design

Note: PHD ≠Ph.D.
Ph.D. :: Doctor of Philosophy

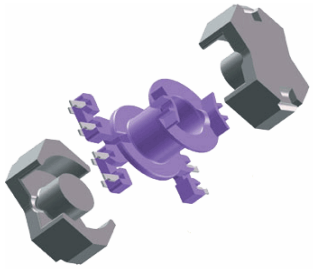
• Overview of Conventional Choke Design….

A. Power choke prior-arts overview (for SMPS):

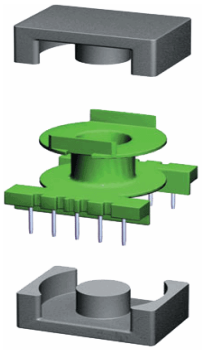
All the shape cores are in soft ferrites but the ring cores are in alloy powder materials!



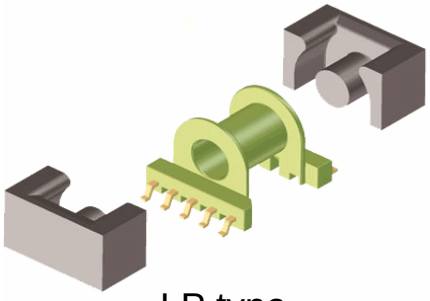
PQ type



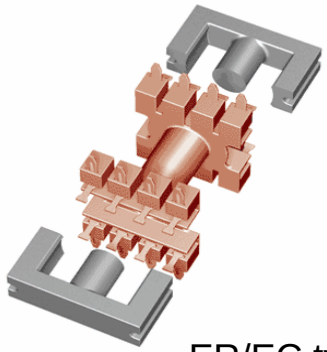
RM type



EQ type



LP type



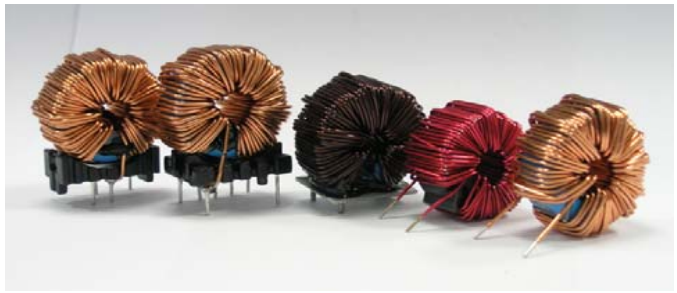
ER/EC type

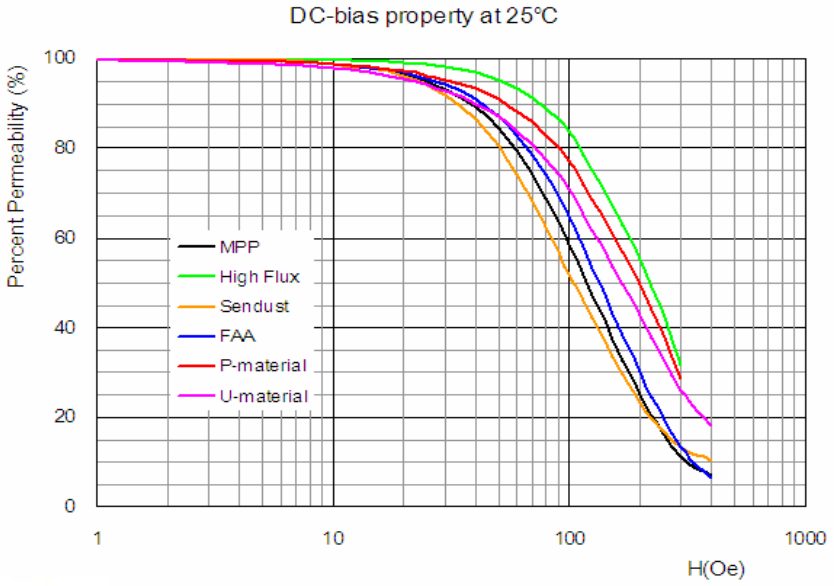
Ring core type in MPP/Hi-Flux/Sendust

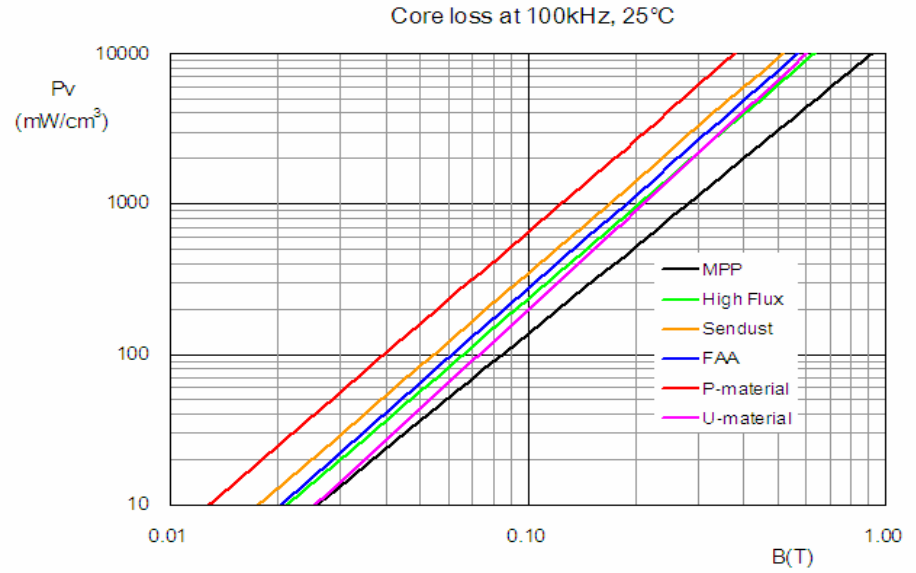
Though the above market popular types serve as the major stream, they still can not satisfy the users on the needs of hi-efficiency and reasonable price!

B. The toroidal power chokes in alloy powder cores by BW:

The core and manual winding costs are big challenge nowadays!



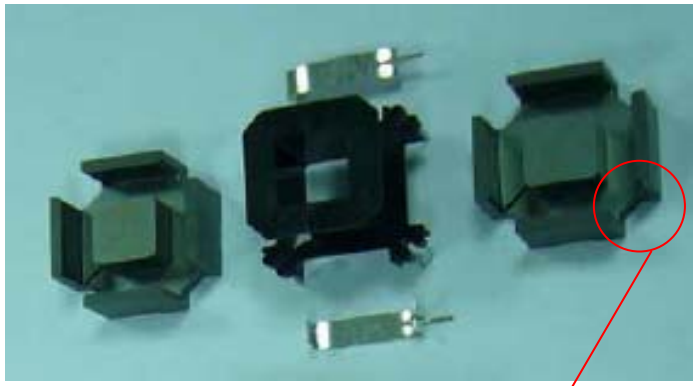




Bull Will has long been involved in manufacturing the toroidal chokes in various types of metal alloy powder cores.

C. A representative design for hi-end market: QP type in ferrites by Yujing

The flux saturation of ferrites is about 0.5 Tesla and big Ae of the core design is realized to be one of the key parameters.



Wire outlet is narrow!

The key point of QP type design is to obtain the maximum cross area of the magnetic core at a specified layout space so as to get the best flatness of L v.s. Idc and energy storage performance.

However, the drawbacks of QP type are as follows:

1. Complicated core shape and center gapping result core production cost higher.
2. Increasing the cross area of the core is at the cost of reducing winding area.
3. Wire outlet space is narrow and not easy for wire lead termination on the pins of the bobbin.

D. The material comparison:

Ferrites performs lower core loss but worse saturation while alloy powder cores perform higher saturation but worse core loss.

Type	Component	Saturation flux density (Tesla)	Core loss(mW/cm^3) @25kHz/100mT/25℃
Electrical steel shee	Fe-Si 6.5% (JNHF)	~2.0	~300
Amorphous ribbon	Fe-Si-Cr	1.56	~100
Metal alloy powder	Fe-Si-Al or Fe-Ni	1.0~1.6	100~400
Ferrites	$MnZn\text{-}Fe_2O_4$	0.5	~30

When a ferrite is gapped the core loss will be higher than what the core with closed magnetic loop should perform!

Material types of metal alloy powder cores

Type	Composition	Saturation flux density (Tesla)	Core loss(mW/cm^3) @100kHz/100mT/25℃
MPP	Fe-Mo-Ni	0.7	~250
High Flux	Fe-Ni	1.5	~530
Sendust	Fe-Si-Al	1.0	~750
FAA	Fe-Si-B-Cr amorphous	1.0	~620
P-material	Fe-Si	1.6	~1350
U-material	Fe-Si-Cr	1.4	~410

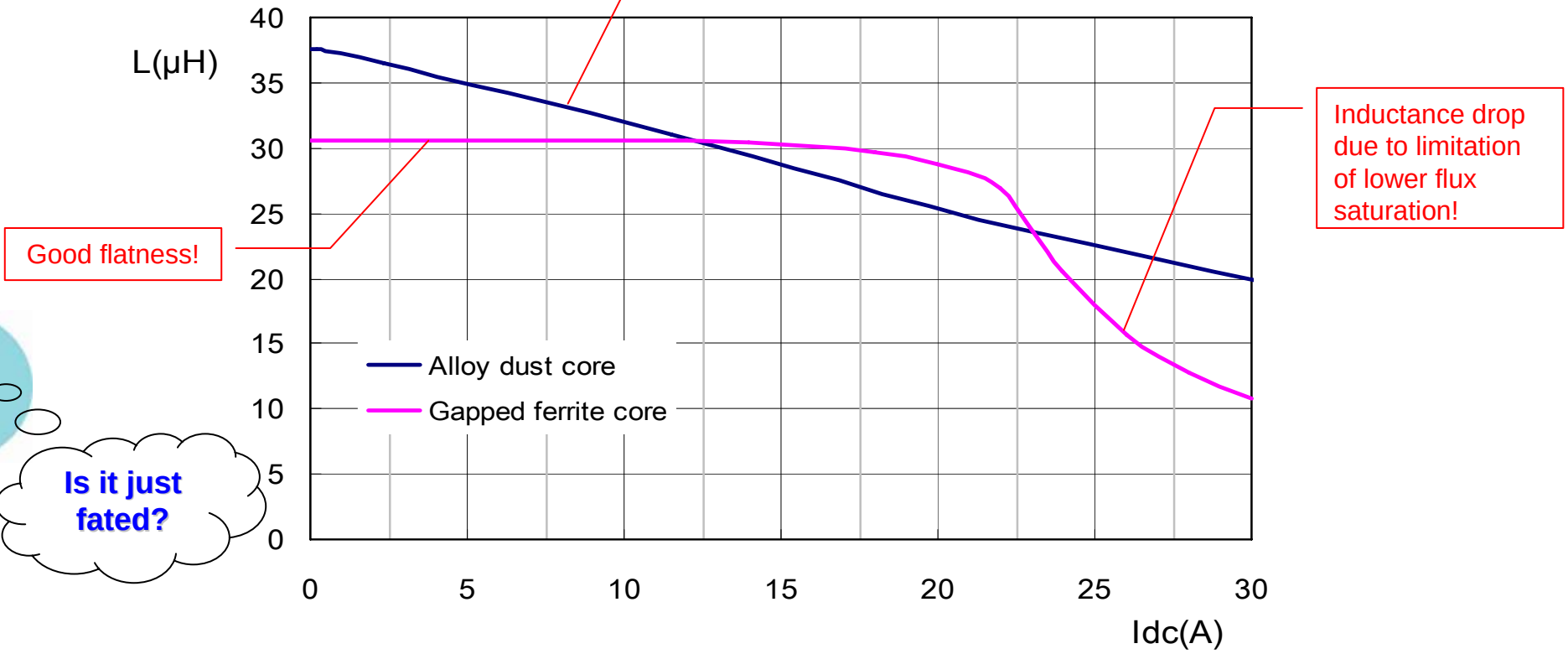
※Specified by μ=60 grade

Bull Will has full knowledge on various types of soft magnetic materials for product innovation!

E. Case study on inductance (L) v.s. bias current (Idc) test:

- Alloy dust core – Sendust 106: OD=27mm/ID=14.5mm/H=11.5mm
- Gapped ferrite core – QP29/20

Though the flux saturation is much higher but the drop slope normally leads to nonlinear current wave which causes higher harmonic noise!



Inductance drop due to limitation of lower flux saturation!

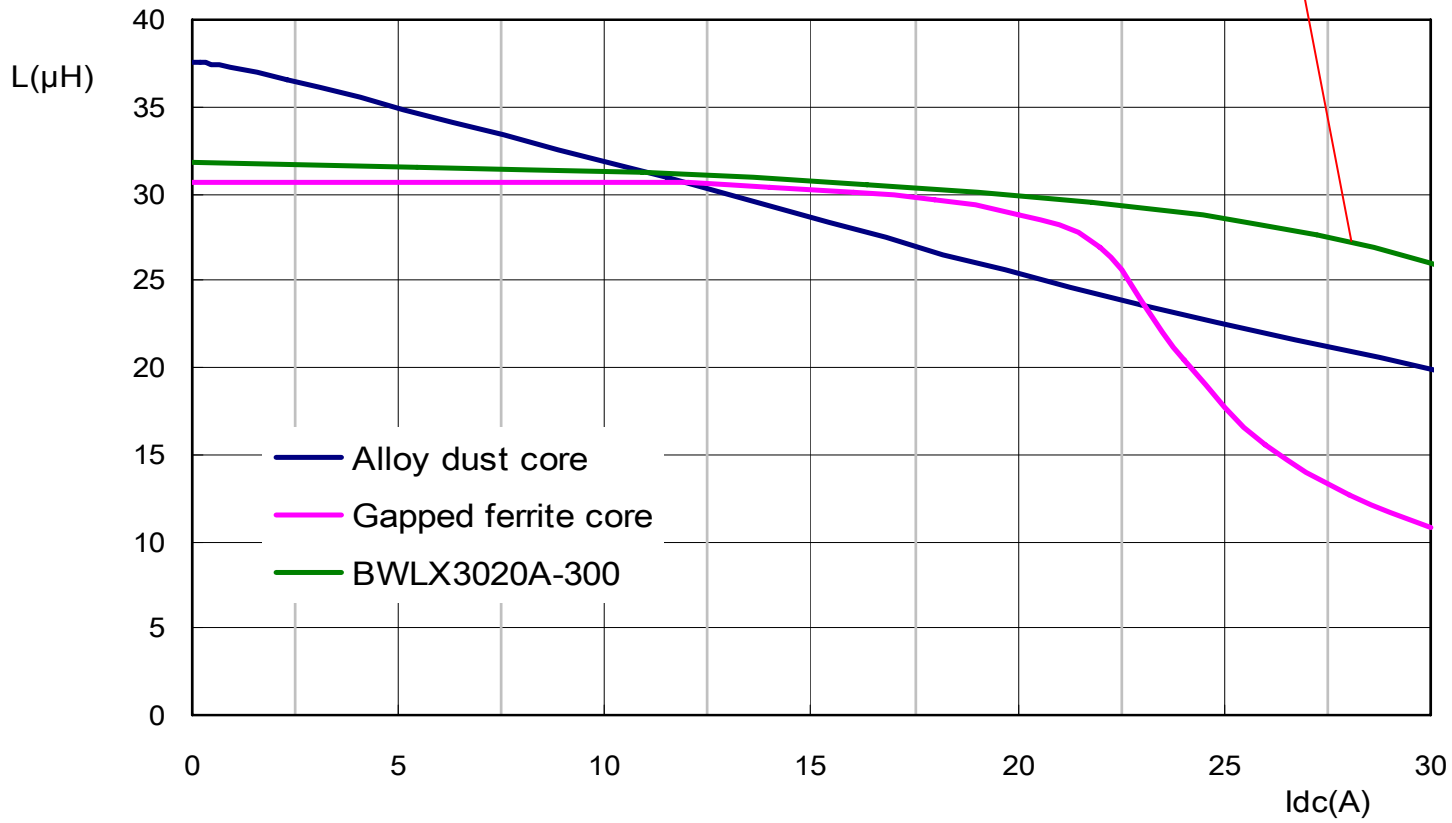
Good flatness!

F. The breakthrough components by PHD of BW: BWLX series

With excellent balance on flatness, high saturation and low power loss!

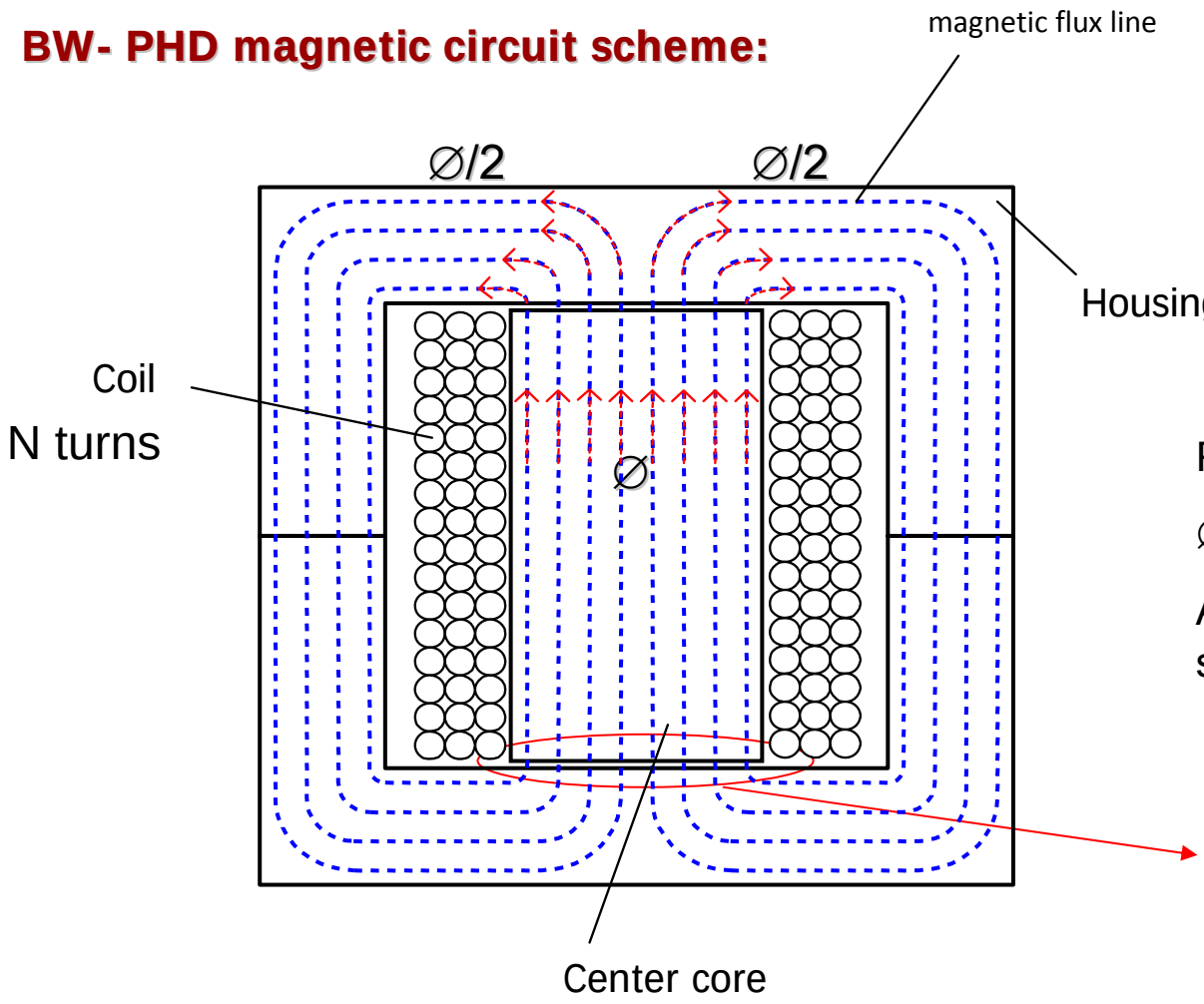
Patent protected!

BW's PHD successfully overcomes the limitation of flux saturation and drop slope!



• What “Powerful Hybrid Design” ?

BW- PHD magnetic circuit scheme:



Magnetic flux lines are created by the magnetic motive force NxI due to the coil with loaded current I.

Flux density B ≡ ∅/Ai

∅: Total flux amount

Ai: Cross area of magnetic circuit segment i

Gap at the two ends of the center core can effectively reduce the coil thermal issue.

BW PHD perspective….

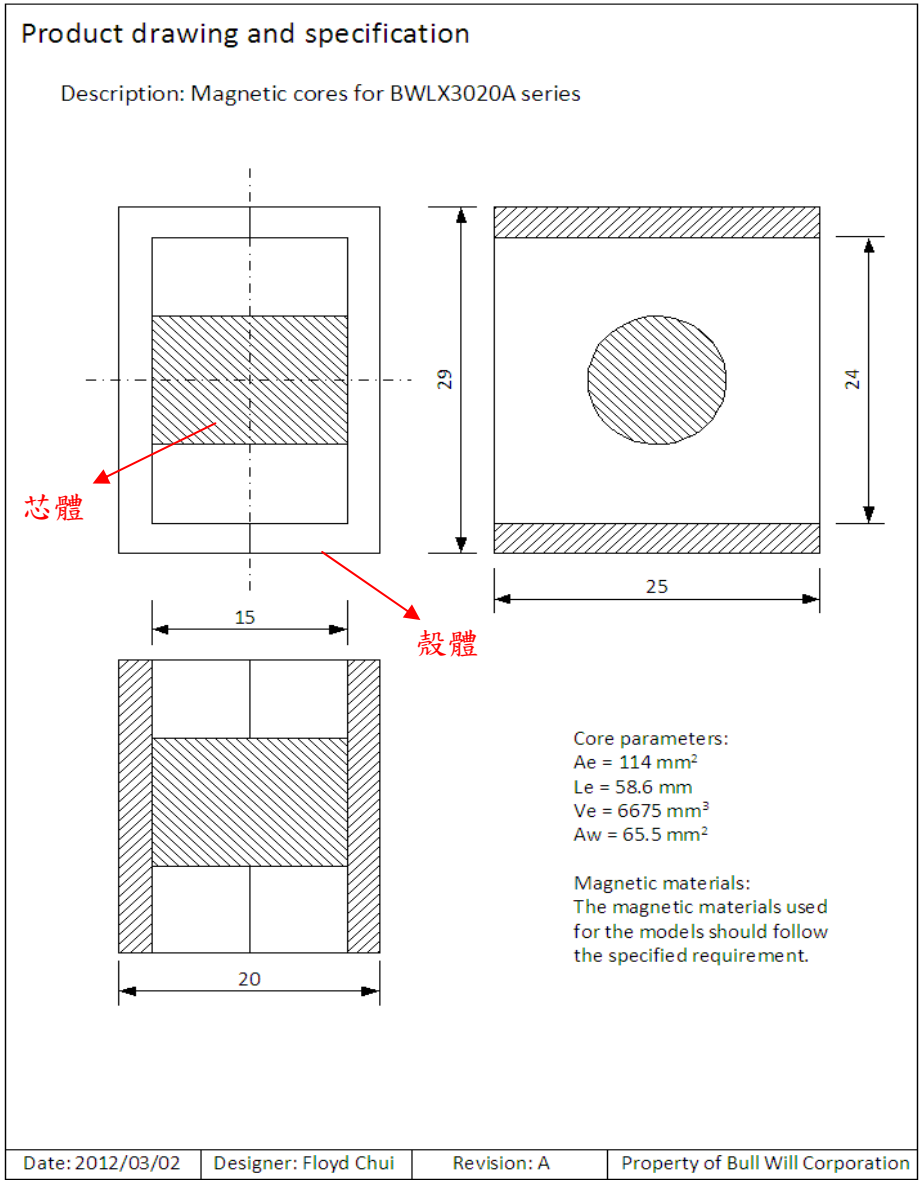
Patented construction:

Center core + Housing cores

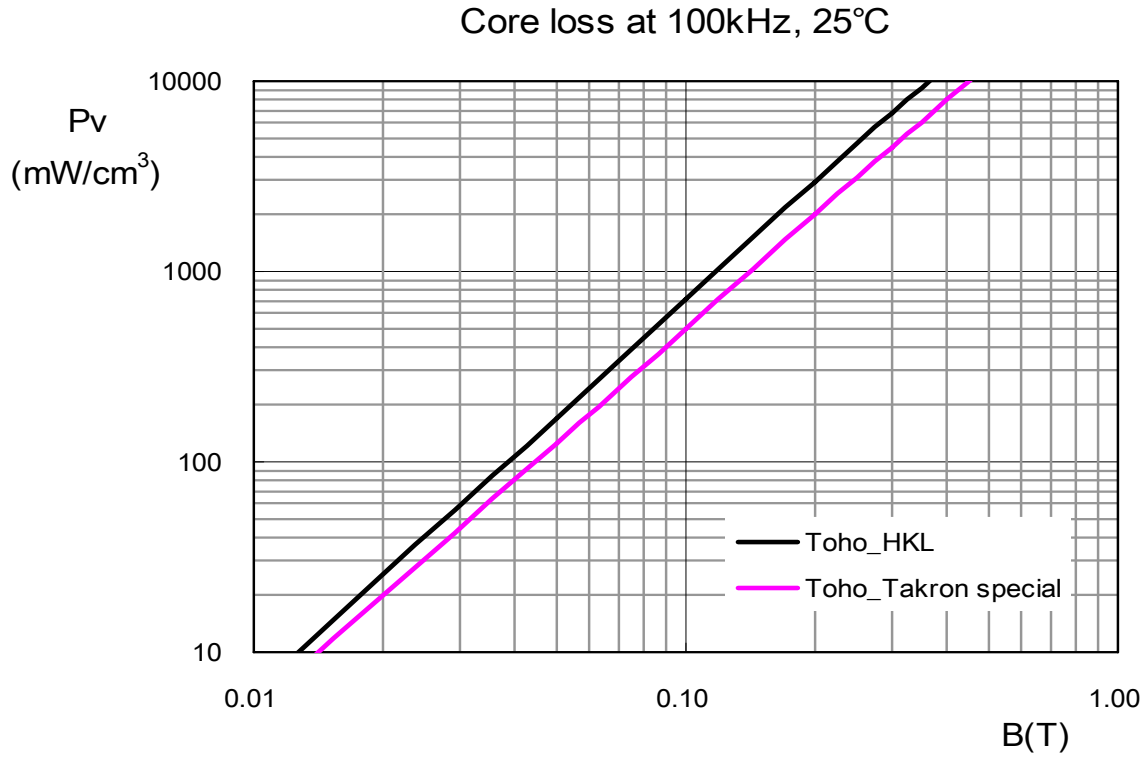
To get excellent performance the materials are specified as follows:

- Center core 芯體 –
Takron special alloy powder by Toho Zinc
“ST” grade alloy powder by Furukawa

- Housing cores 殼體 --
Wide-temperature low loss MnZn-ferrites approved: DMEGC DMR95, FXC 3C95, ACME P45, JFE MBT1, TDK PC95



Takron special alloy powder core is an improved material with core loss 30% lower than traditional sendust HK cores perform and without change on the saturation flux density.



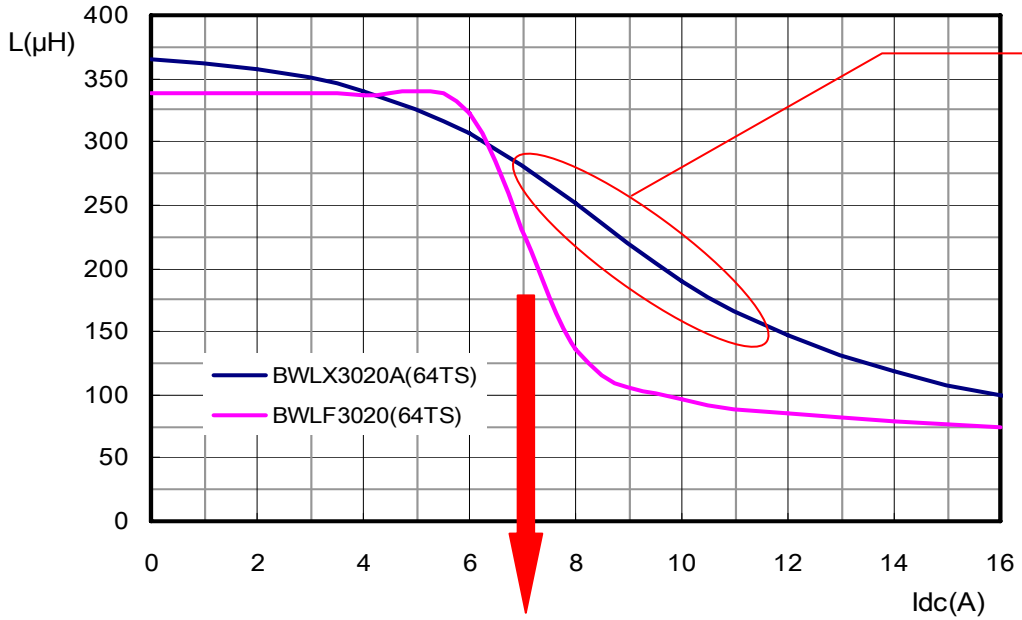
• Case study: Advantages of PHD- BWLX products for PFC choke design

• Example: 320W Power with the concern of low line working (Vac=90V), Brown-out (Vac=75V) and OPP(140% overload at low line working)

1. PFC choke (BWLX3020A-351)

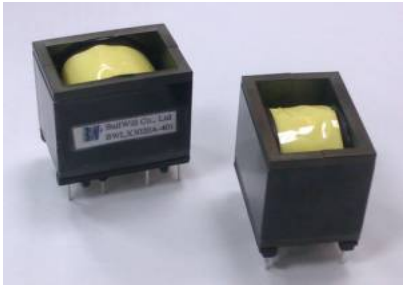
	Line input voltage	Core parameters		Operation frequency	Winding turns	Max duty	Flux swing	Efficiency	Output power	Line input peak current	Inductance @ Ip	Exciting current	Max current on the choke	Inductance @ Im	Max field strength (magnetizing force)		Approximately Peak flux density
	Vac(V)	Ae(cm^2)	Le(cm)	f(Hz)	N(TS)	D	ΔB(T)	η	Po(W)	Ip(A)	L1(μH)	Ie(A)	Im(A)	L2(μH)	Hm(A/m)	Hm(Oe)	Bp(Gauss)
Condition																	
Low line working	90	1.14	5.86	68000	64	0.5	0.023	0.86	320	5.847	320.00	0.89	6.74	285.00	7356.9	92.4	4500
Brown out	75	1.14	5.86	68000	64	0.5	0.019	0.86	320	7.016	280.00	0.85	7.86	260.00	8587.7	107.9	4900
OPP(140% overload)	90	1.14	5.86	68000	64	0.5	0.023	0.86	448	8.186	250.00	1.14	9.32	200.00	10183.1	128.0	5100

1mT=10Gauss

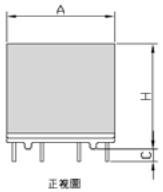


BWLF3020 is a typical ferrite PFC choke with flux saturation happening instantaneously which is the fatal drawback of ferrites!

PHD BWLX products successfully overcome the instant saturation and can withstand the concerned abnormal test conditions, such as low line working, brown-out and OPP. As a result of that, there is no need to enlarge the core size to pass the abnormal test!



BWLX3020A series for PFC chokes



Product series: BWLX3020A series

Patent protected!

Features:

- Excellent performance on efficiency
- Extremely low power loss
- Without thermal aging problem
- Very good heat dissipation
- High reliability and temperature stability

Applications:

- 90 Plus - Power supply units
- Buck-boost converters
- Energy storage requirement

- Dimensional specifications:

unit in mm

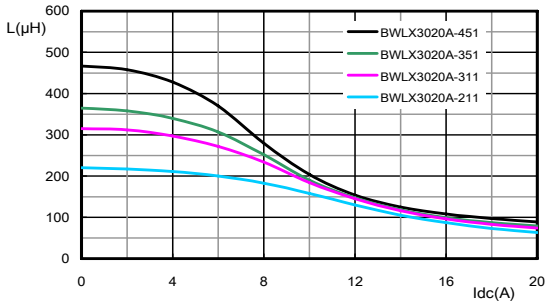
A	B	H	C	∅d	P1	P2	P3
30max	21max	30max	3.5±0.3	0.8±0.1	15.6±0.2	10±0.2	25±0.2

- Electrical specifications:

Product name	Inductance ± 10% (μH)	Max. Rdc (mΩ)	PF value	Suitable power*
BWLX3020A-451	450	160	> 95%	300W
BWLX3020A-351	350	130	> 95%	300W
BWLX3020A-311	310	105	> 95%	400W
BWLX3020A-211	210	85	> 95%	500W

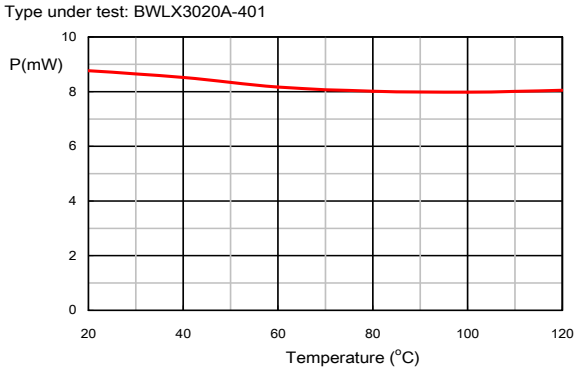
*Only reference for PFC choke applications for PSU with Vin=90Vac

- DC-bias property: (typical curves)

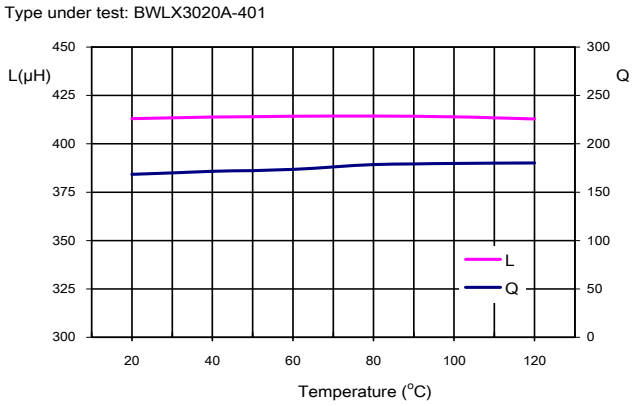


Temperature stability features of BWLX3020A series in use of specified wide-temperature magnetic materials:

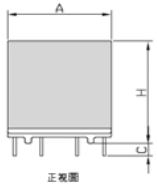
A. Power loss v.s. temperature @ 100KHz, 18Vrms (sine wave)



B. Inductance and Q-factor v.s. temperature @ 100KHz, 1Vs (sine wave)



• A high C/P value choice to replace traditional solution in sendust core with 106 size: No change on dimension and even better performance!



Product series: BWLX3015A series

Patent protected!

Features:

- Excellent performance on efficiency
- Cost effective design
- Without thermal aging problem
- Very good heat dissipation
- High reliability and temperature stability

Applications:

- 90 Plus - Power supply units
- Buck-boost converters
- Energy storage requirement

• Dimensional specifications:

unit in mm

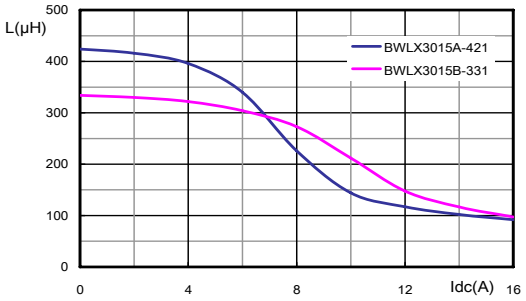
A	B	H	C	∅d	P1	P2	P3
30max	16max	30max	3.5±0.3	0.8±0.1	10.5±0.2	10±0.2	25±0.2

• Electrical specifications:

Product name	Inductance ± 10% (μH)	Max. Rdc (mΩ)	PF value	Suitable power*
BWLX3015A-421	420	170	> 95%	300W
BWLX3015B-331	330	170	> 95%	300W

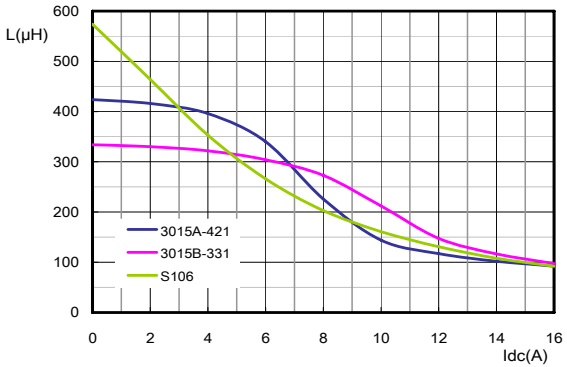
*Only reference for PFC choke applications for PSU with Vin=90Vac

• DC-bias property: (typical curves)

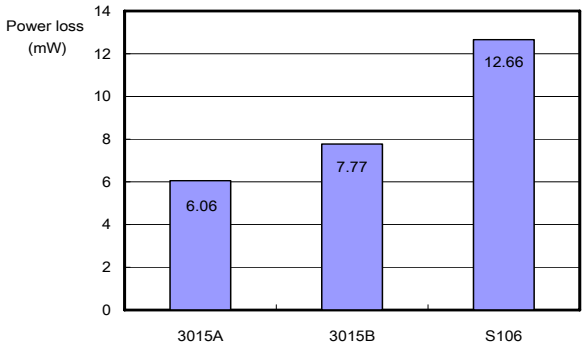


• A high C/P value choice to replace traditional alloy dust cores without change on dimension!

A. DC-bias property in comparison with a dust core in 106 size



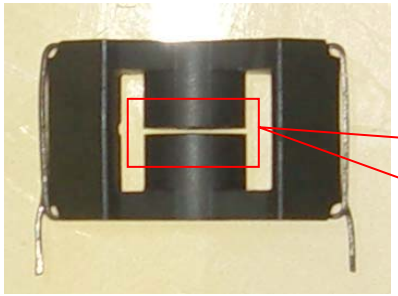
B. Power loss comparison@ 100KHz, 18V (sine wave)

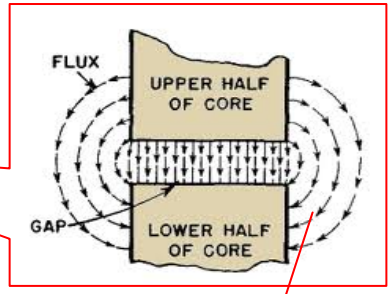


• The features & advantages of the PHD

Confidential !

	Prior-arts limits	BW- PHD product features
1	Gap in the center area of the coil easily leads to the thermal dissipation problem.	Gap at the two ends of the center core can effectively reduce the coil thermal issue.
2	Winding area is fixed once the specific core structure is confirmed.	The winding arera can be adjusted by choosing different size of the center core without changing the housing core.
3	The throughput power is limited by a specified core diemnsion.	Flexible combination of the center core and housing core can suit wide range of power requirement.
4	The magnetic cores for assembly is limited by only one type of material grade.	Different type of material grades can be easily designed for the core assembly.
5	For the strict safety requirement on mains isolation, the insulation wrapping process on the cores is not easy.	Easy to do insulation wrapping process on the housing cores.





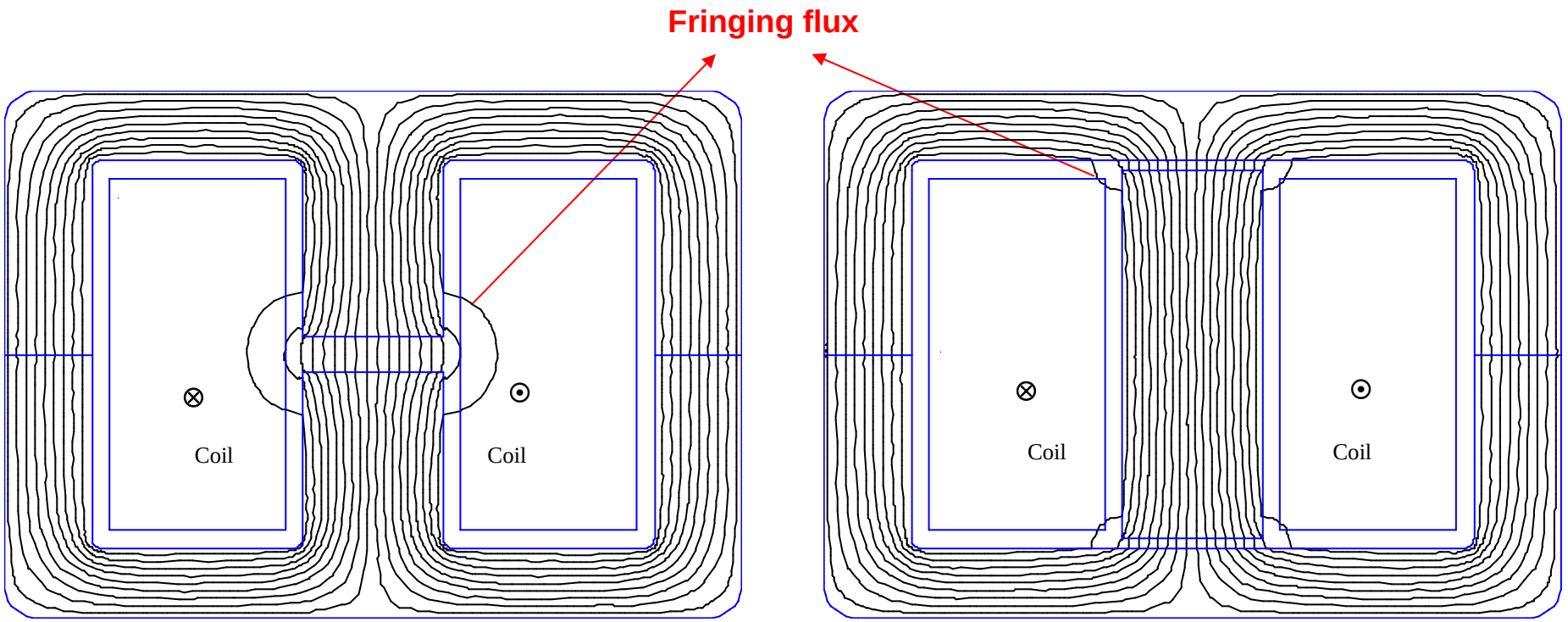
Prior art

Fringing flux due to the gap will affect its surrounded coils!

Prior-art: flyback x'fmr for switching adaptor

For safety concern sometimes the core has to be wrapped by insulation tape and shape core with curvature or polygon will make the wrapping process difficult!

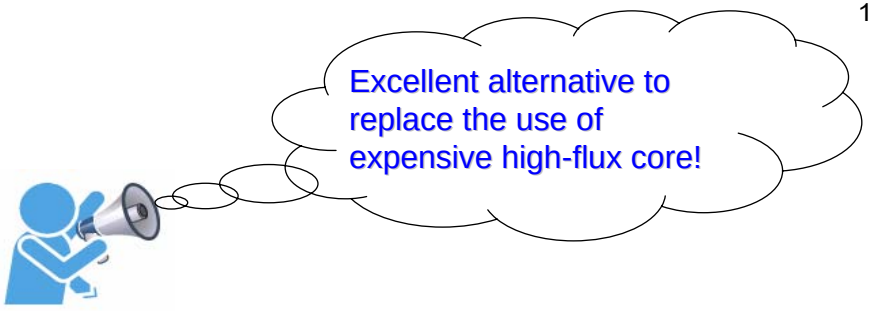
Magnetic flux simulation by FEMM

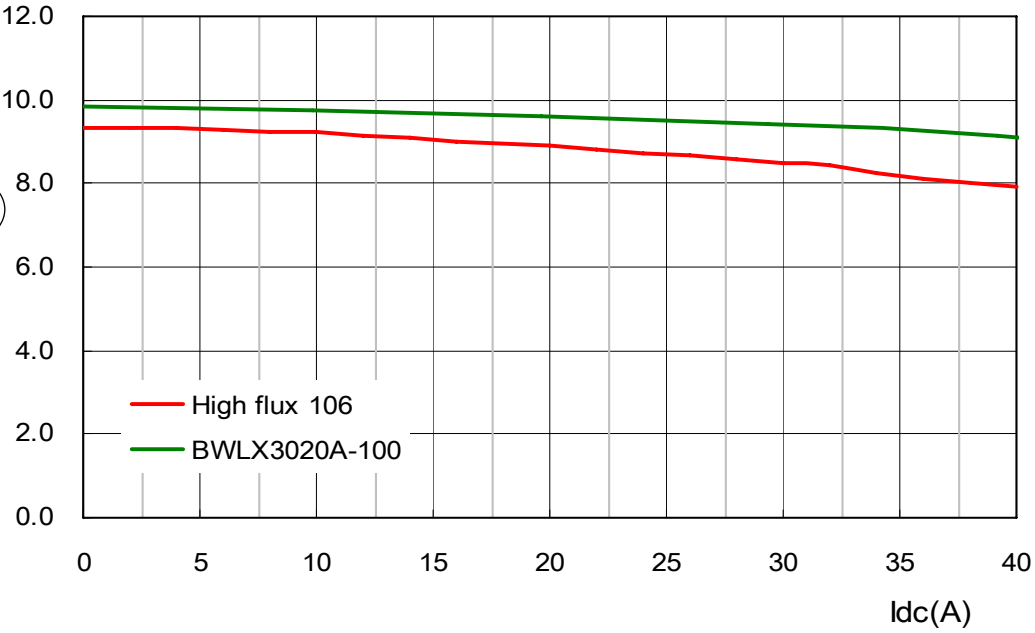


Conventional center gapped EE-paired core set

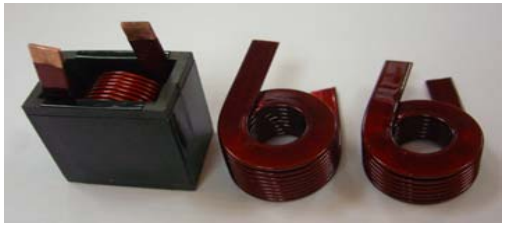
BW PHD- Shell core + Center rod core

• PHD Summary: The applications of Bull Will's PHD series

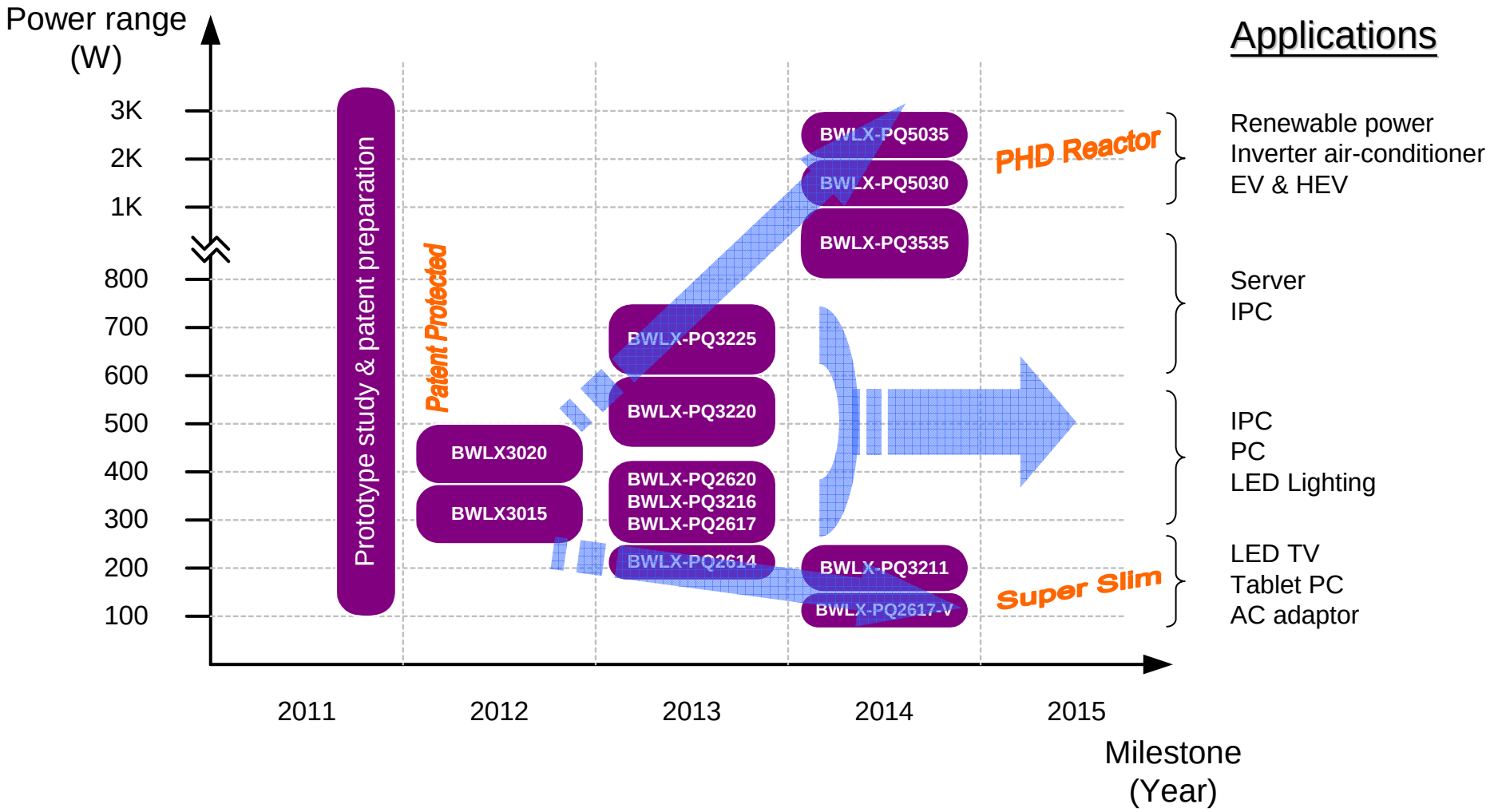




- PFC chokes
- Output chokes
- Flyback transformers
- Power chokes for buck/boost circuitry
- Resonance inductors for LLC circuitry
- Low pass filter for Class D audio amplifiers
- Energy storage requirement



PHD design roadmap:



Applications

Renewable power
Inverter air-conditioner
EV & HEV

Server
IPC

IPC
PC
LED Lighting

LED TV
Tablet PC
AC adaptor

Q & A ?

Thank you