

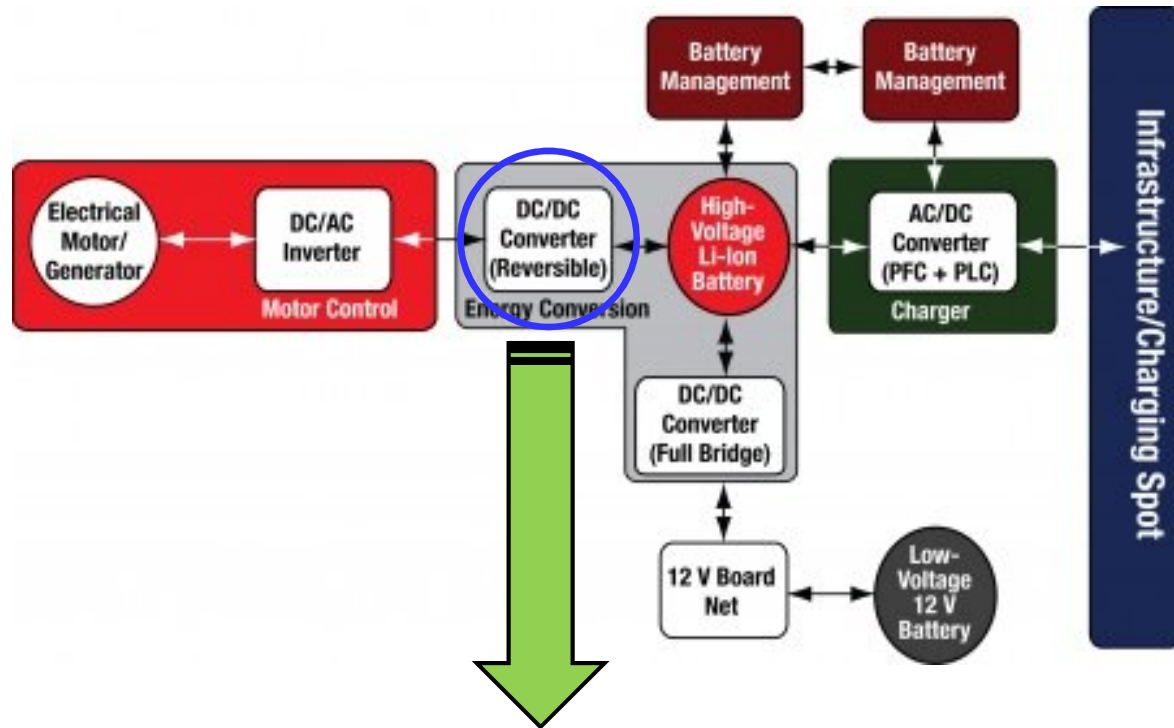
Changsung Corp.

High Current Inductor for EV(PHEV,FCEV)

1. Applications
2. Analysis of boost inductors
3. Ideal choices for boost inductors in EV(PHEV, FCEV)
4. Design examples
5. Ellipse cores
6. Round blocks + Cylinder cores

- CSC -

1. Applications



A Boost converters(High DC/DC converter) pump up voltage in battery to the higher voltage up to 650V for high torque in inverter motor of EV(PHEV/FCEV). Boost inductors in boost converters should be small, light with excellent electrical performance.

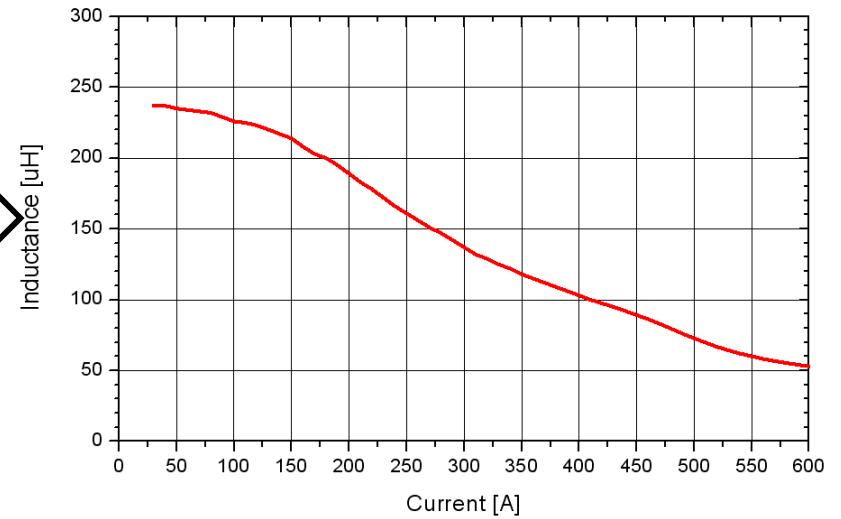


2. Analysis of boost inductors

[Real Boost Inductor]

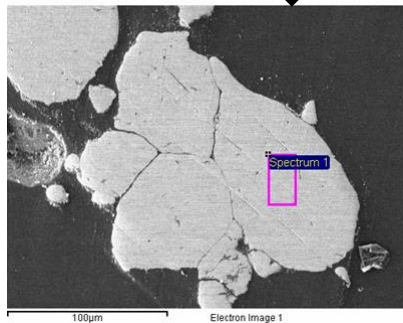


Inductance Analysis



<Soft and slow saturation at high Current >

EDS Analysis



Element	Weight%
Si	11.02
Fe	88.98
Totals	100%

<Fe-Si alloy powder cores>

3. Ideal choices for boost inductors in EV(PHEV, FCEV)

Requirements

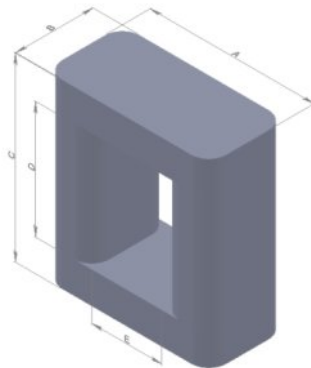
- * Particle Shape à Powder Shape for **Low Core Loss**
- * Core Material à High Saturation Flux Density Material
for **Small Size**
- * Gap Type à Distributed Air Gap + Bulk Air Gap to **Prevent Saturation** at High Current
- * Core Shape à Short Winding 1 Turn Length for **Low DCR**

CSC Suggestion

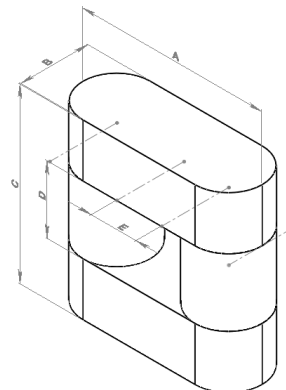
- * CSC **Powder Core**
- * Fe-Si Alloy Material
Mega Flux ($B_s=16,000$ Gauss)
- * Smaller **Bulk Air Gap**
- * **Ellipse or Cylinder Shape**



[Ellipse Core]



[Cylinder + Round Block]



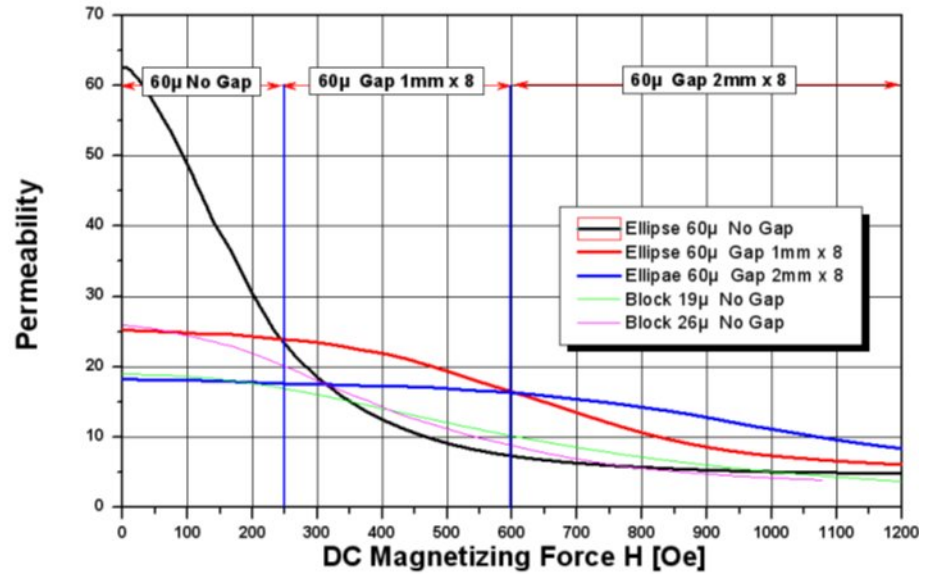
Mega Flux Ellipse Core,
Cylinder + Round Block Core
with Bulk Air Gap

4. Design examples



Ellipse Core assembly

- * Plate = LK6035- 18C
- * Post = LK3520- 20C 3 Stacks
- * Gap = No bulk gap



Bulk gap Ellipse Core assembly

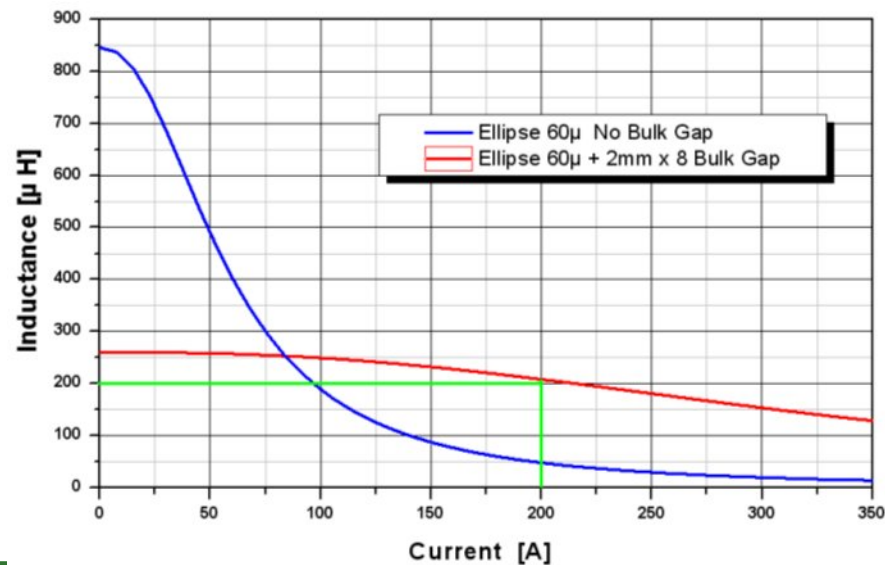
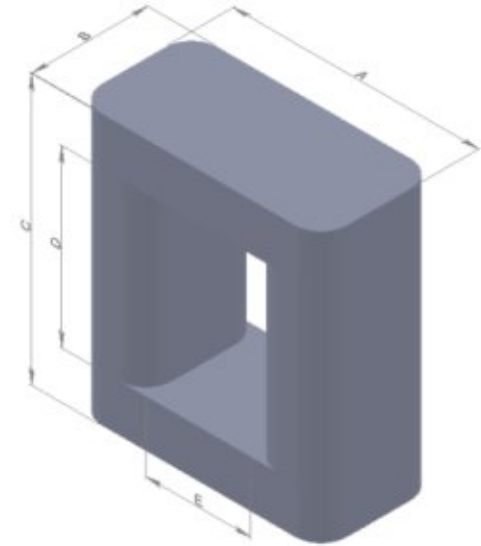
- * Plate = LK6035- 18C
- * Post = LK3520- 20C 3 Stacks
- * Gap = Air gap 1mm x 8
2mm x 8

DC magnetizing force	The highest effective μ
0 ~ 250 Oe	No bulk gap Ellipse 60μ
250 ~ 600 Oe	1mm x 8 air gap (Better than 26μBlock)
600 Oe ~	2mm x 8 air gap (Better than 19μBlock)

4. Design examples

L(200A)=200 μ H Design : Water Cooling

Plate Core	LK6035- 18C : Mega Flux Ellipse Core 60 μ , 60mm x 35mm x18.5mm Size
Post Core	LK3520- 20C : Mega Flux Ellipse Core 60 μ , 35mm x 20mm x 20.0mm Size 3Stack
Air Gap	1leg 2mm x 4 = 8mm, 2leg à Total 16mm air gap
Assembled Core Size	A x B x C = 60mm x 35mm x 105mm(Core 97mm + Air Gap 8mm)
Copper Size & Turns	Rectangular wire Width 7mm x Thickness 1.6mm, 62(31+31)Turns

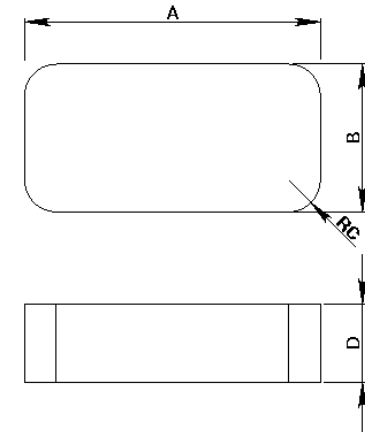


L(0A)	260 μ H
L(200A)	208 μ H
L(300A)	154 μ H
DCR	13m Ω

5-1. Ellipse Core Part lists

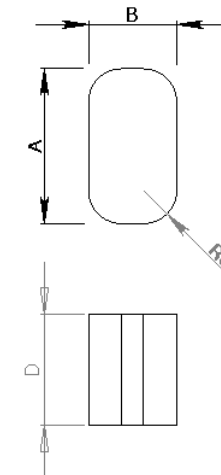
(1) Plates

P/N	Dimensions				Cross Section Area(cm ²)
	A Length (mm)	B Width (mm)	RC Radius (mm)	D Height (mm)	
LK5035- 13	50.5±0.5	35.3±0.3	7.5±0.2	13.5±0.2	4.77
LK5035- 18	50.5±0.5	35.3±0.3	7.5±0.2	18.5±0.2	6.52
LK6035- 13	60.5±0.5	35.3±0.3	7.5±0.2	13.5±0.2	4.77
LK6035- 18	60.5±0.5	35.3±0.3	7.5±0.2	18.5±0.2	6.52
LK7035- 13	70.5±0.5	35.3±0.3	7.5±0.2	13.5±0.2	4.77
LK7035- 18	70.5±0.5	35.3±0.3	7.5±0.2	18.5±0.2	6.52



(2) Posts

P/N	Dimensions				Cross Section Area (cm ²)
	A Length (mm)	B Width (mm)	RC Radius (mm)	D Height (mm)	
LK3515- 20	35.3±0.3	15.2±0.2	7.5±0.2	20.0±0.2	4.77
LK3515- 25	35.3±0.3	15.2±0.2	7.5±0.2	25.0±0.2	4.77
LK3520- 20	35.3±0.3	20.2±0.2	7.5±0.2	20.0±0.2	6.52
LK3520- 25	35.3±0.3	20.2±0.2	7.5±0.2	25.0±0.2	6.52



5-2. Ellipse Core Assembly

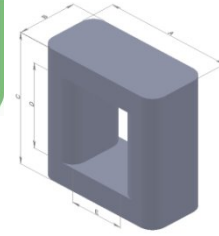
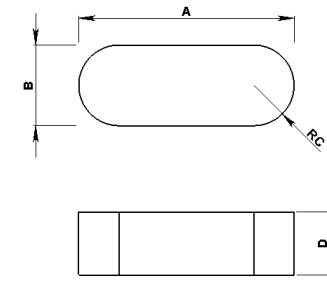


PLATE	POST		Dimensions					Path length (cm)	Cross Section Area (cm ²)	Window Area (cm ²)	AL value (nH/n ²)±12%		
	P/N	1 LEG STACK	A Length (mm)	B Width (mm)	C Height (mm)	D Inner HT (mm)	E Inner Length (mm)				A= 026u	B= 040u	C= 060u
LK5035-13	LK3515-20	2	50.5±0.5	35.3±0.3	67.0±0.5	40.0±0.4	20.0±0.4	16.47	4.77	8	113	146	218
	LK3515-25	2	50.5±0.5	35.3±0.3	77.0±0.5	50.0±0.4	20.0±0.4	18.47	4.77	10	101	130	195
	LK3515-20	3	50.5±0.5	35.3±0.3	87.0±0.5	60.0±0.4	20.0±0.4	20.47	4.77	12	91	117	176
LK5035-18	LK3515-20	2	50.5±0.5	35.3±0.3	67.0±0.5	40.0±0.4	10.0±0.4	16.04	6.52	4	158	204	306
	LK3515-25	2	50.5±0.5	35.3±0.3	77.0±0.5	50.0±0.4	10.0±0.4	18.04	6.52	5	141	182	273
	LK3515-20	3	50.5±0.5	35.3±0.3	87.0±0.5	60.0±0.4	10.0±0.4	20.04	6.52	6	127	164	245
LK6035-13	LK3515-20	2	60.5±0.5	35.3±0.3	67.0±0.5	40.0±0.4	30.0±0.4	18.47	4.77	12	101	130	195
	LK3515-25	2	60.5±0.5	35.3±0.3	77.0±0.5	50.0±0.4	30.0±0.4	20.47	4.77	15	91	117	176
	LK3515-20	3	60.5±0.5	35.3±0.3	87.0±0.5	60.0±0.4	30.0±0.4	22.47	4.77	18	83	107	160
LK6035-18	LK3520-20	2	60.5±0.5	35.3±0.3	77.0±0.5	40.0±0.4	20.0±0.4	18.04	6.52	8	141	182	273
	LK3520-25	2	60.5±0.5	35.3±0.3	87.0±0.5	50.0±0.4	20.0±0.4	20.04	6.52	10	127	164	245
	LK3520-20	3	60.5±0.5	35.3±0.3	97.0±0.5	60.0±0.4	20.0±0.4	22.04	6.52	12	115	149	223
LK7035-13	LK3515-20	2	70.5±0.5	35.3±0.3	67.0±0.5	40.0±0.4	40.0±0.4	20.47	4.77	16	91	117	176
	LK3515-25	2	70.5±0.5	35.3±0.3	77.0±0.5	50.0±0.4	40.0±0.4	22.47	4.77	20	83	107	160
	LK3515-20	3	70.5±0.5	35.3±0.3	87.0±0.5	60.0±0.4	40.0±0.4	24.47	4.77	24	76	98	147
LK7035-18	LK3520-20	2	70.5±0.5	35.3±0.3	77.0±0.5	40.0±0.4	30.0±0.4	20.04	6.52	12	127	164	245
	LK3520-25	2	70.5±0.5	35.3±0.3	87.0±0.5	50.0±0.4	30.0±0.4	22.04	6.52	15	115	149	223
	LK3520-20	3	70.5±0.5	35.3±0.3	97.0±0.5	60.0±0.4	30.0±0.4	24.04	6.52	18	106	136	204

6-1. Round blocks + Cylinder cores Part List

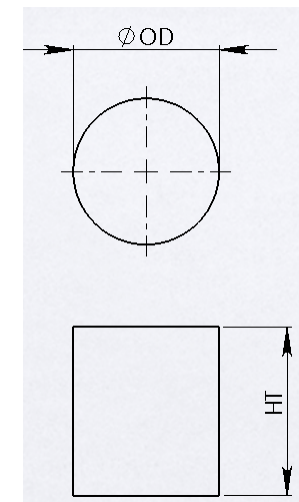
1) Plates

P/N	Dimensions				Cross Section Area (cm ²)	POST
	A Length (mm)	B Width (mm)	RC Radius (mm)	D Height (mm)		
RBK5420A	54.5±0.5	20.2±0.3	10.0±0.2	15.7±0.2	3.14	CK2020
RBK6424A	64.5±0.5	24.2±0.3	12.0±0.2	18.8±0.2	4.52	CK2424
RBK6725A	67.5±0.5	25.2±0.3	12.5±0.2	19.6±0.2	4.91	CK2525
RBK7428A	74.5±0.5	27.5±0.3	13.7±0.2	21.7±0.2	6.00	CK2828
RBK8030A	80.5±0.5	30.2±0.3	15.0±0.2	23.5±0.2	7.07	CK3030



2) Posts

P/N	Dimensions		1 Turn length (mm)	Cross Section Area (cm ²)	PLATE
	OD (mm)	HT (mm)			
CK2020	20.2±0.3	20.0±0.2	62.80	3.14	RBK5420A
CK2424	24.2±0.3	24.0±0.2	75.40	4.52	RBK6424A
CK2525	25.2±0.3	25.0±0.2	78.50	4.91	RBK6725A
CK2828	27.5±0.3	27.5±0.2	86.40	6.00	RBK7428A
CK3030	30.2±0.3	30.0±0.2	94.20	7.07	RBK8030A



6-2. Round blocks + Cylinder cores Assembly

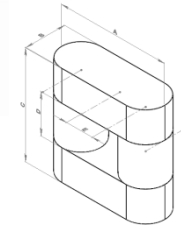


PLATE P/N	POST		Dimensions					Path Length (cm)	Cross Section Area (cm ²)	Window Area (cm ²)	AL value (nH/n ²) ± 12%		
	P/N	1 LEG STACK	A Length (mm)	B Width (mm)	C Height (mm)	D Inner Height (mm)	E Inner Length (mm)				026u	040u	060u
RBK5420A	CK2020	1	54	20	51.4	20	14	12.41	3.14	2.8	99	127	191
		2	54	20	71.4	40	14	16.41	3.14	5.6	75	96	144
		3	54	20	91.4	60	14	20.41	3.14	8.4	60	77	116
RBK6424A	CK2424	1	64	24	61.6	24	16	14.72	4.52	3.84	120	154	232
		2	64	24	85.6	48	16	19.52	4.52	7.68	90	116	175
		3	64	24	109.6	72	16	24.32	4.52	11.52	72	93	140
RBK6725A	CK2525	1	67	25	64.2	25	17	15.41	4.91	4.25	124	160	240
		2	67	25	89.2	50	17	20.41	4.91	8.5	94	121	181
		3	67	25	114.2	75	17	25.41	4.91	12.75	75	97	146
RBK7428A	CK2828	1	74	27.5	71.4	28	19	17.13	6.00	5.32	136	176	264
		2	74	27.5	99.4	56	19	22.73	6.00	10.64	103	133	199
		3	74	27.5	127.4	84	19	28.33	6.00	15.96	83	106	160
RBK8030A	CK3030	1	80	30	77	30	20	18.4	7.07	6	150	193	290
		2	80	30	107	60	20	24.4	7.07	12	113	146	218
		3	80	30	137	90	20	30.4	7.07	18	91	117	175