625kHz Wake Signaling Relative Costs

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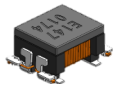
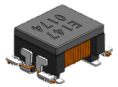
Len Stencel (TDK)

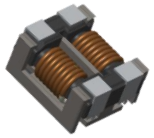
Wake Signaling

- 12 periods of 625kHz square wave triggers ‘sleeping’ nodes to wake
- Wake system designed for T1S with 8 nodes @ 25m reach
- Proposed wake signaling may require >320uH per node for 802.3da
  - Compared to 80uH that we have been modeling for 3 years
- Increasing inductor size has costs in either:
  - Power loss / heat
    - If same inductor core can be used for both 80uH/Unit and 320uH/Unit
  - Relative cost and solution size
    - If a larger inductor core is required for 320uH/Unit

MPoE Type 1 TDK Inductor Possibilities








80uH / Unit

Inductance	138uH	60uH	25uH	12uH	6.5uH	110uH
Area (mm^2)	~8	~8	~8	~8	~42	~144
Volume (mm^3)	~20	~20	~20	~20	~147	~1440

1U ↓ 2U ↓ 4U ↓ 8U ↓ 16U ↓ PSE ↓

320uH / Unit

Inductance	400uH	200uH	110uH	50uH	25uH	380uH
Area (mm^2)	~49	~49	~14.4	~49	~49	~225
Volume (mm^3)	~220	~220	~36	~220	~333	~3262

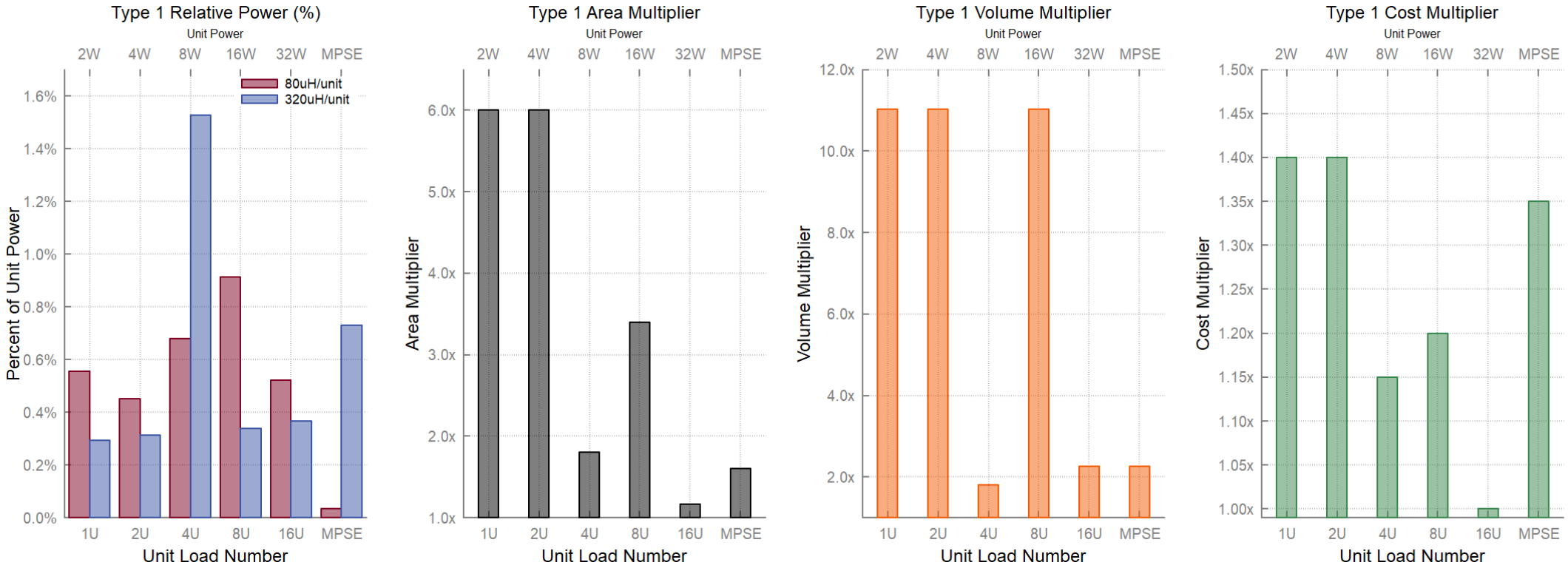





* All windings with RDC < 2Ω

**inductor pictures not to scale

TDK Relative Inductor Costs - 320uH / 80uH

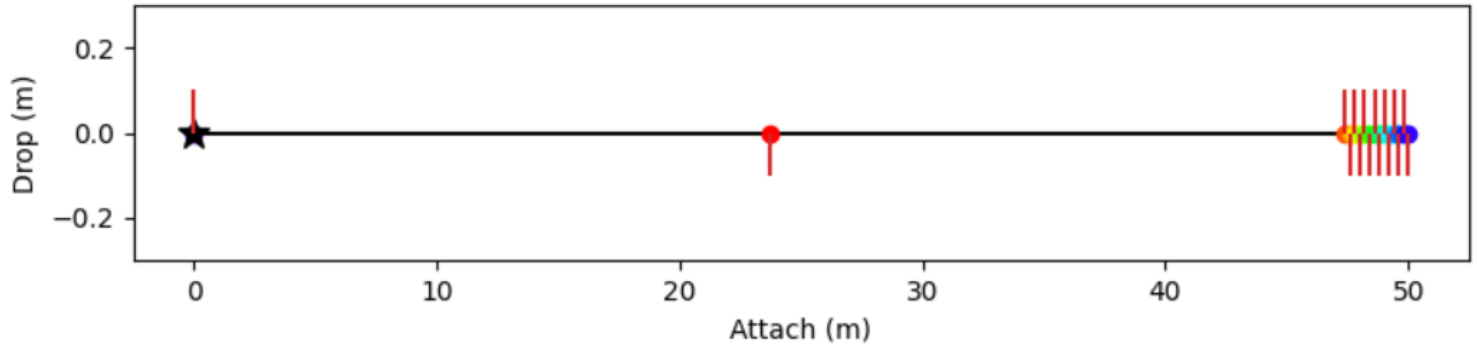


- All packages get dramatically bigger
- Costs are significantly increased
- Weight is proportional to volume

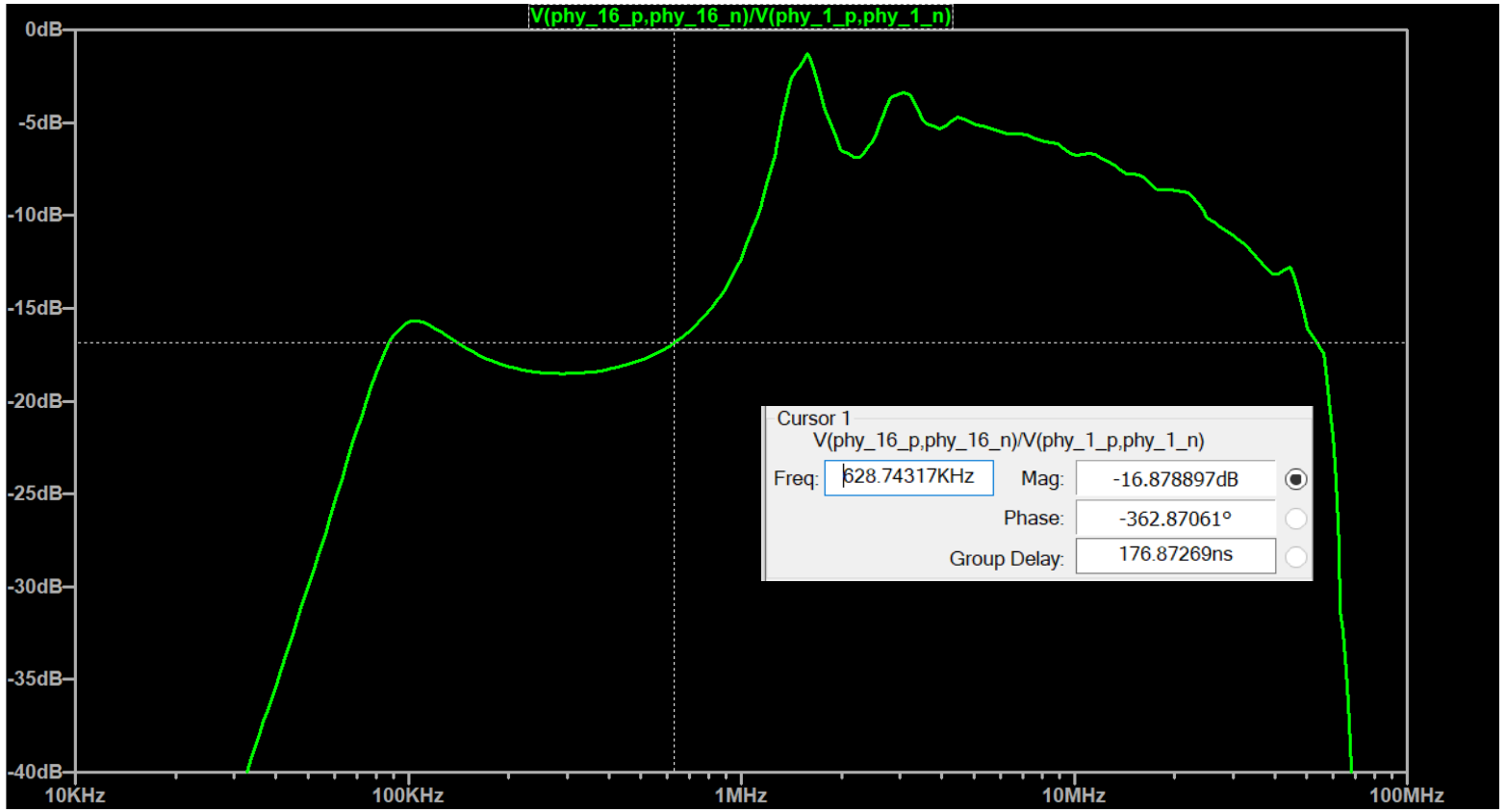
Solutions

- Possible to restrict wake signaling to other Clauses?
  - Clause 147
  - Open Alliance
- Change RX specifications so RX can cope with droop and attenuation?

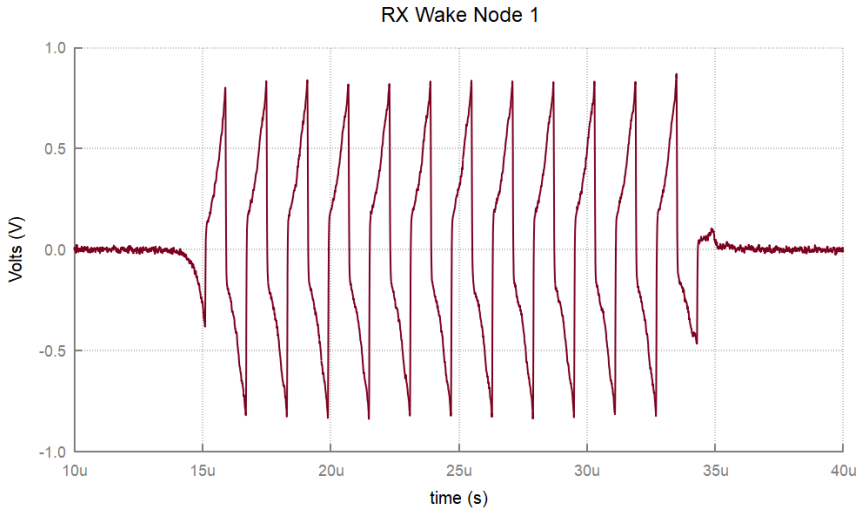
Wake Signal Simulations on 802.3da Mixing Segment

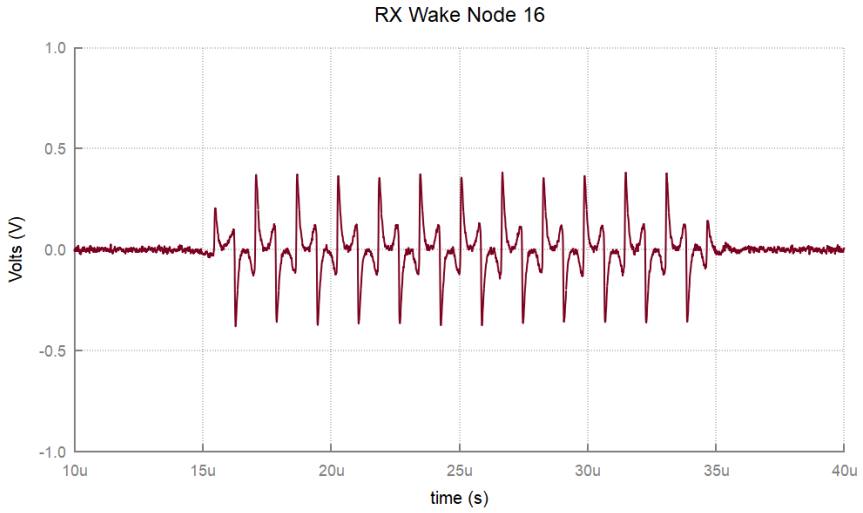


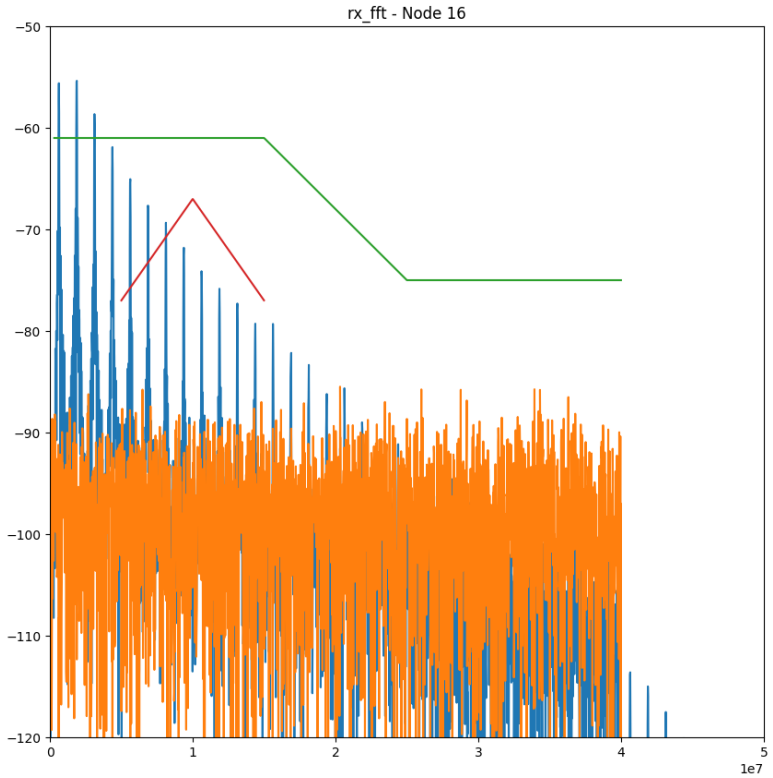
- 80uH / Node
- 16nodes
- 50meters of 23g cable
- 0.1m drops
- Simulated on modifed consenses model (github)

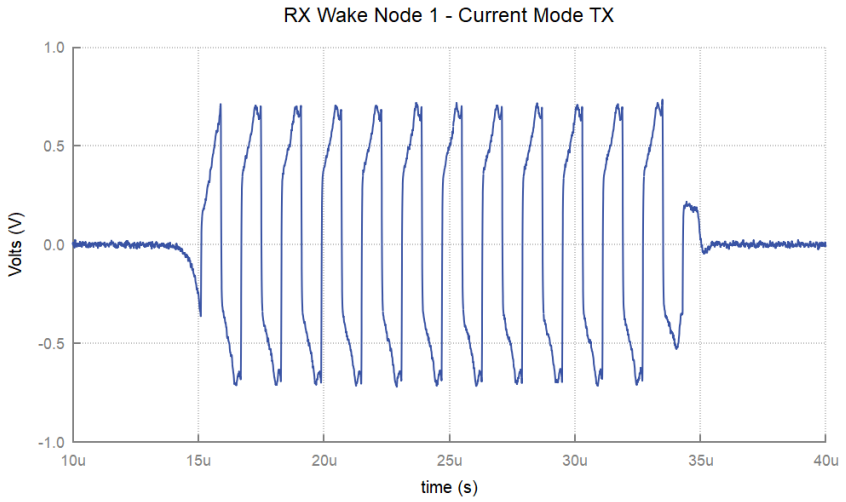


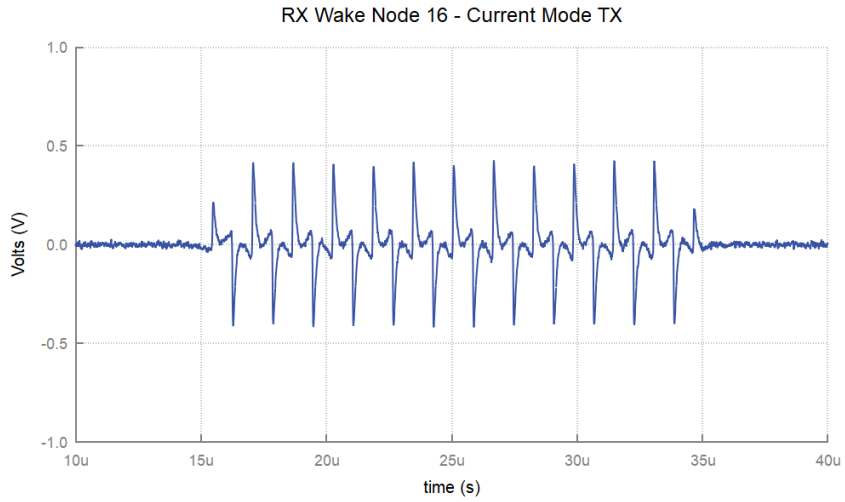
Wake Waveforms V-mode / I-Mode











Conclusion

- Thanks to Len Stencel (TDK) and Felipe Jerez (TDK)
- Increasing power coupling inductor size to accommodate 625kHz wake signal will cause significant cost, size, and weight on power delivery
- Options
  - Restrict 625kHz wake signaling to Clause 147
  - Improve detection
    - Work with droop and attenuation in 802.3da powered mixing segments
    - Bandpass filtering at 625kHz
  - Move wake up tone to higher frequency (2-4MHz)

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MPoE solutions for 10Base-T1M

Updated November 7th 2023

TDK Electronics AG
Magnetics Business Group • MAG IN D
Heidenheim, Germany
November 7th , 2023

Summary

Type 1 (35-50V @MPD)
Type 1 (35-50V @ MPD) w/ Wake Signaling 320uH
Type 1 (35-50V @ MPD), comparison w/wo Wake Signaling 320uH

Type 0 (16-30V @MPD)
Type 0 (16-30V @ MPD) w/ Wake Signaling 320uH
Type 0 (16-30V @MPD) comparison w/wo Wake Signaling 320uH

Premises:

All windings with RDC < 2 Ohms
Solutions with high coupling for PHY side injection and and low coupling for Line side injection
RDC is related to single winding
Itemp and Isat is related to the PoDL construction (both windings in series)

Type 1, Vmin 35V systems

Type 1 (35-50V @MPD)

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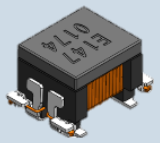
ADI inputs

TDK calculations

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)	Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)	Notes
1	2	35	0.0571	80	100	3.2x2.5x2.5	A	36.0	~138	1.7	0.23	0.27	(1)
2	4	35	0.1143	40	50	3.2x2.5x2.5	A	18.0	~60	0.69	0.32	0.39	(1)
4	8	35	0.2286	20	25	3.2x2.5x2.5	A	7.2	~25	0.52	0.41	0.65	(1)
8	16	35	0.4571	10	12.5	3.2x2.5x2.5	A	3.7	~12	0.35	0.50	0.86	(1)
16	32	35	0.9143	5	6.25	7x6x3.5	B	2.3	~6.5	0.10	1.4	2.5	(1)
PSE	41.1	45	0.9143	80	100	12x12x10.5	C	36.0	~110	0.066	1.6	2.5	(1)

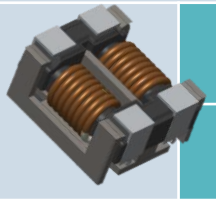
Notes 1: Check coupling level

Format A, Low coupling



Footprint (mm²)	3.2x2.5x2.5 mm (~8mm²)
Volume (mm³)	~20

Format B, Low coupling



Footprint (mm²)	7x6x3.5 mm (42mm²)
Volume (mm³)	~ 147

Format C, Low coupling

Footprint (mm²)	12x12x10.5 mm (144mm²)
Volume (mm³)	~1500

Type 1 (35-50V @ MPD) w/ Wake Signaling 320uH

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TDK

ADI inputs

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)
1	2	35	0.0571	320	400
2	4	35	0.1143	160	200
4	8	35	0.2286	80	100
8	16	35	0.4571	40	50
16	32	35	0.9143	20	25
PSE	41.14	45	0.9143	320	400

TDK calculations

Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)	Notes
7x7x4.5 or 7x7x7	D,E	120.0	~ 400	0.90	0.30	0.45	(1)
7x7x4.5 or 7x7x7	D,E	56.0	~ 200	0.48	0.50	0.80	(1)
4.5x3.2x2.5	F	36.0	~110	1.17	0.38	0.40	(1)
7x7x4.5 or 7x7x7	D,E	15.0	~50	0.13	1.00	1.20	(1)
7x7x4.5 or 7x7x7	D,E	6.8	~25	0.07	1.30	2.00	(1)
15x15x14.5	G	130.0	~380	0.14	1.33	1.70	(1)

Notes 1: Check coupling level

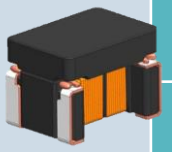
Format D, High Coupling

Footprint (mm²)	7x7x4.5 mm (49mm²)
Volume (mm³)	~220

Format E, Low Coupling

Footprint (mm²)	7x7x7 mm (49mm²)
Volume (mm³)	~343

Format F, Low or High Coupling.



Footprint (mm²)	4.5x3.2x2.5 mm (14.4mm²)
Volume (mm³)	~36

Format G, Low or High Coupling

Footprint (mm²)	15x15x14.5 mm (225mm²)
Volume (mm³)	~3263

Type 1 (35-50V @ MPD) comparison w/wo Wake Signaling 320uH

Attracting Tomorrow TDK

ADI inputs

TDK calculations

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)	Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)
1	2	35	0.0571	80	100	3.2x2.5x2.5	A	36.0	~138	1.7	0.23	0.27
				320	**400**	**7x7x4.5 or 7x7x7**	**D,E**	**120.0**	**~ 400**	**0.90**	**0.30**	**0.45**
2	4	35	0.1143	40	50	3.2x2.5x2.5	A	18.0	~60	0.69	0.32	0.39
				160	**200**	**7x7x4.5 or 7x7x7**	**D,E**	**56.0**	**~ 200**	**0.48**	**0.50**	**0.80**
4	8	35	0.2286	20	25	3.2x2.5x2.5	A	7.2	~25	0.52	0.41	0.65
				80	**100**	**4.5x3.2x2.5**	**F**	**36.0**	**~110**	**1.17**	**0.38**	**0.40**
8	16	35	0.4571	10	12.5	3.2x2.5x2.5	A	3.7	~12	0.35	0.50	0.86
				40	**50**	**7x7x4.5 or 7x7x7**	**D,E**	**15.0**	**~50**	**0.13**	**1.00**	**1.20**
16	32	35	0.9143	5	6.25	7x6x3.5	B	2.3	~6.5	0.10	1.4	2.50
				20	**25**	**7x7x4.5 or 7x7x7**	**D,E**	**6.8**	**~25**	**0.07**	**1.3**	**2.00**
PSE	41.1	45	0.9143	80	100	12x12x10.5	C	36.0	~110	0.066	1.6	2.50
				320	**400**	**15x15x14.5**	**G**	**130.0**	**~380**	**0.140**	**1.3**	**1.70**

Type 1 (35-50V @ MPD) comparison w/wo Wake Signaling 320uH

Attracting Tomorrow TDK

ADI inputs

TDK calculations

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)	Size	Format	L(µH)	L-PoDL (µH)	Relative PCB area diff. mm²	Relative price diffe.
1	2	35	0.0571	80	100	3.2x2.5x2.5	A	36.0	~138	x 6	x 1.4
				320	**400**	**7x7x4.5 or 7x7x7**	**D,E**	**120.0**	**~ 400**		
2	4	35	0.1143	40	50	3.2x2.5x2.5	A	18.0	~60	x 6	x 1.4
				160	**200**	**7x7x4.5 or 7x7x7**	**D,E**	**56.0**	**~ 200**		
4	8	35	0.2286	20	25	3.2x2.5x2.5	A	7.2	~25	x 1.8	X 1.15
				80	**100**	**4.5x3.2x2.5 (U.D)**	**F**	**36.0**	**~110**		
8	16	35	0.4571	10	12.5	3.2x2.5x2.5	A	3.7	~12	x 3.4	x 1.2
				40	**50**	**7x7x4.5 or 7x7x7**	**D,E**	**15.0**	**~50**		
16	32	35	0.9143	5	6.25	7x6x3.5	B	2.3	~6.5	≈	≈
				20	**25**	**7x7x4.5 or 7x7x7**	**D,E**	**6.8**	**~25**		
PSE	41.1	45	0.9143	80	100	12x12x10	C	36.0	~110	x 1.6	x 1.35
				320	**400**	**15x15x14.5**	**G**	**130.0**	**~380**		

Type 0, Vmin 16V systems

Type 0 (16-30V @MPD)

Attracting Tomorrow TDK

ADI inputs

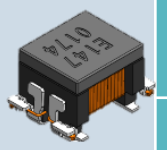
unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)
1	1	16	0.0625	80	100
2	2	16	0.1250	40	50
4	4	16	0.2500	20	25
8	8	16	0.5000	10	12.5
16	16	16	1.0000	5	6.25
PSE	18	18	1.0000	80	100

TDK calculations

Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)	Notes
3.2x2.5x2.5	A	36.0	~138	1.7	0.23	0.27	(1)
3.2x2.5x2.5	A	18.0	~60	0.69	0.32	0.39	(1)
3.2x2.5x2.5	A	7.2	~25	0.52	0.41	0.65	(1)
4.5x3.2x2.5	F	3.7	~12	0.3	0.6	0.8	(1)
7x6x3.5	B	2.3	~6.5	0.10	1.4	2.5	(1)
12x12x10.5	C	36	~110	0.066	1.6	2.5	(1) (2)

Note 1: Check coupling level , Note 2: Potential downsizing to 10x10x6 if high coupling is used

Format A, Low coupling

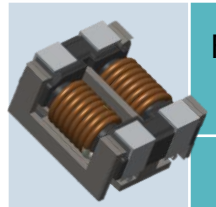


Footprint (mm²)	3.2x2.5x2.5 mm (~8mm²)
Volume (mm³)	~20

Format F, Low or High Coupling.

Footprint (mm²)	4.5x3.2x2.5 mm (14.4mm²)
Volume (mm³)	~36

Format B, Low coupling



Footprint (mm²)	7x6x3.5 mm (42mm²)
Volume (mm³)	~ 147

Format C, Low coupling

Footprint (mm²)	12x12x10.5 mm (144mm²)
Volume (mm³)	~1500

Type 0 (16-30V @ MPD) w/ Wake Signaling 320uH

Attracting Tomorrow

TDK

ADI inputs

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)
1	1	16	0.0625	320	400
2	2	16	0.1250	160	200
4	4	16	0.2500	80	100
8	8	16	0.5000	40	50
16	16	16	1.0000	20	25
PSE	18	18	1.0000	320	400

TDK calculations

Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)	Notes
7x7x4.5 or 7x7x7	D,E	120.0	~ 400	0.90	0.30	0.45	(1)
7x7x4.5 or 7x7x7	D,E	56.0	~200	0.48	0.5	0.8	(1)
4.5x3.2x2.5 (U.D)	F	36.0	~110	1.17	0.38	0.40	(1)
7x7x4.5 or 7x7x7	D,E	15.0	~50	0.13	1.0	1.2	(1)
7x7x4.5 or 7x7x7	D,E	6.8	~25	0.07	1.3	2	(1)
15x15x14.5	G	130.0	~380	0.14	1.33	1.70	(1)

Notes 1: Check coupling level

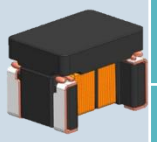
Format D, High Coupling

Footprint (mm²)	7x7x4.5 mm (49mm²)
Volume (mm³)	~220

Format E, Low Coupling

Footprint (mm²)	7x7x7 mm (49mm²)
Volume (mm³)	~343

Format F, Low or High Coupling.



Footprint (mm²)	4.5x3.2x2.5 mm (14.4mm²)
Volume (mm³)	~36

Format G, Low or High Coupling

Footprint (mm²)	15x15x14.5 mm (225mm²)
Volume (mm³)	~3263

Type 0 (16-30V @MPD) comparison w/wo Wake Signaling 320uH

Attracting Tomorrow TDK

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unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)	Size	Format	L(µH)	L-PoDL (µH)	RDC (Ohms)	Itemp (A)	Isat (A)
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				320	**400**	**7x7x4.5 or 7x7x7**	**D,E**	**120.0**	**~ 400**	**0.90**	**0.30**	**0.45**
2	2	16	0.125	40	50	3.2x2.5x2.5	A	18.0	~60.0	0.69	0.32	0.39
				160	**200**	**7x7x4.5 or 7x7x7**	**D,E**	**56.0**	**~ 200**	**0.48**	**0.50**	**0.80**
4	4	16	0.250	20	25	3.2x2.5x2.5	A	7.2	~25.0	0.52	0.41	0.65
				80	**100**	**4.5x3.2x2.5 (U.D)**	**F**	**36.0**	**~110**	**1.17**	**0.38**	**0.40**
8	8	16	0.500	10	12.5	4.5x3.2x2.5 (U.D)	F	3.7	~12.0	0.3	0.6	0.8
				40	**50**	**7x7x4.5 or 7x7x7**	**D,E**	**15.0**	**~50**	**0.13**	**1.00**	**1.20**
16	16	16	1.000	5	6.25	7x6x3.5	B	2.3	~6.5	0.10	1.40	2.5
				20	**25**	**7x7x4.5 or 7x7x7**	**D,E**	**6.8**	**~25**	**0.07**	**1.30**	**2.00**
PSE	18	18	1.000	80	100	12x12x10.5	C	36	~110	0.066	1.60	2.5
				320	**400**	15x15x14.5	G	130	~380	0.14	1.33	1.70

Type 0 (16-30V @MPD) comparison w/wo Wake Signaling 320uH

Attracting Tomorrow TDK

ADI inputs

TDK calculations

unit size	Power (W)	Vmin (V)	I mpd (A)	Lcouple min (µH)	Lcouple_ typ (µH)	Size	Format	L(µH)	L-PoDL (µH)	Relative PCB area diff. mm²	Relative price diffe.
1	1	16	0.0625	80	100	3.2x2.5x2.5	A	36.0	~138.0	x 6	x 1.4
				320	**400**	**7x7x4.5 or 7x7x7**	**D,E**	**120.0**	**~ 400**		
2	2	16	0.125	40	50	3.2x2.5x2.5	A	18.0	~60.0	x 6	X 1.4
				160	**200**	**7x7x4.5 or 7x7x7**	**D,E**	**56.0**	**~ 200**		
4	4	16	0.250	20	25	3.2x2.5x2.5	A	7.2	~25.0	x 1.8	X 1.15
				80	**100**	**4.5x3.2x2.5 (U.D)**	**F**	**36.0**	**~110**		
8	8	16	0.500	10	12.5	4.5x3.2x2.5 (U.D)	F	3.7	~12.0	x 3.4	X 1.2
				40	**50**	**7x7x4.5 or 7x7x7**	**D,E**	**15.0**	**~50**		
16	16	16	1.000	5	6.25	7x6x3.5	B	2.3	~6.5	≈	≈
				20	**25**	**7x7x4.5 or 7x7x7**	**D,E**	**6.8**	**~25**		
PSE	18	18	1.000	80	100	12x12x10.5	C	36	~110	x 1.6	x 1.35
				320	**400**	15x15x14.5	G	130	~380		


TDK