VPA

Configurable automotive grade inductor/transformer

Product features

- AEC-Q200
- Six winding, surface mount devices that offer more than 500 usable inductor or transformer configurations
- High power density and low profile
- Low radiated noise and tightly coupled windings
- Frequency range to over 1 MHz
- 500 Vac Isolation
- Ferrite core material

Applications

Commercial:

- Motion controls
- Robotics
- IoT, 5G,
- AMRs (Meter readers)
- DC-DC converters
- Solar Inverters, power supplies

Automotive:

- EV inverters
- ECU (engine control unit)
- Motor drive
- On-Board Chargers
- DC/DC converters
- Wireless Chargers
- Battery Management (BMS)
- Infotainment systems
- Interior & exterior LED lighting

Environmental compliance and general specifications

- Storage temperature (component): -55 °C to +125 °C
- Operating temperature range: -40 °C to +125 °C (ambient plus self-temperature rise)

Powering Business Worldwide

Product specifications

Part number[9]	$L_{(BASE)}$[1] (µH) nominal	FLL0[2] (µH) minimum	FLL1[3] (µH) reference	FLL2[4] (µH) reference	$I_{RMS(BASE)}$[5,6] (A) typical	$I_{SAT(BASE)}$[6,7] (A) typical	$R_{(BASE)}$[8] (mΩ) maximum @ +25 °C
VP2A1V							
VP2A1V-1600-R[10]	78.4 ±30%	38.4	48	57	1.26	0.05	90
VP2A1V-0216-R	10.6 ±20%	5.93	7.9	2	1.26	0.78	90
VP2A1V-0116-R	5.7 ±20%	3.19	4.6	1.5	1.26	1.6	90
VP2A1V-0083-R	4.1 ±20%	2.29	3.5	1.1	1.26	2.26	90
VP2A1V-0066-R	3.2 ±20%	1.79	2.9	0.7	1.26	2.85	90
VP3A1V							
VP3A1V-0780-R[10]	63.2 ±30%	30.9	29	49	1.47	0.05	61
VP3A1V-0138-R	11.2 ±20%	6.27	8.3	2.7	1.47	0.53	61
VP3A1V-0084-R	6.8 ±20%	3.8	5	0.9	1.47	1.1	61
VP3A1V-0055-R	4.5 ±20%	2.52	3.3	0.6	1.47	1.73	61
VP3A1V-0047-R	3.8 ±20%	2.12	2.8	0.5	1.47	2	61
VP4A1V							
VP4A1V-0860-R[10]	87.0±30%	42.6	38	66	1.7	0.06	57
VP4A1V-0140-R	11.3 ±20%	6.32	8	6.3	1.7	1	57
VP4A1V-0075-R	6.1 ±20%	3.41	4.5	0.8	1.7	2.33	57
VP4A1V-0060-R	4.9 ±20%	2.74	3.7	0.7	1.7	2.83	57
VP4A1V-0047-R	3.8 ±20%	2.12	2.8	0.6	1.7	3.66	57
VP5A1V							
VP5A1V-1200-R[10]	76.8 ±30%	37.6	35	55	2.08	0.083	47
VP5A1V-0155-R	9.9 ±20%	5.54	7.4	3	2.08	1.4	47
VP5A1V-0083-R	5.3 ±20%	2.96	4.5	2	2.08	2.58	47
VP5A1V-0067-R	4.3 ±20%	2.4	3.5	1.7	2.08	3.33	47
VP5A1V-0053-R	3.4 ±20%	1.9	3	1.2	2.08	3.9	47

1. $L_{(BASE)}$: Nominal inductance of a single winding. Test parameters: 300 kHz, 0.1 V_{rms}, 0.0 Adc, +25 °C
2. Full load inductance (FLL0): Inductance tested with all six windings in parallel at 6 x $I_{SAT(BASE)}$ Test parameters: 300 kHz, 0.1 V_{rms}, +25 °C
3. Full load inductance (-55 °C) (FLL1): Inductance tested with all six windings in parallel at 6 x $I_{SAT(BASE)}$ Test parameters: 300 kHz, 0.1 V_{rms}, -55 °C
4. Full load inductance (+125 °C) (FLL2): Inductance tested with all six windings in parallel at 6 x $I_{SAT(BASE)}$ Test parameters: 300 kHz, 0.1 V_{rms}, 125 °C
5. $I_{RMS(BASE)}$: RMS current that results in a surface temperature of approximately 40 °C above ambient. The 40 °C rise occurs when the specified current flows through each of the six windings
6. $I_{(BASE)}$ is the lessor of $I_{SAT(BASE)}$ and $I_{RMS(BASE)}$
7. $I_{SAT(BASE)}$: Peak current that will result in 30% saturation of the core. This current value assumes that equal current flows in all six windings. For applications in which all windings are not simultaneously driven (i.e. flyback, SEPIC, Cuk, etc.), the saturation current per winding may be calculated as follows:

$$I_{SAT} = \frac{6 \times I_{SAT(BASE)}}{Number\ of\ Winding\ Driven}$$

8. Maximum DC resistance of each winding
9. Part Number Definition: VP2A1V-xxxx-R
   VP2A1V: Product code & size;
   -xxxx specify the A_L, or nano Henries per turn squared;
   -R indicates RoHS compliant
10. These devices are designed for feed-forward applications, where load current dominates magnitizing current.

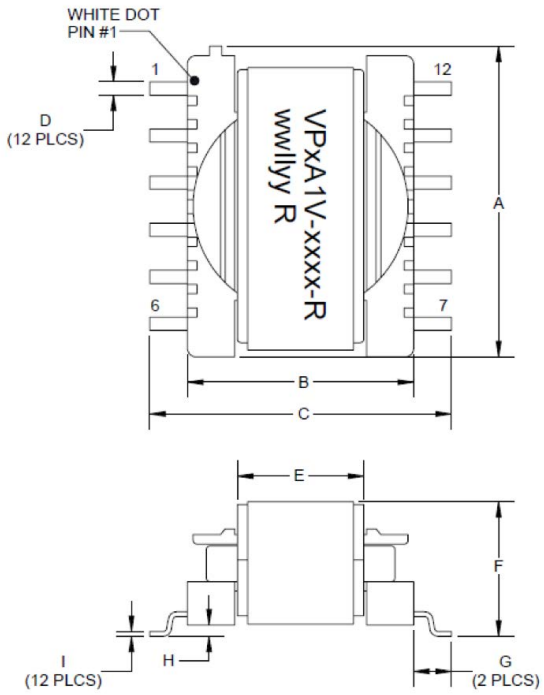
Hi-pot at 700 Vdc from winding to winding and from the windings to the core for 1 second

VPxA1V temperature rise depends on total power losses and size. Certain topologies or applications must be analyzed for needed requirements and matched with the best VPxA1V size and configuration. Proper consideration must be used with all parameters, especially those associated with current rating, or energy storage.

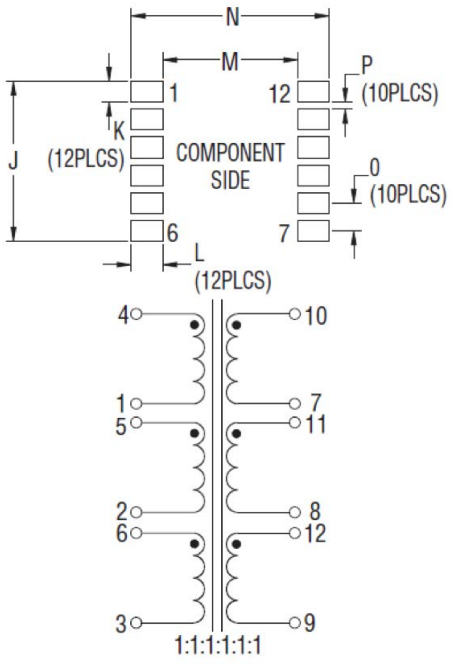
VPxA1V should not be used in off-line or safety related applications. The breakdown voltage from one winding to any other winding is 700 Vdc maximum.

VP2A1V

Mechanical specifications -mm



Recommended PCB layout/ Schematic



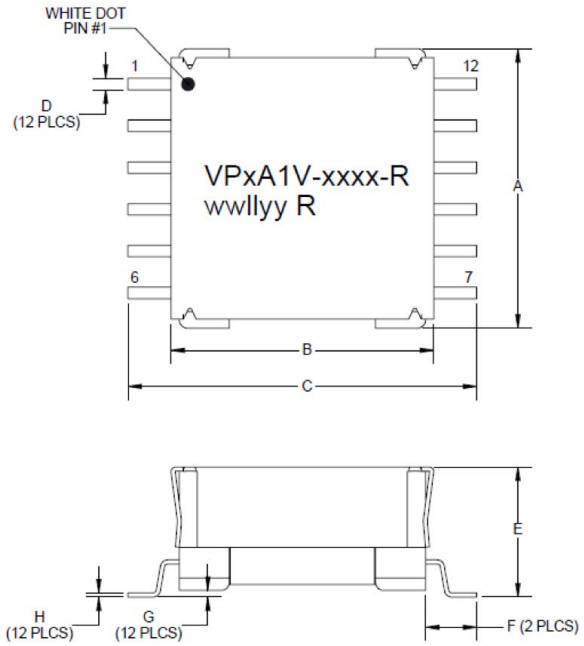
Part number	A	B	C	D	E	F	G	H
VP2A1V-xxxx-R	16.3 maximum	12.0 reference	16.8 maximum	0.7 reference	6.7 reference	7.8 maximum	2.0 reference	0.5 reference

Part number	I	J	K	L	M	N	O	P
VP2A1V-xxxx-R	0.5 reference	14.25 reference	1.75	2.5	13.0 reference	18.0 maximum	2.5	0.75

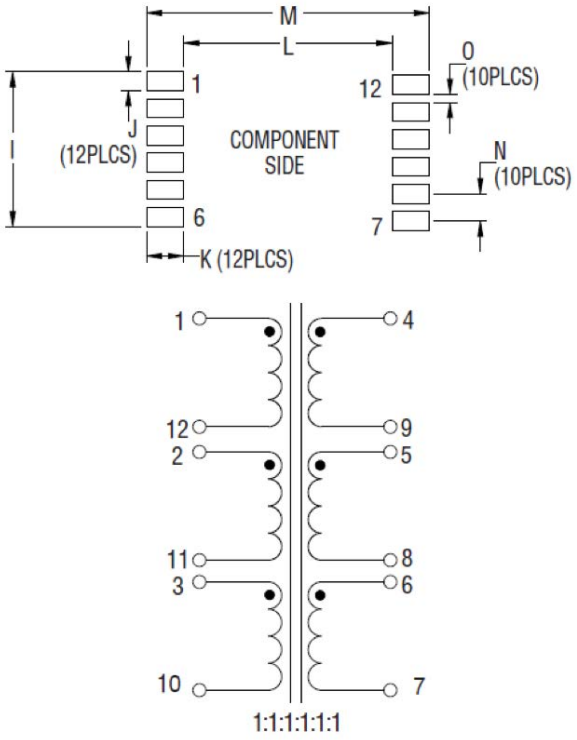
Tolerances A – H are ± 0.25 mm unless specified otherwise.
Tolerances I - P are +/- 0.1 mm unless specified otherwise.
Marking: Dot for pin #1 identification ,
VPxA1V-xxxx-R: VPxA1V (product code and size, -xxxx (4 digit part number per product specification table), -R (RoHS compliant)
wwllyy R = Lot code
All soldering surfaces must be coplanar within 0.102 mm.
Traces or vias underneath the inductor/transformer is not recommended

VP3A1V

Mechanical specifications -mm



Recommended PCB layout/ Schematic



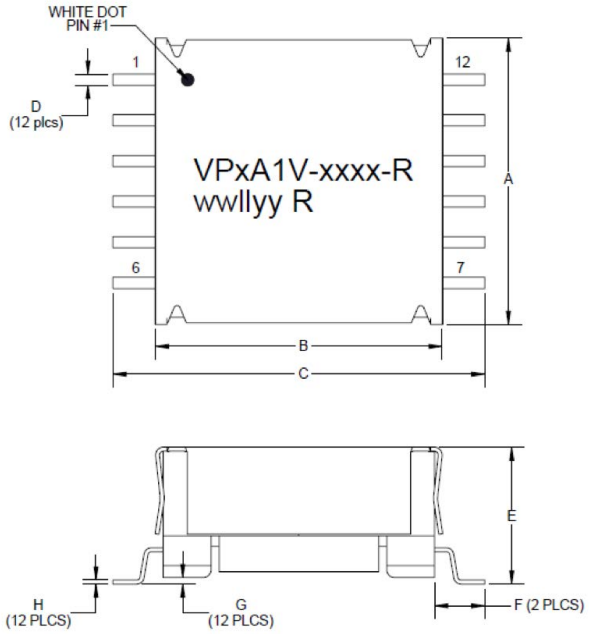
Part number	A	B	C	D	E	F	G	H
VP3A1V-xxxx-R	17.1 maximum	16.0 reference	22.3 maximum	0.7 reference	8.4 maximum	3.0 reference	0.4 reference	0.5 reference

Part number	I	J	K	L	M	N	O
VP3A1V-xxxx-R	14.49 reference	1.79	3.43	16.88 reference	23.74 maximum	2.54	0.75

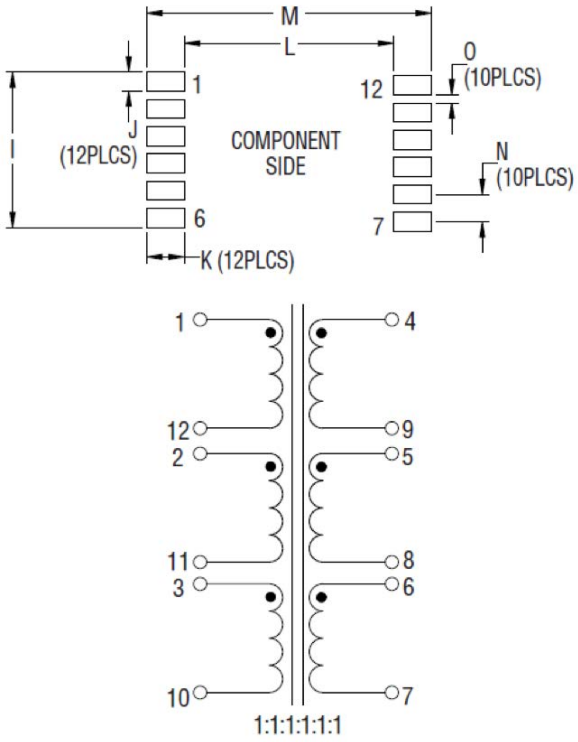
Tolerances A – H are ± 0.25 mm unless specified otherwise.
Tolerances I – O are +/- 0.1 mm unless specified otherwise.
Marking:
Dot for pin #1 identification
VPxA1V-xxxx-R: VPxA1V (product code and size), -xxxx (4-digit part number per product specification table), -R (Rohs compliant)
wwllyy R = Lot code.
All soldering surfaces must be coplanar within 0.102 mm.
Traces or vias underneath the inductor/ransformer is not recommended

VP4A1V

Mechanical specifications -mm



Recommended PCB layout/ Schematic



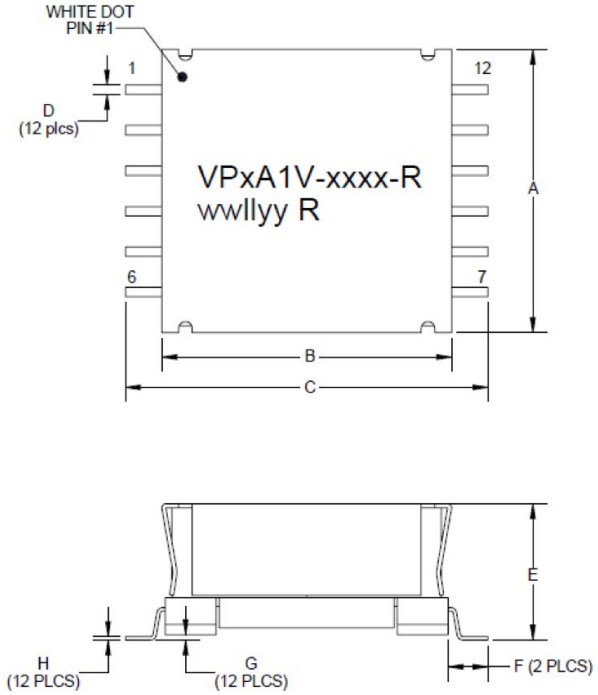
Part number	A	B	C	D	E	F	G	H
VP4A1V-xxxx-R	18.5 maximum	18.5 reference	24.6 maximum	0.7 reference	10.0 maximum	3.3 reference	0.25 reference	0.5 reference

Part number	I	J	K	L	M	N	O
VP4A1V-xxxx-R	14.25 reference	1.75	3.43	19.14 reference	26.0 maximum	2.5	0.75

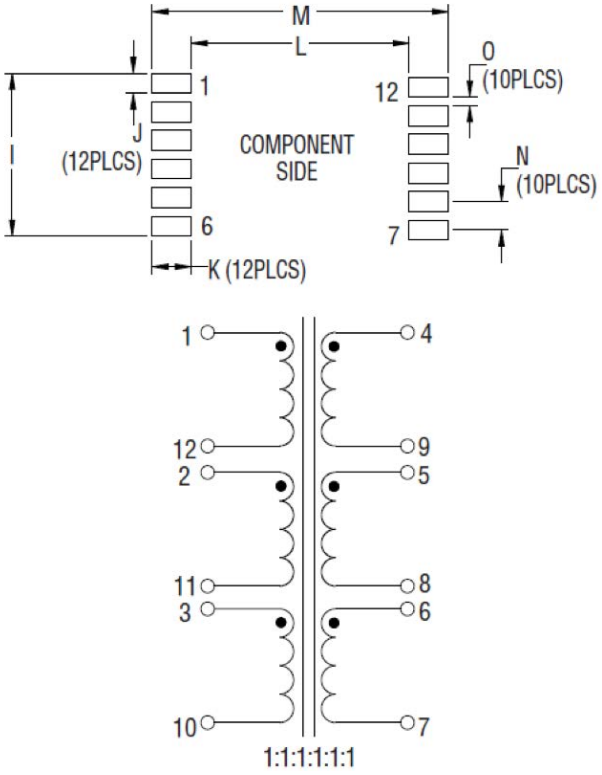
Tolerances A – H are ± 0.25 mm unless specified otherwise.
Tolerances I - O are +/- 0.1 mm unless specified otherwise.
Marking:
Dot for pin #1 identification
VPxA1V-xxxx-R VPxA1V (product code and size) -xxxx (4-digit part number per specification table), -R (RoHS compliant)
wwllyy R = Lot code
All soldering surfaces must be coplanar within 0.102 mm.
Traces or vias underneath the inductor/ransformer is not recommended

VP5A1V

Mechanical specifications -mm



Recommended PCB layout/ Schematic



Part number	A	B	C	D	E	F	G	H
VP5A1V-xxxx-R	21.5 maximum	21.5 reference	28.5 maximum	0.7 reference	10.8 maximum	2.95 reference	0.2 reference	0.5 reference

Part number	I	J	K	L	M	N	O
VP5A1V-xxxx-R	17.25 reference	2.25	3.15	22.7 reference	29.0 maximum	3.0	0.75

Tolerances A – H are ± 0.25 mm unless specified otherwise.
Tolerances I – O are +/- 0.1 mm unless specified otherwise.
Marking:
Dot for pin #1 identification
VPxA1V-xxxx-R (product code and size) -xxxx (4-digit part number per product specification table), -R (RoHS compliant)
wwllyy R = Lot code
All soldering surfaces must be coplanar within 0.102 mm.
Traces or vias underneath the inductor/ransformer is not recommended

How to use multiple windings

Discrete inductors combine like resistors, when connected in series or parallel. For example, inductors in series add and inductors in parallel reduce in a way similar to Ohm's Law.

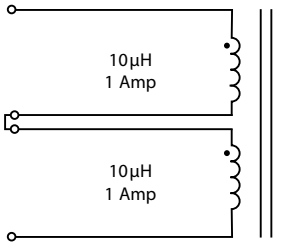
$L_{Series} = L1 + L2 + L3...Ln$

$L_{Parallel} = 1/ [1/L1 + 1/L2 + 1/ L3....1/Ln]$

Windings on the same magnetic core behave differently. Two windings in series result in four times the inductance of a single winding. This is because the inductance varies proportionately to the square of the turns.

Paralleled VPxA1V windings result in no change to the net inductance because the total number of turns remains unchanged; only the effective wire size becomes larger. Two parallel windings result in approximately twice the current carrying capability of a single winding. The net inductance of a given configuration is based on the number of windings in series squared multiplied by the inductance of a single winding $L_{(BASE)}$. The current rating of a configuration is derived by multiplying the maximum current rating of one winding $I_{(BASE)}$ by the number of windings in parallel. Examples of simple two-winding devices are shown below:

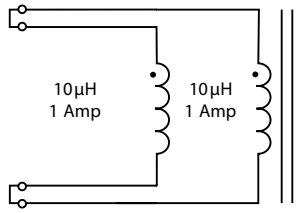
Series Connected (2 Windings)



$L_{TOTAL} = L_{BASE} \times S^2 = 10\ \mu H \times 2^2 = 40\ \mu H$

$I_{MAX} = I_{BASE} \times P = 1\ Amp \times 1 = 1\ Amp$

Parallel Connected (2 Windings)



$L_{TOTAL} = L_{BASE} \times S^2 = 10\ \mu H \times 1^2 = 10\ \mu H$

$I_{MAX} = I_{BASE} \times P = 1\ Amp \times 2 = 2\ Amps$

Where:

L_{BASE} = Inductance of a single winding

P = Number of windings in parallel (use 1 with all windings in series)

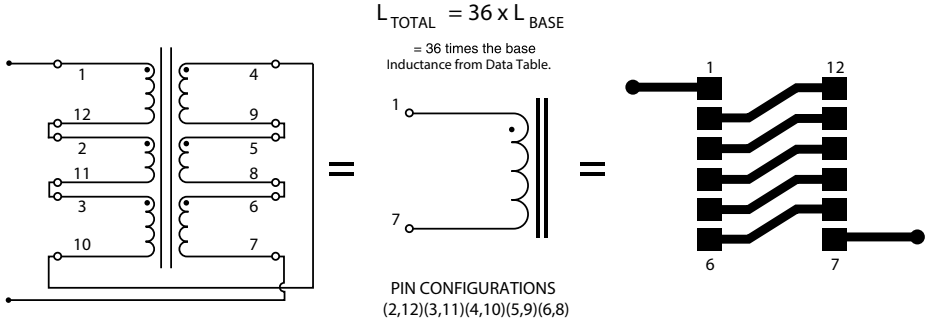
S = Number of windings in series

I_{BASE} = Maximum current rating of one winding

How to pin-configure VPxA1V

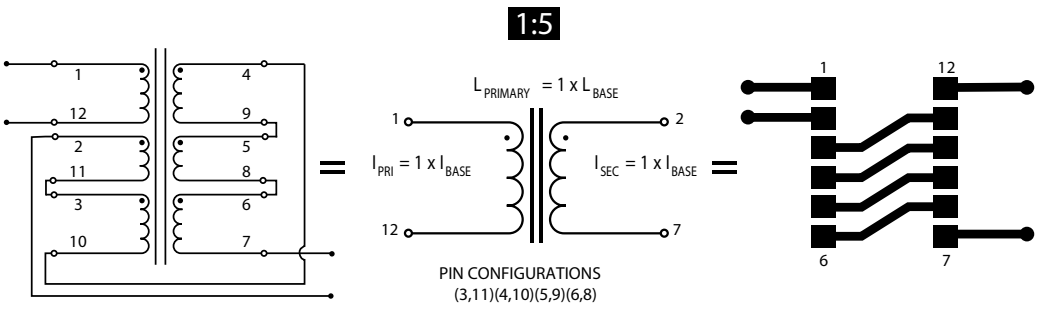
Each VPxA1V can be configured in a variety of ways by simply connecting pins together on the Printed circuit board (PCB). As shown below, the connections on the PCB are equal to the pin configuration statement shown at the bottom of the schematic symbol. Connecting a number of windings in parallel will increase the current carrying capability, while connecting in series will multiply the inductance. Each VPxA1V part can be configured in at least 6 combinations for inductor use or configured in at least 15 turns ratios for transformer applications. The VPxA1V allows for at least 500 magnetic configurations. The following inductor example shows 6 windings in series, which result in an inductance of 36 times the base inductance and 1 times the base current.

Inductor example
For sizes VP3, VP4 and VP5



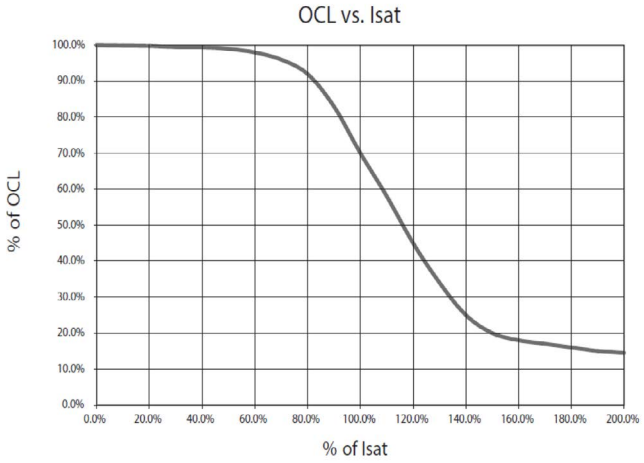
Each VPxA1V may be used in at least 15 transformer applications. More than 375 transformer combinations may be achieved using the available VPxA1V parts.

Transformer example
For sizes VP3, VP4 and VP5



The configurations may be selected from the examples above or created by the designer. The printed circuit board layout in each example illustrates the connections to obtain the desired inductance or turns ratio. The examples may be used by the PCB designer to configure VPxA1V as desired.
To assist the designer, VPxA1V phasing, coupling and thermal issues have been considered in each of the configurations illustrated. Additionally, the inductance and current ratings, as a function of the respective base values are shown in each example. It is important to carefully select the proper VPxA1V part in order to minimize the component size without exceeding the RMS current capability or saturating the core. The product specification table indicates maximum ratings.

Inductance characteristics

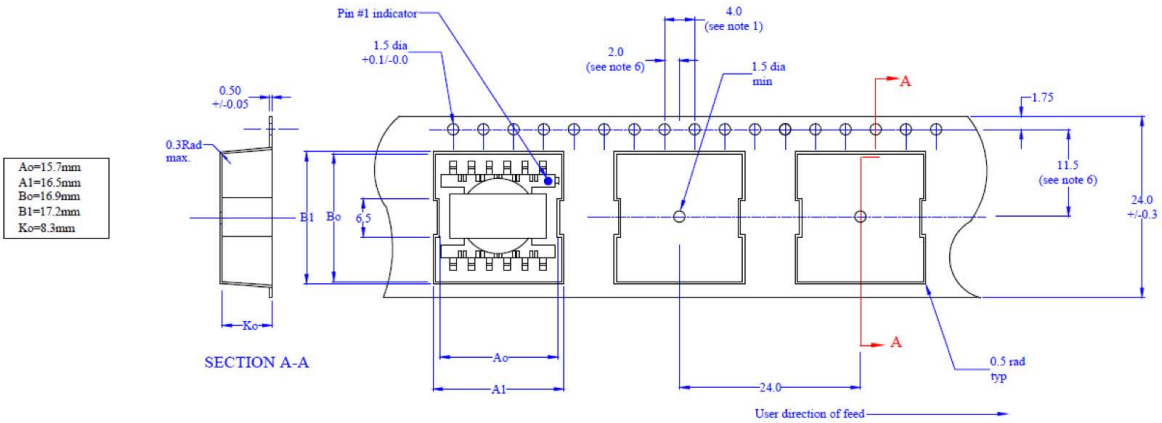


Packaging information -mm

VP2A1V

Supplied in tape and reel packaging, 13" diameter reel (EIA-481 compliant)

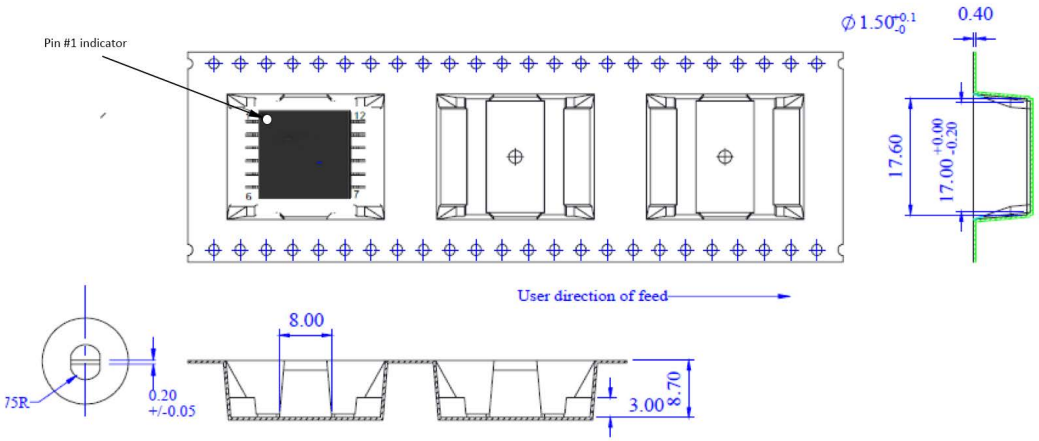
300 parts per reel



VP3A1V

Supplied in tape and reel packaging, 13" diameter reel (EIA-481 compliant)

200 parts per reel

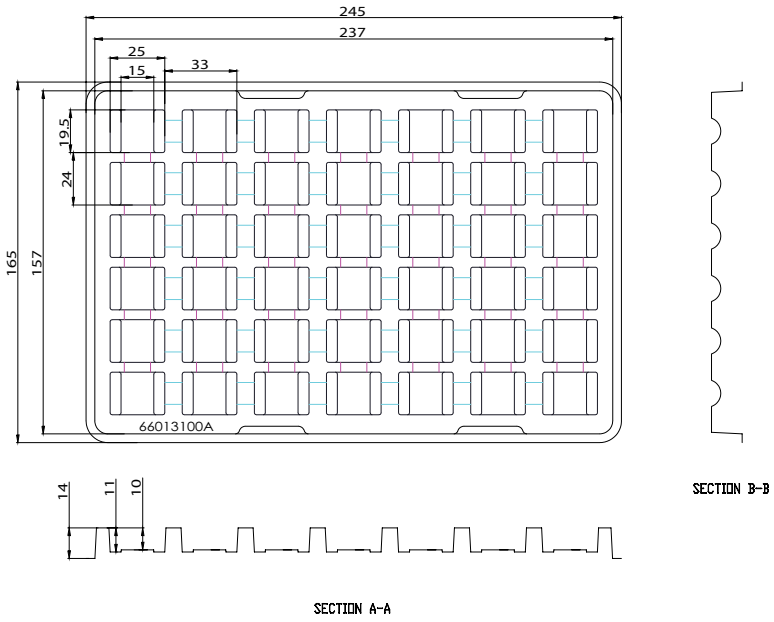


Packaging information -mm (continued)

VP4A1V

Supplied in plastic tray packaging

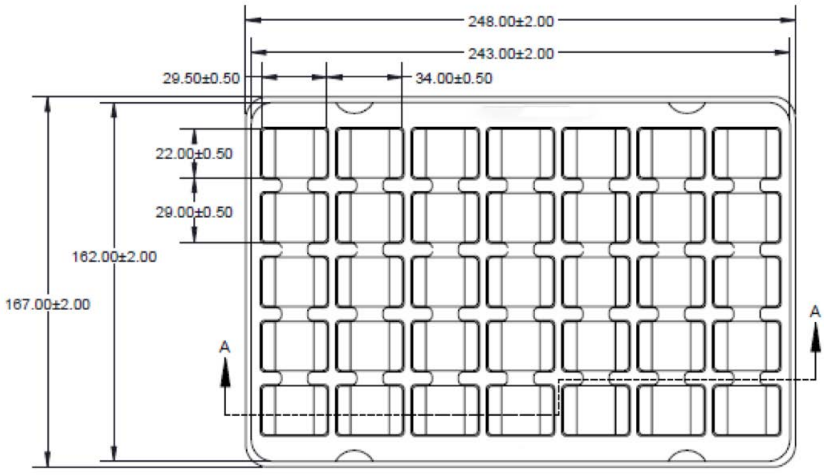
42 parts per tray



VP5A1V

Supplied in plastic tray packaging

35 parts per reel



Solder reflow profile

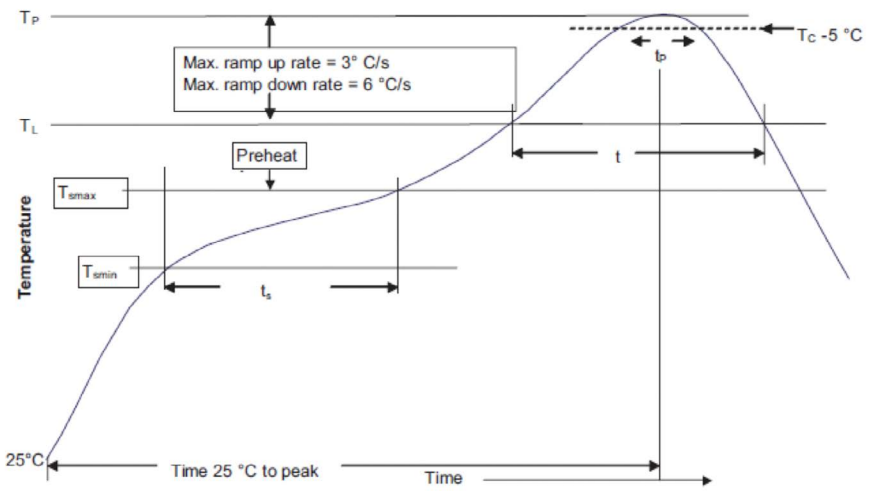


Table 1 - Standard SnPb solder (T_C)

Package Thickness	Volume mm3 <350	Volume mm3 ≥350
<2.5 mm)	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2 - Lead (Pb) free solder (T_C)

Package thickness	Volume mm³ <350	Volume mm³ 350 - 2000	Volume mm³ >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 – 2.5 mm	260 °C	250 °C	245 °C
>2.5 mm	250 °C	245 °C	245 °C

Reference J-STD-020

Profile feature		Standard SnPb solder	Lead (Pb) free solder
Preheat and soak	• Temperature min. (T_{smin})	100 °C	150 °C
	• Temperature max. (T_{smax})	150 °C	200 °C
	• Time (T_{smin} to T_{smax}) (t_s)	60-120 seconds	60-120 seconds
Ramp up rate T_L to T_p		3 °C/ second max.	3 °C/ second max.
Liquidous temperature (T_L) Time (t_L) maintained above T_L		183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body temperature (T_P)*		Table 1	Table 2
Time (t_p)* within 5 °C of the specified classification temperature (T_C)		20 seconds*	30 seconds*
Ramp-down rate (T_p to T_L)		6 °C/ second max.	6 °C/ second max.
Time 25 °C to peak temperature		6 minutes max.	8 minutes max.

* Tolerance for peak profile temperature (T_p) is defined as a supplier minimum and a user maximum.

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Publication No. ELX1210 BU-ELX22070
June 2023