

Vibration Damping PID

Particle Impact Damper Component

Protect PCB from Cracks

Increase Life of PCB

Surface Mount

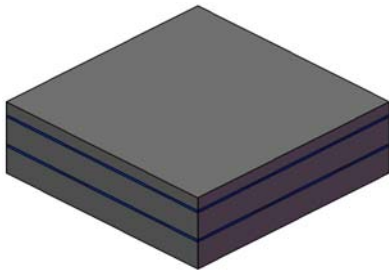


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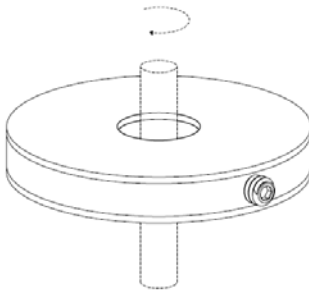
Product Guide 2022-B



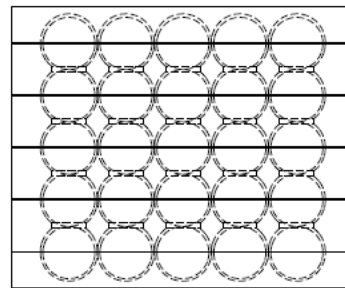
FA Series
Adhesive Mounting
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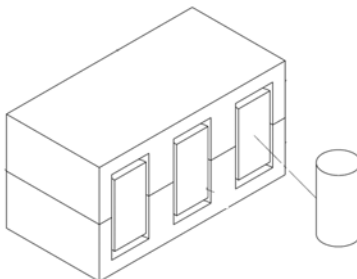
FS Series
Screw Mount
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Toroidal Shape
Page 10



Quick Response
Page 11



Unidirectional PID
Page 12

<u>F</u>	<u>A</u>	<u>1.0</u>	<u>SQ</u>	<u>13x4.0</u>
Series	Mounting To PCB	Tungsten Mass Grams (Min.)	Shape	Body Dimensions Outside (mm)

Part Number System
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Tungsten Particles
Page 9



Where to Buy
Page 14~15

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We accept credit cards:



Ready to assist you.



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What is PID? Quick Answers

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About TopLine

TopLine manufactures PID Particle Impact Dampers for PCB printed circuit board assemblies under an exclusive technology transfer license from NASA and other patents granted.

How PID works

PID technology reduces vibration and increases reliability in circuit board assemblies. The **PID** Particle Impact Damper is a sealed container that is filled to 90% with tungsten (W) balls. The impact of tungsten balls colliding in the **PID** dampens fundamental frequency f_o mode vibrations in the PCB assembly. This maximizes energy transfer to the **PID** which dampens the vibration. The weight of the moving particles inside the **PID** is approximately 10% the mass of the PCB assembly. The motion of the particles (tungsten balls) in the sealed PID housing removes vibratory energy from non-linear vibro-acoustic environments such as PCB card assemblies. The PID straightens the PCB at the central lobe and attenuates vibration by pushing or pulling the PCB in the opposite direction after the tungsten balls overcome gravity.

Tungsten Material Properties

Tungsten (W) is environmentally friendly. Tungsten's properties include high density and tensile strength.

- Atomic Number 74
- Density 19.3g/cc (@20°C)
- Linear CTE 4.3 ppm/°C
- Poisson's Ratio 0.284
- Melting Point 3400°C
- Tensile Strength 700-3400 MPa @25°C

Where to Mount on PCB

Vibration is attenuated by mounting the **PID** near the geometric center (anti-node) of the PCB. The damping effect increases reliability in the PCB. The **PID** may be located on either side of the board. Alternatively, **PID** may be elevated to bridge and avoid interference (straddle) existing components on the board.

Vibration Frequency

Vibration at the fundamental frequency f_o causes bending, fatigue and cracks in the PCB assembly. Excessive vibration from external excitations leads to catastrophic failure. Typical fundamental vibration frequency ranges from 100Hz to 2000Hz.

Patents & Trademarks

TopLine holds 5 U.S. Patents in the field of Vibration Damping.

U.S. Patent	Description	Granted
9,521,753	Original NASA Circuit card assembly	2016
10,041,558	Tunable PID	2018
10,021,779	Quick Response	2018
D842351	Toroidal Shape PID	2019
10,704,639	Unidirectional PID	2020

Inspired by Gravity ®

Electrical Power and Temperature

- No electrical power is needed.
- Operating temperature -55°C to +175°C without derating.

How to Select the Correct PID

Step 1. Tungsten payload should be approximately 10% of the mass of your PCB assembly (PCA/PWA).

Step 2. Attach the PID near the geometric center of the board. Or, locate where the board is oscillating the most.

Step 3. Select mounting style. For most boards, it is best to attach the PID to the board with strong adhesive glue. Optional PID models can be attached with screws.

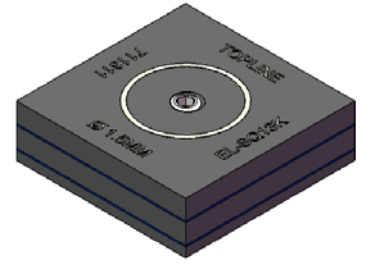
Step 4. select the physical package size that fits the space available on your board. Multiple PIDs can be distributed across your board where room permits.



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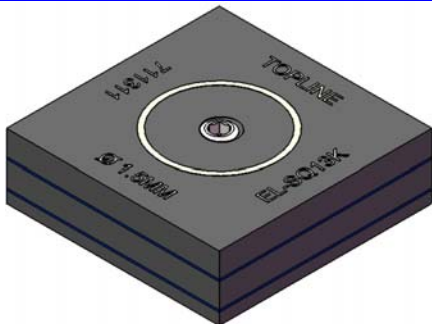
FA Series Adhesive Mount Particle Impact Damper PCB Mass 1 ~ 29 gm

US Patent 10,041,558

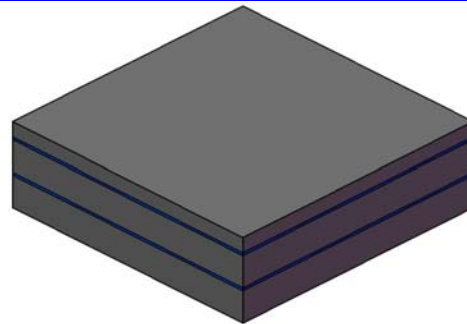


PCB Mass Grams	Tungsten Weight Min.	Total Weight Max.	Body Size X / Y	Height Max.	Tungsten Ball Size	Nbr Balls	Part Number	Order Nr
1 g	0.1 g	0.5 g	7 x 7mm	4.0mm	Ø1.5mm	4	FA 0.1 SQ7x4.0 A	139101
2 g	0.2 g	0.7 g	8 x 8mm	4.0mm	Ø1.5mm	7	FA 0.2 SQ8x4.0 A	139201
3 g	0.3 g	0.9 g	9 x 9mm	4.0mm	Ø1.5mm	10	FA 0.3 SQ9x4.0 A	139301
4 g	0.4 g	1.2 g	10 x 10mm	4.0mm	Ø1.5mm	13	FA 0.4 SQ10x4.0 A	139401
5 g	0.5 g	1.4 g	11 x 11mm	4.0mm	Ø1.5mm	17	FA 0.5 SQ11x4.0 A	139501
6 g	0.6 g	1.7 g	12 x 12mm	4.0mm	Ø1.5mm	20	FA 0.6 SQ12x4.0 A	139601
8 g	0.8 g	2.0 g	13 x 13mm	4.0mm	Ø1.5mm	25	FA 0.8 SQ13x4.0 A	139801
10 g	1.0 g	2.4 g	14 x 14mm	4.0mm	Ø1.5mm	32	FA 1.0 SQ14x4.0 A	131901
11 g	1.1 g	2.7 g	14 x 14mm	4.5mm	Ø2.0mm	17	FA 1.1 SQ14x4.5 A	131911
12 g	1.2 g	2.8 g	14 x 14mm	5.0mm	Ø2.3mm	10	FA 1.2 SQ14x5.0 A	131921
13 g	1.3 g	3.8 g	14 x 14mm	7.5mm	Ø2.5mm	13	FA 1.3SQ14x7.5 A	131931
14 g	1.4 g	3.2g	15 x 15mm	4.5mm	Ø2.0mm	19	FA 1.4 SQ15x4.5 A	131941
15g	1.5 g	3.5g	16 x 16mm	4.5mm	Ø2.0mm	21	FA 1.5 SQ16x4.5 A	131951
16 g	1.6 g	4.2g	18 x 18mm	4.0mm	Ø1.5mm	54	FA 1.6 SQ18x4.0 A	131961
18 g	1.8 g	4.0 g	17 x 17mm	4.5mm	Ø2.0mm	25	FA 1.8 SQ17x4.5 A	131981
19 g	1.9 g	4.5 g	19 x 19mm	4.0mm	Ø1.5mm	63	FA 1.9 SQ19x4.0A	131991
20 g	2.0 g	4.5 g	18 x 18mm	4.5mm	Ø2.0mm	29	FA 2.0 SQ18x4.5 A	132901
21 g	2.1 g	4.6 g	18 x 18mm	5.0mm	Ø2.3mm	21	FA 2.1 SQ18x5.0 A	132911
22 g	2.1 g	5.5 g	21 x 21mm	4.0mm	Ø1.5mm	68	FA 2.2 SQ21x4.0 A	132912
25 g	2.5 g	6.5 g	18x 18mm	7.5mm	Ø2.5mm	18	FA 2.5 SQ18x7.5 A	132951
25 g	2.5 g	5.1 g	19 x 19mm	4.5mm	Ø2.0mm	34	FA 2.5 SQ19x4.5 A	132952
26 g	2.6 g	5.3 g	19 x 19mm	5.0mm	Ø2.3mm	25	FA 2.6 SQ19x5.0A	132961
28 g	2.8 g	6.2 g	21 x 21mm	4.5mm	Ø2.0mm	39	FA 2.8 SQ21x4.5 A	132981
28 g	2.8 g	7.0 g	23 x 23mm	4.0mm	Ø1.5mm	93	FA 2.8 SQ23x4.0A	132982

TOP



BOTTOM VIEW

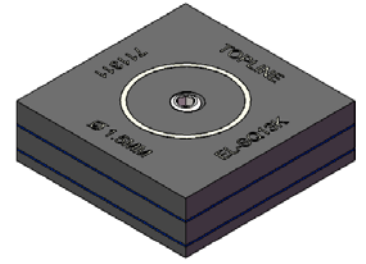


- INFO**
- Note 1: "FA" series adhesive (glue) mount to PCB. Change part series to "FS" for screw mount.
 - Note 2: Bottom is insulated to avoid shorting to board surface.
 - Note 3: PCB assembly includes the mass (weight) of the board and components in the *f₀* vibration zone.
 - Note 4: Custom sizes available.



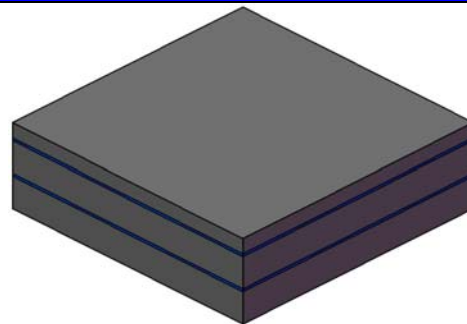
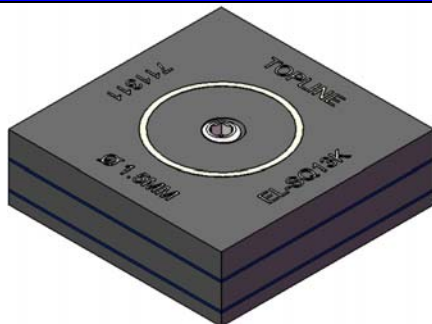
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FA Series Adhesive Mount Particle Impact Damper PCB 30 ~ 99 gm



PCB Mass Grams	Tungsten Weight Min.	Total Weight Max.	Body Size X / Y	Height Max.	Tungsten Ball Size	Nbr Balls	Part Number	Order Nr
30 g	3.0 g	6.5 g	21 x 21mm	5.0mm	Ø2.3mm	30	FA 3.0 SQ21x5.0A	133901
33 g	3.3 g	9.0 g	21 x 21mm	7.5mm	Ø2.5mm	24	FA 3.3 SQ21x7.5A	133931
35 g	3.5 g	8.0 g	25 x 25mm	4.0mm	Ø1.5mm	115	FA 3.5 SQ25x4.0A	133951
36 g	3.6 g	7.5 g	23 x 23mm	4.5mm	Ø2.0mm	50	FA 3.6 SQ23x4.5A	133961
40 g	4.0 g	8.0 g	23 x 23mm	5.0mm	Ø2.3mm	39	FA 4.0 SQ23x5.0 A	134901
45 g	4.5 g	11.0 g	23 x 23mm	7.5mm	Ø2.5mm	32	FA 4.5 SQ23x7.5 A	134951
45 g	4.5 g	9.5 g	25 x 25mm	4.5mm	Ø2.0mm	64	FA 4.5 SQ25x4.5 A	134952
45 g	4.5 g	9.5 g	27 x 27mm	4.0mm	Ø1.5mm	147	FA 4.5 SQ27x4.0 A	134953
50 g	5.0 g	10 g	25 x 25mm	5.0mm	Ø2.3mm	55	FA 5.0 SQ25x5.0 A	135901
54 g	5.4 g	11 g	29 x 29mm	4.0mm	Ø1.5mm	175	FA 5.4 SQ29x4.0 A	135941
55 g	5.5 g	11 g	27 x 27mm	4.5mm	Ø2.0mm	80	FA 5.5 SQ27x4.5 A	135952
60 g	6.0 g	14 g	25 x 25mm	5.0mm	Ø2.5mm	42	FA 6.0 SQ25x7.5 A	136901
60 g	6.0 g	12 g	27 x 27mm	5.0mm	Ø2.3mm	60	FA 6.0 SQ27x5.0 A	136902
65 g	6.5 g	13 g	31 x 31mm	4.0mm	Ø1.5mm	220	FA 6.5 SQ31x4.0 A	136951
70 g	7.0 g	16 g	27x 27mm	7.5mm	Ø2.5mm	49	FA 7.0 SQ27x7.5 A	137901
70 g	7.0 g	13 g	29x 29mm	4.5mm	Ø2.0mm	96	FA 7.0 SQ29x4.5 A	137902
75 g	7.5 g	14 g	29 x 29mm	5.0mm	Ø2.3mm	75	FA 7.5 SQ29x5.0 A	137951
75 g	7.5 g	15 g	33 x 33mm	4.0mm	Ø1.5mm	240	FA 7.5 SQ33x4.0 A	137952
80 g	8.0 g	16 g	31 x 31mm	4.5mm	Ø2.0mm	120	FA 8.0 SQ31x4.5 A	138901
85 g	8.5 g	19 g	29 x 29mm	7.5mm	Ø2.5mm	60	FA 8.5 SQ29x7.5 A	138951
90 g	9.0 g	17 g	31 x 31mm	5.0mm	Ø2.3mm	95	FA 9.0 SQ31x5.0 A	139901
90 g	9.0 g	18 g	35 x 35mm	4.0mm	Ø1.5mm	300	FA 9.0 SQ35x4.0 A	139903
95 g	9.5 g	17 g	33 x 33mm	4.5mm	Ø2.0mm	130	FA 9.5 SQ33x4.5A	139951

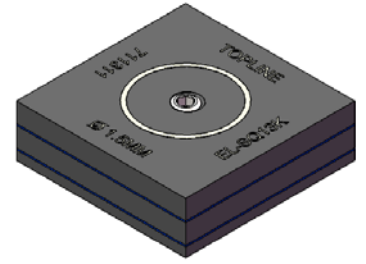
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BOTTOM VIEW



INFO

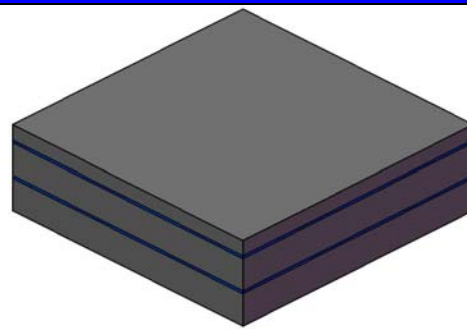
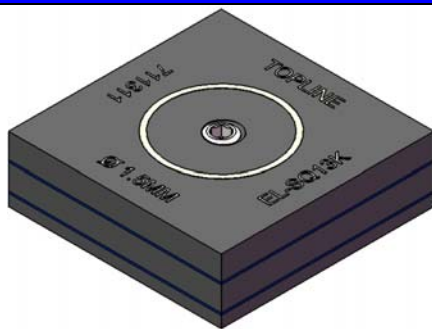
- Note 1: "FA" series adhesive (glue) mount to PCB. Change part series to "FS" for screw mount.
- Note 2: Bottom is insulated to avoid shorting to board surface.
- Note 3: PCB assembly includes the mass (weight) of the board and components in the *f_o* vibration zone.
- Note 4: Custom sizes available.

FA Series Adhesive Mount Particle Impact Damper PCB Mass 100 ~ 250 gm



PCB Mass Grams	Tungsten Weight Min.	Total Weight Max.	Body Size X / Y	Height Max.	Tungsten Ball Size	Nbr Balls	Part Number	Order Nr
100 g	10 g	22 g	27 x 27mm	10 mm	Ø4.0mm	18	FA 10 SQ27x10 A	130103
100 g	10 g	22 g	31 x 31mm	7.5mm	Ø2.5mm	80	FA 10 SQ31x7.5 A	130104
100 g	10 g	18 g	33 x 33mm	5.0mm	Ø2.3mm	100	FA 10 SQ33x5.0 A	130105
110 g	11 g	24g	33 x 33mm	7.5mm	Ø2.5mm	81	FA 11 SQ33x7.5 A	130111
120 g	12 g	21 g	35 x 35mm	4.5mm	Ø2.0mm	170	FA 12 SQ35x4.5 A	130121
130 g	13 g	22 g	35 x 35mm	5.0mm	Ø2.3mm	125	FA 13 SQ35x5.0 A	130131
130 g	13 g	24 g	37.5 x 37.5mm	5.0mm	Ø2.3mm	130	FA 13 SQ37.5x5.0 A	130132
140 g	14 g	29 g	35 x 35mm	7.5mm	Ø2.5mm	100	FA 14 SQ35x7.5 A	130141
150 g	15 g	32 g	37.5 x 37.5mm	7.5mm	Ø2.5mm	105	FA 15 SQ37.5x7.5 A	130151
150 g	15 g	27 g	40 x 40mm	5.0mm	Ø2.3mm	150	FA 15 SQ40x5.0 A	130152
160 g	16 g	29 g	42.5 x 42.5mm	5.0mm	Ø2.3mm	160	FA 16 SQ42.5x5.0 A	130161
170 g	17 g	36 g	40 x 40mm	7.5mm	Ø2.5mm	119	FA 17 SQ40x7.5 A	130171
180 g	18g	36 g	37.5 x 37.5mm	8.0mm	Ø3.0mm	72	FA 18 SQ37.5x8.0 A	130181
180 g	18g	40 g	42.5 x 42.5mm	7.5mm	Ø2.5mm	132	FA 18 SQ42.5x7.5 A	130182
180 g	18g	33 g	45 x 45mm	5.0mm	Ø2.3mm	200	FA 18 SQ45x5.0 A	130183
200 g	20 g	40 g	40 x 40mm	8.0mm	Ø3.0mm	81	FA 20 SQ40x8.0 A	130202
210 g	21 g	47 g	45 x 45mm	7.5mm	Ø2.5mm	166	FA 21 SQ45x7.5 A	130211
210 g	21 g	37 g	47.5 x 47.5mm	5.0mm	Ø2.3mm	206	FA 21 SQ47.5x5.0 A	130212
220 g	22 g	45 g	42.5 x 42.5mm	8.0mm	Ø3.0mm	92	FA 22 SQ42.5x8.0 A	130222
230 g	23 g	42 g	50 x 50mm	5.0mm	Ø2.3mm	250	FA 23 SQ50x5.0 A	130231
240 g	24 g	50 g	47.5 x 47.5mm	7.5mm	Ø2.5mm	168	FA 24 SQ47.5x7.5 A	130241
250 g	25 g	45 g	52.5 x 52.5mm	5.0mm	Ø2.3mm	250	FA 25 SQ52.5x5.0 A	130251

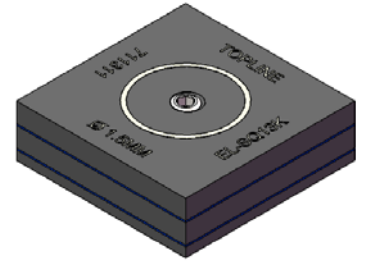
TOP
BOTTOM VIEW



- INFO

 - Note 1: "FA" series adhesive (glue) mount to PCB. Change part series to "FS" for screw mount.
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 - Note 3: PCB assembly includes the mass (weight) of the board and components in the *fo* vibration zone.
 - Note 4: Custom sizes available.

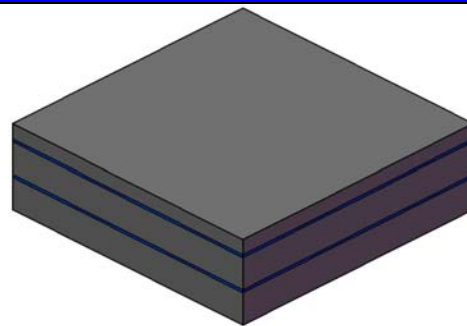
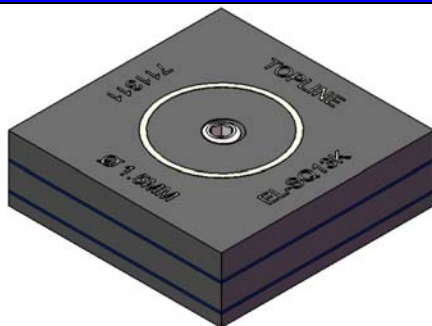
FA Series Adhesive Mount Particle Impact Damper PCB Mass 260 ~ 1000gm



PCB Mass Grams	Tungsten Weight Min.	Total Weight Max.	Body Size X / Y	Height Max.	Tungsten Ball Size	Nbr Balls	Part Number	Order Nr
260 g	26 g	50 g	40 x 40mm	9.0mm	Ø4.0mm	45	FA 26 SQ40x9.0 A	130261
260 g	26 g	51 g	45 x 45mm	8.0mm	Ø3.0mm	105	FA 26 SQ45x8.0 A	130262
270 g	27 g	57 g	50 x 50mm	7.5mm	Ø2.5mm	189	FA 27 SQ50x7.5 A	130271
280 g	28 g	60 g	37.5 x 37.5mm	13 mm	Ø5.0mm	25	FA 28 SQ37.5x13 A	130281
280 g	28 g	56 g	47.5 x 47.5mm	8.0mm	Ø3.0mm	116	FA 28 SQ47.5x8.0 A	130282
290 g	29 g	56 g	42.5 x 42.5mm	9.0mm	Ø4.0mm	50	FA 29 SQ42.5x9.0 A	130291
300 g	30 g	62 g	52.5 x 52.5mm	7.5mm	Ø2.5mm	210	FA 30 SQ52.5x7.5 A	130301
310 g	31 g	65 g	40 x 40mm	13 mm	Ø5.0mm	27	FA 31 SQ40x13 A	130311
320 g	32 g	64 g	50 x 50mm	8.0 mm	Ø3.0mm	132	FA 32 SQ50x8.0 A	130326
340 g	34 g	68 g	52.5 x 52.5mm	8.0 mm	Ø3.0mm	140	FA 34SQ52.5x8.0 A	130341
360 g	36 g	76 g	42.5 x 42.5mm	13 mm	Ø5.0mm	32	FA 36SQ42.5x13 A	130361
370 g	37 g	72 g	47.5 x 47.5mm	9.0 mm	Ø4.0mm	64	FA 37SQ47.5x9.0A	130371
400 g	40 g	85 g	45 x 45mm	13 mm	Ø5.0mm	35	FA 40SQ40x13A	130401
420 g	42 g	80 g	50 x 50mm	9.0 mm	Ø4.0mm	80	FA 42SQ50x9.0A	130421
450 g	45 g	96 g	47.5 x 47.5mm	13 mm	Ø5.0mm	40	FA 45SQ47.5x13A	130451
450 g	45 g	90 g	52.5 x 52.5mm	9.0 mm	Ø4.0mm	80	FA 45SQ52.5x9.0A	130452
520 g	52 g	106 g	50 x 50 mm	13 mm	Ø5.0mm	45	FA 52SQ50x13A	130521
570 g	57 g	120 g	52.5 x 52.5mm	13 mm	Ø5.0mm	50	FA 57SQ52.5x13A	130571
1000 g	100 g	220 g	50 x 5 0mm	26 mm	Ø5.0mm	90	FA 100SQ50x26A	131002

TOP


BOTTOM VIEW




- INFO
- Note 1: "FA" series adhesive (glue) mount to PCB. Change part series to "FS" for screw mount.
 - Note 2: Bottom is insulated to avoid shorting to board surface.
 - Note 3: PCB assembly includes the mass (weight) of the board and components in the *f_o* vibration zone.

Part Number System					
<u>F</u>	<u>A</u>	<u>1.0</u>	<u>SQ</u>	<u>13x4.0</u>	<u>A</u>
Series	Mounting To PCB	Tungsten Mass Grams (Min.)	Shape	Body Dimensions Outside (mm)	Version/Option
Filled Case F = FR4 Case	Mounting Style A = Adhesive S = Screw Fastener	Code Grams 0.1 ~ 0.1 ~ 1000 1000 g Other Mass Available	Code Shape SQ Square R Rectangle C Cylindrical T Toroidal Z Custom	Width Height 3~ 4.0~ 100mm 25mm Custom Dimensions Available	Code Version A • 01 B • 02 C • 03 Z • 26

Drawing Number System			
<u>1</u>	<u>3</u>	<u>591</u>	<u>1</u>
Alloy	Mounting to PCB	Mass (gram) 9 = Decimal	Option Code
Code • Description 1 = Filled PID	Code Description 2 = Screw 3 = Adhesive 9 = Custom	Code Weight 910 = 0.10 g 951 = 0.51 g 297 = 2.7 g 590 = 5.0 g 010 = 10 g 051 = 51 g 123 = 123 g Other Mass Available 9 = Decimal	Code 1 Version A 2 Version B 3 Version C ... 9 Version J

OPTIONS	
<p>ADHESIVE (GLUE) MOUNT FA Series</p> 	<p>SCREW MOUNT FS Series</p> 
Without Holes	Thru Holes in Corners



Tungsten Particles						
Type	Diameter	Diameter	Weight Per Ball	Balls Per Kg	Part Nbr	DWG
	Ø1.5mm	0.059-in	0.031gm	32,000	TB1.5	720059
	Ø2.0mm	0.079-in	0.073gm	13,700	TB2.0	720079
	Ø2.3mm	0.090-in	0.102gm	9,800	TB2.3	720090
	Ø2.5mm	0.100-in	0.143gm	7,000	TB2.5	720100
	Ø3.0mm	0.118-in	0.248gm	4,000	TB4.0	720118
	Ø4.0mm	0.157-in	0.587gm	1,700	TB4.0	720157
	Ø5.0mm	0.197-in	1.146gm	870	TB5.0	720197

Material Properties:

Tungsten (W) is environmentally friendly.
Tungsten's properties include high density and tensile strength.

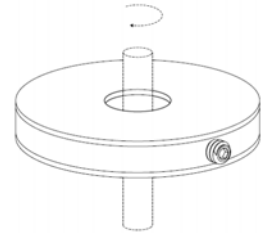
- Atomic Number 74
- Density 19.3g/cc (@20°C)
- Linear CTE 4.3 ppm/°C
- Poisson's Ratio 0.284
- Melting Point 3400°C
- Tensile Strength 700~3400 MPa @25°C



Contact: info@TopLine.tv
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Toroidal Shape PID Particle Impact Damper

U.S. Patent D842,351



Description: Toroidal PID has a through hole in the center.

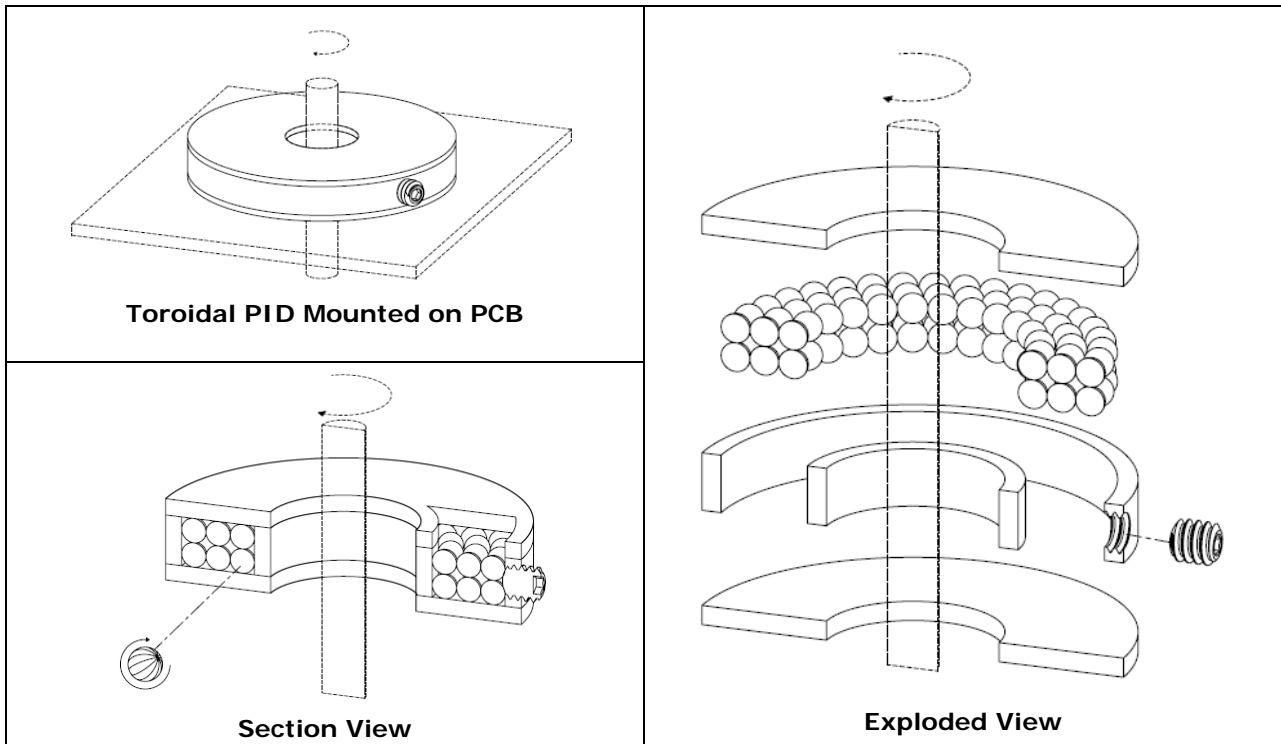
Application: A rotating motor shaft or cables can safely extend through the damper.

Construction: Tungsten particles are in a sealed chamber inside the housing.
Housing is typically constructed of FR4, although other housing materials are available.

How it works: Similarly with standard PID, particles inside the chamber escape gravity when highly excited by a massive random vibration. The particles collide against the inside walls of the chamber, lifting or pushing the PC Board into position to mitigate damage to components mounted on the surface of the board.

Fundamental frequency f_o 100Hz to 2000Hz Broadband.

Board mass: 10g to 1000g





Contact: info@TopLine.tv
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Quick Response PID Particle Impact Damper

U.S. Patent 10,021,779



Description: Particles are separately sealed inside individual spherical cavities. Particles are unencumbered and can quickly move upon the onset of massive random vibration.

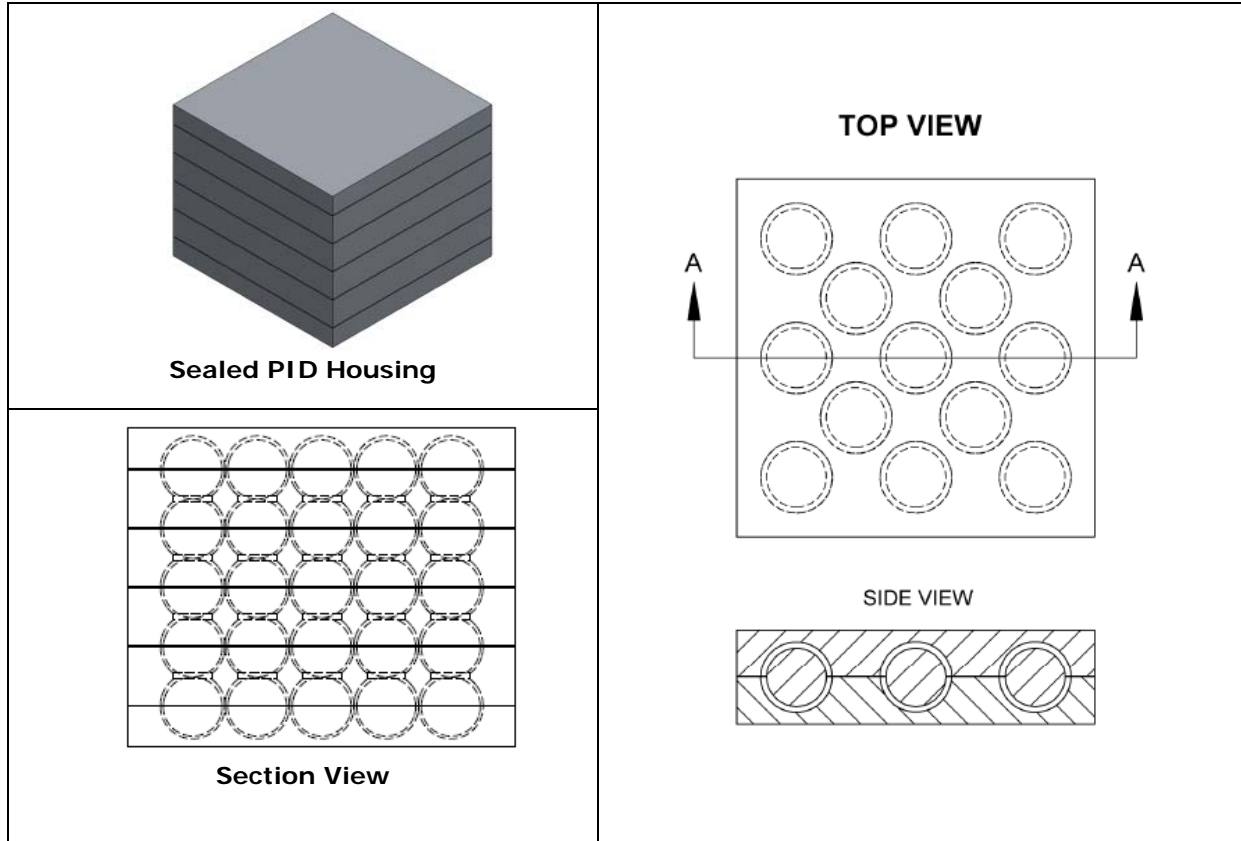
Application: Planar surfaces such as a PCB which require more sensitivity and quicker response to random massive vibrations.

Construction: Tungsten particles are in a sealed chamber inside the housing. Housing is typically constructed of FR4, although other housing materials are available. Layers are honeycomb and stackable inside the housing.

How it works: Particles are unencumbered and can quickly move upon the onset of vibration. Particles escape gravity when highly excited by a massive random vibration. The particles collide against the inside walls of the chamber, lifting or pushing the PC Board into position to mitigate damage to components mounted on the surface of the board.

Fundamental frequency f_0 100Hz to 2000Hz Broadband.

Board mass: 10g to 1000g

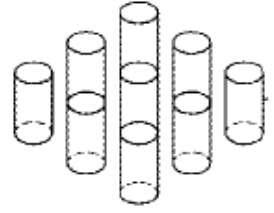




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Unidirectional PID Particle Impact Damper

U.S. Patent 10,704,639



Description: Rod shaped particles are sealed inside individual cylindrical cavities. The particles travel in one (unidirectional) direction upon the onset of massive random vibration.

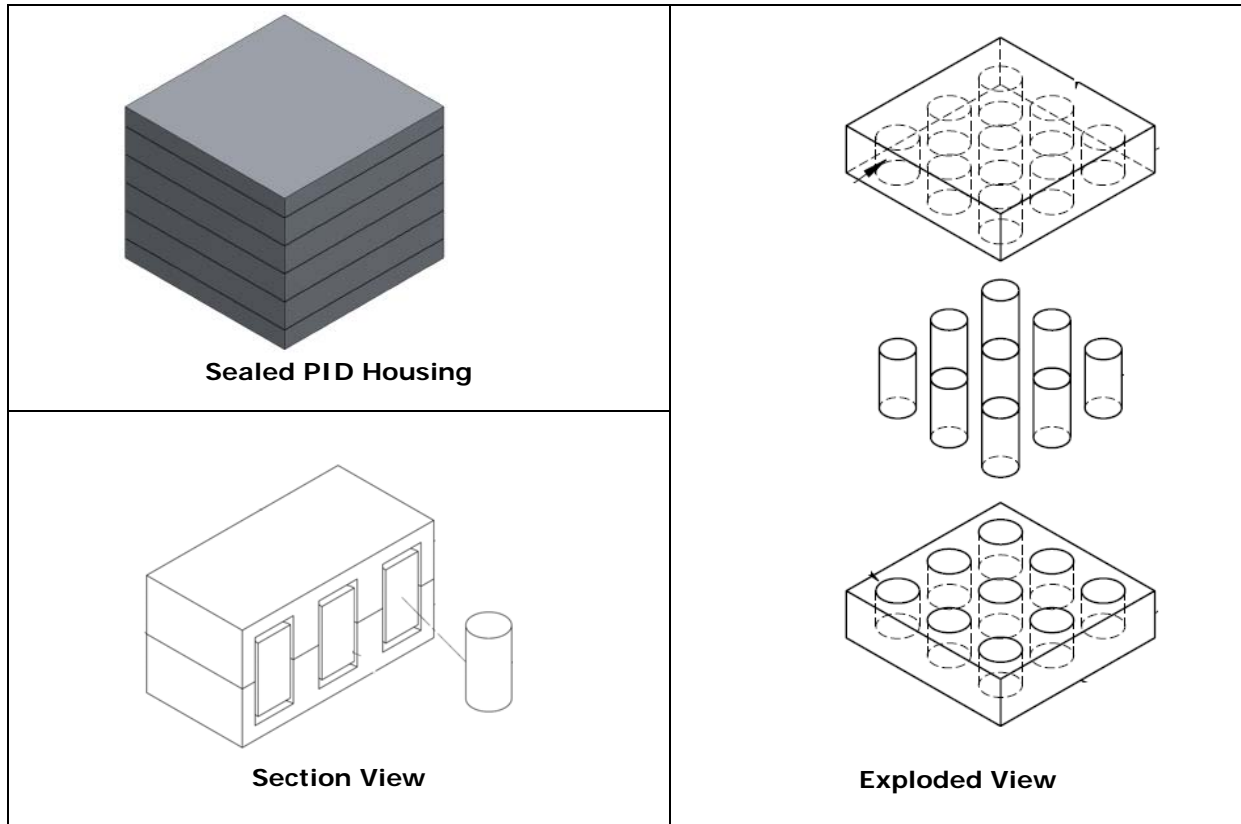
Application: Dampens planar surfaces such a PC Boards, floors, walls or glass windows.

Construction: Tungsten particles in a sealed cylindrical chamber inside the housing. Housing is typically constructed of FR4, although other housing materials are available.

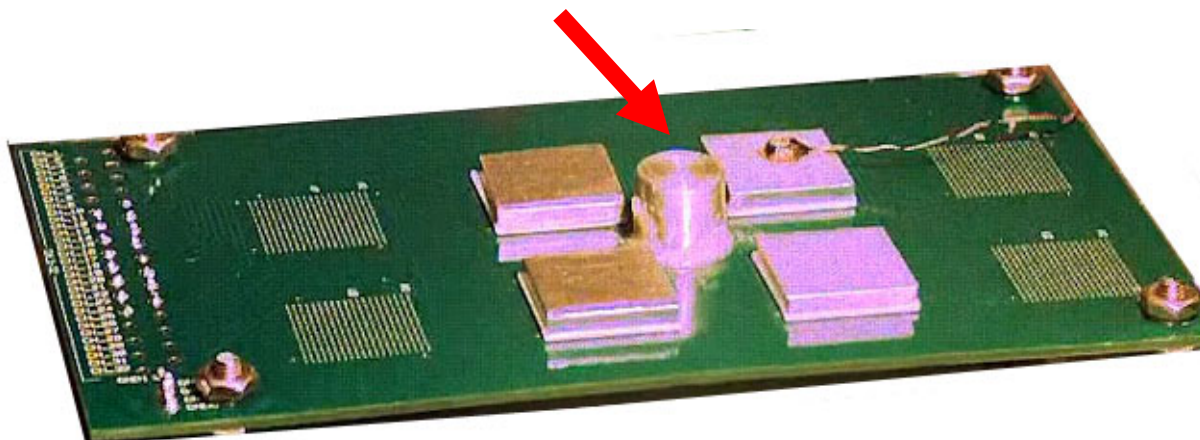
How it works: Particles quickly move unidirectionally back and forth in one plane upon the onset of vibration. Particles escape gravity when highly excited by a massive random vibration. The particles collide against the floor and ceiling of the cylindrical chamber, lifting or pushing the PC Board or planar surface into position to mitigate damage to components mounted on the surface of the board.

Fundamental frequency f_0 100Hz to 2000Hz Broadband.

Board mass: 10g to 1000g



PID mounted on PCB



See NASA Video showing how PID mitigates destructive vibration on a PC Board.



<https://www.youtube.com/watch?v=P4SQuBaKXWw>

About the Video:

Video shows a destructive life test performed on NASA Marshall Space Flight Center printed circuit card assemblies 4" x 7" (10 x 18cm) 0.090-inch (2.3mm) thick. Four 21mm x 21mm daisy-chained 400L CCGA column grid array components are mounted on each card. One card was left undamped. A PID damper was glued at the center of the second card. The cards were mounted side by side onto a vibration table and subjected to excessive vibrations. 19 channels on the undamped boards (without PID) failed within 12 minutes. By comparison, 19 channels on the damped boards (with PID) survived 5 hours (306 minutes) before ultimately failing.



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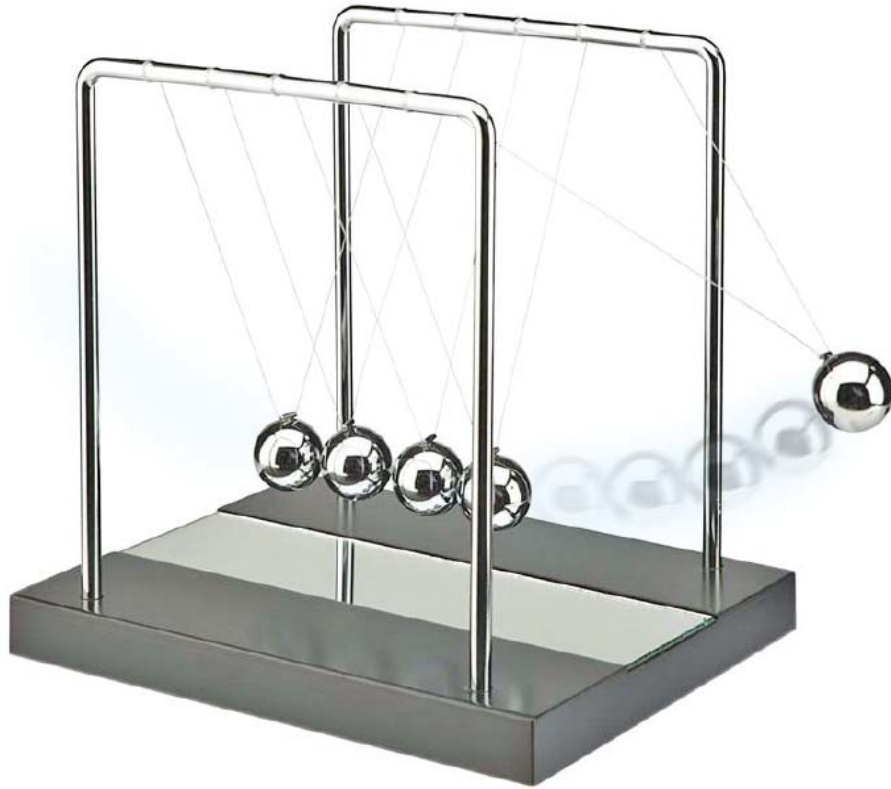
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