Industrial power goes SM*P*D

Mounting solutions and modularity

Rutronik-Webinar, April 27th, 2022

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Expertise Applied | Answers Delivered

Your Speaker Today

Dr.-Ing. Martin Schulz

Global Principal, Application Engineering

- Joined Littelfuse in February ‘21
- More than 20 years of experience in power semiconductors
- Education
    - PhD in Power Electronics and Electrical Drives
    - Several patents in the fields of power semiconductors
    - Senior IEEE-Member

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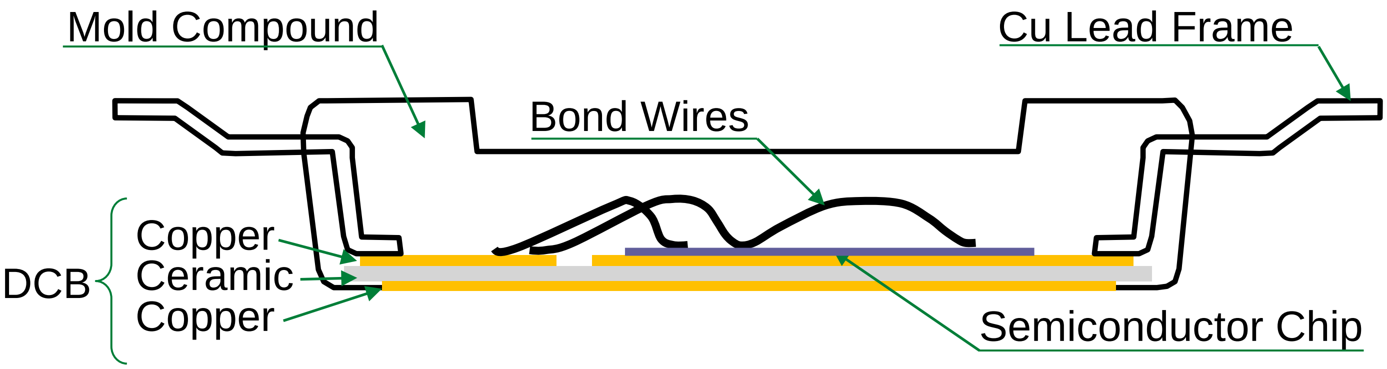
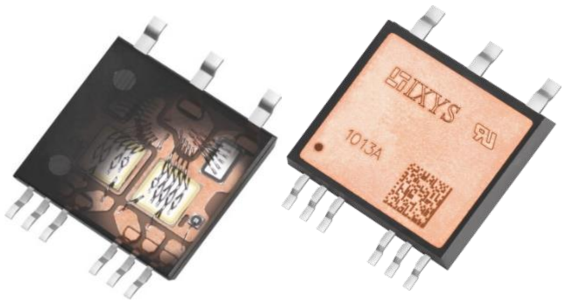
Isolated Power Semiconductor Packages



- Low profile
- Top-side electrically isolated
- High insulation strength
- Allows multiple packages on a common heat sink



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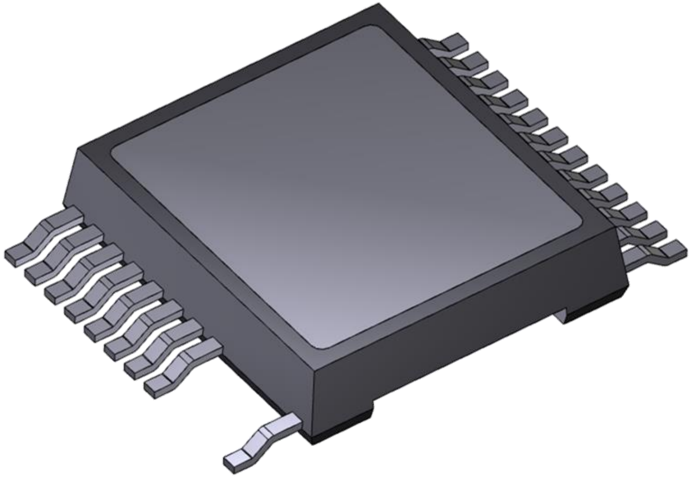
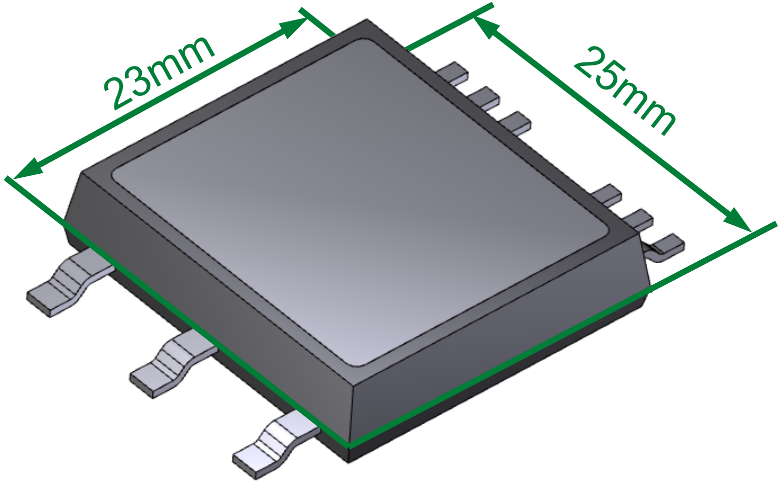
The SMPD-Packages





- SMPD-X
- Single switches and Co-Packs for highest power demands

- SMPD-B
- Building blocks in a variety of topologies, technologies and voltage classes

Both packages share the same dimensions

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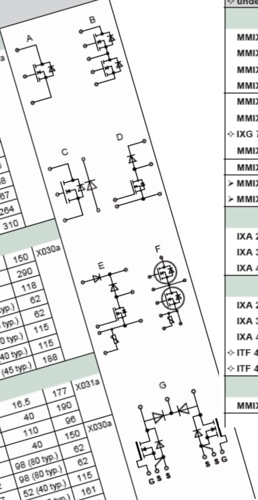
ISOPLUS-SMPD™ – Modular Construction Kit

Si/SiC MOSFETs, 40-1700V

MOSFETs

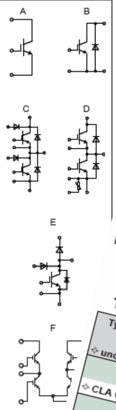
Type ○ Not for new design ✧ under development ➢ New	Circuit diagram / Technology	V_{DSS} V	I_{D25} T_C = 25°C A	$R_{DS(on)}$ max. T_C = 25°C mΩ	Q_G nC	Fig. No.
SINGLE						
MMIX 1T600N04T2	A Trench2	40	600	1.3	590	X031a
➢ MMIX 1T550N055T2	A Trench2	55	550	1.3	595	
➢ MMIX 1F520N075T2	A Trench2 HiPerFET™	75	500	1.6	545	
MMIX 1F420N10T	A Trench HiPerFET™	100	334	2.6	670	
MMIX 1F360N15T2	A Trench2 HiPerFET™	150	235	4.4	715	
MMIX 1F230N20T	A Trench HiPerFET™	200	156	8.3	358	
MMIX 1F180N25T	A Trench HiPerFET™	250	132	13	364	
MMIX 1F160N30T	A Trench HiPerFET™	300	102	20	376	
MMIX 1F210N30P3	A Polar3 HiPerFET™		108	16	268	
MMIX 1F132N50P3	A Polar3 HiPerFET™	500	63	43	267	
MMIX 1F44N100Q3	A Q3 HiPerFET™	1000	30	245	264	
MMIX 1F40N110P	A Polar HiPerFET™	1100	24	290	310	
BUCK / BOOST						
MKE 38RK600DFELB	C MOSFET © CP & FRED	600	50	45	150	X030a
○ MKG 40RK600LB	C MOSFET © C6 & SONIC		54	41	290	
➢ MKH 17RP650DCGLB	G Dual MOSFET© CFD & SiC	650	2x 22	110	118	
✧ MCB 25R1200LB	D SiC MOS & SiC Diode	1200	32	98 (80 typ.)	62	
✧ MCB 25RP1200LB	G Dual SiC MOS & Diode		2x 32	98 (80 typ.)	62	
✧ MCB 30RL1200TLB	E SiC & Bypass & NTC		37	52 (40 typ.)	115	
✧ MCB 45R1200LB	D SiC MOS & SiC Diode		55	52 (40 typ.)	115	
✧ MCB 35R1700LB	D SiC MOS & SiC Diode	1700	35	70 (45 typ.)	188	
PHASE-LEG						
➢ MMIX 2F150N20T	B Trench™ HiPerFET™	200	84	16.5	177	X031a
➢ MMIX 2F94N30T	B Trench™ HiPerFET™	300	52	40	190	
➢ MMIX 2F60N50P3	B Trench™ HiPerFET™	500	30	110	96	
MKE 38P600LB	B MOSFET © CP	600	50	40	150	X030a
✧ MCB 20P1200LB	B SiC	1200	22	98 (80 typ.)	62	
✧ MCB 25P1200TLB	F SiC & NTC		32	98 (80 typ.)	62	
✧ MCB 30P1200LB	B SiC		37	52 (40 typ.)	115	
➢ MCB 40P1200LB	B SiC		58	34 (25 typ.)	161	
➢ MCB 45P1200TLB	F SiC & NTC		55	52 (40 typ.)	115	
✧ MCB 60P1200TLB	F SiC & NTC		77	34 (25 typ.)	161	
✧ MCB 35P1700TLB	F SiC & NTC	1700	35	70 (45 typ.)	188	



IGBTs 600 to 3000V

IGBTs

Type ➢ New ✧ under development	Circuit Diagram No. / Technology	V_{CES} V	I_{C25} T_C = 25°C A	$V_{CE(sat)}$ typ. T_C = 25°C V	E_{off} typ. T_J = 150°C (125°C) mJ	Fig. No.
SINGLE and COPACK						
MMIX 1X200N60B3	A XPT	600	223	1.40	3.45	X031a
MMIX 1X100N60B3H1	B XPT & SONIC		145	1.50	2.80	
MMIX 1X200N60B3H1	B XPT & SONIC		175	1.40	3.45	
MMIX 1X340N65B4	A XPT™ IGBT GenX4™		450	1.40	2.54	X031a
MMIX 1Y82N120C3H1	B XPT fast & SONIC	1200	78	2.90	(3.70)	
MMIX 1Y100N120C3H1	B XPT fast & SONIC		92	2.90	3.55	
✧ IXG 70IF1200LB	B X2PT & SONIC2		105	1.9 (70A)	5.3 (50A)	X030a
MMIX 1G120N120A3V1	B GenX3 IGBT @ SONIC		110	1.85	58	X031a
MMIX 1G75N250	A IGBT for cap discharge	2500	110	2.50	-	
➢ MMIX 1B15N300C	B BiMOSFET™	3000	37	4.70	-	
➢ MMIX 1B20N300C	B BiMOSFET™		50	4.50	-	
BOOST						
IXA 20RG1200DHGLB	E XPT & SONIC	1200	32	1.80	1.7	X030a
IXA 30RG1200DHGLB	E XPT & SONIC		43	1.90	3.0	
IXA 40RG1200DHGLB	E XPT & SONIC		63	1.85	4.1	
PHASE-LEG						
IXA 20PG1200DHGLB	C XPT & SONIC	1200	32	1.80	1.7	X030a
IXA 30PG1200DHGLB	C XPT & SONIC		43	1.90	3.0	
IXA 40PG1200DHGLB	C XPT & SONIC		63	1.85	4.1	
✧ ITF 40PF1200DHGTLB	D Trench IGBT & SONIC & NTC		56	2.05	2.6	
✧ ITF 40PG1200DHGLB	C Trench IGBT & SONIC		56	2.05	2.6	
FULL-BRIDGE						
MMIX 4G20N250	F IGBT for cap discharge	2500	23	3.1 max	-	X031b



Diodes, Thyristors, Triacs

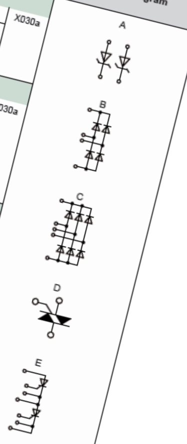
Diodes

Type ➢ New ✧ under development	Circuit diagram / Diode type	V_{RRM} V	$I_{D(AV)M}$ A	@ T_C °C	Fig. No.
DUAL					
DSA 120X150LB	A Schottky	150	2x 60	150	X030a
DSA 120X200LB	A Schottky	200	2x 60	150	
✧ DSA 240X200LB	A Schottky		2x 120		
✧ DCG 40X1200LB	A SiC	1200	2x 14.5	80	
1~ BRIDGE					
DPG 60B600LB	B HiPerFRED	600	60	110	X030a
➢ DCG 20B650LB	B SiC	650	21	80	
DLA 100B800LB 1)	B Rectifier	800	124	80	
DLA 100B1200LB	B Rectifier	1200	124	80	
➢ DHG 40B1200LB	B SONIC		34	80	
✧ DCG 20B1200LB	B SiC		18	80	
3~ BRIDGE					
DHG 60U1200LB	C SONIC	1200	62	80	X030a
DMA 90U1800LB	C Rectifier	1800	99	80	

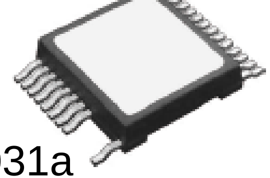
1) AECQ qualified
* in progress

Thyristors, Triacs

Type ✧ under development	Circuit diagram / Bipolar type	V_{RRM} V	I_{TAV} A	@ T_C °C	Fig. No.
DUAL					
✧ CLA 60MU1200LB	2x D Triac	1200	2x 30	100	X030a
PHASE-LEG					
✧ CMA 50P1600LB	E Thyristor	2x 1600	50	90	

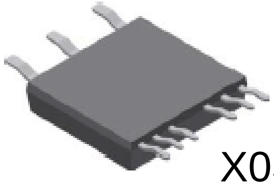


SMPD-X



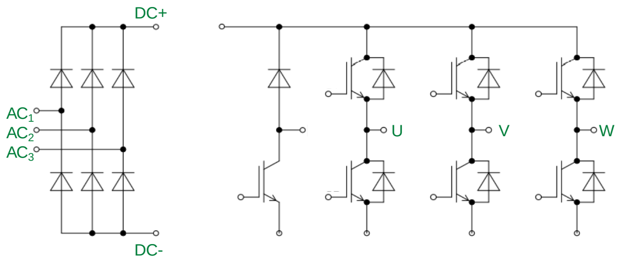
X031a

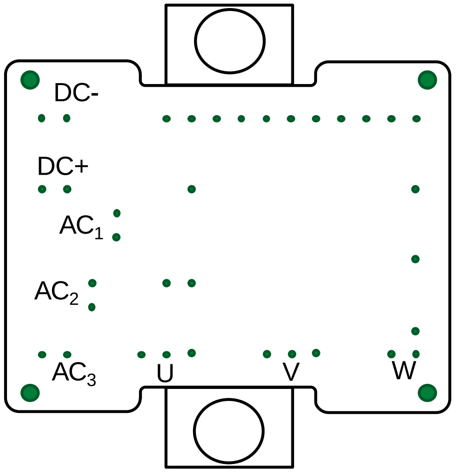
SMPD-B



X030a

Compact vs. Convenient





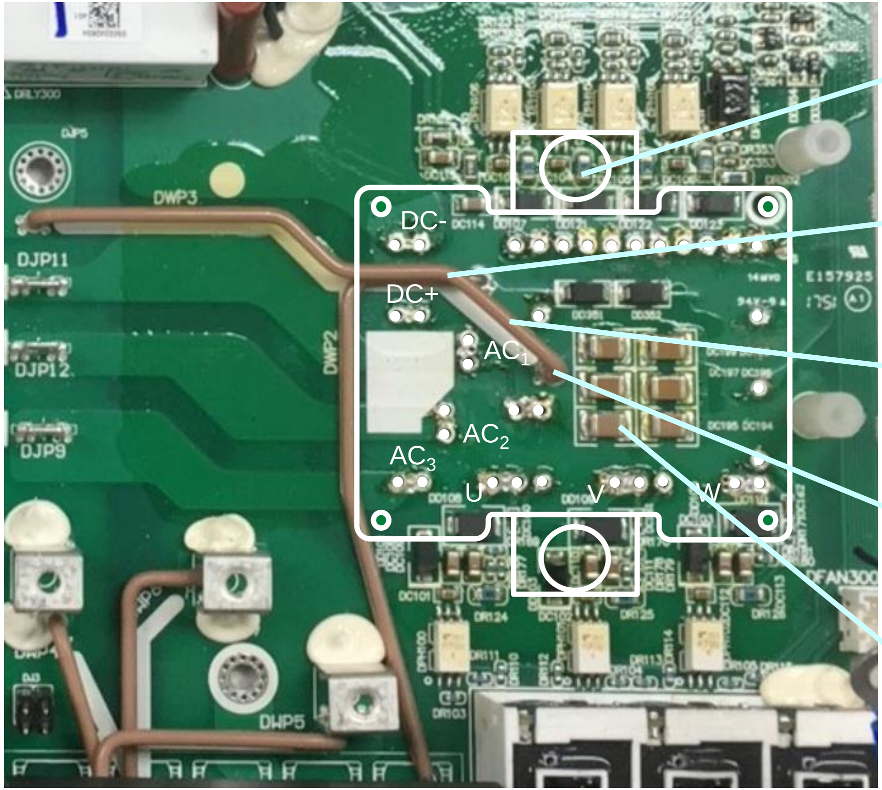
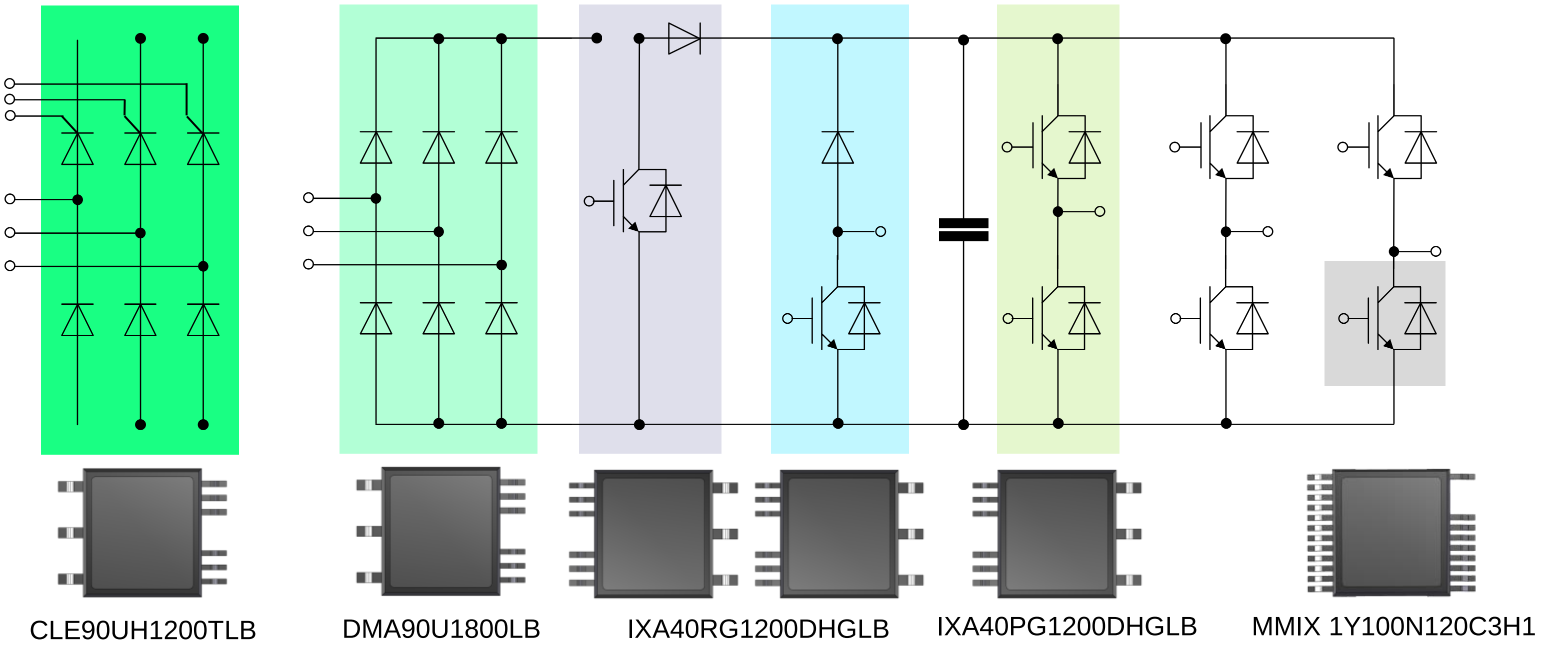


Photo by Dr. Martin Schulz

- Mounting?
- Stray Inductance?
- Assembly?
- Selective soldering
- Snubber capacitors

Power stage design *LEGO®-Style*



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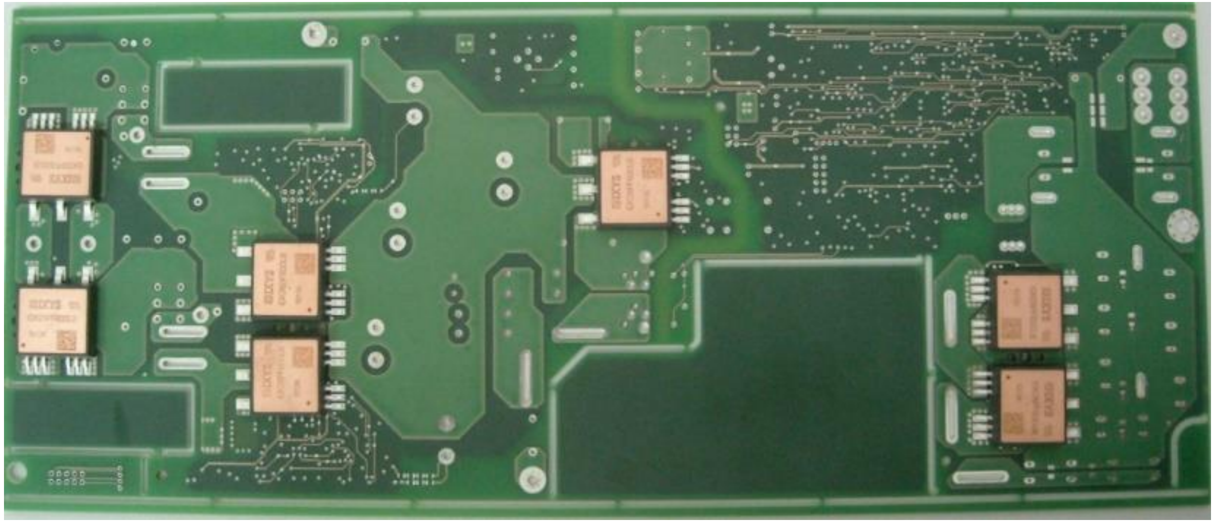
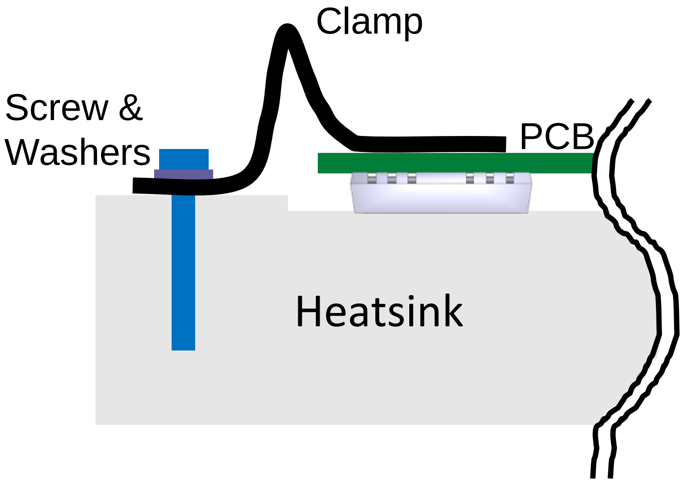
The benefits using the SMPD



Industrial Switch-Mode Power Supply

- Convenient placing of input- and output-stages to simplify routing
- Distributed arrangement of functional groups simplifies thermal management
- Assembly by fully automated pick & place and standardized reflow soldering

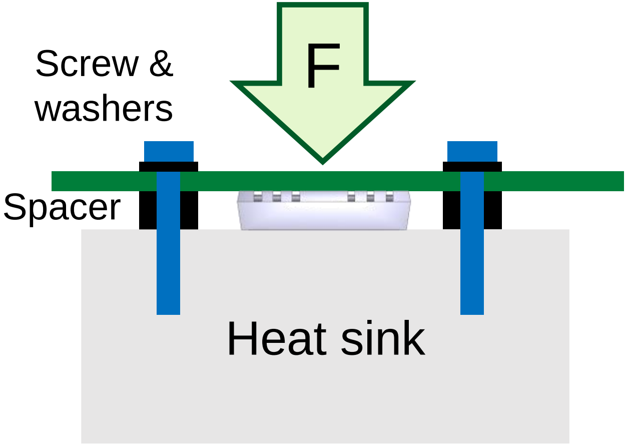
Mounting Options I/IV

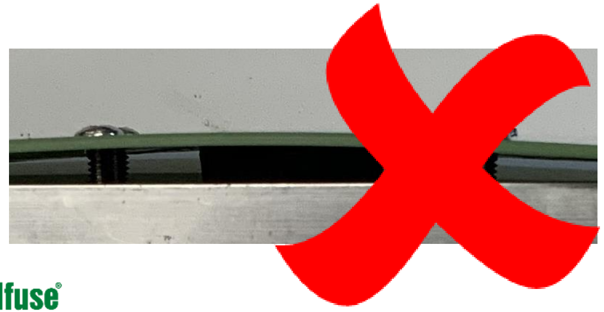


Mounting force applied by Clamp

- Single screw or push-in clamps
- F>50N is recommended
- Common clamps up to 100N available
- Typically used for modules close to the edge of the PCB
- Use of clamps inside the PCB’s perimeter is possible but consumes larger area for mounting

Mounting Options II/IV





Mounting force applied by PCB

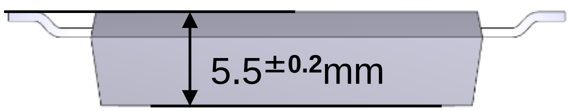
- Two screws sufficient, aligned to the center of the module
- Metric screws, 3mm in diameter, 0.9Nm torque applied
- F>50N is sufficient while several hundred Newton are possible

- Supports or spacers are mandatory to prevent bending of the PCB

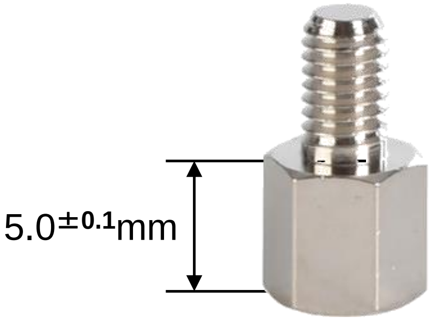
Important: device tolerances

- Any mechanical part has tolerances in its dimensions:

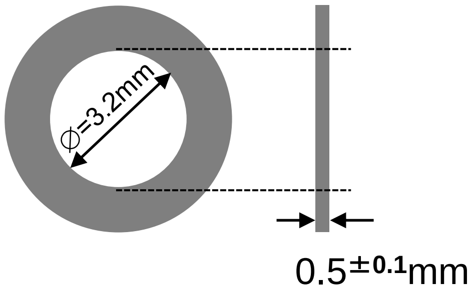
SMPD-X:



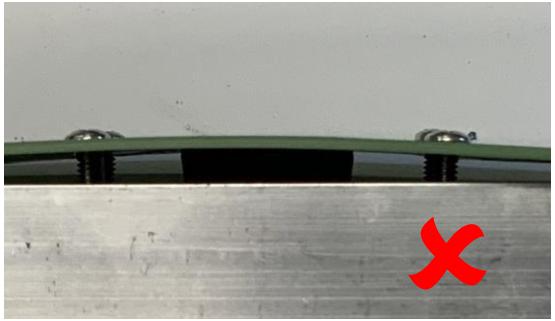
Common spacers:

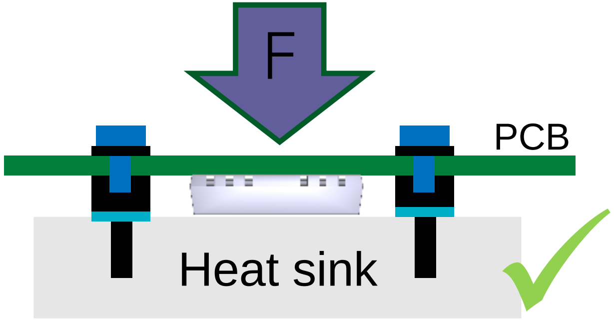


Washers, DIN125 / ISO7089 :



Module-Spacer-Washer … Does it work *reliably*?





	Power Device height [mm]	Spacer height [mm]	Washer thickness [mm]	Difference in height Δh	Force	Force with 50µm TIM applied
Min/Min	5.3	4.9	0.4	0	~0	>0
Rated	5.5	5.0	0.5	0	~0	>0
Max/Max	5.7	5.1	0.6	0	~0	>0
Min/Max	5.3	5.1	0.6	+0.4	<<0	<<0
Max/Min	5.7	4.9	0.4	-0.3	>>0	>>0

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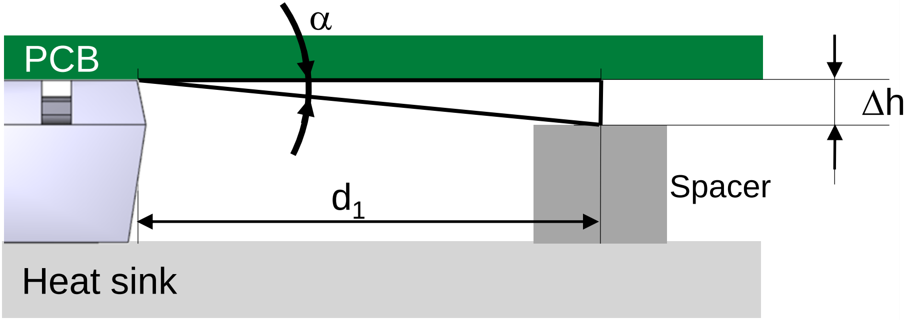
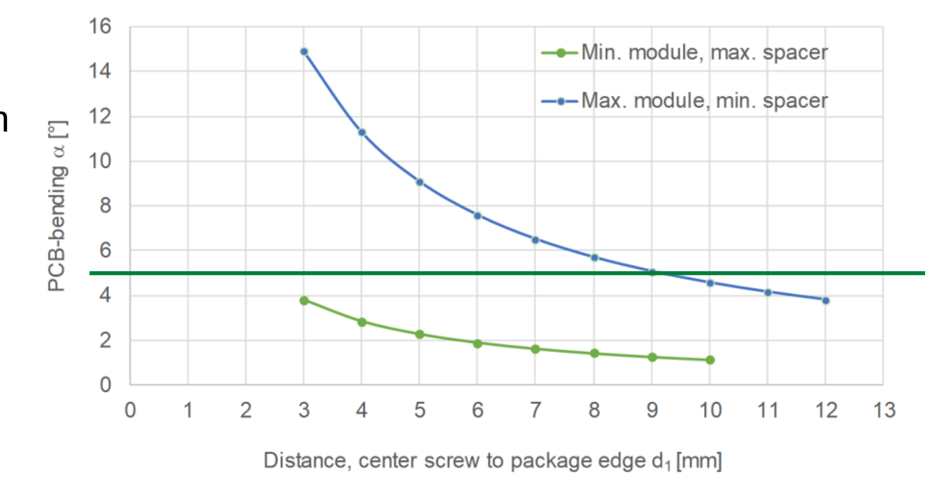
How about using spacers without washers?

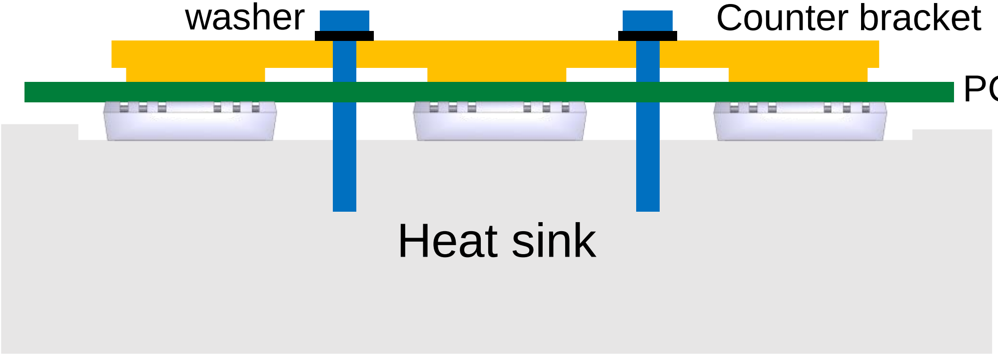
- Without washers, a difference in height Δh remains.
- The potential maximum is (5.7-4.9) mm or 0.8mm





With a distance d_1>10mm, reliable mounting is achieved.

Mounting Options III/IV



Use of a counter bracket

- *n* modules in a row held down by a bracket, fixed with *(n-1)* screws
- Metric screws, 3mm in diameter, 0.9Nm torque applied
- F>50N is sufficient while several hundred Newton are possible
- Supports are obsolete when pressure is applied to the module only
- The bracket can be injection molded, 3D-printed or milled from suitable, non-conductive materials

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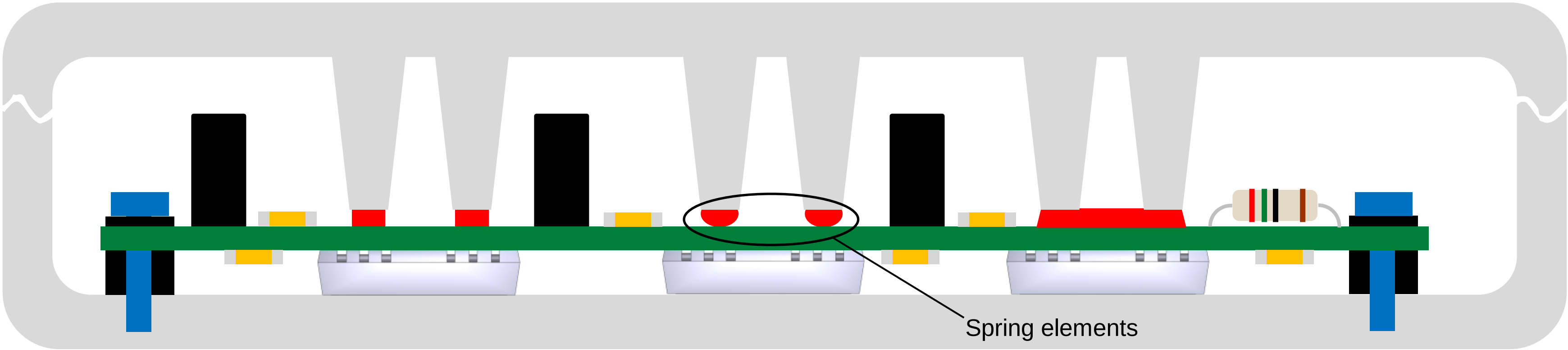
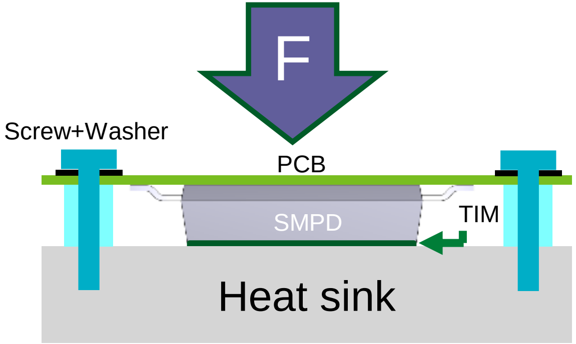
Mounting Options IV/IV

Holistic approach, built around the SMPD

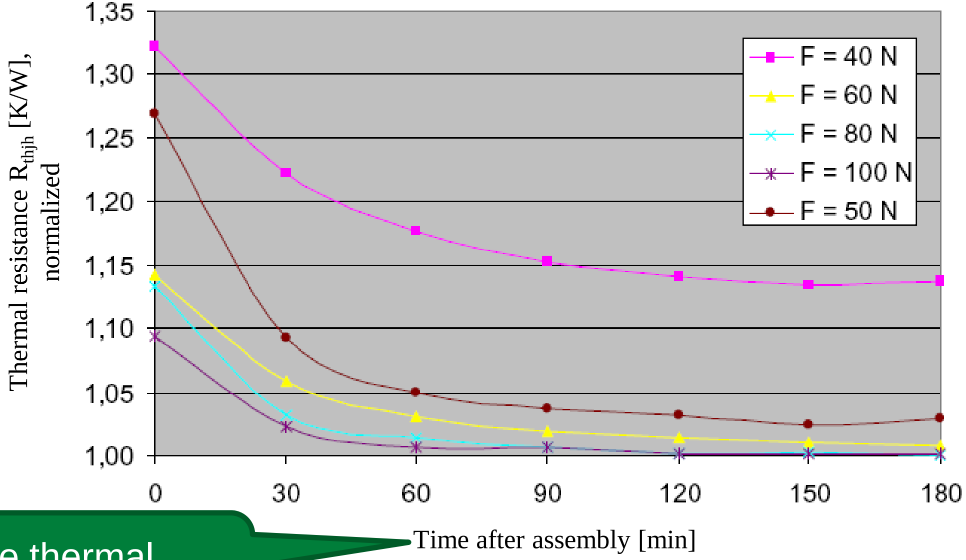


- Mounting force >50N/module applied by the encapsulating housing
- Housing acts as a heat sink, reducing mounting effort and assembly time
- Simplified design of IP65-encapsulation for pollution-intense environments
- Spring elements can be helical metal springs, elastic materials like TPU or rubber

Mounting force and thermal transfer



Correlation of mounting force F and thermal resistance R_{thch}=f(F,t)



Depends on the thermal interface material (TIM) in use

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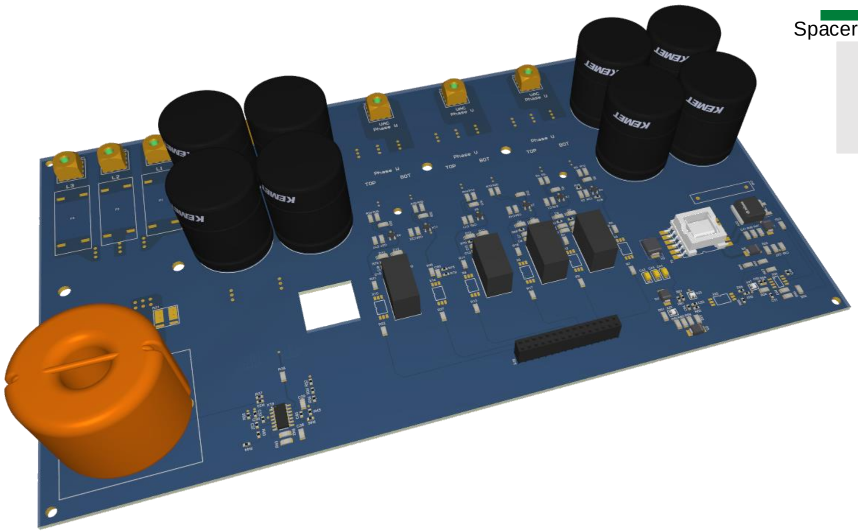
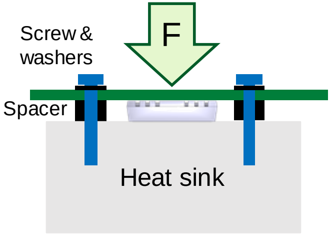
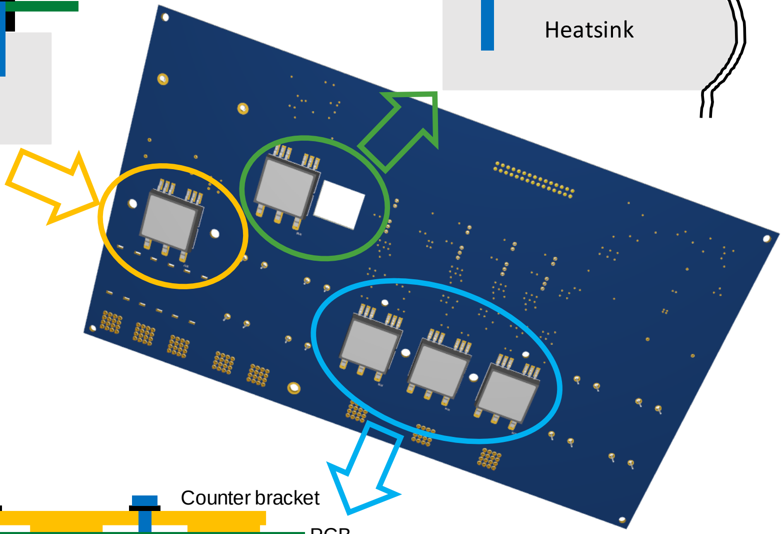
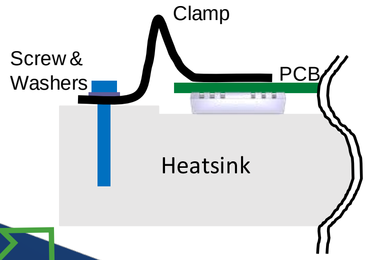
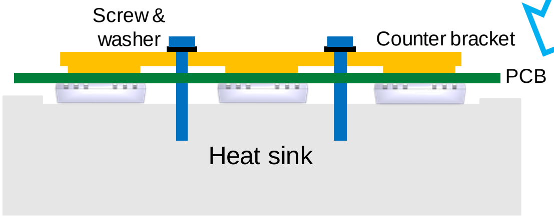
SMPD-Demo, PCIM 2022 – exclusive preview



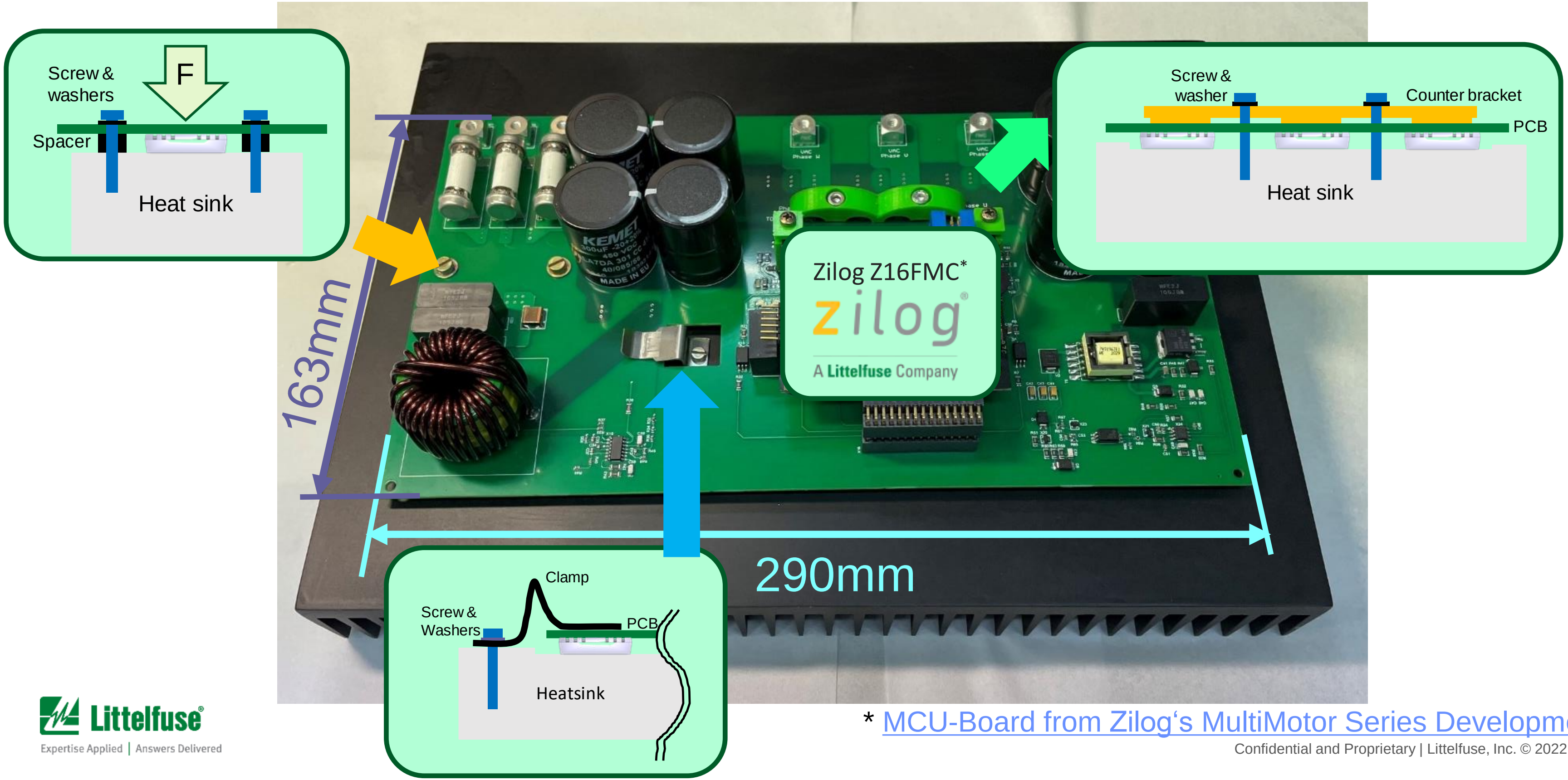








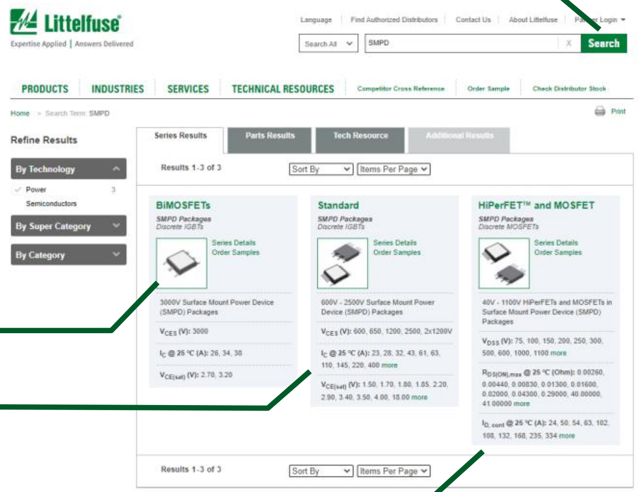
From idea to hardware



* MCU-Board from Zilog's MultiMotor Series Development Kit

Where to find detailed documentation

Search for “SMPD” on our website www.littelfuse.com



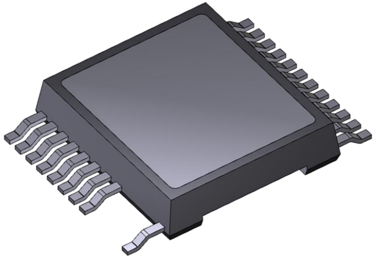
Click here to get to the 3000V BIMOSFETs

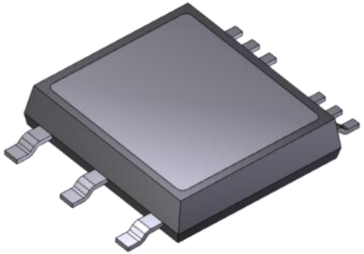
Click here to see the IGBTs in SMPD

Use this link to get to the MOSFETs in SMPD

You can also download the Application Note
Mounting and Cooling Solutions for SMPD Packages

Conclusion





- Littelfuse's ISOPLUS-SMPD™ family offers a comprehensive, coordinated system of power electronic components to serve a multitude of topologies and applications
- Modularity is a key to increase power density by improving placing options and thermal management.
- Increasing the power levels handled by SMD-components eases manufacturing and reduces processing times

Finally…

… there is time
to answer your questions.

