Texas Instruments QMLP Update

QML-P: The Latest QML Standard for Radiation-Hardened Plastic Space Packaging

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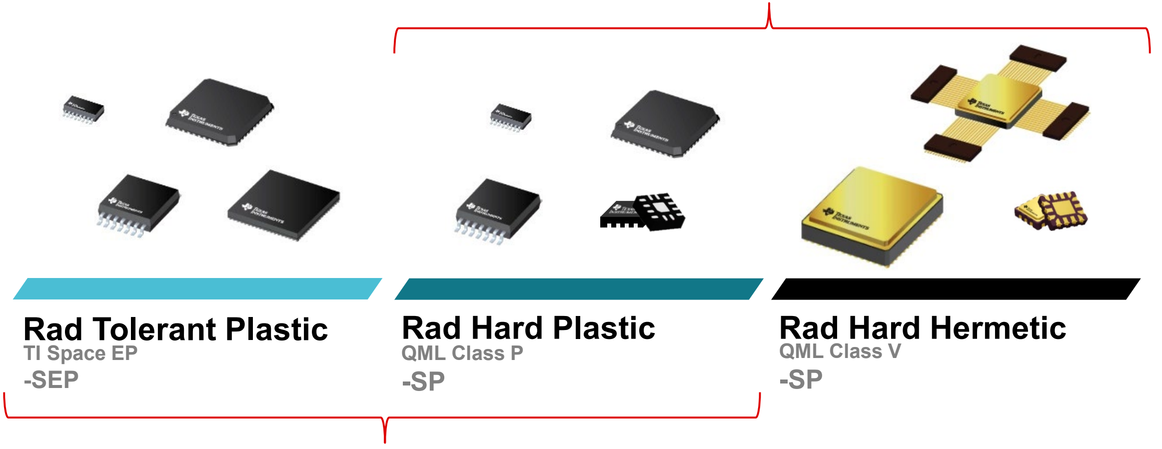
TI Space product grades

Same radiation levels, MIL qualification, different package



Pin-to-pin compatible, different radiation levels

Packaging	Plastic	Plastic	Ceramic / Metal Can
Mil. Spec	VID	SMD	SMD
Burn- in	No	Yes	Yes
TID Char	**30 – 50 krad(Si)**	**< - - - - - - - - - - - - - 50krad(Si) – 300 krad(Si) - - - - - - - - - - - - - >**	
TID RLAT	**20, 30, or 50 krad(Si)**	**< - - - - - - - - - - Non-RHA, 50, 100, or 300 krad(Si) - - - - - - - - - >**	
SEL	**43 MeV·cm^2/mg**	**< - - - - - - - - - - - - - - $\geq$ 60 MeV·cm^2/mg - - - - - - - - - - - - - - - - - >**	

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TI’s Space-grade manufacturing flows

	Rating	Space				
	Classification	Space EP	SHP	QML-P	QML-Y	QML-V
Production testing and documentation provided	Vendor item drawing (VID)	✓	✓	✕	✕	✕
	Standard microcircuit drawing (SMD)	✕	✕	✓	✓	✓
	Process conformance report	✓	✓	✓	✓	✓
	Process conformance report content	See product page		MIL-PRF-38535 Group A, B, C, D, E		
Manufacturing	Single controlled baseline	✓	✓	✓	✓	✓
	Multiple wafer lots per reel possible	✕	✕	✕	✕	✕
	Life test per wafer lot	✕	✓	✓	✓	✓
Packaging	Package construction	Plastic	Plastic	Plastic - Wirebond or flip chip with overmold	Plastic - flip chip w/o overmold	Hermetic
	Bond wires	Au	Au	Au	N/A	Al
	Pure tin (Sn) lead finish possible?	✕	✕	✕	✕	✕
	>97% Tin (Sn) inside package possible*	✓ for flip chip				✕
	Production burn-in required	✕	✓	✓	✓	✓
	Outgassing tested per ASTM E595	✓	✓	✓	✓	N/A
Radiation	TID characterization range (krad/Si)	30 to 50	50 to 300			
	TID radiation lot acceptance testing (RLAT) range – RHA (krad/Si)	20, 30 or 50	50, 100 or 300			
	SEL immunity (MeV*cm2/mg)	≥ 43	≥ 60			
Typical temperature range		−55−125°C				

Table illustrates typical values for each Classification rating. For precise data or detailed information, please refer to the product-specific page.

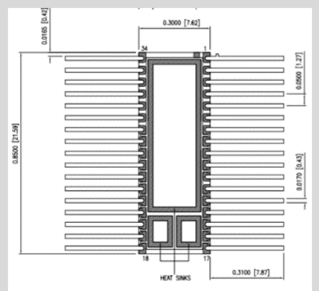
* BI unless Optimization aligned with DLA

TID = Total Ionizing Dose
VID = Vendor Item Drawing
SEL= Single-Event Latch-up

RHA = Radiation Hardness Assured
QML = Qualifed Manufacturers List
SMD = Standard Microcircuit Drawing

Benefits of QML Class-P

TI TPS7H4001-SP
18A Ceramic
<u>QMLV</u>
5962R1820501VXC

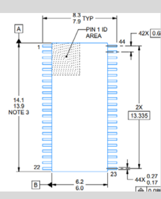


Pkg Size w/2mm leads:
21.8mm x 11.8mm = 257mm^2

Power density at 1 V output
~70 mW/mm^2

Mass 2611.6 mg

TI TPS7H4001-SP
18A Plastic
<u>QMLP</u>
5962R1820502PYE

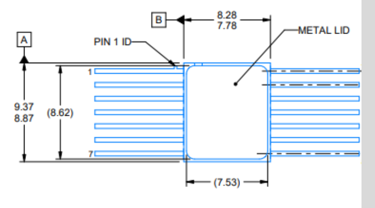


Pkg Size w/leads:
14.1mm x 8.3mm = 117mm^2

Power density at 1 V output
~154 mW/mm^2

Mass 218 mg

TI TPS7H1111-SP
1.5A Ceramic
<u>QMLV</u>
5962R2120301VXC

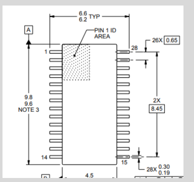


Pkg Size w/2mm leads:
9.3mm x 12.3mm = 115mm^2

Power density at 1 V output
~13 mW/mm^2

Mass 1229.2 mg

TI TPS7H1111-SP
1.5A Plastic
<u>QMLP</u>
5962R2120302PYE



Pkg Size w/leads:
9.8mm x 6.6mm = 65mm^2

Power density at 1 V output
~23 mW/mm^2

Mass 198.3 mg

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Ceramic vs Plastic Comparison

Device	Package Type	Size (mm^2)	Size Reduction	Mass (mg)	Mass Reduction	Power Density (mw/mm^2)	Power Density Increase by
TPS7H4001-SP	Plastic	117	54.47%	218	91.65%	154	120%
	Ceramic	257		2611.6		70	
TPS7H1111-SP	Plastic	65	43.48%	198.3	83.87%	23	76.92%
	Ceramic	115		1229.2		13	

Screening procedure for hermetic class V and non-hermetic class P microcircuits

Screening Tests	MIL-STD-883, test method (TM) and conditions	
	Hermetic classes	Non-hermetic classes
	Class V (class level S)	Class P (PEM) (class level S)
1. Wafer lot acceptance test	QM plan	QM plan
	TM 5007 of MIL-STD-883 (all lots)	TM 5007 of MIL-STD-883 (all lots)
2. Nondestructive bond pull (NDBP) test	TM 2023	Not part of plastic packages screening
3. Internal visual inspection	TM 2010, condition A	TM 2010, condition A
4. Temperature cycling	TM 1010, **condition C**, 10 cycles minimum	TM 1010, **condition B**, -55 to 125 °C 15 cycles minimum
5. Constant acceleration	TM 2001, condition E (minimum), Y1 orientation only	No wires in the package that can move and create shorts
6. Visual inspection	100%	100%
7. Particle Impact Noise Detection (PIND) test	TM 2020, test condition A on each device	No cavity in molded plastic packages
8. Serialization	In accordance with device specification (100%)	In accordance with device specification (100%)
9. Pre burn-in (Interim) electrical parameters test	In accordance with device specification	In accordance with device specification
10. Burn-in Test	TM 1015 240 hours at 125°C, condition D	TM 1015 240 hours at 125°C , condition D
11. Post burn-in (Interim) electrical parameters test	In accordance with device specification	In accordance with device specification
12. Reverse bias burn-in test (Static burn-in)	TM 1015, Condition A or C; 144 hours at +125°C or 72 hours at +150°C minimum	TM 1015, Condition A or C; 144 hours at +125°C or 72 hours at +150°C minimum
13. Post burn-in (Interim-reverse bias) electrical parameters test	In accordance with device specification	In accordance with device specification
14. Percent defective allowable (PDA) calculation	5 percent PDA, 3 percent PDA for functional parameters at 25°C (all lots)	5 percent PDA, 3 percent PDA for functional parameters at 25°C (all lots)

Screening procedure for hermetic class V and non-hermetic class P microcircuits

Screening Tests	MIL-STD-883, test method (TM) and conditions	
	Hermetic classes	Non-hermetic classes
	Class V (class level S)	Class P (PEM) (class level S)
16. Seal test a. Fine leak b. Gross leak	TM 1014	Non-hermetic package, no lid to seal
17. Radiographic (X-ray)	X-ray: TM 2012	X-ray: TM 2012
18. External visual inspection	TM 2009	TM 2009
19. Qualification or quality conformance inspection / TCI test sample selection	PCR	PCR

TEXAS INSTRUMENTS

Group B – Conformance Inspection

Group B	Frequency - once each week of seal for each package family and lead finish						
			Hermetic Classes		Non-Hermetic Classes		Comment
			Class V		Class P		
Test/Subgroup	Test	Method	Condition	Sample/Accept	Condition	Sample/Accept	
B1	Resistance to Solvents	2015	-	3/0	-	3/0*	*Resistance to solvents testing required only on devices using inks or paints as a marking medium, not required for laser marking
B2	Bond strength	2011	-	22/ 0	-	22/ 0	
	Die shear or stud/cube pull	2019 or 2027	-	3/ 0	-	3/ 0	
B3	Solderability	2003	+245°C ±5°C	22/0	+245°C ±5°C	22/0	3 devices minimum / 22 leads total
B4	Ball Shear Testing	JESD22-B117	-	45/0	-	45/0	Only for BGA Packages – 2 package minimum
	Solder Column Pull Testing	TM2038	-	45/0	-	45/0	Only for CGA package – 2 package minimum

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Group C/E – Conformance Inspection

Group C/E								
			Hermetic Classes			**Non-Hermetic Classes**		
			Class V			**Class P**		
Test/Subgroup	**Test**	**Method**	**Condition**	**Sample/Accept**	**Frequency**	**Condition**	**Sample/Accept**	**Frequency**
C	Steady-state life test	1005	1000 hrs at 125°C or equivalent	45/0	Each wafer lot	1000 hrs at 125°C or equivalent	45/0	Each wafer lot
	End Point Electrical Test	SMD				SMD		
E	Total Ionization Dose (TID)	1019	25°C maximum supply voltage	2(0) devices/wafer or 5(0) devices/wafer lot	Each wafer lot	25°C maximum supply voltage	2(0) devices/wafer or 5(0) devices/wafer lot	Each wafer lot
	End Point Electrical Test	SMD				SMD		

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Group D – Conformance Inspection

Group D	**Frequency** - once every 36 weeks for each package family						
			Hermetic Classes		**Non-Hermetic Classes**		
			Class V		**Class P**		
Test/Subgroup	**Test**	**Method**	**Condition**	**Sample/ Accept**	**Condition**	**Sample/Accept**	**Comment**
D1	Physical Dimensions	2016		15/0		15/0	
D2	Lead/terminal integrity test (ceramic)	2004	B2	45/0	B2	45/0	3 devices minimum / 45 leads or terminals total.

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Group D – Conformance Inspection

Group D	Frequency - once every 36 weeks for each package family						
			Hermetic Classes		Non-Hermetic Classes		
			Class V		Class P		
Test/Subgroup	**Test**	**Method**	**Condition**	**Sample/ Accept**	**Cond**	**Sample/Accept**	**Comment**
D3	a. Thermal Shock	1011	Condition B, 15 cycles	15/0	N/A	N/A	
	Acoustic Microscopy (SAM)		N/A	N/A		30/0	
	Preconditioning (note 17)	JESD22-A113	N/A	N/A		30/0	After preconditioning and SAM 15 units go to TC and 15 units to UHAST.
	b. Temperature cycling	1010	Condition C, 100 cycles	15/0	JESD22-A104 150 cycles -55C to 125C	15/0	Condition C: -65°C to 150°C
	Acoustic Microscopy (SAM)		N/A	N/A		15/0	
	c. Moisture Resistance	1004		15/0	JESD22-A118 Unbiased HAST Condition B and/or (JESD22-A110) Biased HAST Condition B	15/0	
	d. Visual Examination	1001 or 1010	As applicable	15/0	As applicable	30/0	After preconditioning and SAM 15 units from TC and 15 units from UHAST, all 30 units need visual inspection
	e. Seal (Fine and Gross leak)	1014	As applicable	15/0	N/A	N/A	Non-hermetic package, no lid to seal
	f. End-point electrical parameters	Data sheet / SMD / JAN Slash-sheet		15/0		30/0	After preconditioning and SAM 15 units from TC and 15 units from UHAST, all 30 units need electrical end-point

Group D – Conformance Inspection

Group D	Frequency - once every 36 weeks for each package family						
			Hermetic Classes		Non-Hermetic Classes		
			Class V		Class P		
Test/Subgroup	Test	Method	Condition	Sample/ Accept	Condition	Sample/Accept	Comment
D4	a. Mechanical shock	2002	Condition B	15/0	N/A	N/A	Non-hermetic package, no lid to seal, no cavity
	b. Vibration, variable frequency	2007	Condition A	15/0	N/A	N/A	
	c. Constant acceleration	2001	condition E, Y1 orientation only	15/0	N/A	N/A	
	d. Seal (Fine and Gross leak)	1014	As applicable	15/0	N/A	N/A	
	e. Visual examination	2007	As applicable	15/0	N/A	N/A	
	f. End-point electrical test	Data sheet / SMD / JAN Slash-sheet		15/0	N/A	N/A	
D5	a. Salt atmosphere	1009	Condition A	15/0	Condition A	15/0	
	b.Visual examination	1009	As applicable	15/0	As applicable	15/0	
	c.Seal (Fine and Gross leak)	1014	As applicable	15/0	N/A	N/A	Non-hermetic package, no lid to seal
D6	Internal gas analysis (IGA) test (cavity packages)	1018	5000 PPM @ 100C	3/0	N/A	N/A	Non-hermetic package, no cavity
D7	Adhesion of lead finish	2025		15/0		15/0	Not for LCCC. Sample size number 15 leads from 3 devices minimum are based on number of leads with zero failure.

Group D – Conformance Inspection

Group D	**Frequency** - once every 36 weeks for each package family						
			Hermetic Classes		Non-Hermetic Classes		
			Class V		Class P		
Test/Subgroup	Test	Method	Condition	Sample/ Accept	Condition	Sample/Accept	Comment
D8	Lid torque	2024		5/0	5/0 (Where applicable)	5/0 (Where applicable)	
D9	a. Soldering Heat	2036	Stress during assembly	3/0	N/A	N/A	N/A for non-hermetic package
	b. Seal (Fine and Gross)	1014					
	c. External Visual Inspection	2009					
	d. End-point electrical test	Data sheet / SMD / JAN Slash-sheet					

TI Released 6 QMLP Products in 2023

SMD	Generic Part Number	PKG Type
5962R1820502PYE	TPS7H4001-SP	HTSSOP
5962R1822201PYE	TPS7H5001-SP	TSSOP
5962R2120302PYE	TPS7H1111-SP	HTSSOP
5962R1422802PYE	TPS7H3302-SP	HTSSOP
5962R1722002PYE	TPS7H2201-SP	HTSSOP
5962R1822002PYE	TPS7H2211-SP	HTSSOP

Approved by Qualifying Activity (DLA, NASA, Aerospace, JPL):

- MIL-PRF-38535 Class P with optimizations aligned with DLA
- New sites added for QMLP Class P using Class V wafer fabs
- Package Integrity Demonstration Test Plan (PIDTP) aligned with DLA for package technologies

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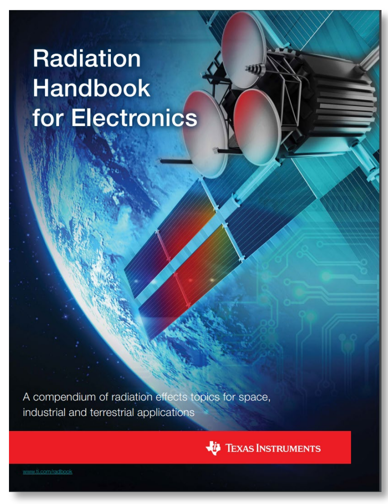
Space Power plastic pkg pin for pin compatibility

	Rad-hard QMLV Version Ceramic package	Rad-hard QMLP Version Plastic package	Rad-tolerant SEP Version Plastic package
Function		Pin for pin	
7V, 18A Buck	TPS7H4001-SP Production: **Now** *5962R1820501VXC*	TPS7H4001-SP Production: **Now** *5962R1820502PYE*	TPS7H4003-SEP Production: **Now** *V62/21609-01XE*
Dual phase PWM controller	TPS7H5001-SP Production: **Now** *5962R1822201VXC*	TPS7H5001-SP Production: **Now** *5962R1822201PYE*	TPS7H5005-SEP Production: **Now** *V62/22607-01XE*
Low-noise, high PSRR LDO	TPS7H1111-SP Production: **Now** *5962R2120301VXC*	TPS7H1111-SP Production: **Now** *5962R2120302PYE*	TPS7H1111-SEP Production: **Now** *V62/23602-01XE*
DDR memory termination LDO	TPS7H3301-SP Production: **Now** *5962R1422801VXC*	TPS7H3302-SP Production: **Now** *5962R1422802PYE*	TPS7H3302-SEP Production: **Now** *V62/22615-01XE*
7V, 6A smart load switch	TPS7H2201-SP Production: **Now** *5962R1722001VXC*	TPS7H2201-SP Production: **Now** *5962R1722002PYE*	TPS7H2201-SEP Production: **Now** V62/23608-01XE
14V, 3.5A load switch	TPS7H2211-SP Production: **Now** *5962R1822001VXC*	TPS7H2211-SP Production: **Now** *5962R1822002PYE*	TPS7H2211-SEP Production: **Now** V62/23609-01XE

TI Space documentation



Space Product Guide

- All TI products for Space
- Includes device listing for QMLV, Space-EP, Die, EMs, and Mechanical Samples
- Updated in Spring 2023

Space Circuit Handbook

- Ebook of useful space circuit designs including step-by-step instructions, formulas, and simulations to quickly get your design started

Radiation Handbook

- Provides explanation of radiation effects on semiconductors including TID, NDD, and SEE
- Written by industry experts Rob Baumann and Kirby Kruckmeyer

Visit www.ti.com/space for additional information