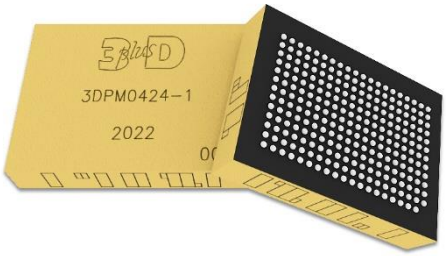
SPACE DDR4 TERMINATION REGULATOR

3DPM0424-1

Datasheet



1. GENERAL DESCRIPTION

The 3DPM0424-1 is a compact and flexible, Rad Hard by Design, sink/source Termination Regulator for low input voltage, low-noise Double Data Rate (DDR) memory. The 3DPM0424-1 maintains fast transient response times; offers a remote sensing function; supports control via Command pin and provides all power requirements for DDR4 V_{TT} bus designs.

By incorporating radiation effect mitigation techniques, the 3DPM0424-1 offers SEL/SET LETth of 60 MeV.cm²/mg and a TID of 75krad(Si).

The 3DPM0424-1 is manufactured with 3D PLUS's space qualified stacking technology designed for high reliability applications, and is available in a compact, low weight 259-pin BGA package.

2. KEY FEATURES

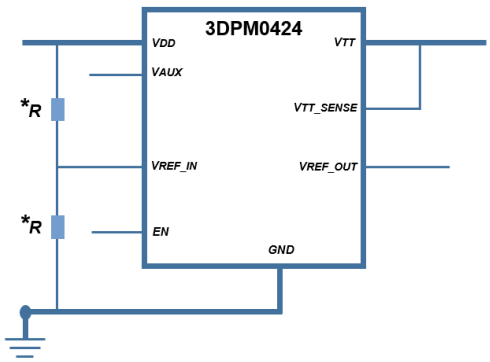
- Source and Sink current capability ±2A
- Output voltage (V_{TT}) regulated to V_{REF_IN}
- Reference voltage is set externally (V_{REF_IN})
- Reference voltage is buffered inside the module (V_{REF_OUT})
- Remote V_{TT} voltage sensing (V_{TT_SENSE})
- An Enable command is used to put V_{TT} output in high impedance state (Suspend-to-RAM mode)
- Thermal protection
- Eliminates the need for external output capacitors
- Tightly regulated voltage on V_{TT} output
- Radiation Hardened design:
  - TID > 75 krad(Si)
  - SEL and SET > 60 MeV.cm²/mg
- Operating temperature -40°C / +105°C
- Compact footprint with BGA259 package,

  30 x 22 x 6.4 mm

3. APPLICATIONS

Space Qualified Termination Regulator for DDR4 memories

4. TYPICAL APPLICATION SCHEMATIC



* External resistor value should be less than 470 Ω (330Ω ± 0.1% recommended).

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5. PINS DEFINITION AND ASSIGNMENTS

	1	2	3	4	5	6	7	8	9	10	11	12	13
Y	GND	VAUX	VAUX	GND	GND	VREF_OUT	VREF_OUT	GND	GND	GND	GND	GND	GND
W	VREF_IN	VAUX	VAUX	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
V	VREF_IN	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
U	GND	GND	GND	GND	GND	NC	NC	NC	NC	NC	NC	NC	GND
T	GND	GND	GND	GND	GND	NC	NC	NC	NC	NC	NC	NC	NC
R	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
P	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	VTT	VTT	VTT
N	NC	VTT_SENSE	VTT_SENSE	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT
M	NC	VTT_SENSE	VTT_SENSE	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT	VTT
L	NC	NC	NC	NC	NC	NC	VTT	VTT	VTT	VTT	VTT	NC	NC
K	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
J	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	EN
H	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	EN
G	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
F	VDD	VDD	VDD	VDD	VDD	NC	NC	NC	NC	NC	NC	NC	NC
E	VDD	VDD	VDD	VDD	VDD	NC	NC	NC	NC	NC	NC	NC	NC
D	VDD	VDD	VDD	VDD	VDD	NC	NC	NC	NC	GND	GND	GND	NC
C	VDD	VDD	NC	NC	NC	NC	NC	NC	NC	GND	GND	GND	NC
B	VDD	VDD	NC	NC	NC	NC	NC	NC	NC	GND	GND	GND	NC
A		VDD	NC	NC	NC	NC	NC	NC	DNU	GND	GND	GND	GND

Table 1: Module ball assignment

NAME	TYPE	NUMBER	FUNCTION
VAUX	Input	W2, W3, Y2, Y3	Auxiliary supply pins used to power the internal control circuits of the TR.
VDD	Input	A2, B1, B2, C1, C2, D1:D5, E1:E5, F1:F5	Supply voltage pins used to power the output stage of the TR (VTT output).
GND	Output	A10:A13, B10:B12, C10:C12, D10:D12, T1:T5, U1:U5, U13,V2:V13, W4:W13, Y1,Y4, Y5, Y8:Y13	Reference ground pins for the TR module.
VREF_IN	Input	V1, W1	Input reference voltage pin, shall be set to VDD/2.
VREF_OUT	Output	Y6, Y7	Buffered output reference voltage pin. This output may be used to provide reference voltage to the memory subsystem.
VTT	Output	L7:L11, M4:M13, N4:N13, P11:P13	Regulated output voltage pins, capable of sinking and sourcing up to 2A while regulating to the input reference voltage VREF_IN.
VTT_SENSE	Input	M2, M3, N2, N3	VTT sensing pin, used for improving remote load regulation. If remote sensing is not needed, this pin shall be connected to VTT output pins. This pin cannot be left open.
EN	Input	H13, J13	Active high enable command, used to set VTT output in regulation mode. When connected to GND, VTT output is in high impedance (Suspend to RAM mode).
DNU	-	A9	Do Not Use pins. These pins shall be left unconnected.
NC	-	A3:A8, B3:B9, B13, C3:C9, C13, D6:D9, D13, E6:E13, F6:F13, G1:G13, H1:H12, J1:J12, K1:K13, L1:L6, L12, L13, M1, N1, P1:P10, R1:R13, T6:T13, U6:U12	Pins not electrically connected.

Table 2: Pins description

6. SPECIFICATIONS

6.1 ABSOLUTE MAXIMUM RATINGS

Operation beyond the following limits may cause module degradation, affect module reliability or cause permanent damage to the module.

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Input Voltage	V_{DD}	0		3.5	V
Auxiliary Voltage	V_{AUX}	0		6	V
Output Current	I_{OUT}	-2		2	A
Input Reference Voltage	V_{REF_IN}	-0.3		7	V
Junction Temperature	T_J			+125	°C
Storage Temperature	T_{STG}	-55		+150	°C

Table 3: Absolute maximum ratings

6.2 RECOMMENDED OPERATING CONDITIONS

For proper operation, the module should be used within the recommended operating conditions.

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Input Voltage	V_{DD}	1.1		1.3	V
Auxiliary Voltage	V_{AUX}	3		5.5	V
Output Current	I_{OUT}	-2		2	A
Thermal Resistance Junction to Case	$R_{TH(J-C)}$			*TBD*	°C/W
Thermal Resistance Junction to Ambient	$R_{TH(J-A)}$			*TBD*	°C/W

Table 4: Recommended operating conditions

6.3 MECHANICAL AND ENVIRONMENTAL SPECIFICATIONS

PARAMETER	CONDITIONS	TYP			UNIT
Weight			8		g
Dimensions	balls included	30 (L)	22 (W)	6.4 (H)	mm

Table 5: Mechanical specifications

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Total Ionizing Dose		75			krad(Si)
SEL LET Threshold		60			MeV.cm²/mg
SET LET Threshold		60			MeV.cm²/mg

Table 6: Environmental specifications

6.4 INPUT & OUTPUT SPECIFICATIONS

Parameters are defined over the specified input voltage, output load and temperature range unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY CHARACTERISTICS						
Input Voltage Range	V_{DD}		1.1		1.3	V
Auxiliary Voltage	V_{AUX}		3		5.5	V
Input Reference Voltage	V_{REF_IN}		0.55		0.65	V
Auxiliary Supply Current	I_{AUX}		5		50	mA
OUTPUT CHARACTERISTICS						
Output Voltage	V_{TT}		V_{REF_IN} -0.04	V_{REF_IN}	V_{REF_IN} +0.04	V
Output Source Current	I_{OUTP}				-2	A
Output Sink Current	I_{OUTN}		+2			A
Buffered Reference Voltage	V_{REF_OUT}		V_{REF_IN} -10mV	V_{REF_IN}	V_{REF_IN} +10mV	V
Buffered Reference Output Current	I_{REF_OUT}		-840		100	µA

Table 7: Input and output specifications

6.5 COMMANDS AND PROTECTIONS SPECIFICATIONS

Parameters are defined over the specified input voltage, output load and temperature range unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
ON/OFF COMMANDS CHARACTERISTICS						
Enable Level	V_{ON}	EN	1			V
Inhibit Level	V_{OFF}	EN			0.35	V
Input impedance	Z_{IN}			24		kΩ

Table 8: Commands specifications

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
THERMAL PROTECTION CHARACTERISTICS						
Internal thermal shutdown temperature			+120		+135	°C
Junction Temperature	T_J		-40		+125	°C

Table 9: Protections specifications

7. FEATURES DESCRIPTION

One of the most critical aspects of a DDR4-TR module is its capability to maintain the regulated V_{TT} output within the regulation limits regardless of the output load.

Achieving tight regulation performance using a linear regulation method is difficult, as it requires a high regulation bandwidth with good stability margins.

To overcome these constraints on V_{TT} output regulation, a Bang-Bang regulation principle is used enabling the best dynamic performance without the risk of control loop instability or insufficient stability margins. This solution minimizes the size of the V_{TT} filter and guarantees a V_{TT} voltage that remains within the predefined limits under any output current transient.

The regulation circuit uses switches, comparators and an output filter. The integral output filter supports a continuous bipolar (sourced or sinked) 2A output current. The filter approach used ensures inherent stability of the V_{TT} output.

The series resistor in the RC output filter provides intrinsic output current limitation in case of output short-circuit to V_{DD} or GND improving the robustness of the DDR4-TR module. In case of permanent short-circuit, the module is protected from damage by a thermal protection circuit, which switches off the module to limit its internal temperature.

The resistive component of the filter has been divided into two parts. This solution improves module robustness by current limitation if spurious HS and LS command supervene under any overload condition without complex protection circuits.

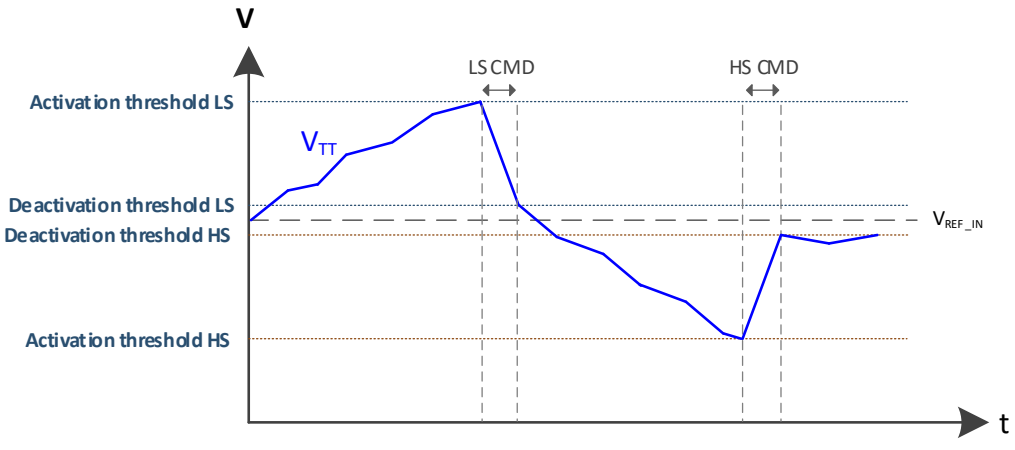


Figure 1: Regulated VTT output profile

The previous figure details the Bang-Bang regulation of the DDR4-TR module. The voltage is regulated close to V_{REF_IN} voltage. Several internal thresholds are generated to guarantee a ±40mV regulation such as HS activation/deactivation thresholds as well as LS activation/deactivation thresholds. The principle is explained as follows:

- If V_{TT} output voltage goes over LS activation threshold, a LS command is sent. Then, V_{TT} signal will decrease until it reaches LS deactivation threshold.
- If V_{TT} output voltage goes under HS activation threshold, a HS command is sent. Then, V_{TT} signal will increase until it reaches HS deactivation threshold.

An input filter is present on the V_{DD} supply input to attenuate AC current generated from the Bang-Bang regulation. V_{DD} filter is a low pass filter to draw a DC current from the V_{DD} line. A damped LC filter is included to not limit DDR4-TR source current and to avoid oscillations on the V_{DD} line.

The voltage reference (input supplied by the external resistor divider) is buffered and available as an output to be distributed to DDR4 memories.

The module also generates a voltage regulator to power internal circuits. This regulator allows to supply DDR4-TR module with a V_{AUX} auxiliary voltage between 3V and 5.5V.

A dedicated VTT_SENSE pin is also provided if remote V_{TT} sensing is needed. If the VTT_SENSE pin is not used, this pin shall be connected to VTT output pins.

An external ENABLE command is available to set V_{TT} output to high impedance state (output switches open) for suspend-to-RAM mode.

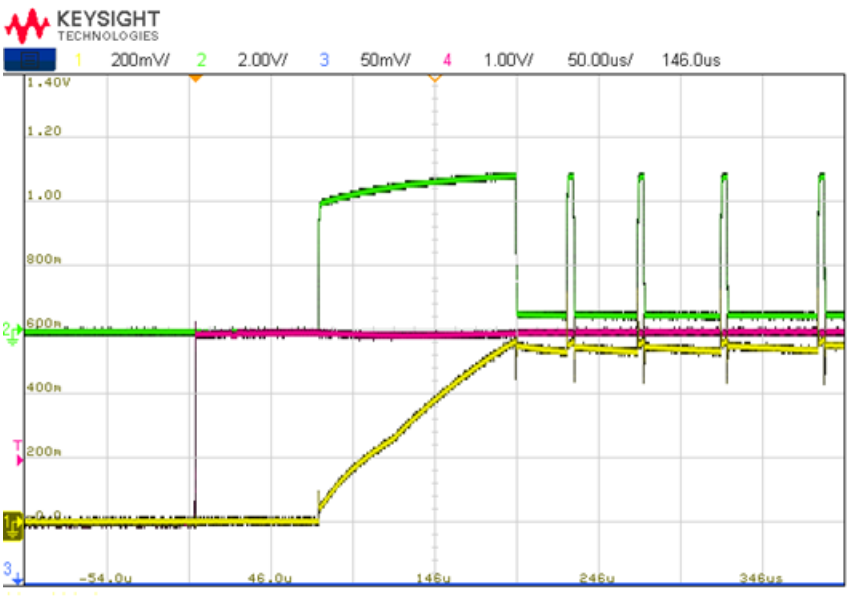


Figure 2: VTT regulation at start-up (V_{TT} HS_CMD ENABLE)

During start-up, the HS_CMD is ON. Once the thresholds are reached, the V_{TT} signal is regulated. As can be seen in Figure 2, 0.1A output current is sinked at DDR4-TR V_{TT} output.

8. BLOCK DIAGRAM

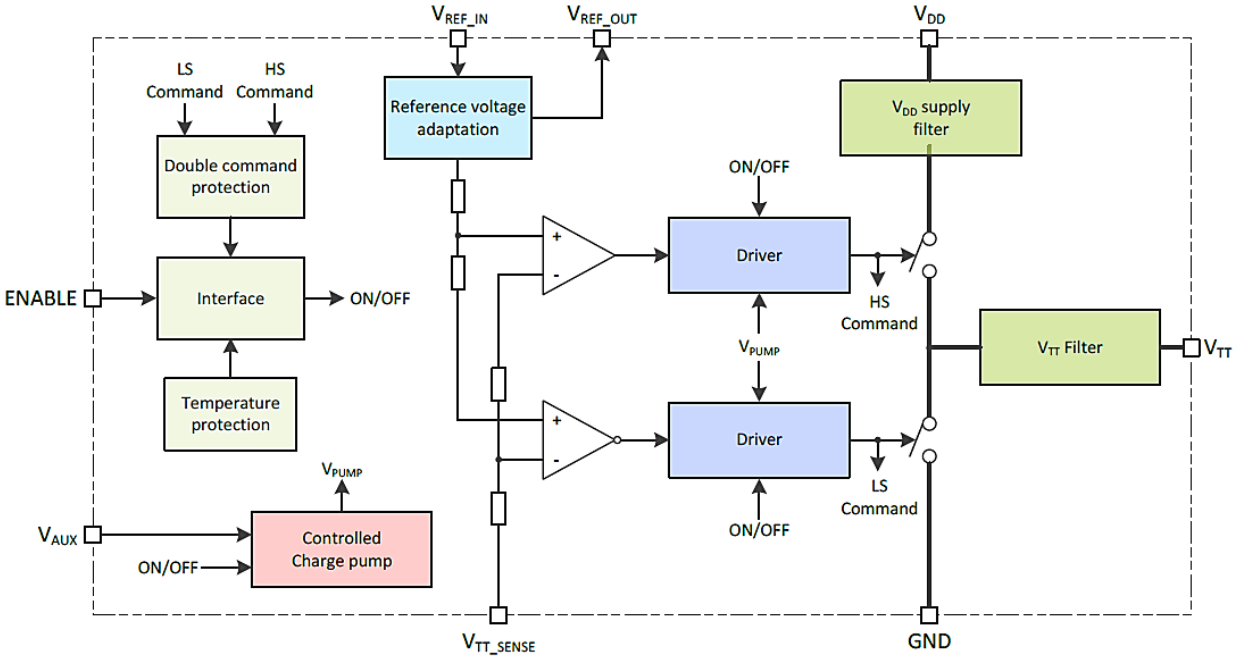


Figure 3: Functional block diagram

9. LAYOUT RECOMMENDATIONS

The DDR4-TR module has to be mounted close to the memories to reduce parasitic inductances. The resistor divider at V_{REF_IN} input has to be carefully chosen, with accurate resistors. Large copper pads have to be placed at VDD and VTT.

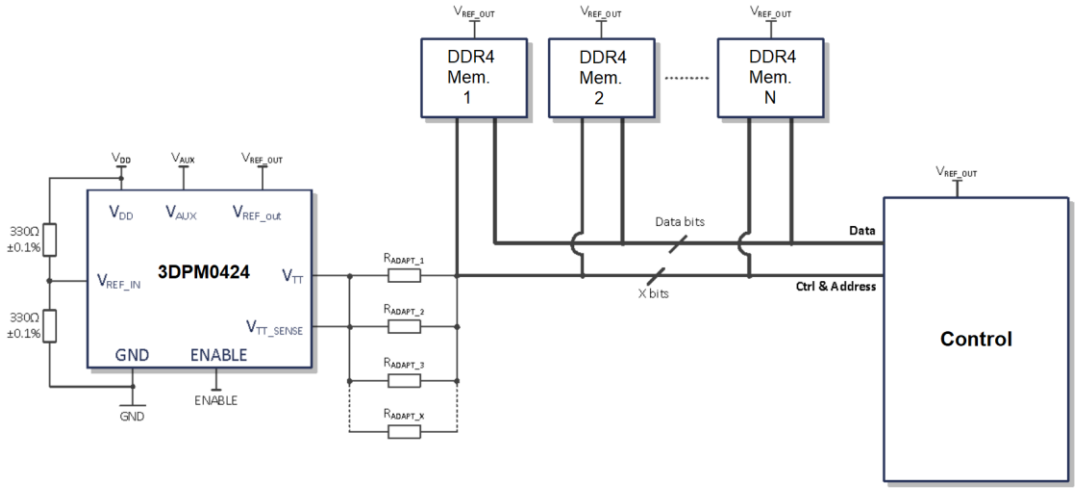


Figure 4: Typical application schematic with memories

10. MODULE MECHANICAL DRAWING (mm)

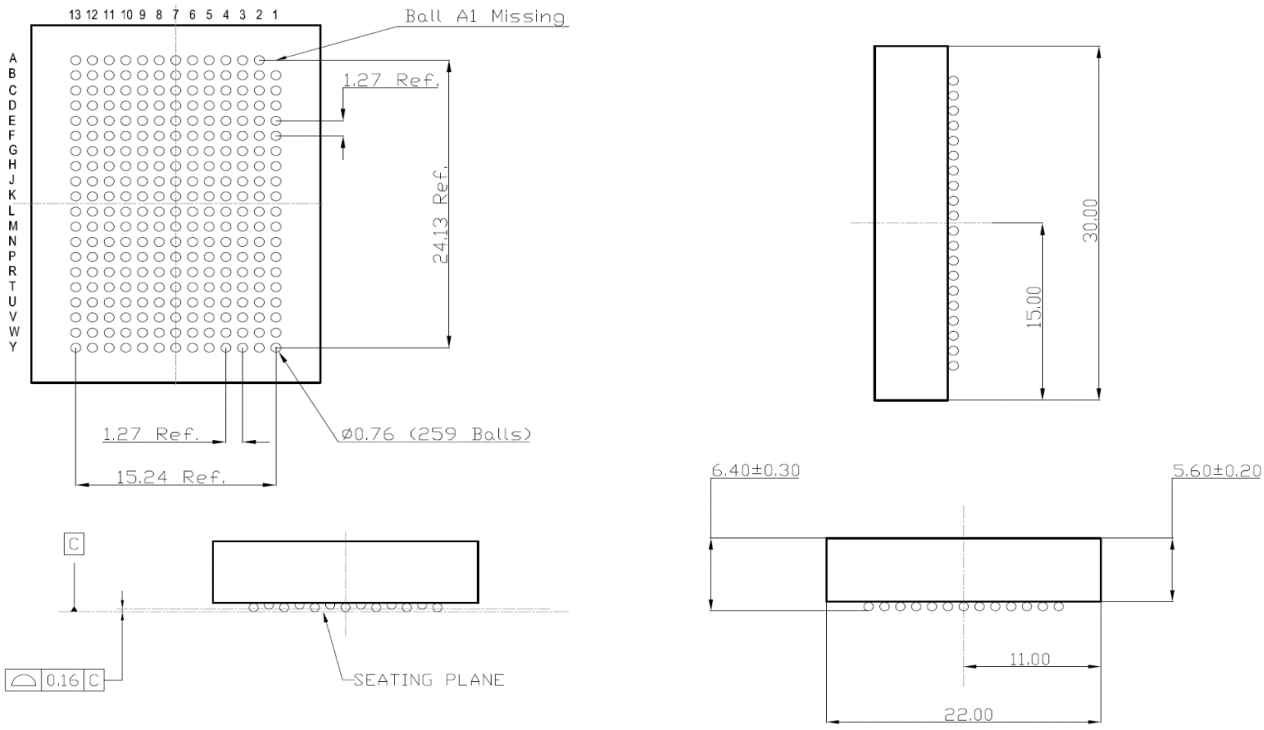
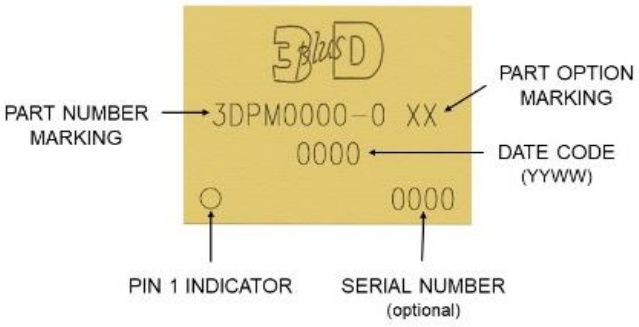


Figure 5: Mechanical drawing

Note: Module assembly must follow reflow guidelines as defined in: http://www.3d-plus.com/technical-documentation.php

11. PART NUMBER / ORDERING INFORMATION



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Temperature range

C = (0°C to +70°C)
I = (-40°C to +85°C)
S = (-40°C to +105°C)

Quality level

N = Commercial grade
B = Industrial grade
S = Space Grade

12. REVISION HISTORY

ED./REV.	DATE (DD/MM/YYYY)	DESCRIPTION
1	27/05/2020	Initial Document

Table 10: Revision history

HEADQUARTERS (FRANCE)	TECHNICAL CENTER (USA)	DISTRIBUTOR
408, rue Hélène Boucher - ZI 78530 Buc Tel: +33 (0)1 30 83 26 50 E-mail: sales@3d-plus.com www.3d-plus.com	151 Callan Avenue - Suite #310 San Leandro, CA 94577 Tel: (510) 824-5591 E-mail: sales@3d-plus.com	