M.2 Module Datasheet

10/01/2024 rev: 1.0

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1. Introduction

This datasheet details the design and configuration of MemryX's M.2 AI Acceleration Module (hereafter referred to as M.2 Module). The M.2 Module enables high performance, yet power-efficient AI inference for edge devices and edge servers. The M.2 Module is an ideal companion module for offloading the processing of deep neural network (DNN) computer vision (CV) models from the Host CPU. Its unique dataflow architecture excels in performing real-time, low latency neural network inference while saving system power.

The M.2 Module is based on MemryX's MX3 AI Accelerator IC. The M.2 Module's industry compliant PCIe Gen 3 connectivity supports high throughput for streaming input data and inference results to the Host processor. Its industry compliant M.2 2280 compact form-factor simplifies installation into a wide selection of Host platforms.

Features

- Four (4) MemryX MX-3TM "digital at-memory compute" AI ASICs
- Dataflow architecture optimized for high throughput, low latency applications
- Advanced power management
- Up to 20 TFLOPs dependent on available power
- Up to 80 million weight (4-bit) parameters
- Model parameters and matrix operators stored on-chip
- 2/4-lane PCIe Gen3 for up to 4GT/s bandwidth
- Multi-stream and multi-model support
- Floating-point activations for high accuracy
- Support for hundreds of AI models with no re-tuning required
- PyTorch, TensorFlow, Keras and ONNX model support
- OS Support for Windows 10/11 64-bit, Ubuntu 18.04 and later 64-bit

Specifications

SYSTEM	
AI Processor	MemryX MX3 (x4)
Host Processor Support	ARM, x86, RISC-V
ELECTRICAL	
Input Voltage	3.3V +/- 5%
Interface	PCIe Gen 3, 2 x 2-lanes
MECHANICAL	
Form Factor	NGFF M.2-2280-D5-M, Socket 3
Dimensions	3.15" x 0.87" (22 x 80 mm)
ENVIRONMENTAL	
Operating Temperature	0°-70° C
COMPLIANCE	
Certification	CE / FCC Class A, RoHS

2. Form Factor

The M.2 Module is designed to be compliant with M.2-2280-D5-M form factor defined in the spec. Refer to below table for the nomenclature and actual board picture/size.

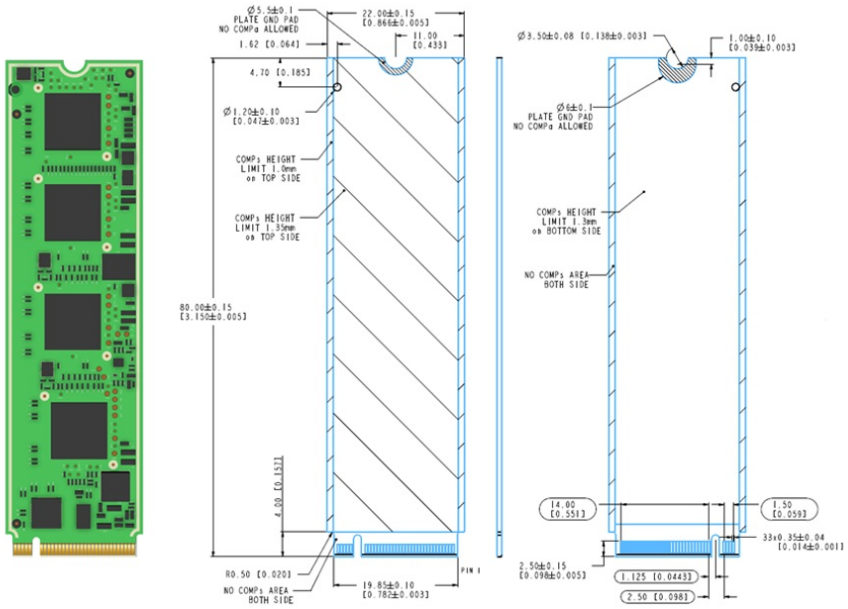
Type XX XX – XX – X – X[1]

Width (mm)
12
16
20
22[9]
25
28
30[9]

Length (mm)
16
20
24
26
28
30
42
60
80
110

Label[2]	Component Max Ht (mm) Top Max	Bottom Max
S1	1.2[4]	0[5]
S2	1.35[4]	0[5]
S3	1.5[4]	0[5]
S4	1.75[4]	0[5]
S5	2.0[4]	0[5]
D1	1.2	1.35
D2	1.35	1.35
D3	1.5	1.35
D4	1.5	0.7
D5	1.5	1.5
D6	3.2	1.5
D7	3.2	2.0
D8	6.5	1.5

Key ID	Pin	Interface
A	8-15	2x PCIe x1/USB 2.0/I2C/DP x4
B	12-19	PCIe x2/SATA/USB 2.0/USB 3.0/HSIC/SSIC/Audio/UIM/I2C/SMBus
C	16-23	PCIe/M-PCIe/USB 2.0/USB 3.0/SSIC/I2C-SlimBus/UIM/ANTCTL
D	20-27	Reserved for Future Use
E	24-31	2x PCIe x1/USB 2.0/I2C/SDIO/UART/PCM
F	28-35	Future Memory Interface (FMI)
G	39-46	Generic (Not used for M.2)[8]
H	43-50	Reserved for Future Use
J	47-54	Reserved for Future Use
K	51-58	Reserved for Future Use
L	55-62	Reserved for Future Use
M	59-66	PCIe x4/SATA/SMBus



3. Pin Definition

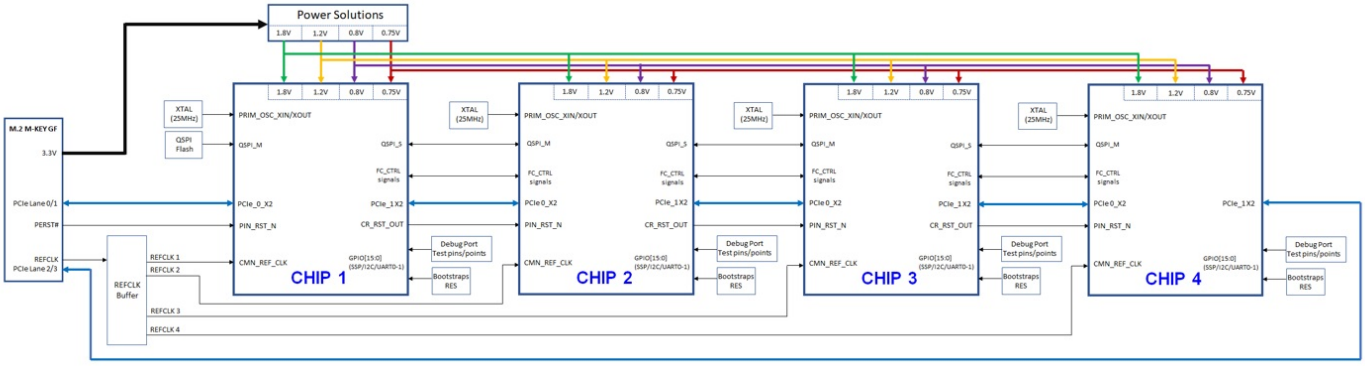
This pinout table and I/O direction is defined in the perspective of module, not baseboard perspective. Pin definition is compatible to PCI-SIG M.2 specification for M-key applications.

74	3.3V	GND	75
72	3.3V	GND	73
70	3.3V	GND	71
68	N/C	N/C	69
	Module Key	N/C	67
	Module Key	Module Key	
	Module Key	Module Key	
	Module Key	Module Key	
	Module Key	Module Key	
58	N/C	GND	57
56	N/C	REFCLKp	55
54	PEWAKE# (I/O)(0/3.3V)	REFCLKn	53
52	CLKREQ# (I/O)(0/3.3V)	GND	51
50	PERST# (I)(0/3.3V)	PERp0	49
48	N/C	PERn0	47
46	N/C	GND	45
44	N/C	PETp0	43
42	N/C	PETn0	41
40	N/C	GND	39
38	N/C	PERp1	37
36	N/C	PERn1	35
34	N/C	GND	33
32	N/C		

30	N/C	PETp1	31
28	N/C	PETn1	29
26	N/C	GND	27
24	N/C	PERp2	25
22	N/C	PERn2	23
20	N/C	GND	21
18	3.3V	PETp2	19
16	3.3V	PETn2	17
14	3.3V	GND	15
12	3.3V	PERp3	13
10	N/C	PERn3	11
8	N/C	GND	9
6	N/C	PETp3	7
4	3.3V	PETn3	5
2	3.3V	GND	3
		GND	1

4. Block Diagram

Below is the block diagram of the M.2 Module.

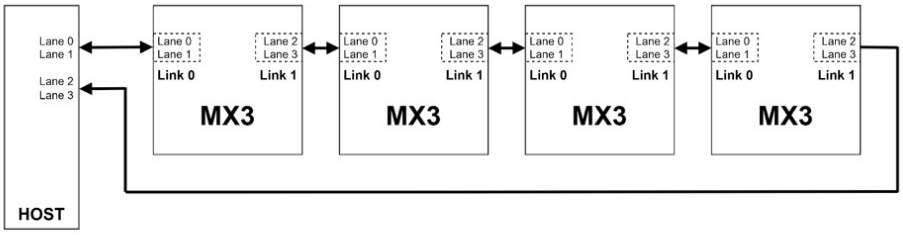


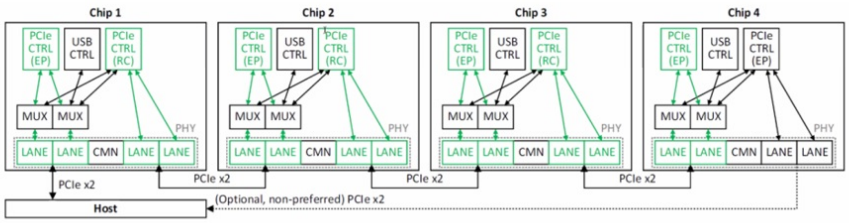
5. Power Design Constraint

The M.2 Specification restricts current draw to 500mA/pin. With nine power pins, that is a limit of 4500mA, or 14.85W power dissappation. The M.2 module uses current sensing to insure the power does not exceed the limit. Some older motherboards do not provide power to all nine pins, so they cannot support the full power. If there is an issue ennumerating or running inference, try a newer motherboard.

6. PCIe Key Features

In normal operation, Chip 1 receives input (video or image stream for CV applications) data from the external Host processor via a PCIe connection. The Host processor expects an inference result in return. If Chip 1 is able to run all the layers of AI model on its own, it will process the data and return a result to the Host using the same bidirectional PCIe link. If the model uses 2 or 3 chips, the data is sent from Chip 1 to Chip 2 and, if required, to Chip 3. The inference result is sent back to the Host via the same PCIe path but in the reverse direction. If the model uses all 4 chips, instead of sending the result in the reverse direction through Chips 1-3, the result can be sent directly from Chip 4's output PCIe port to the M.2 connector to the Host.

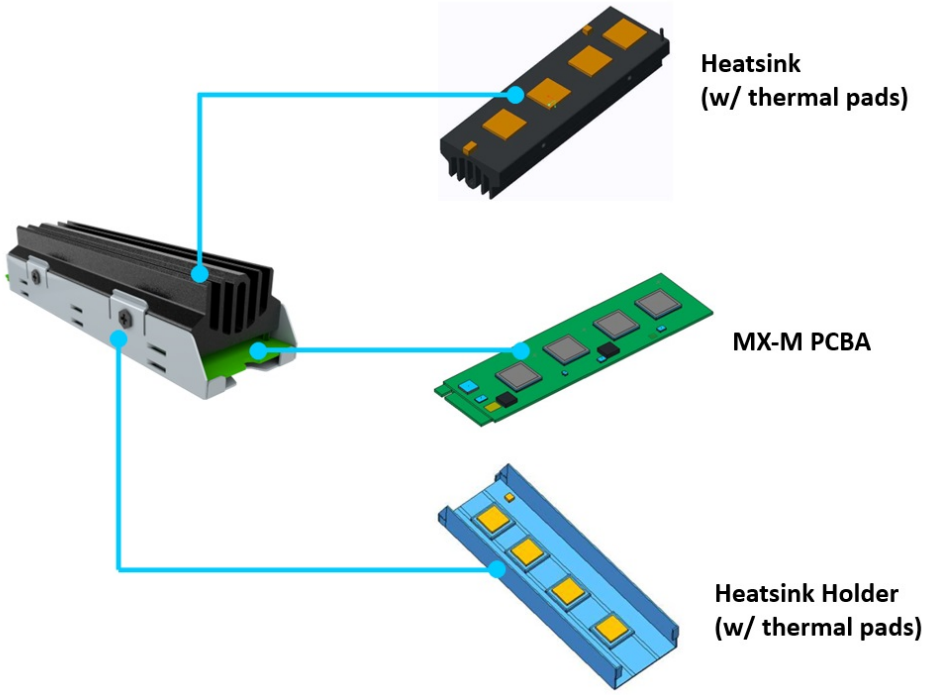




7. Thermal

This section shows the thermal solution using on the M.2 Module for heat dissipation. Here are four simulated cases based on different conditions to showcase the capability of M.2 Module and thermal solution.

Cases	1	2	3	4
Condition	Worst	Normal	Low Power	Low Power
System TDP	14.85W	11.55W	7.115W	4.876W
Ambient Temp	70C	70C	40C	25C
Heatsink	Yes	Yes	Yes	No
Airflow Requirement (Min)	1 CFM	0.8CFM	0 CFM	0 CFM

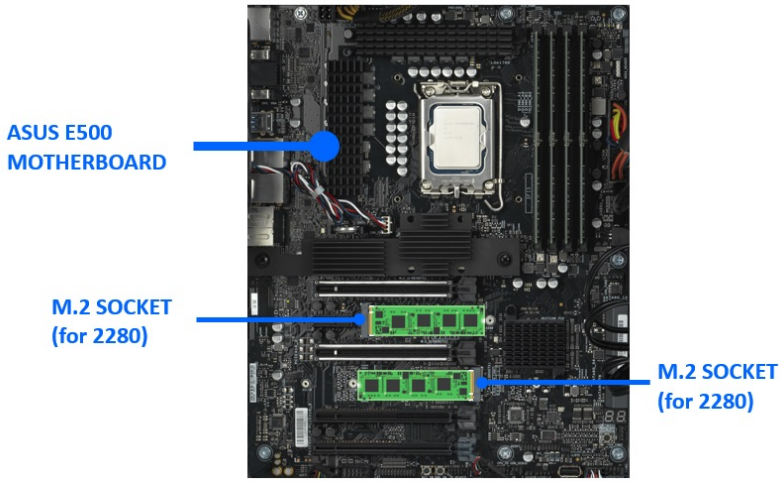


8. Use Cases

This section demonstrates several use cases of M.2 Module.

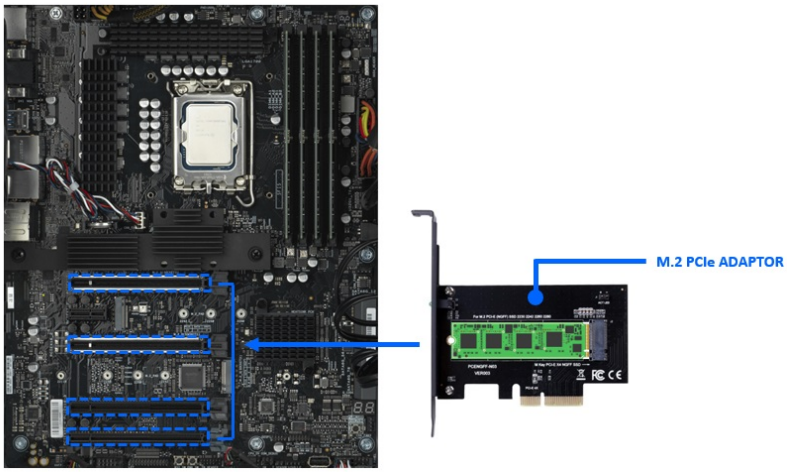
8.1 M.2 socket on Mother board

Many motherboards have two or more M.2 slots. One is typically used to boot from SSD, and the other could be used for the M.2 accelerator. If there is only one slot and its occupied by an SSD M.2 module, it might be possible to configure the motherboard to boot from a SATA SSD instead, freeing up the M.2 slot for the accelerator. If not, see section 8.2 for another solution.



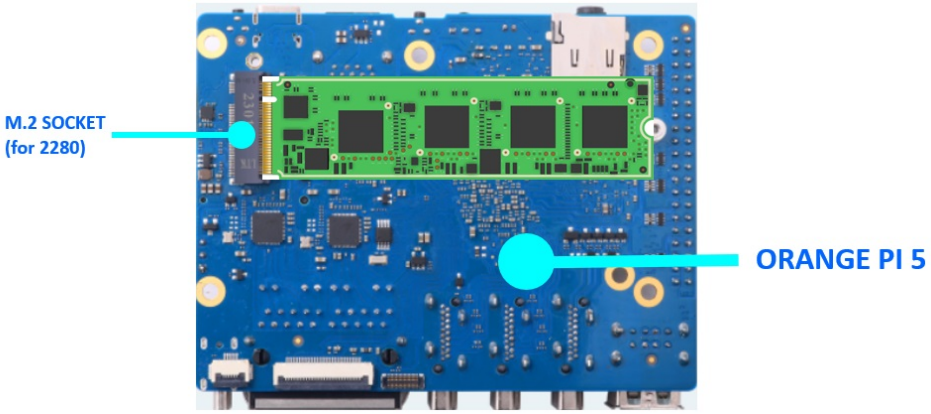
8.2 PCIe-M.2 adaptor on Mother board standard PCIe slot

If there is no M.2 slot on the motherboard, a PCIe adapter board can be used to mount the M.2 module.



8.3 M.2 socket on embedded systems

Orange Pi 5 is a small embedded system with one M-key M.2 socket, which is a good development platform.



9. Ordering Information

PART NUMBER	DESCRIPTION
MX3-2280-M-4-C	4-chip M.2 module, 22x80 mm, M-Key, Commercial Temp

10. Revision History

Date	Version	Revision
2023.11.06	0.1	Initial release.
2023.12.15	0.2	Updated
2024.07.23	0.3	Internal Release for Review
2024.07.24	0.31	Release for Public Distribution
2024.10.03	1.0	Production Release

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