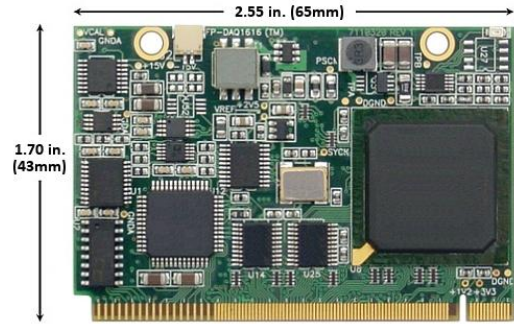


The FeaturePak™ Whitepaper

Overview

The FeaturePak™ Specification defines a highly-compact, low-profile, and inexpensive way to add configurable I/O functions to embedded systems. The tiny modules -- measuring just 1.70 x 2.55 inches (43 x 65 mm) -- can implement snap-in options or upgrades for off-the-shelf single board computers (SBCs) or computer-on-module (COM) baseboards, or can be used as building-blocks to simplify the development of fully-custom embedded electronics.

This new mezzanine-style embedded I/O expansion standard is highly synergistic with existing and emerging bus, I/O, chip and board-level technologies. It leverages the latest high-speed serial expansion standards -- such as PCI Express and USB -- and is compatible with a wide range of current and future processors, including both x86 and RISC architectures. Additionally, the modules provide "zero height expansion," in that they fit within the normal component envelope of an SBC or COM baseboard and add no height to PC/104-style I/O expansion stacks.



FeaturePak History

The FeaturePak standard was originated by Diamond Systems Corp., one of the first supporters of the venerable [PC/104](#) modules standard. Although PC/104 and [PC/104-like](#) stackable modules had evolved to encompass new technologies, there was a perceived need for an even smaller, lower-profile, mezzanine-style I/O expansion format for use on tomorrow's compact, highly-integrated SBCs and COM baseboards. The FeaturePak standard was developed to fill this gap in what was currently available in the embedded market.

Features and Benefits

Key features and benefits of FeaturePak are summarized in the table below:

FeaturePak Features	FeaturePak Benefits
<ul style="list-style-type: none"> • Compact, low profile form-factor — 3/5 the size of a credit card and 1/3 the size of a PC/104 module • Single low-cost connector integrates all host and external I/O interfaces • Provides up to 100 I/O points per module • Leverages industry-standard buses such as PCIe, USB, and I²C • Host processor and form-factor agnostic • Coexists with PC/104, SUMIT, Qseven, ETX, XTX, COM Express, etc. • Multiple FeaturePak modules may be present within one system • Zero height expansion module • Open industry standard • Rugged and reliable 	<ul style="list-style-type: none"> • Shortens time-to-market • Reduces board-level development costs and risks • Simplifies system design • Eliminates cables, resulting in higher reliability, lower cost, and faster assembly • Enables scalable and reconfigurable system design • Enables easy product upgrades • Protects from component obsolescence • Encapsulates intellectual property • Suitable for SBCs, baseboards, and proprietary all-in-one hardware designs • Ideal for rapid-prototyping through high-volume applications • Ideal format for silicon vendor reference designs • Open standard increases market acceptance

FeaturePak Connector Signals

The FeaturePak standard uses a single, high-density, 230-pin card-edge connector. The FeaturePak module inserts into the connector at an angle and then swings down to lie parallel to the host PCB. The module is then secured with two screws.

The use of a single low-cost connector plus gold fingers on the FeaturePak module results in the lowest possible cost for a mezzanine board interconnect solution. The socket's MXM connector is rated for 2.5Gbps operation, fast enough for PCI Express and various high-speed I/O interfaces, including USB 2.0 and gigabit Ethernet.

In comparison with the venerable stackable PC/104 module and socket, the FeaturePak module is about 1/3rd the size of a PC/104 module, and its socket provides 220% of the signal density in 85% of the board space. Additionally, the FeaturePak socket is lower profile, at 0.31 inch (7.8 mm) vs. 0.43 inch (11 mm) for PC/104's.

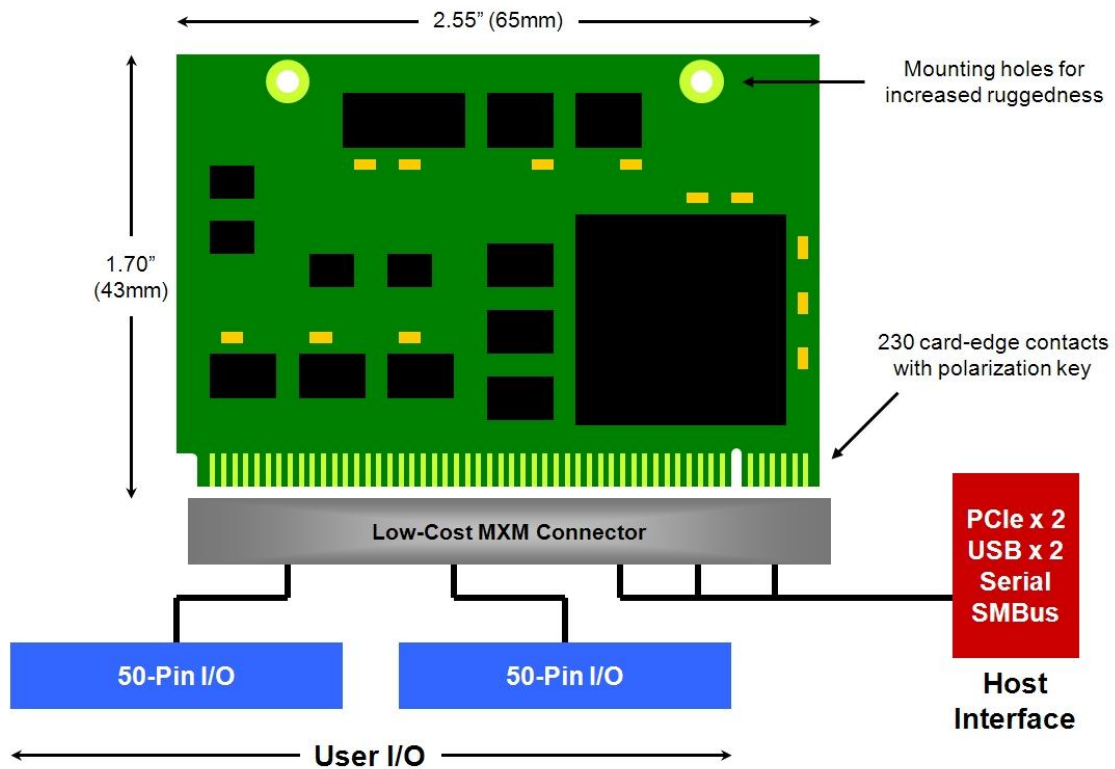


PC/104 stackable expansion – 104 pins in 1.04 inch²



FeaturePak socket – 230 pins in 0.88 inch²

The figure below illustrates the FeaturePak module's host and external I/O bus signals. All connections — including power, host interface, and external I/O — are carried by a single low-cost, high-density, 230-pin MXM connector, originally designed for use with notebook computer graphics modules.



It should be noted that the FeaturePak standard’s utilization of the 230-pin MXM connector differs from that of the [MXM graphics standard](#), as well as from other standards that employ MXM connectors, such as [Qseven COMs](#).

Height Considerations

Although MXM connectors are available with several board-to-board heights, FeaturePak sockets use the MXM connector options that provide 0.2 inch (5.0 mm) spacing between the bottom of the FeaturePak module and the top surface of the baseboard. Allowed component thicknesses on the top and bottom of FeaturePak modules vary according to two types of module – “Standard” and “Tall” – as well as by regions on the top and bottom surfaces.

The maximum topside component thickness on a Standard FeaturePak module is 0.19 inch (4.8 mm), while that on a Tall module is 0.4 inch (10 mm). The Standard height module in a FeaturePak socket on a baseboard can have a PC/104 or similar stacking board with 0.6 inch board-to-board spacing installed above it. Many FeaturePak applications will not require this restriction.

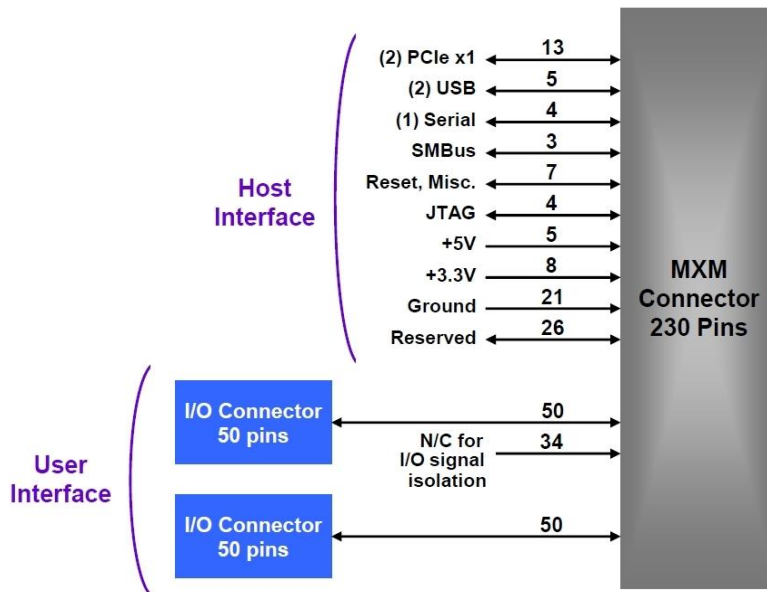
The bottom surface of either type FeaturePak module supports maximum component heights of 2 mm or 3 mm, depending on location. Details are provided in the FeaturePak Specification and Design Guide.

FeaturePak Signal Groups

All of the FeaturePak module's host and external I/O interface and power connections are carried by a single low-cost, high-density, 230-pin connector. These signals consist of the following:

- **Host interface** — includes 2 PCI Express x1 links, 2 USB (1.1 or 2.0) channels, 1 serial port (logic-level TX, RX, RTS, CTS), SMBus, reset, JTAG, auxiliary signals, a slot ID, +3.3V, +12V, and ground.
- **Primary I/O signal group** — includes 50 I/O signals, +5V, and ground. Within this group, 34 signal pairs are implemented with enhanced isolation for use in applications such as high-precision analog, Ethernet, and optically-isolated I/O.
- **Secondary I/O signal group** — includes 50 general purpose I/O signals, +5V, and ground.

The FeaturePak connector interface signals are illustrated in the figure below.



Two frequently asked questions regarding the FeaturePak connector’s signal assignment are:

- How are the two groups of 50 I/O signals intended to be used?
- Why aren’t power and ground pins included in the two 50-line I/O signal groups?

The answer to both these questions is that these two 50-line groups on the FeaturePak’s MXM connector were intentionally left unspecified in order to maximize FeaturePak flexibility. Letting each FeaturePak define its 100 external interface lines broadens the range of applications that can be supported. Power and ground can be assigned to as many lines as required, in a card-specific manner.

This lack of specificity in the initial FeaturePak standard does not preclude the possibility of developing multiple market- or application-specific external interface “profiles” in the future, however.

Power Considerations

FeaturePak modules operate on 3.3V, although they may optionally use 5V power for auxiliary functions (depending on the specific FeaturePak module). All logic levels are implemented with standard 3.3V signaling.

Based on the MXM connector’s maximum per-pin current rating of 0.5A and the number of defined power pins on the FeaturePak interface, maximum FeaturePak module power consumption is 12W from its 3.3V inputs. Additionally, up to 15W of power can be supplied to a FeaturePak via its optional 5V inputs. The connector’s +12V interface pin is not intended for powering the module.

“FeaturePak” vs. “FeaturePak USB” Sockets

The FeaturePak standard defines two types FeaturePak sockets: “FeaturePak” and “FeaturePak USB.” Each requires a minimum set of functions to be implemented, in order to ensure interchangeability with the open market of FeaturePak modules. The only difference between the two is the minimum number of PCI Express and USB links. The minimum set of functions that must be provided by each type of FeaturePak socket appears in the table below.

Function supplied to FeaturePak Socket	Must be provided by “FeaturePak” compliant host sockets	Must be provided by “FeaturePak USB” compliant host sockets
+3.3VDC power	2A, minimum	2A, minimum
+5VDC power	1A, minimum	1A, minimum
PCI Express x1 lanes	1	0
USB 1.1 or 2.0 ports	1	2
Serial port	0	0
PCI Express reset	Yes	Yes
Slot ID	Yes	Yes

FeaturePak modules, on the other hand, are allowed to implement subsets of the host interface signals (although a future release of the FeaturePak Specification may define certain minimum requirements).

Thus, a FeaturePak module may communicate with the host board via any combination of PCI Express, USB, and serial interfaces. All subsets of these interfaces are permitted -- resulting, for example, in possibilities such

as a USB-interfaced serial expansion module, a serial-interfaced GPS module, or a PCI Express-interfaced Ethernet switch or video framegrabber.

How rugged is it?

Another question often asked is: “How rugged is this standard?” or: “Aren’t miniature card-edge finger contacts (230 contacts on 0.5 mm pitch) unreliable?”

With questions like this in mind, Diamond subjected the FeaturePak card and connector design to shock/vibration testing. The company reports that the form-factor and its connector successfully passed random vibration testing up to 6.07Grms over 20Hz through 2000Hz in 3 axes, according to MIL-STD-781D Task 401. Refer to the graph below for the test profile used.

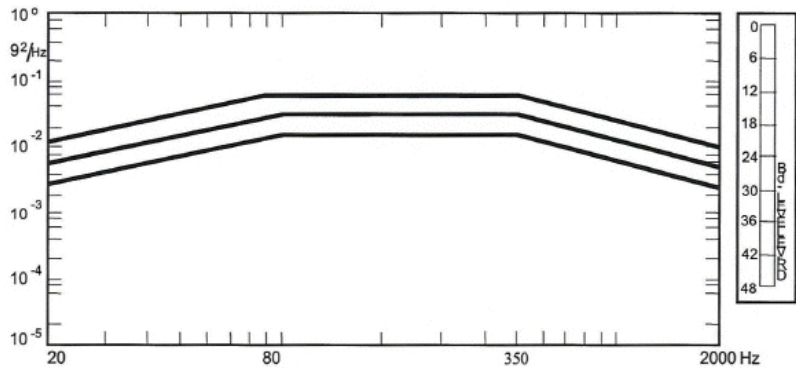
**Vibration Profile
Random Vibration Spectrum**

Frequency (Hz)	Amplitude
20	0.01 g ² /Hz
20 to 80	+3 dB/Octave
80 to 350	0.04 g ² /Hz
350 to 2000	-3 dB/Octave
2000	0.007 g ² /Hz

Overall acceleration = 6.07 G_{RMS}
Vibration duration = 10 minutes

Note: This Random Vibration Profile conforms to MIL-STD-781D Task 401 Figure 401-1.

PM426-48



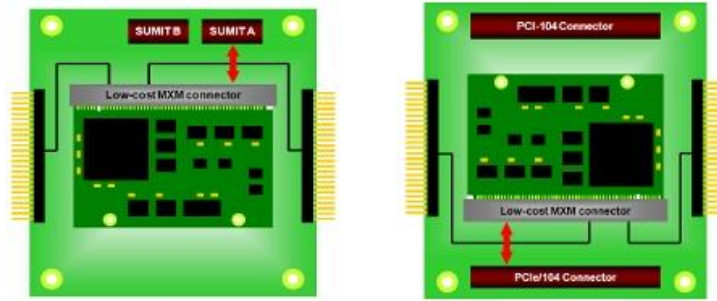
Vibration Profile A. Random Vibration Spectrum

TEST TOLERANCES

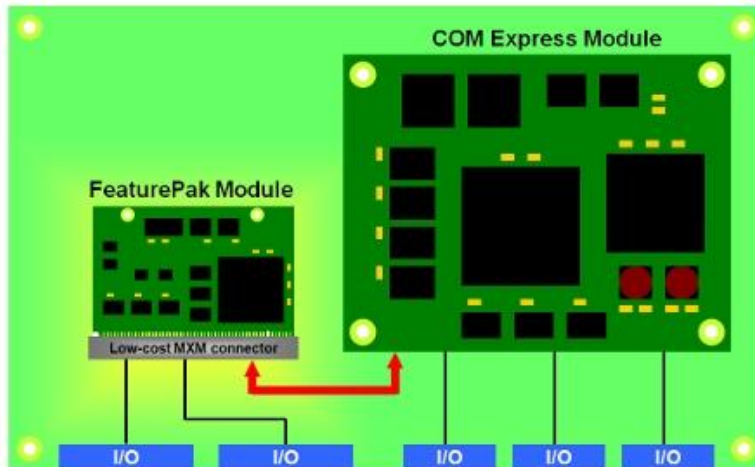
The test tolerances shall be as follows:

Frequency	Greater of ±2% or ±1 Hz
Equalization and analysis bandwidth	≤ 25 Hz
Acceleration spectral density	±3 dB
Overall acceleration	±10%
Duration	+10, -0%

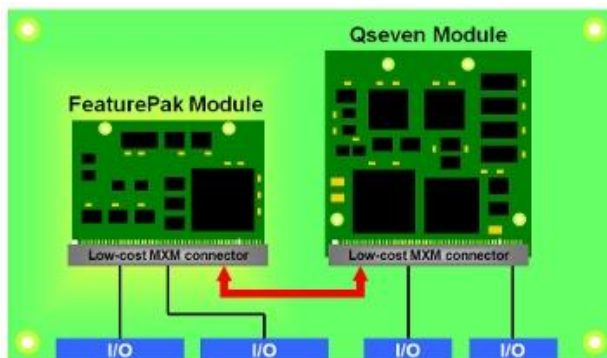
Figure 7: Vibration Profile Task 401



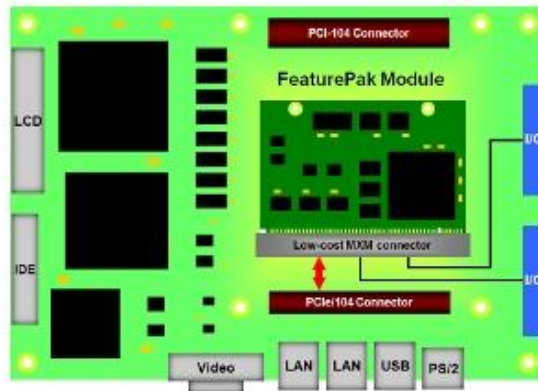
FeaturePak Sockets on stackable [SUMIT-ISM](#) and [PCI/104-Express](#) modules



FeaturePak Socket on a [COM Express](#) baseboard



FeaturePak Socket on a [Qseven](#) COM baseboard



FeaturePak Socket on an [EPIC Express](#) SBC

About the FeaturePak Trade Association

In mid-2010, ownership of the FeaturePak specification, trademark, and logos were transferred to the FeaturePak Trade Association, a California Nonprofit Trade Association (FPTA), in order to ensure that everyone in the embedded market could enjoy its benefits equally. The FPTA is now responsible for maintaining, extending, and promoting the FeaturePak standard and has established restrictions and guidelines pertaining use of the FeaturePak trademark and logos.

You need not join the FPTA or be otherwise licensed, in order to develop or manufacture products based on or incorporating FPTA specifications. However, use of FPTA-owned logos is restricted to FPTA members in good standing or to those explicitly licensed by the FPTA to use them. Please contact the FPTA for details regarding non-member licensing of FPTA logos.

Further Information

To learn more about the FeaturePak standard and the FeaturePak Trade Association, to obtain a copy of the FeaturePak Specification, or to find out how to join the FPTA, visit FeaturePak.org.

(FeaturePak™ is a trademark of the FeaturePak Trade Association)