



How to Design Custom Enclosures for Motherboards

IF YOU'RE LOOKING TO INTEGRATE A STANDARD FORM FACTOR MOTHERBOARD INTO YOUR CUSTOM ENCLOSURE, PROTOCASE IS HERE TO HELP.

Here are the three most common motherboard form factors:

Mini ITX

It is the smallest standard motherboard (6.7" x 6.7" or 170mm x 170mm) that will allow you to mount a PCIe card (but only one!) and is great for cases where small size/volume is a requirement. There will only be connectors for a few peripherals (sata drives, fans, etc).

Micro ATX

It is larger (9.6" x 9.6" or 243.8mm x 243.8mm) than the Mini ITX, allowing you to mount up to four PCIe cards, with more connectors for peripherals.

ATX

This is even larger (9.6" x 12" or 243.8mm x 304.8mm), allowing up to seven PCIe cards and more peripheral connectors than Micro-ATX boards. The ATX form factor is the most common and versatile motherboard.

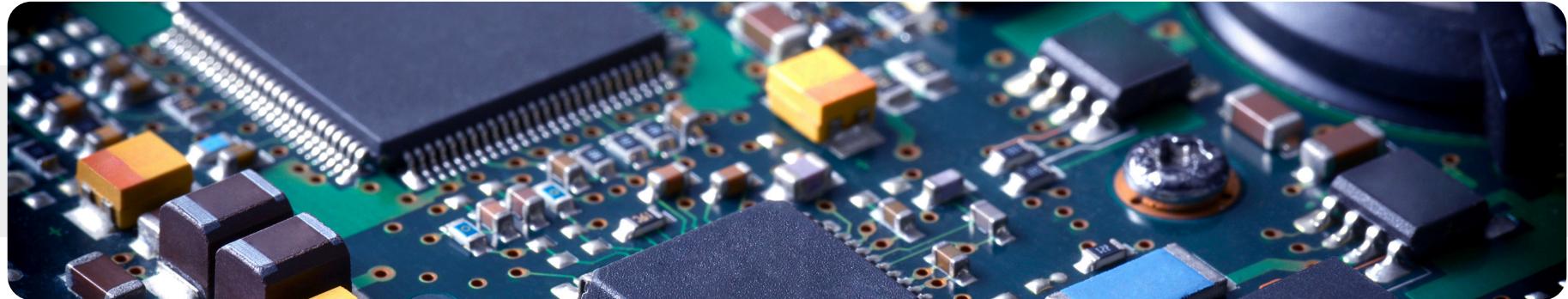
This resource covers the key elements of designing custom enclosures that accommodate ATX, Micro-ATX and Mini-ITX motherboards. It also provides essential details such as dimensions, mounting the boards, and how to access input/output (I/O) connectors.



By VIA Gallery from Hsinlien, Taiwan - VIA Mini-ITX Form Factor Comparison uploaded by Kozuch, CC BY 2.0, <https://commons.wikimedia.org/w/index.php?curid=3928561>

Note: Many of the concepts in this resource also apply when designing enclosures for other motherboard form factors and custom-built circuit boards as well.

CONCEPTS



- Specific dimensions such as mounting hole patterns and I/O connector block locations are standardized on all motherboards of the same form factor.
- You'll want to start by designing the mounting pattern on the base, I/O and (or) PCIe card slot openings.
- Make sure to consider clearances between the edges of the motherboard, fans, components, drives, cables, etc., and the sides of the enclosure.
- Motherboards are typically attached to the enclosure with a stud/threaded post combination to avoid direct contact between board circuitry and the enclosure surface.
- Adequate ventilation must be designed into the enclosure to avoid component overheating.
- Location of mounting holes, and cutouts for I/O and PCI Cards, are given relative to an origin on the corner of the motherboard.
 - These must be offset correctly when transferred to your enclosure design.
 - Key factors such as the desired offset of the board from inside surfaces, thickness of enclosure walls, and height of standoffs must be considered.

WHERE AND HOW TO MOUNT THE BOARD



- The I/O board edge is typically placed 0.065" from the inside enclosure wall to correctly accommodate the I/O plate adapter and the PCI card brackets. (This equates to .020" between PCI bracket and inside enclosure wall.)
- We typically have 0.375" between the bottom of the motherboard and the case. At least 0.250" of space is recommended below the motherboard to keep it from contacting the case and possibly shorting out the board.
- Allow a minimum 0.250" (6.35mm) clearance from other board edges to their corresponding side panels.
 - It is possible to use smaller clearances for these sides. However, if you do, consider possible interferences between the board and enclosure details such as flanges, fasteners, and bend radii. This will also make it harder to access the connectors near the edges of the board.
 - Some PCI cards are longer than the example used in the motherboard images in this document (keep this in mind when designing your case).
 - If using smaller clearances, be sure to discuss this with your Account Manager or technical representative, depending on which stage in the designing process you are in.

WHERE AND HOW TO MOUNT THE BOARD



- Use threaded posts to raise the board above the floor of the enclosure to avoid contact of parts on the underside with the metal casing (see figure below).
- Standard motherboard mounting holes will accept a 6-32 thread size.
- A PEM style self-clinching stud has an external thread; a 1/4" (6.35mm) long PEM stud and a 3/8" (9.53mm) threaded post should be suitable for most enclosure thicknesses.

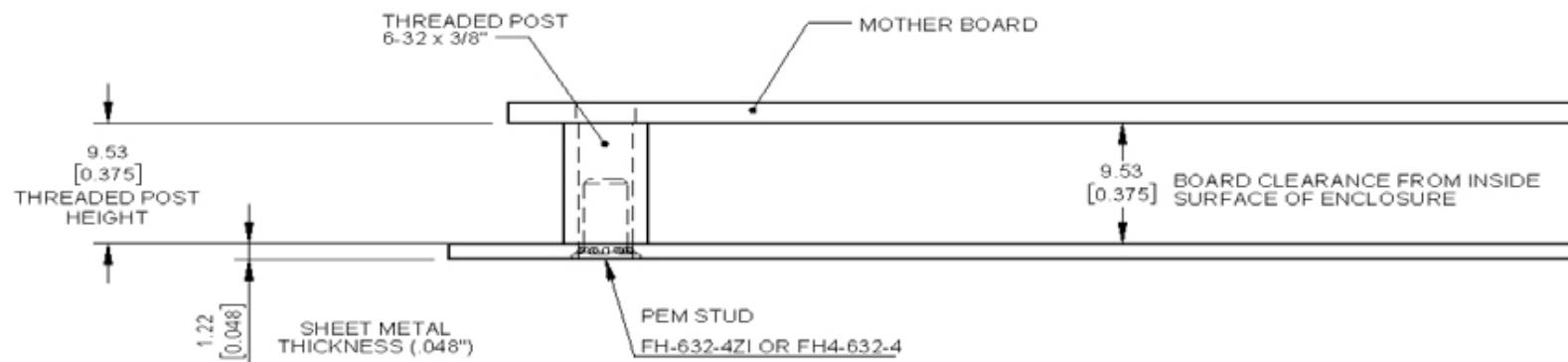


Figure - Minimum offsets from bottom panel of an enclosure

- Allow a minimum of 0.250" (6.35mm) clearance from the bottom of the board to the inside surface of the enclosure. In the image above we allow .375" clearance.
- A 0.375" (9.53mm) threaded post, mounted in an 18 gauge (0.048") enclosure wall, will provide only .375" (9.53mm) clearance between the inside surface of the enclosure and the board.

DESIGNING THE BASE



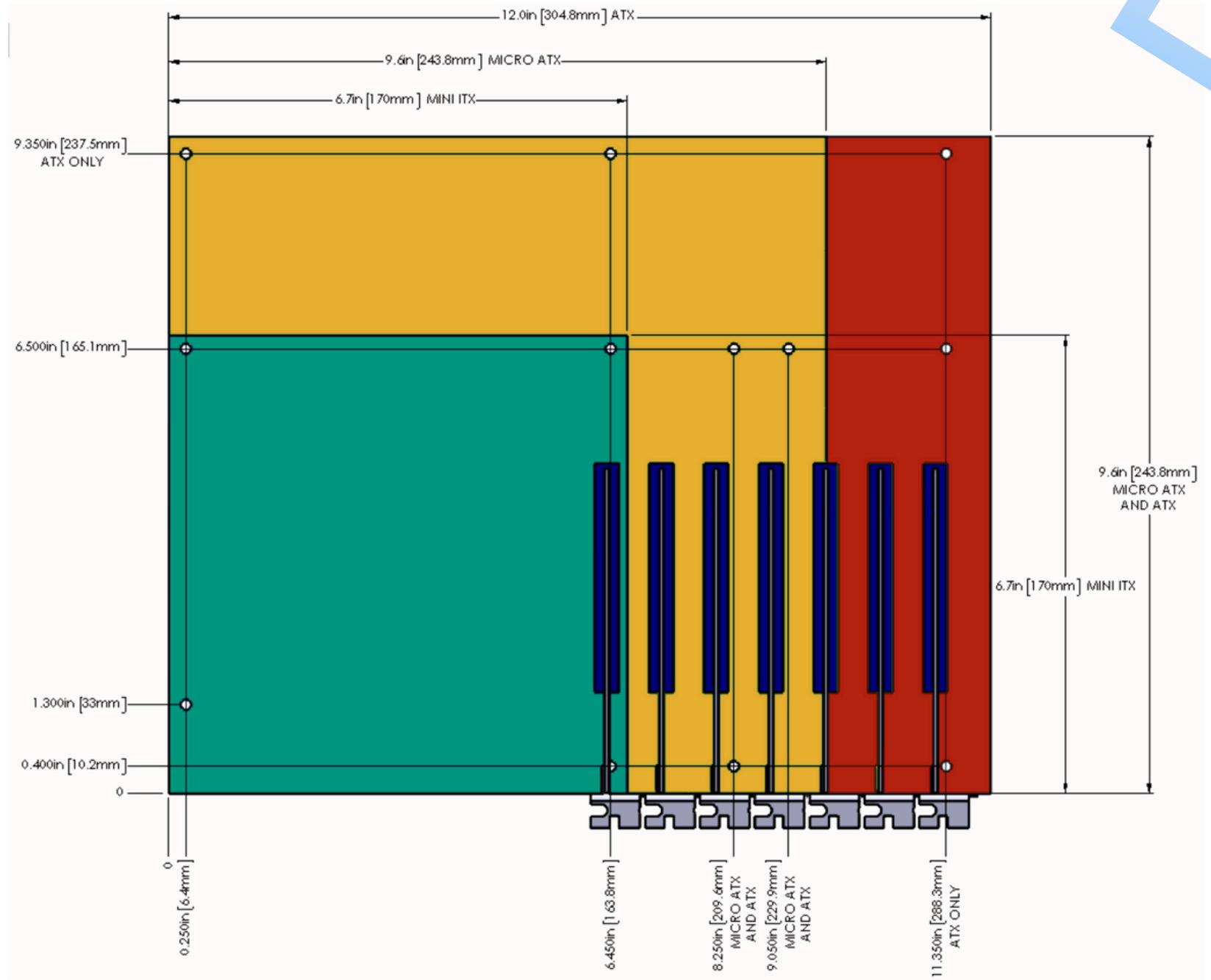
All motherboards of the same form factor have the same overall dimensions, mounting holes, I/O location and PCIe card locations. The location of the rest of the connectors will be laid out differently for different motherboard models, so be sure to check your specific motherboard for connector locations.

In addition, all form factors build on the form of the boards smaller than it. You can easily mount a Mini ITX or a Micro ATX in a case designed for an ATX motherboard, or a Mini ITX in a case designed for a Micro ATX board. If you try to put a motherboard in a case designed for a smaller board, most of the board will not be secured or supported, if it even fits in the case.

Note: For the rest of this document, we'll be using the ATX form factor drawing for simplicity unless noted. You can leave off the extra details not needed if you're using a smaller board size.

Mounting holes, standoffs, and spacing

- To locate the board correctly within your enclosure, it must be positioned so that there is sufficient clearance between the edges of the board and the enclosure walls.
- The I/O edge should be spaced 0.065" (1.65mm) from the inner face of the enclosure wall you want the connectors to be accessible from.
 - This allows the I/O plate (a small metal panel that comes with the motherboard, and mounts over the I/O connectors) and the metal brackets on the PCI cards to fit between the board and the case wall.
- The remaining sides of the motherboard should be spaced a minimum of 0.25" from the inner face of enclosure walls.
- The edge of the I/O opening will be off the side of the motherboard, and the I/O plate is a bit larger than the opening. You'll have to account for this when placing the motherboard and any components that go near it.



**Figure - Motherboard mounting hole locations for
Mini ITX, Micro ATX and ATX Motherboards**

ATX Board All Views

(full-size images, between pages 21-26)

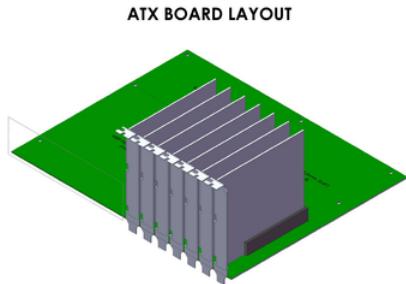


Figure - Isometric View

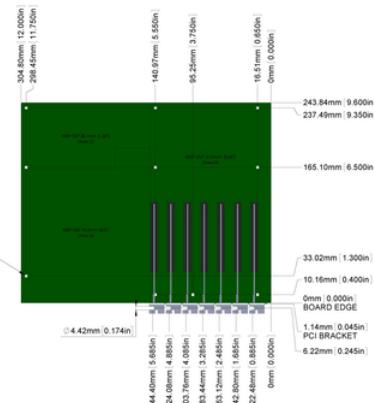


Figure - Top View

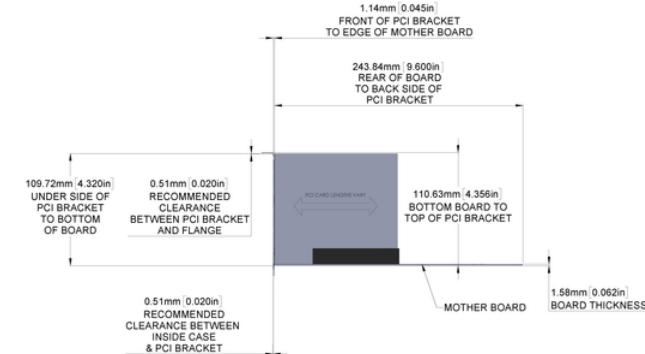


Figure - Left View

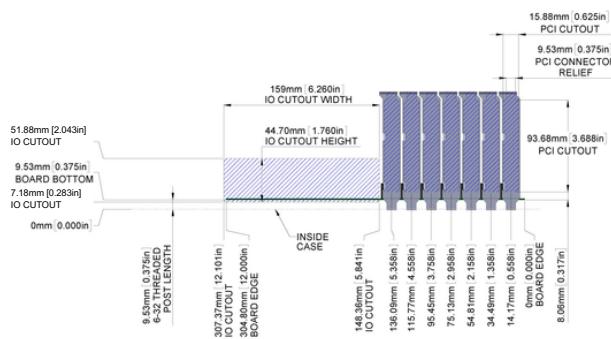


Figure - Front View

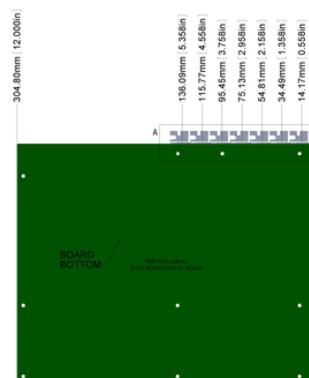


Figure - Bottom View

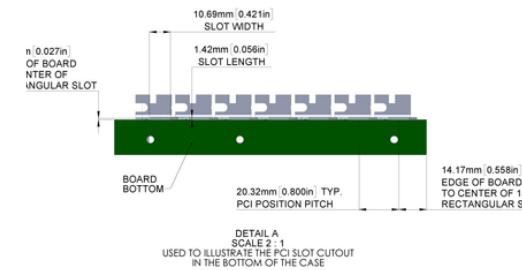


Figure - Detail View

Micro ATX Board All Views

(full-size images, between pages 27-32)



MICRO ATX BOARD LAYOUT

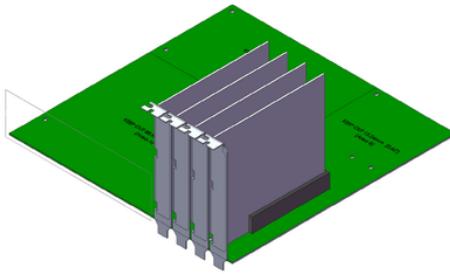


Figure - Isometric View

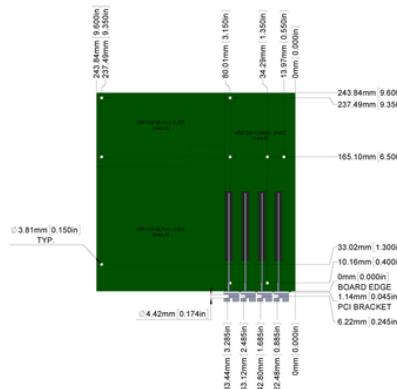


Figure - Top View

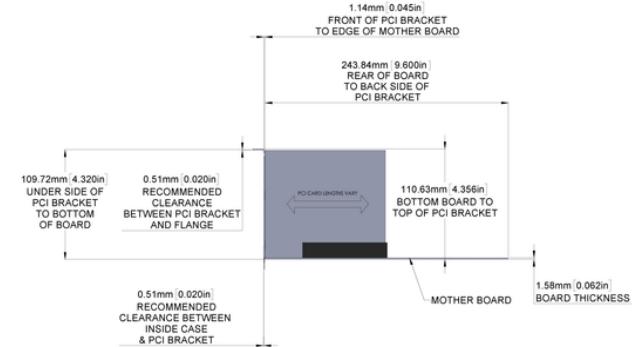


Figure - Left View

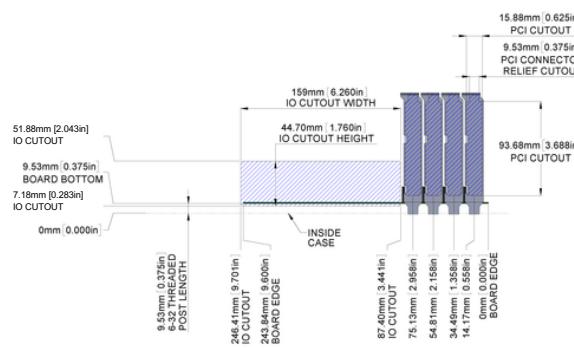


Figure - Front View

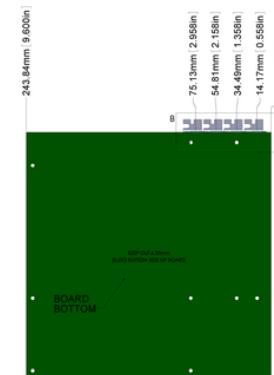


Figure - Bottom View

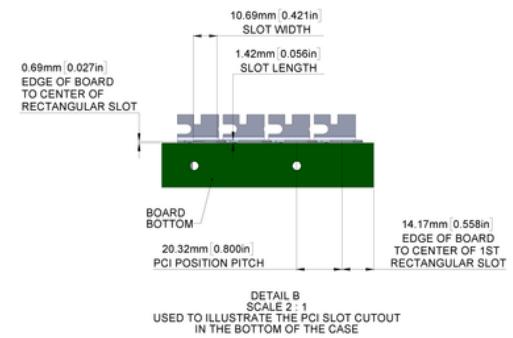


Figure - Detail View

Mini ITX Board All Views

(full-size images, between pages 33-38)

MINI ITX BOARD LAYOUT

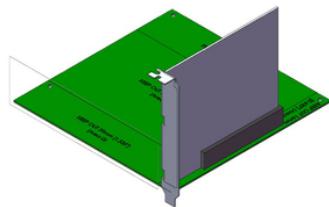


Figure - Isometric View

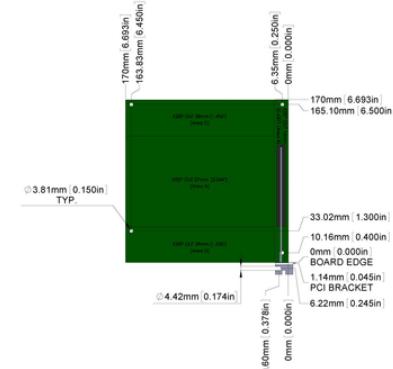


Figure - Top View

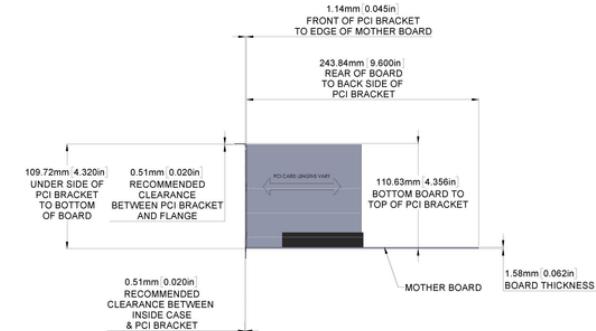


Figure - Left View

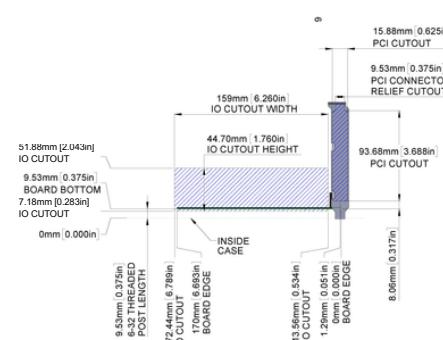


Figure - Front View

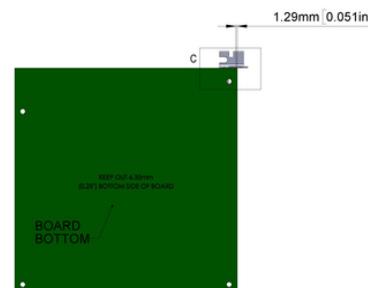


Figure - Bottom View

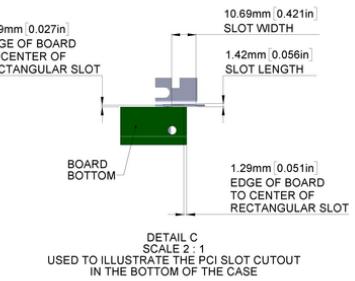
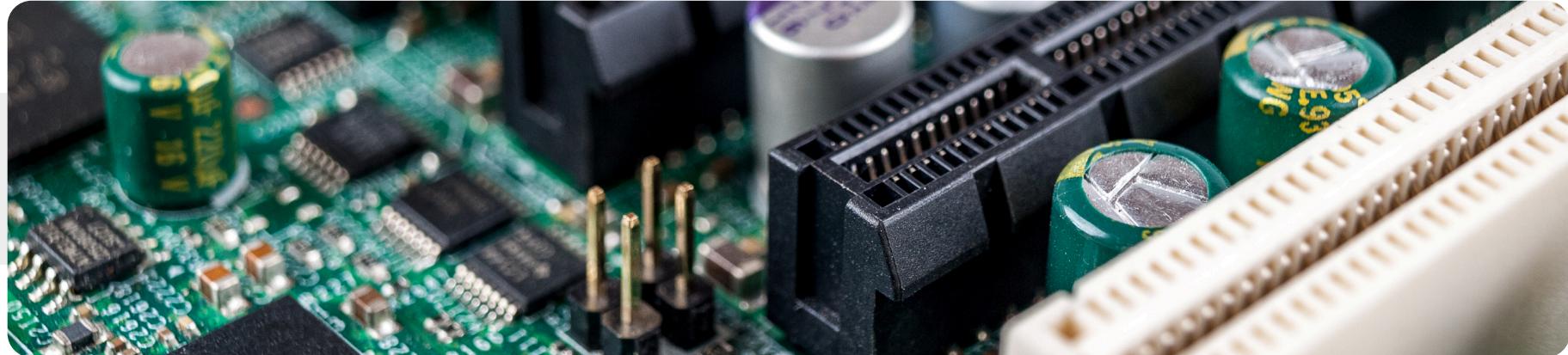


Figure - Detail View

PCIE CARDS



PCIe cards are not all the same size. There are two standard heights: Half Height and Full Height.

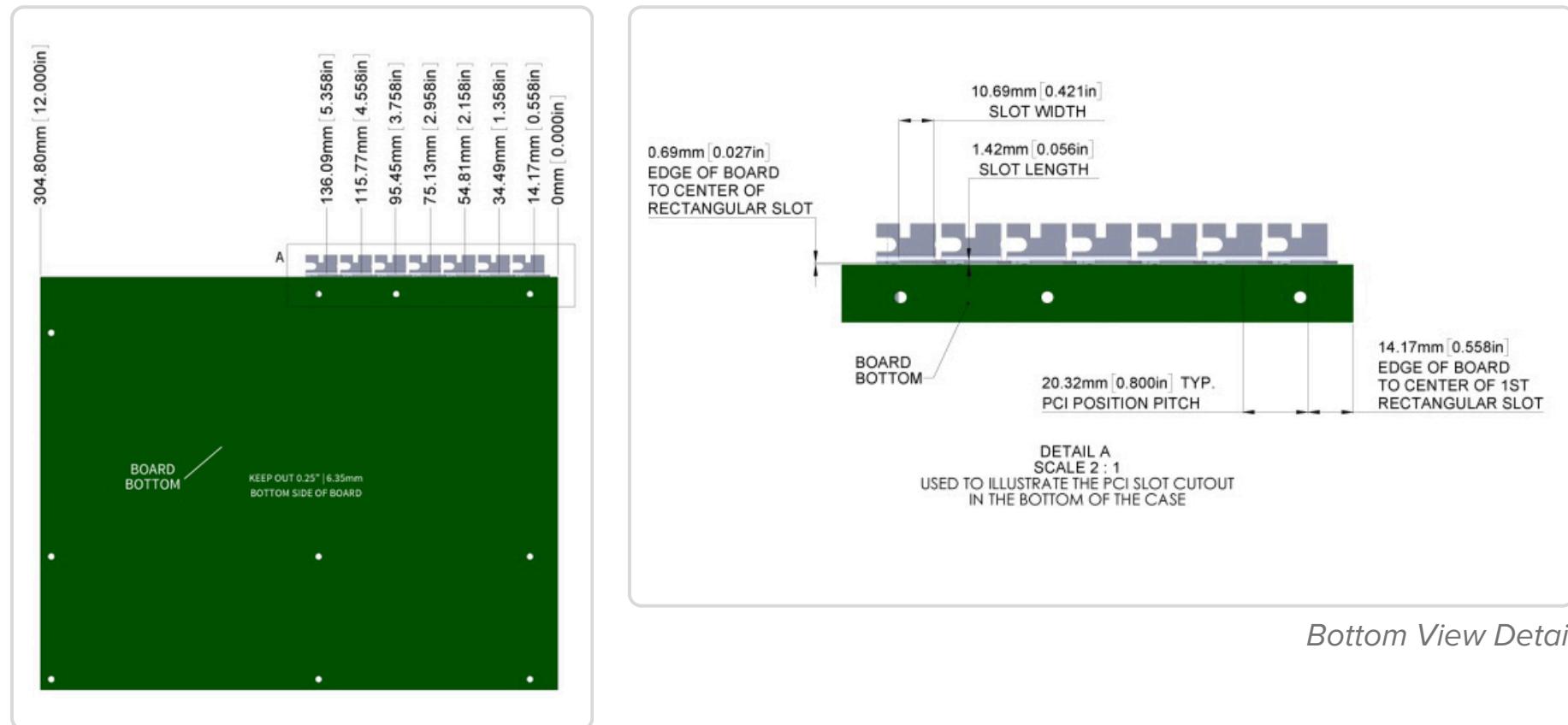
They also come in various lengths, but unless the card is full length or extended length (both of which will hang over the front edge of the motherboard), this is not something you should have to worry about when mounting the motherboard. You will have to be sure to leave enough room in the case for any connectors that come off the PCIe cards though. We'll go over designing to mount the Full Height PCIe card in the Designing the Back Panel Section.

PCI and PCIe cards have different connectors on the motherboard, and are not interchangeable. The locations of the cutouts and connectors for mounting them is the same, so we won't separate them for this guide.

A final detail that must be considered when designing the bottom of the case is the accommodation of tabs that are found on the bottom of PCIe Card Brackets. These tabs are designed to fit into a slot in the base of the enclosure in order to help secure the card.

PCIE CARDS

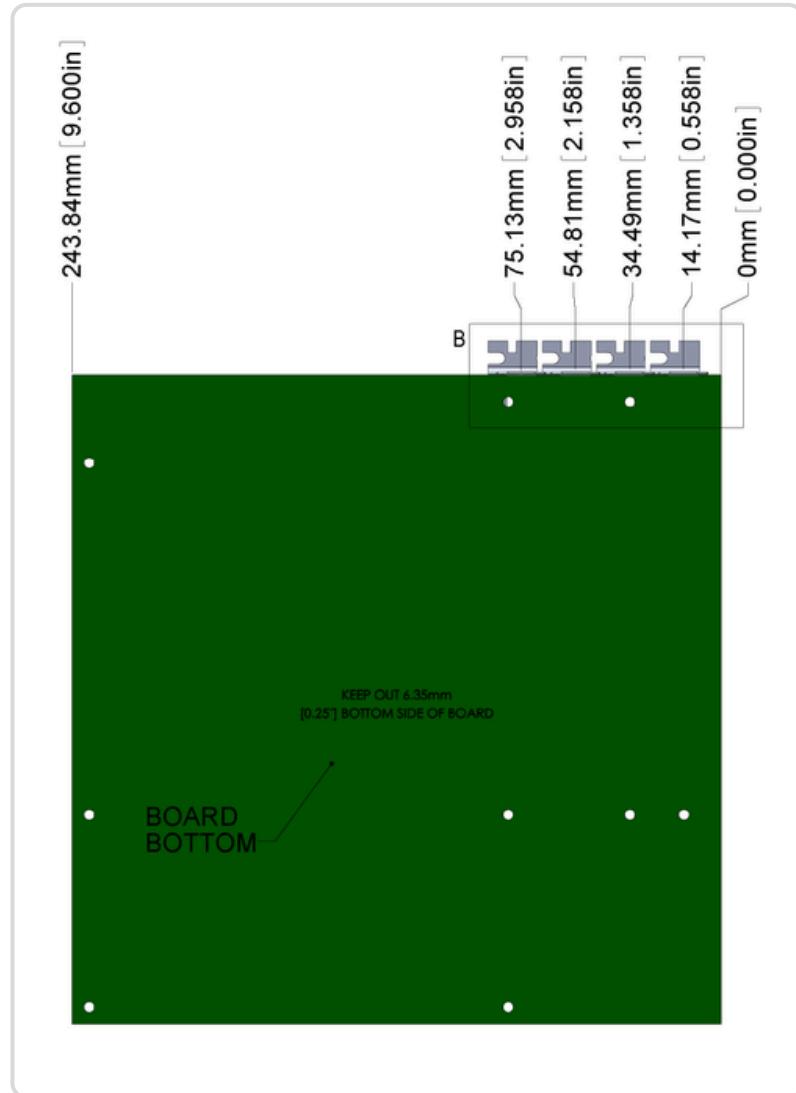
The images on this and the next two pages show the size and position of these rectangular slots. This slot design applies if using the recommended 3/8" high threaded posts. However, this can be avoided by using longer standoffs. Use caution when using shorter standoffs, the end of the brackets may protrude below the base of the enclosure.



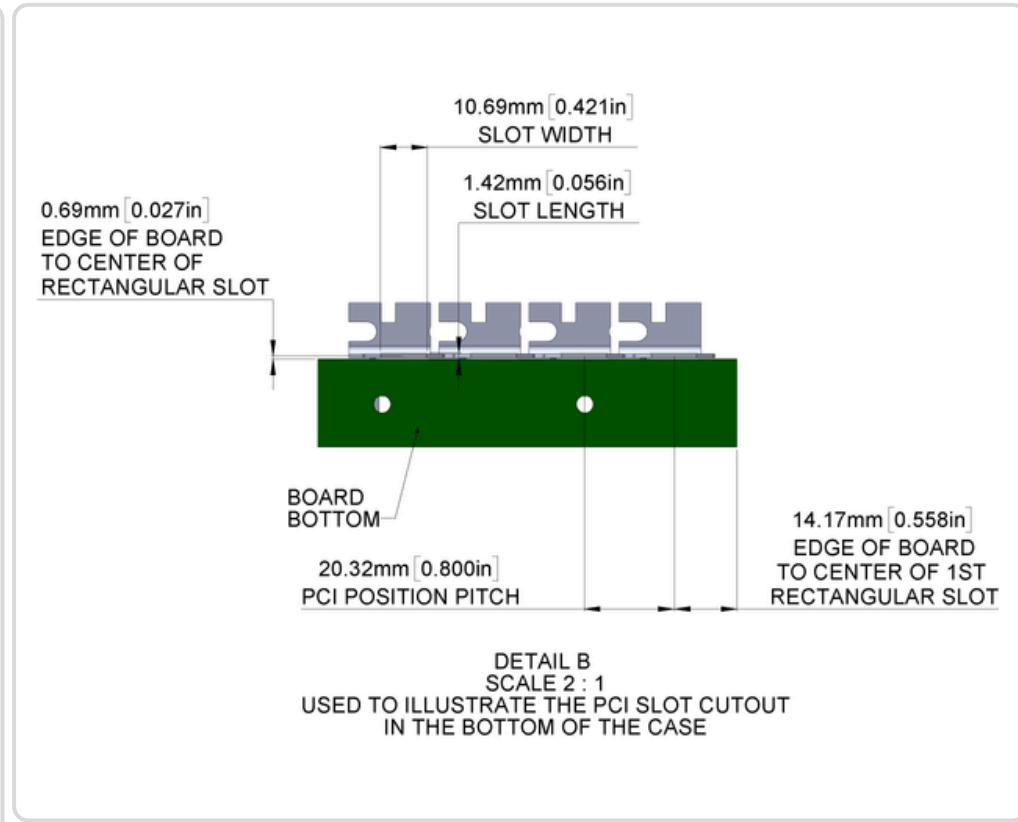
Bottom View

Figures - ATX board bottom view, with dimensions for rectangular slot for PCI tab.

PCIE CARDS



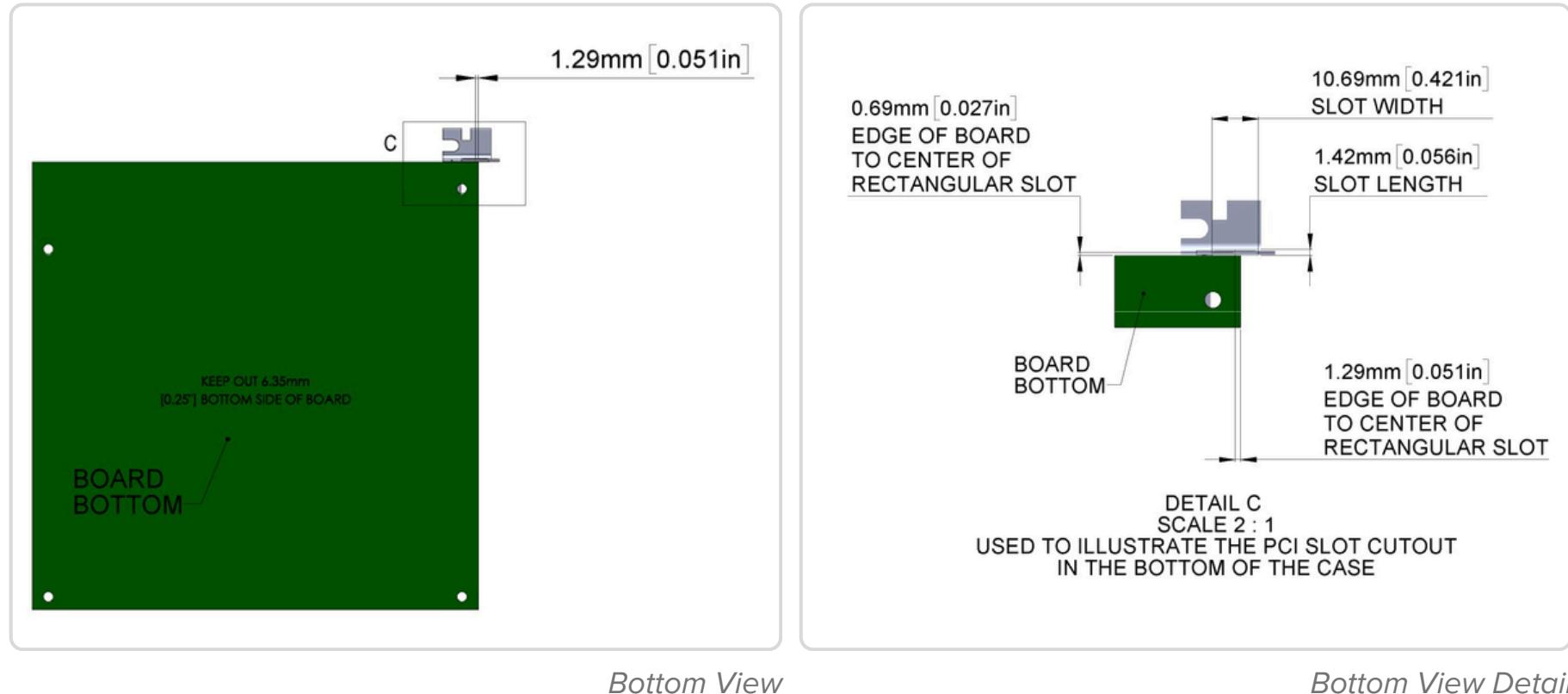
Bottom View



Bottom View Detail

Figures - Micro ATX board bottom view, with dimensions for rectangular slot for PCI tab.

PCIE CARDS



Bottom View

Bottom View Detail

Figures - Mini ITX board bottom view, with dimensions for a rectangular slot for PCI tab.

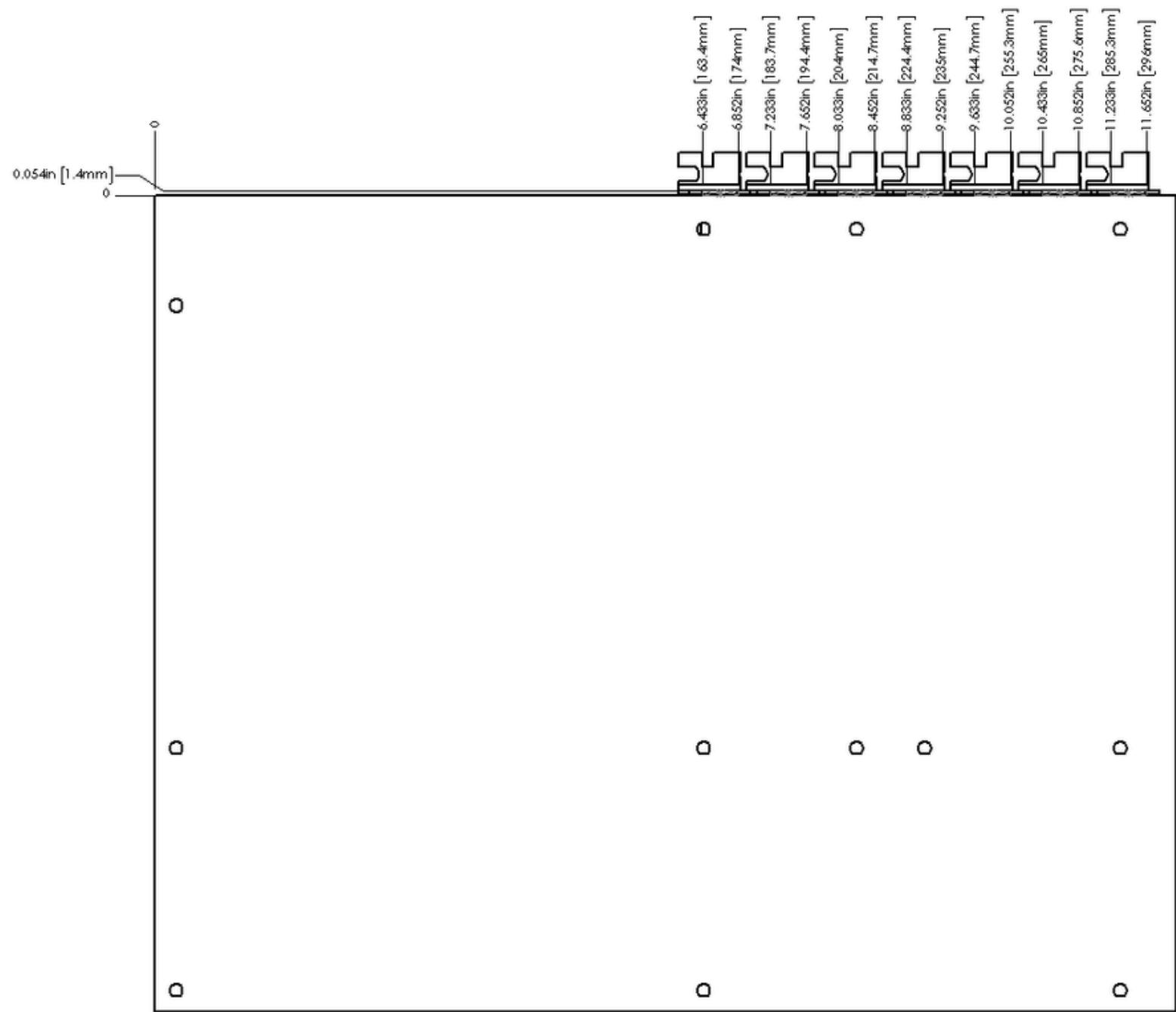


Figure - PCI/PCIetab locations for an ATX mother board. (The tabs, not needed for the smaller boards, can be left out.)

DESIGNING THE BACK PANEL WITH I/O CONNECTOR BLOCK AND PCI CUTOUTS



ATX, Micro ATX and Mini ITX boards have a common, standard size I/O connector panel.

I/O Area

A simple rectangular cutout is all that is required to accommodate the I/O connectors. A metal I/O plate is supplied with most motherboards that will snap into this opening while fitting around the I/O connectors. We oversize our cutout by .005" (.13mm) all around compared to the form factor recommended opening. (This allows the IO plate snap in a little easier.)

PCI Slots

- The standard slot-style cutouts for PCI card access are shown in the image below.
- Adjust vertical and horizontal offsets as per I/O area cutouts.
 - If you do not anticipate using all the PCI slots, you can either omit cutouts as required or specify 'knockouts'. For knockouts, we leave several tiny metal 'bridges' or 'tabs' that keep the center in place until the user decides to physically remove it.
 - Our sister company, 45Drives, came up with a back panel design that features PCI slot covers that screw on instead of using knockouts. More information [here](#).

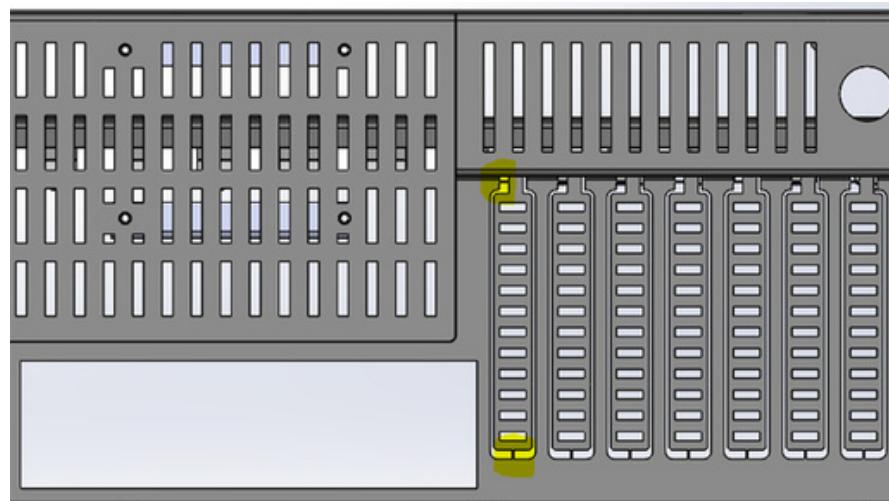


Figure - PCI cutout Knockout example

DESIGNING THE BACK PANEL WITH I/O CONNECTOR BLOCK AND PCI CUTOUTS



- Use caution with knockouts if using cold rolled steel in damp or corrosive environments, as small bare metal patches will be left once the centers are removed.
- If using PCI cards, a flange should be designed into the back panel to allow PCI card brackets to be fastened.
 - Place screw holes at the dimensions shown for the screw opening on the top of the PCI card brackets.
 - Draw the holes as diameter 0.1065" (2.71mm) and noted as "tap with 6-32 thread".
 - There is typically insufficient space to use a self-clinching (PEM) nut here.

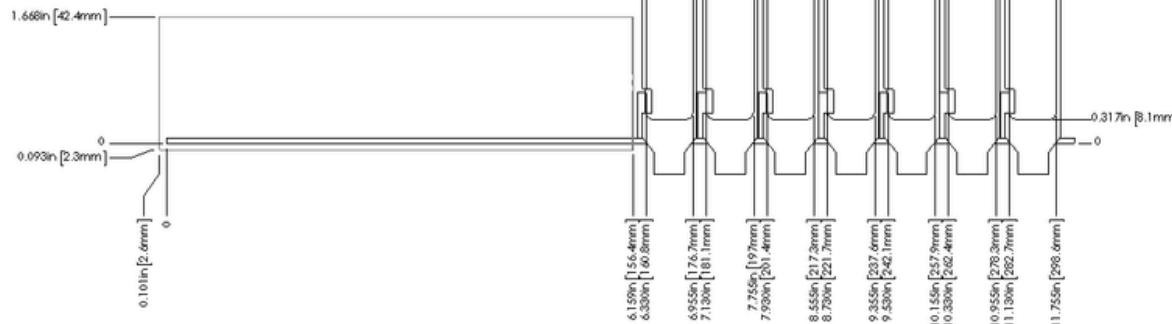
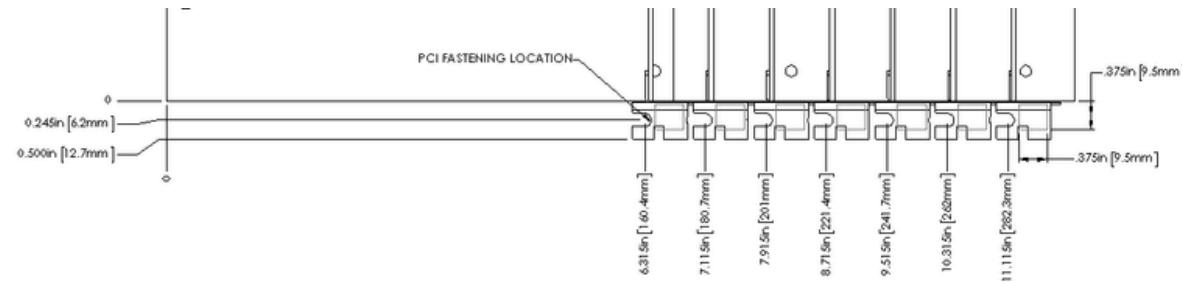


Figure - I/O and PCI card opening locations

VENT CUTOUT PLACEMENT



It's important to consider the layout of fans and venting carefully. A poor layout will not only give poor cooling, it may even cause "hot zones" where the air doesn't flow through the case.

If your case does not have fans, align intake and exhaust outlets. This is so that you can take advantage of the current the hot components create, and make sure they don't conflict with the heat sink fan flow. You can gain better air flow across the top of the board on its way through the enclosure if you arrange the intake and exhaust cutouts accordingly.

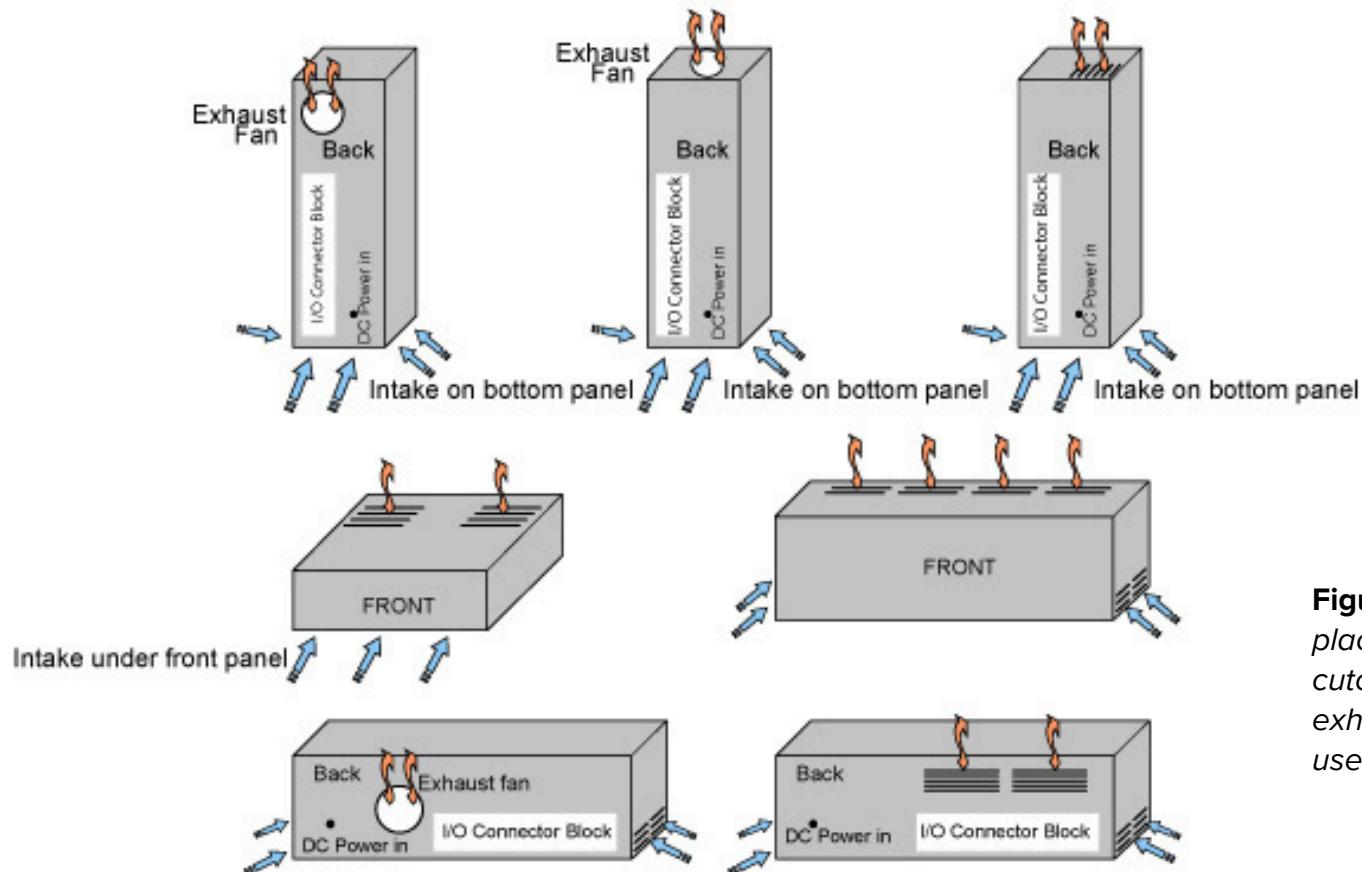


Figure - Suggested placement of ventilation cutouts and enclosure exhaust fans. (Example uses ITX enclosure)

CPU COOLER



If your CPU cooler doesn't have a fan, having venting over the CPU cooler will allow the warm air to exit the case faster. Just be sure to have a place lower on the case for cool air to enter.

If you're using a CPU cooler with fans, you always want to have the case fans blowing in the same direction as the CPU cooler. This enables the fans to work together instead of against each other.

If you have fans on the front or back (or both) sides of a case, having venting along the sides is usually not recommended. Side venting will be a shorter path for airflow and may not allow the fans to move the cooling air through the case effectively.

If you are using fans, remember that larger fans move more air at a lower RPM (and sound volume) than smaller fans, so we recommend you use the largest fan you can fit.

THE REQUIRED VOLUME OF COOLING AIR CAN BE CALCULATED AS:

$$\text{Volume (CFM)} = 3.16 \times \text{Max Heat (watts)} / \Delta T (\text{F})$$

Where Max Heat is the maximum sustained power dissipation of boards and components inside the enclosure, and ΔT is the maximum allowable temperature rise.

Designs with air intake cutouts in the bottom panel should include feet to raise the enclosure off its support surface so there is space for air to flow into the vents. Avoid placing cutouts directly beneath the motherboard which may allow objects to accidentally poke up through the spaces and contact the board, potentially causing damage. It is better to place bottom panel cutouts outside the perimeter of the motherboard.



USING PROTOCASE DESIGNER FOR ENCLOSURE DESIGN



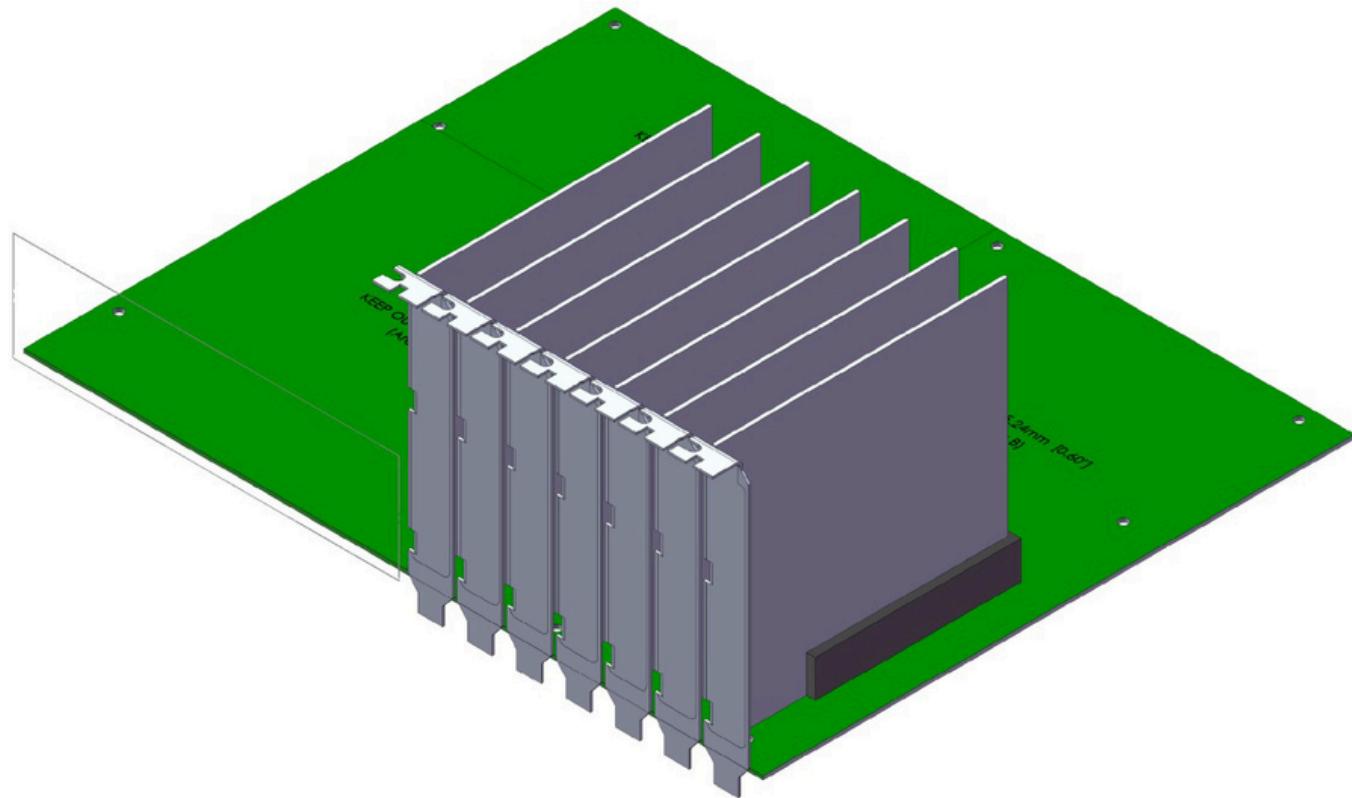
Protocase Designer is our simple design software that enables you to design and order custom electronic enclosures in minutes. It has 80+ in-built base templates, including ATX computer enclosures and Mini ITX computer enclosures. Plus, manufacturability checks as you design, and instant quoting and ordering. It is also directly connected to our ultra-fast custom manufacturing.

Some key points to remember when using Protocase Designer:

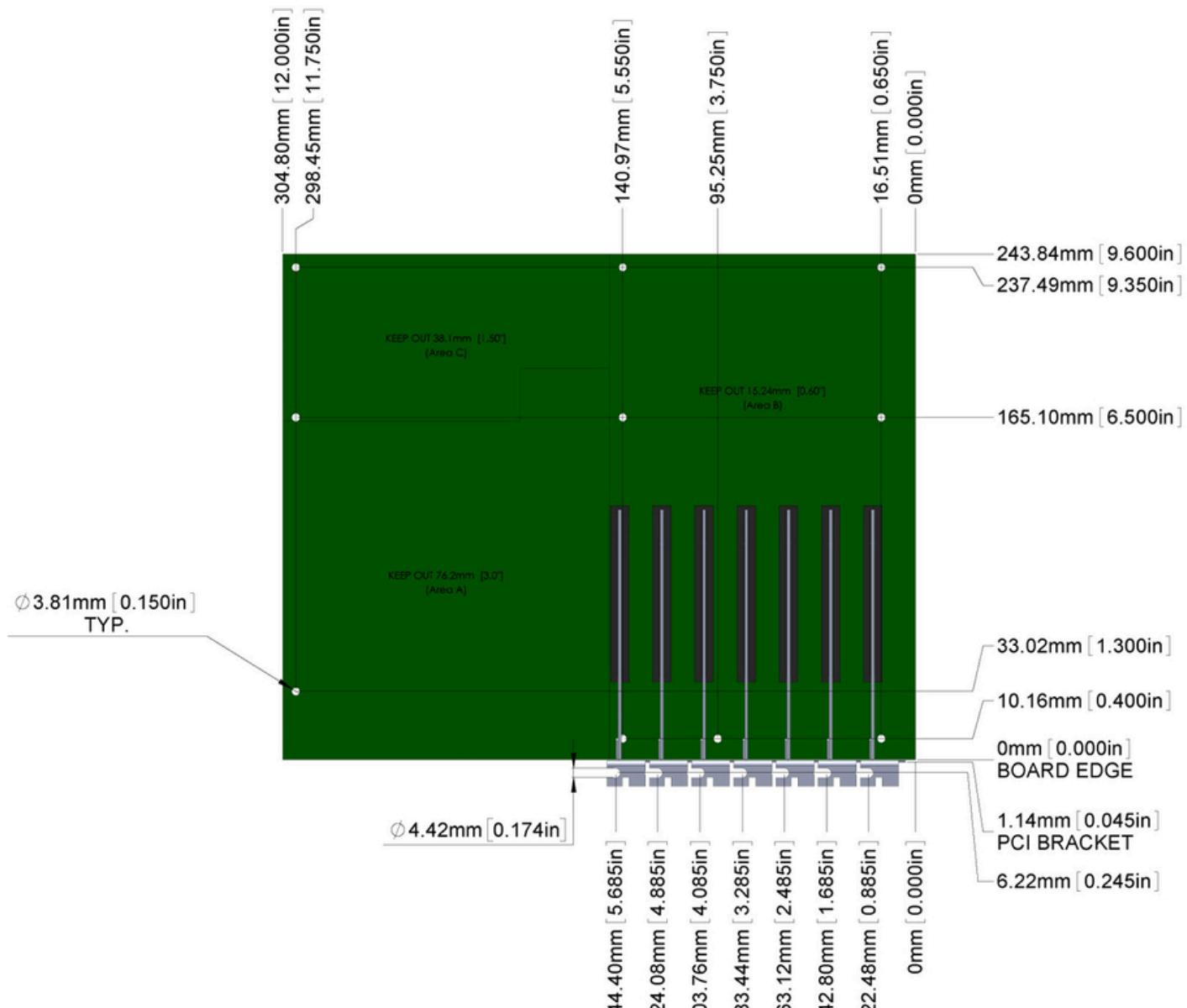
- The origin is the lower left corner of the front face of the enclosure.
- We have templates with IO/PCI cutouts and mounting PEMs included.
- These templates use a combination of a stud and an aluminum threaded post to secure the board.
- The outside face of the rear of the enclosure, where the I/O connector block is placed, has the maximum depth dimension.
- Calculate the standoff positions from the rear of the enclosure, allowing for the metal thickness.

ATX Board: Isometric View

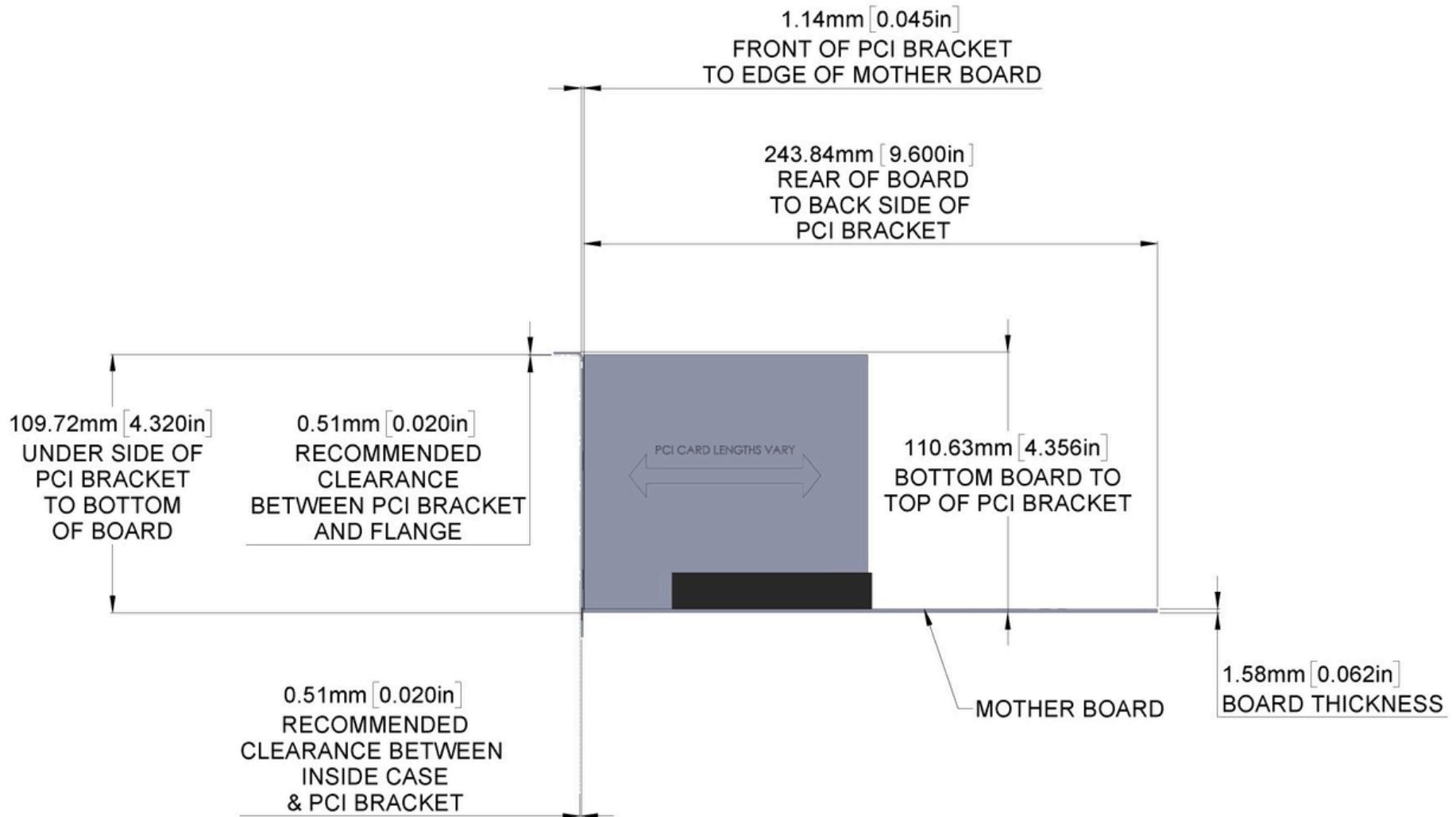
ATX BOARD LAYOUT



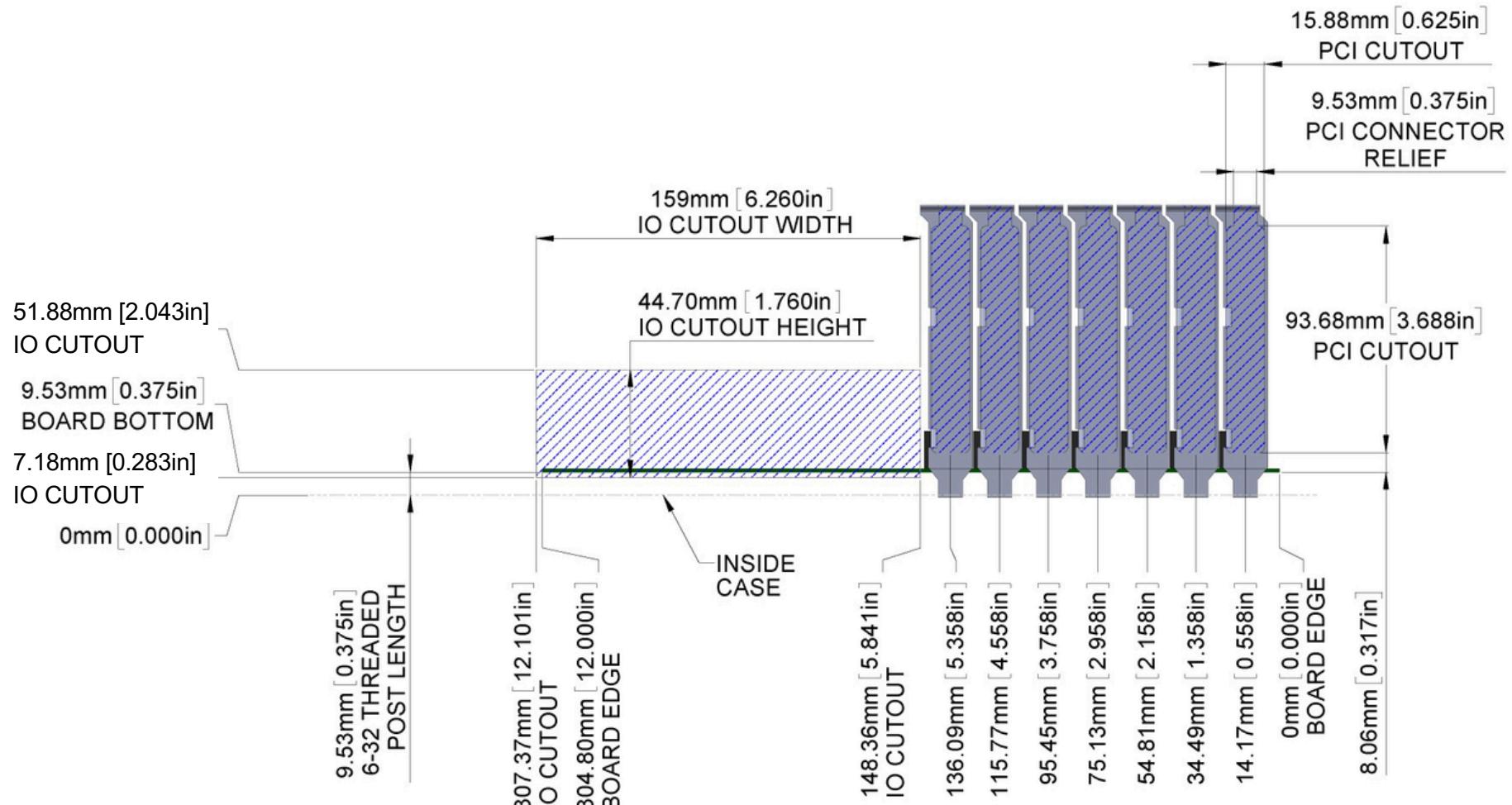
ATX Board: Top View



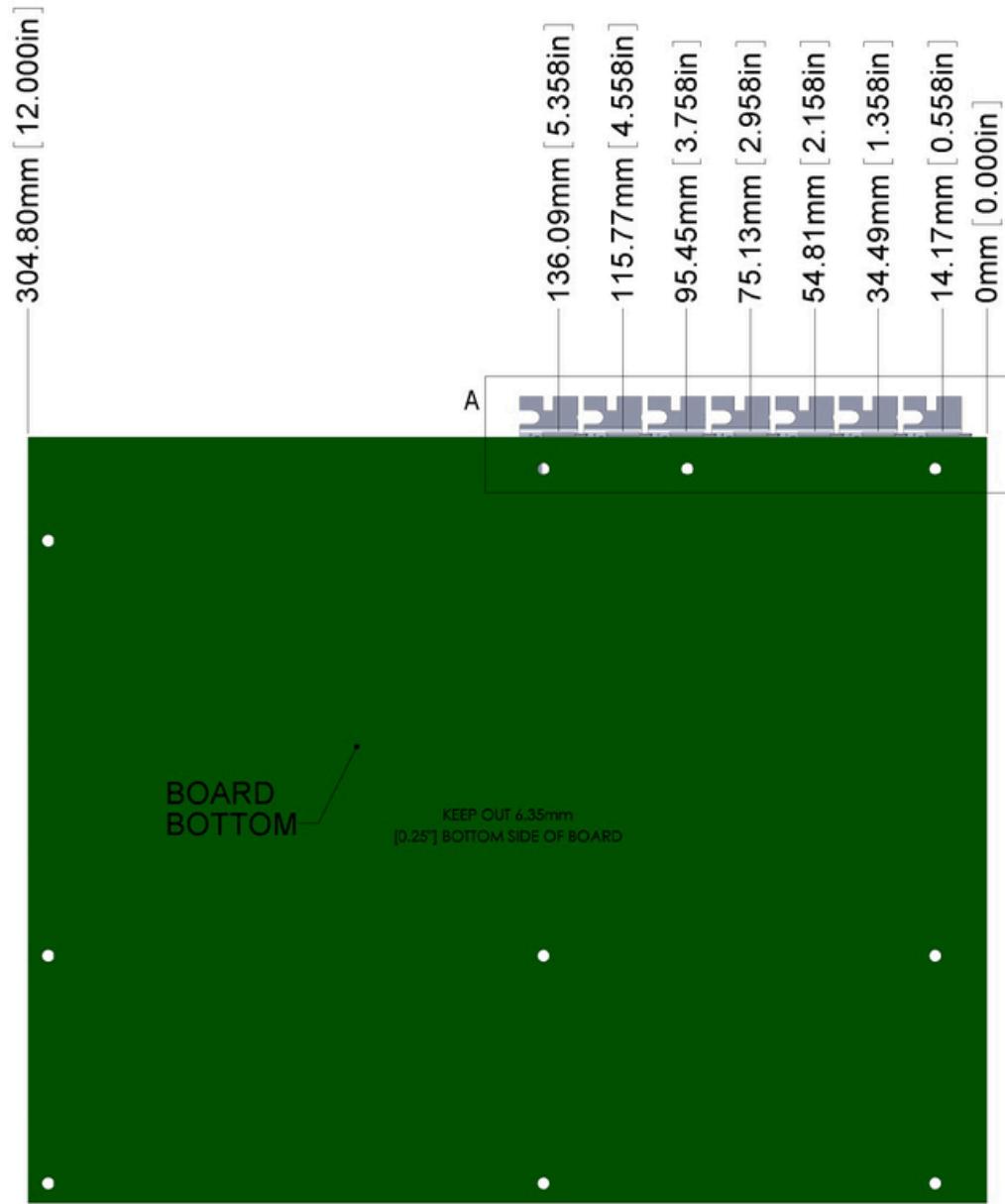
ATX Board: Left View



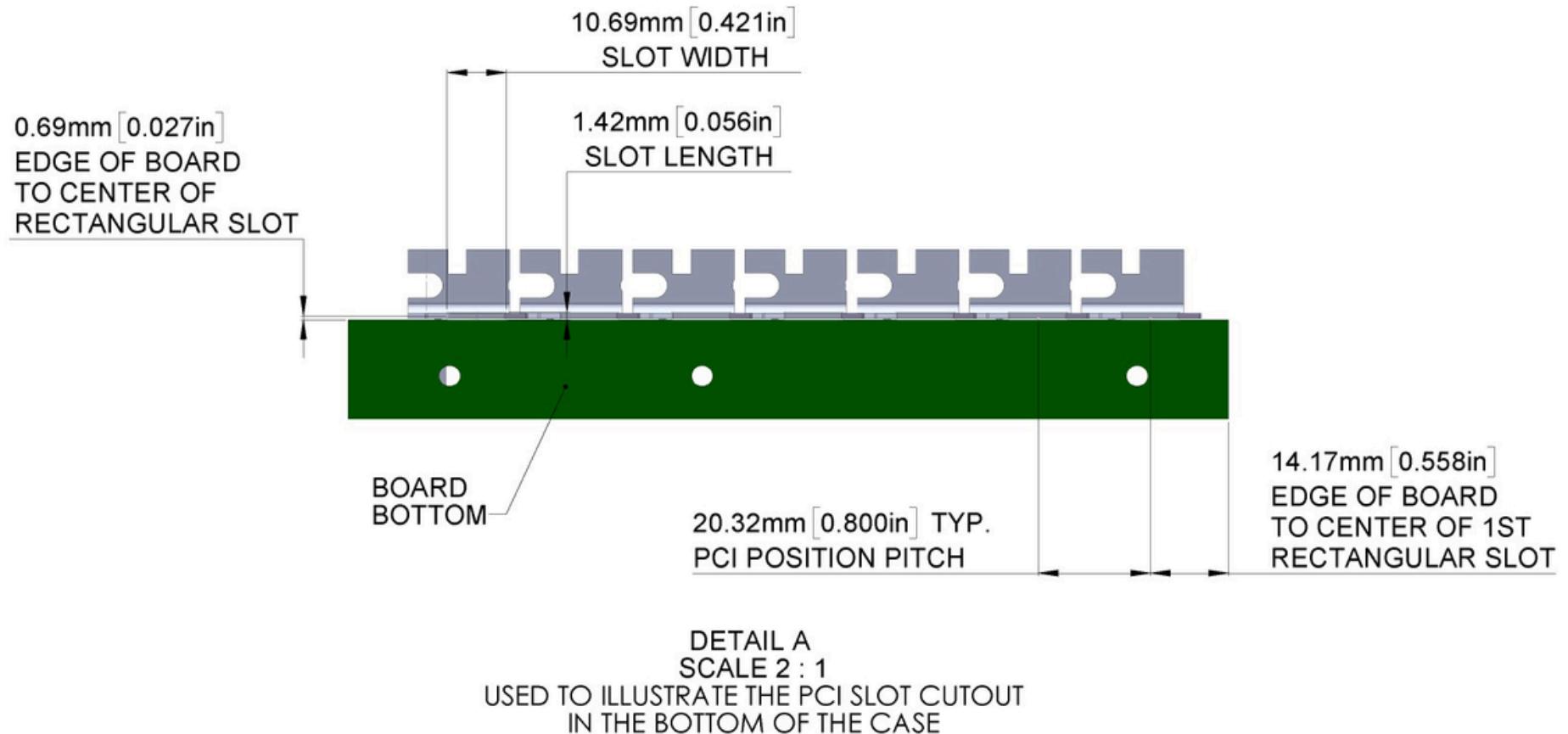
ATX Board: Front View



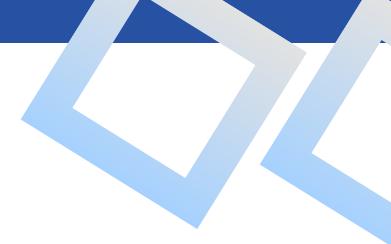
ATX Board: Bottom View



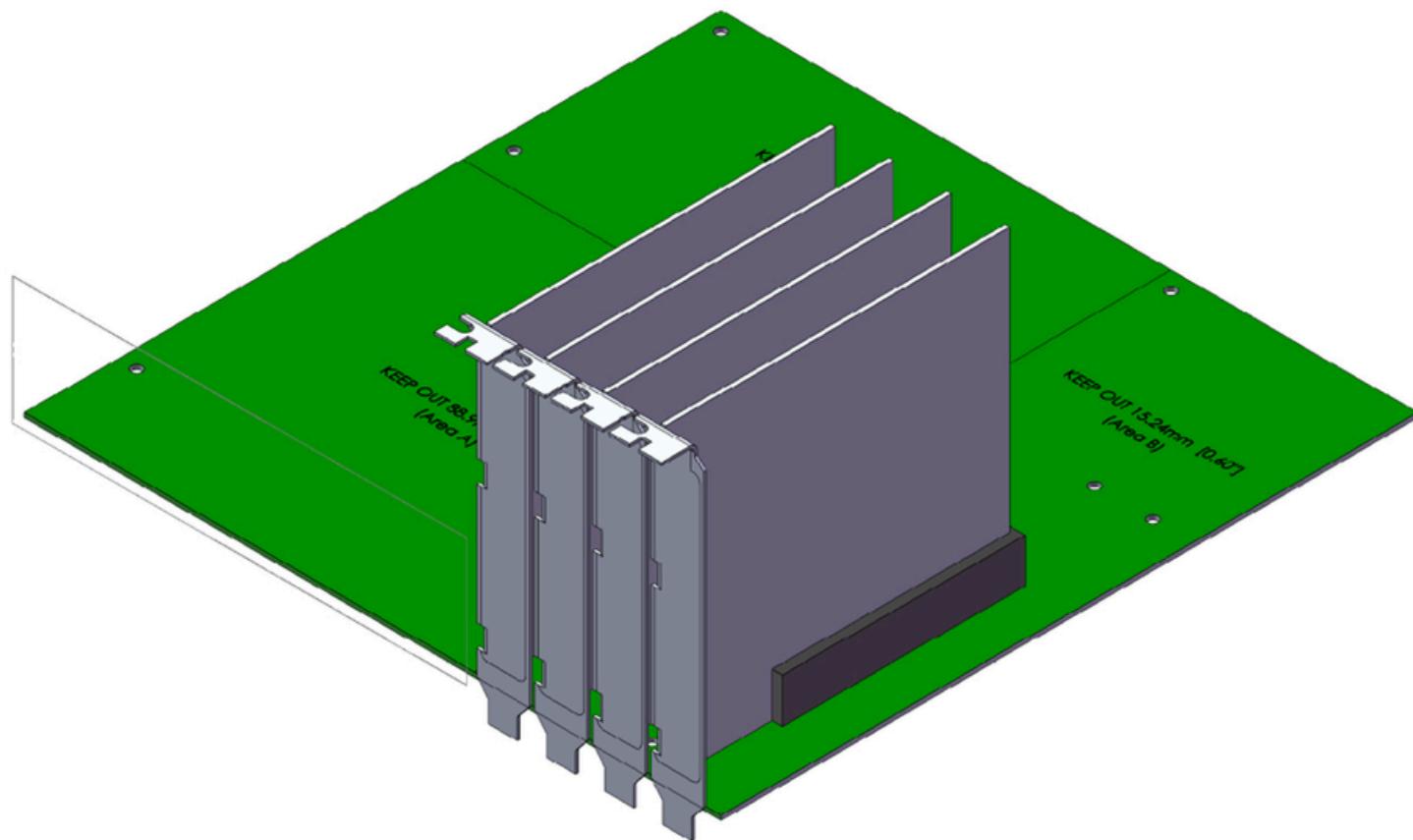
ATX Board: Detail View



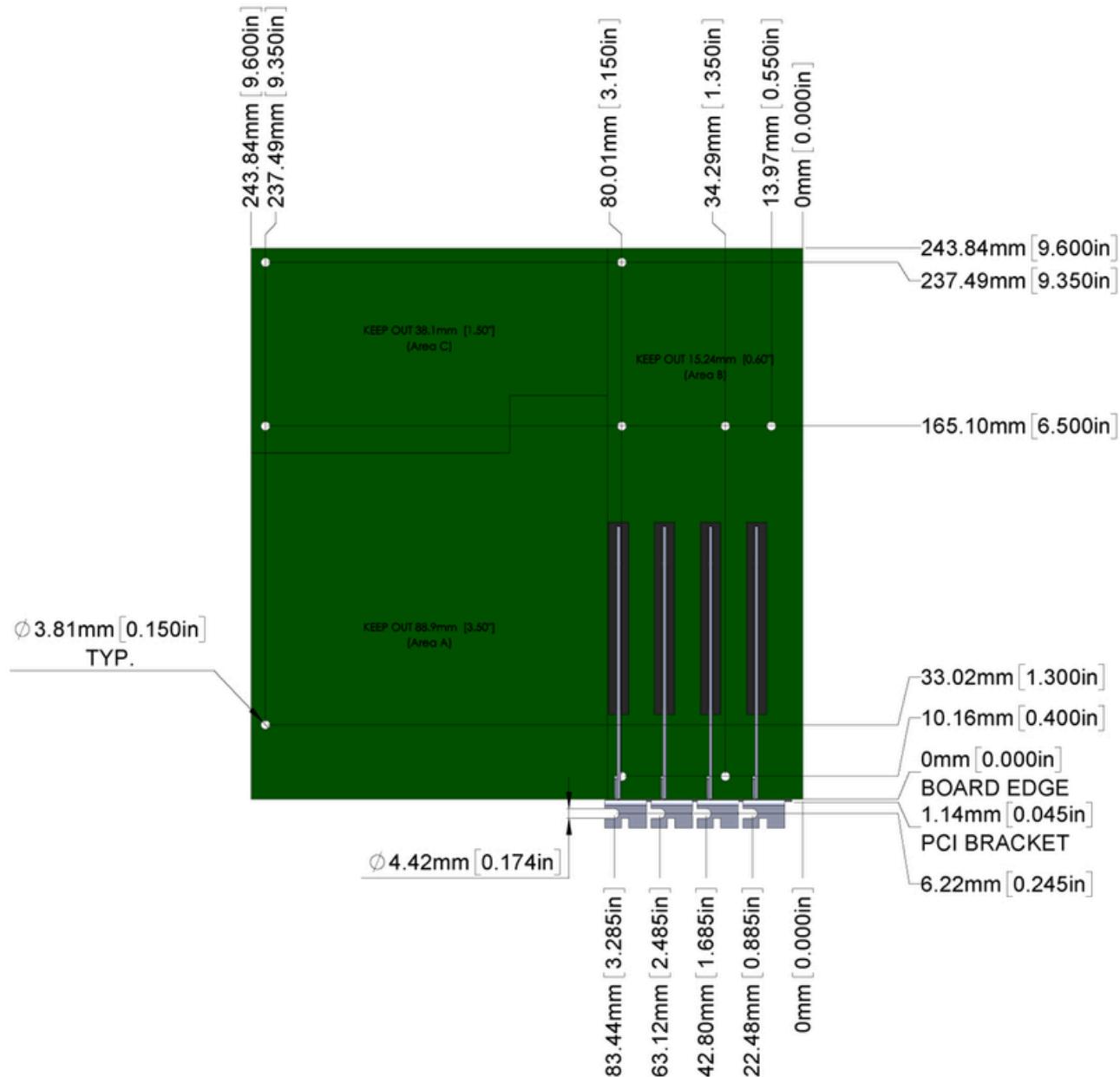
Micro ATX Board: Isometric View



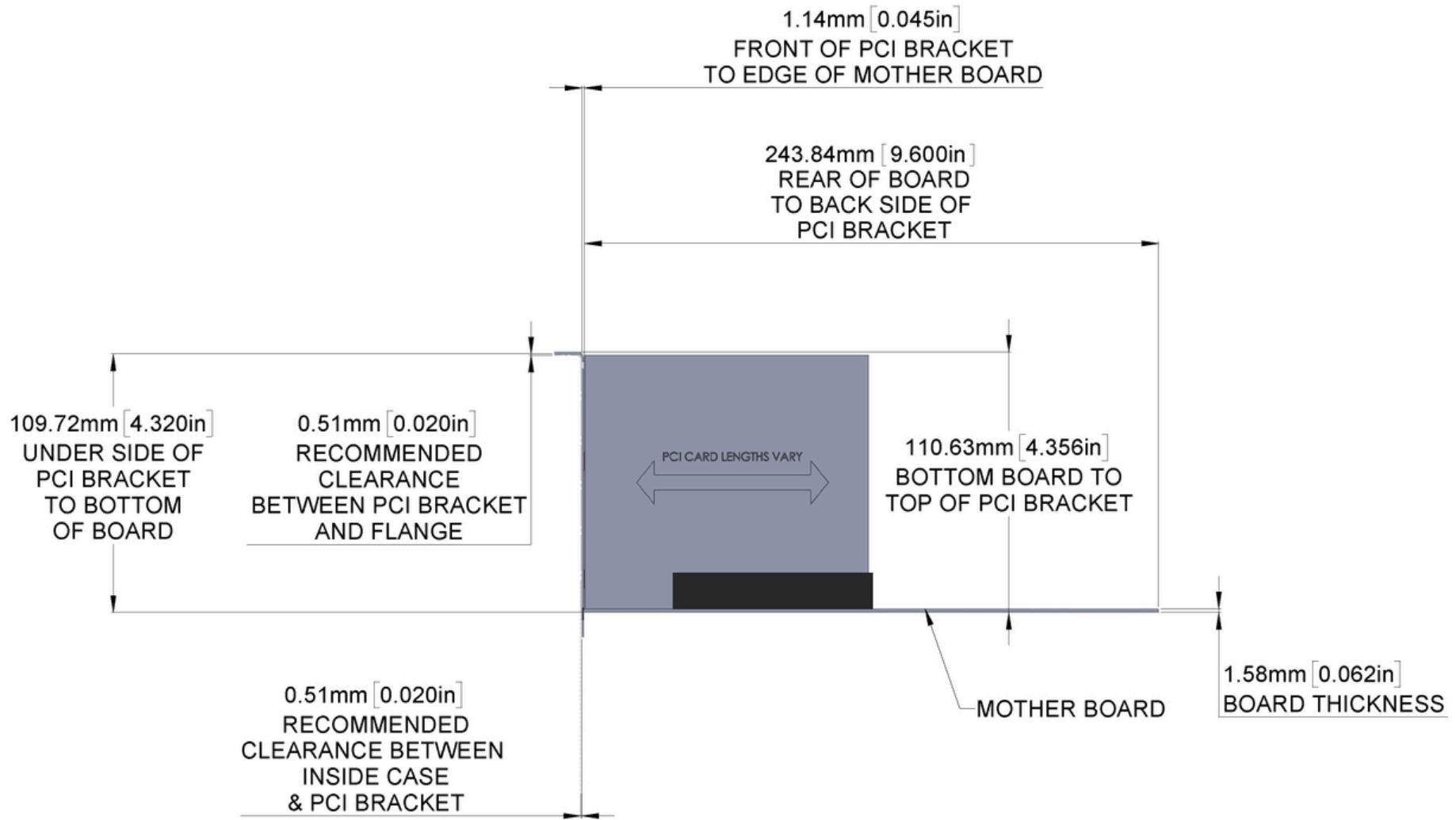
MICRO ATX BOARD LAYOUT



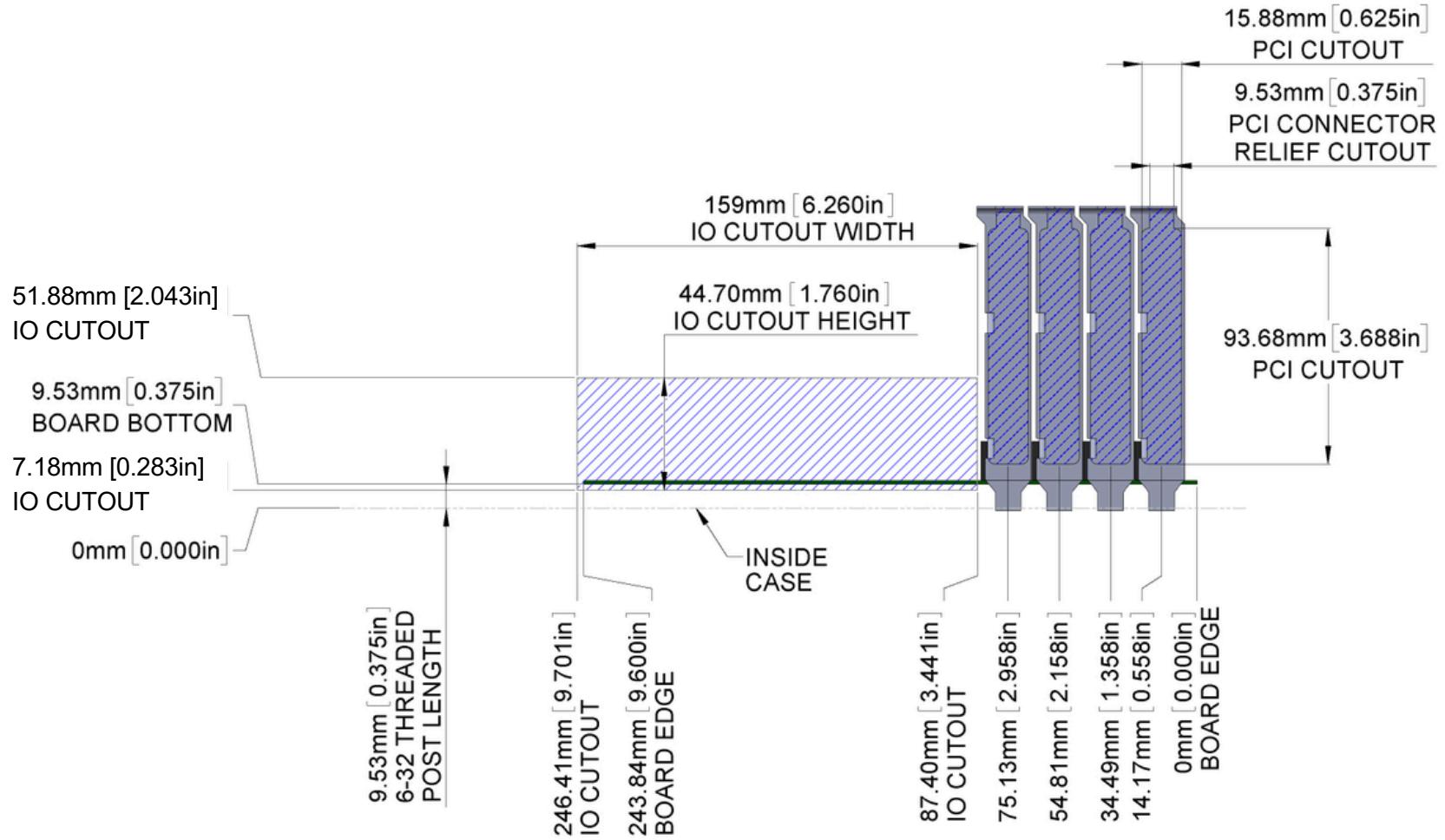
Micro ATX Board: Top View



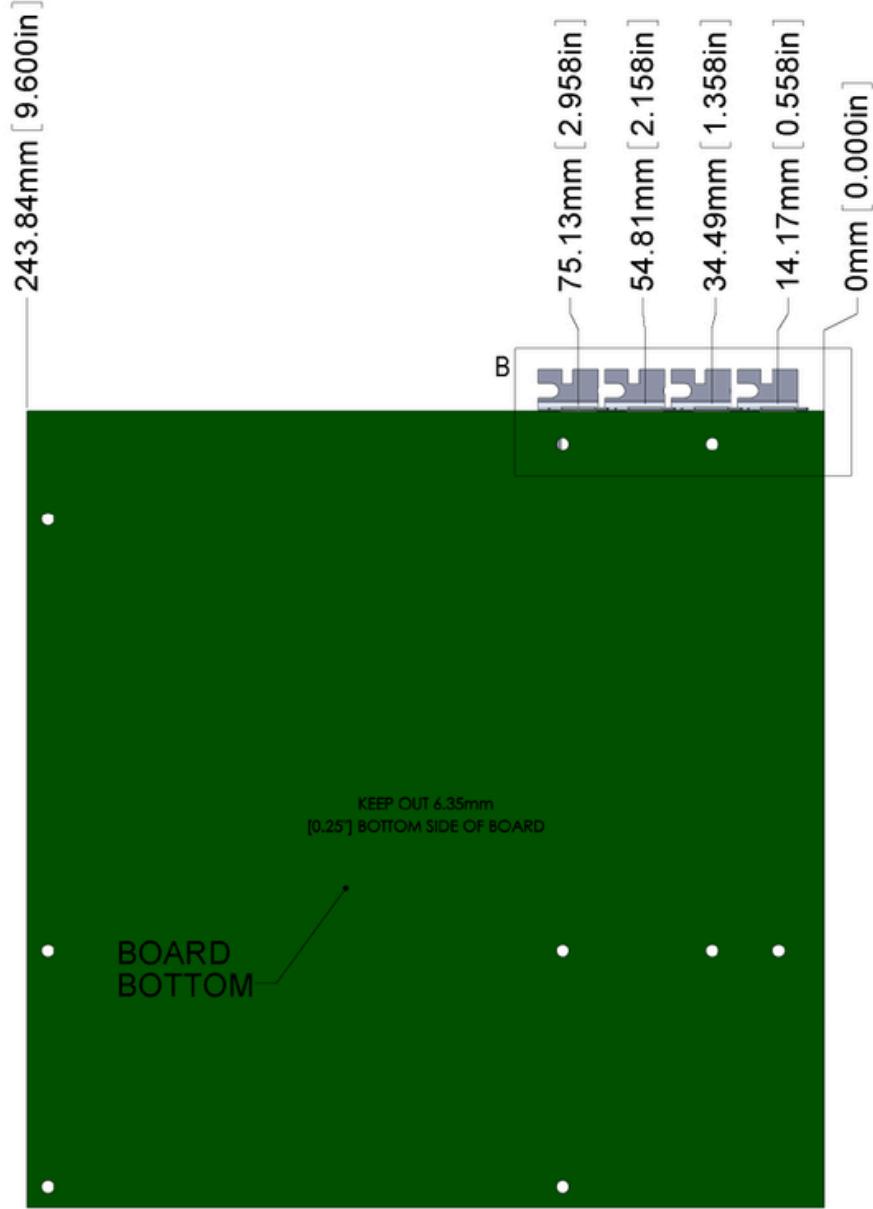
Micro ATX Board: Left View



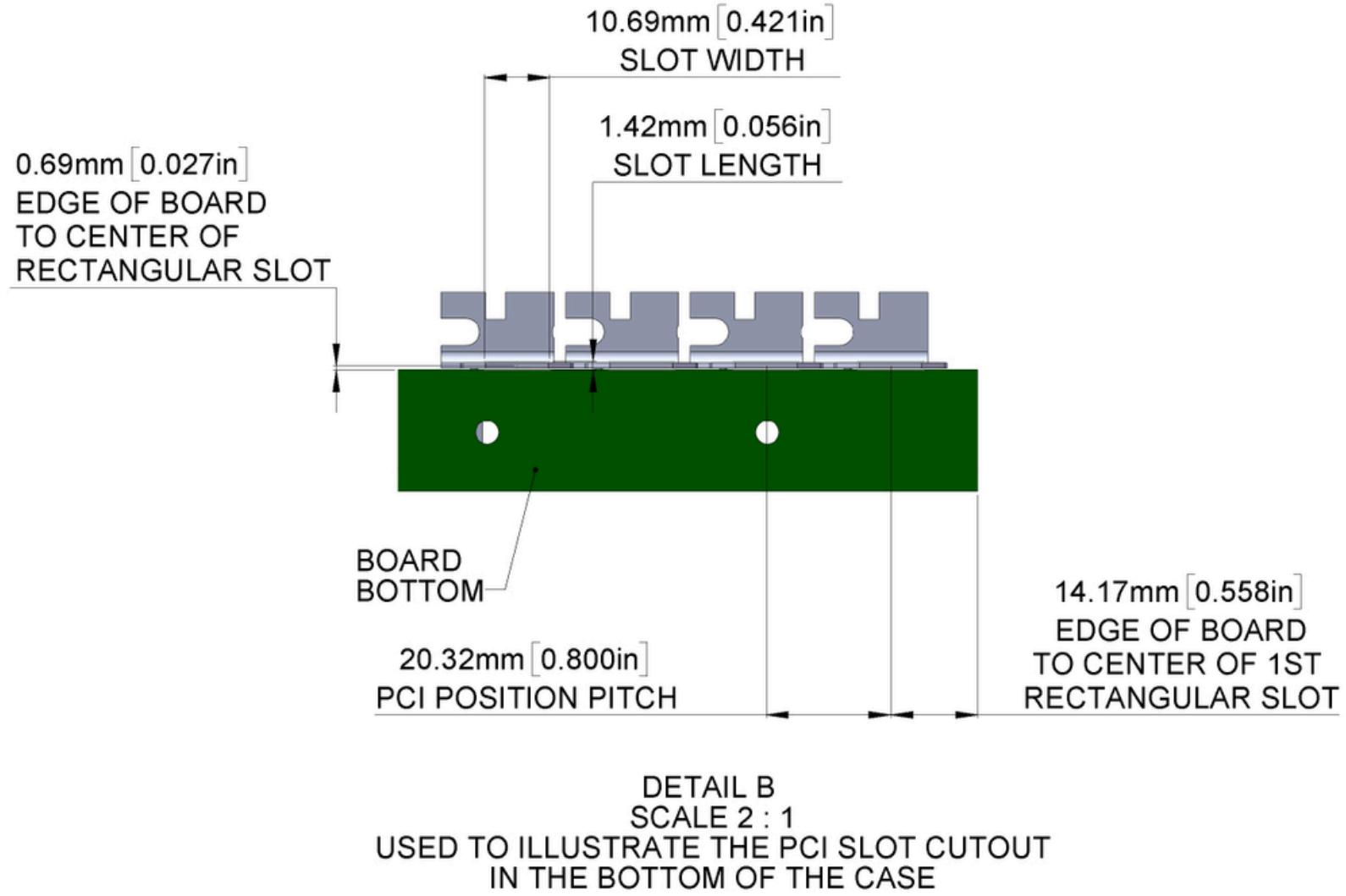
Micro ATX Board: Front View



Micro ATX Board: Bottom View

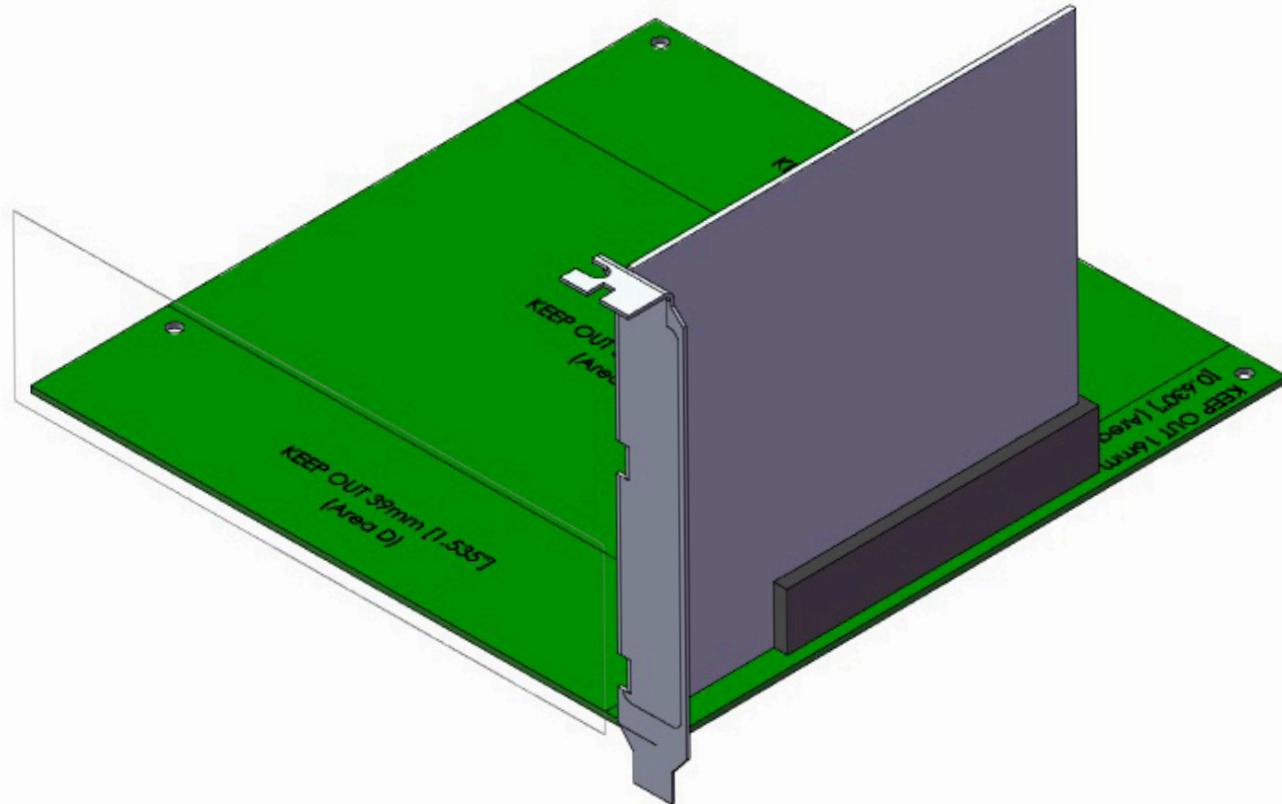


Micro ATX Board: Detail View

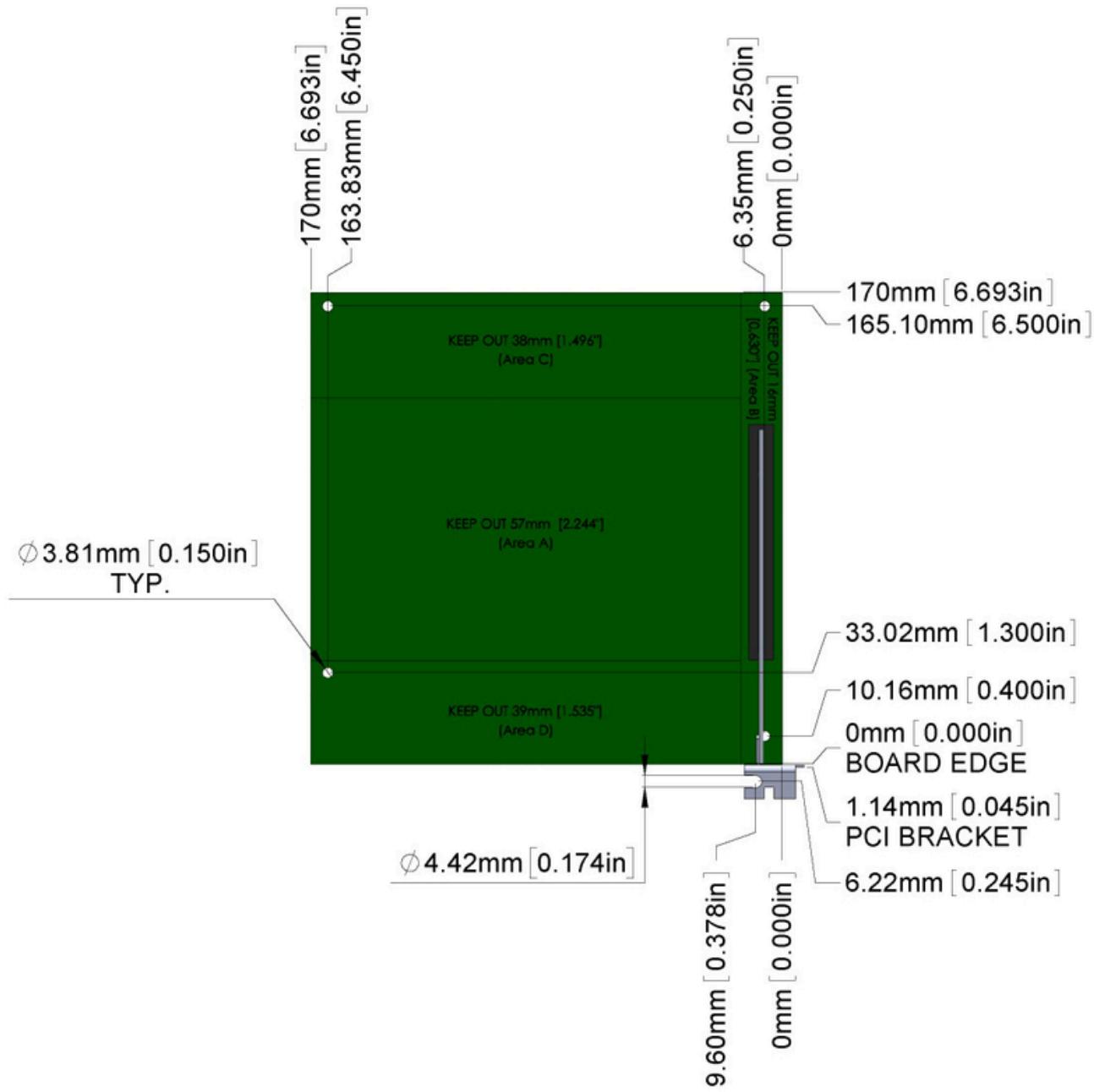


Mini ITX Board: Isometric View

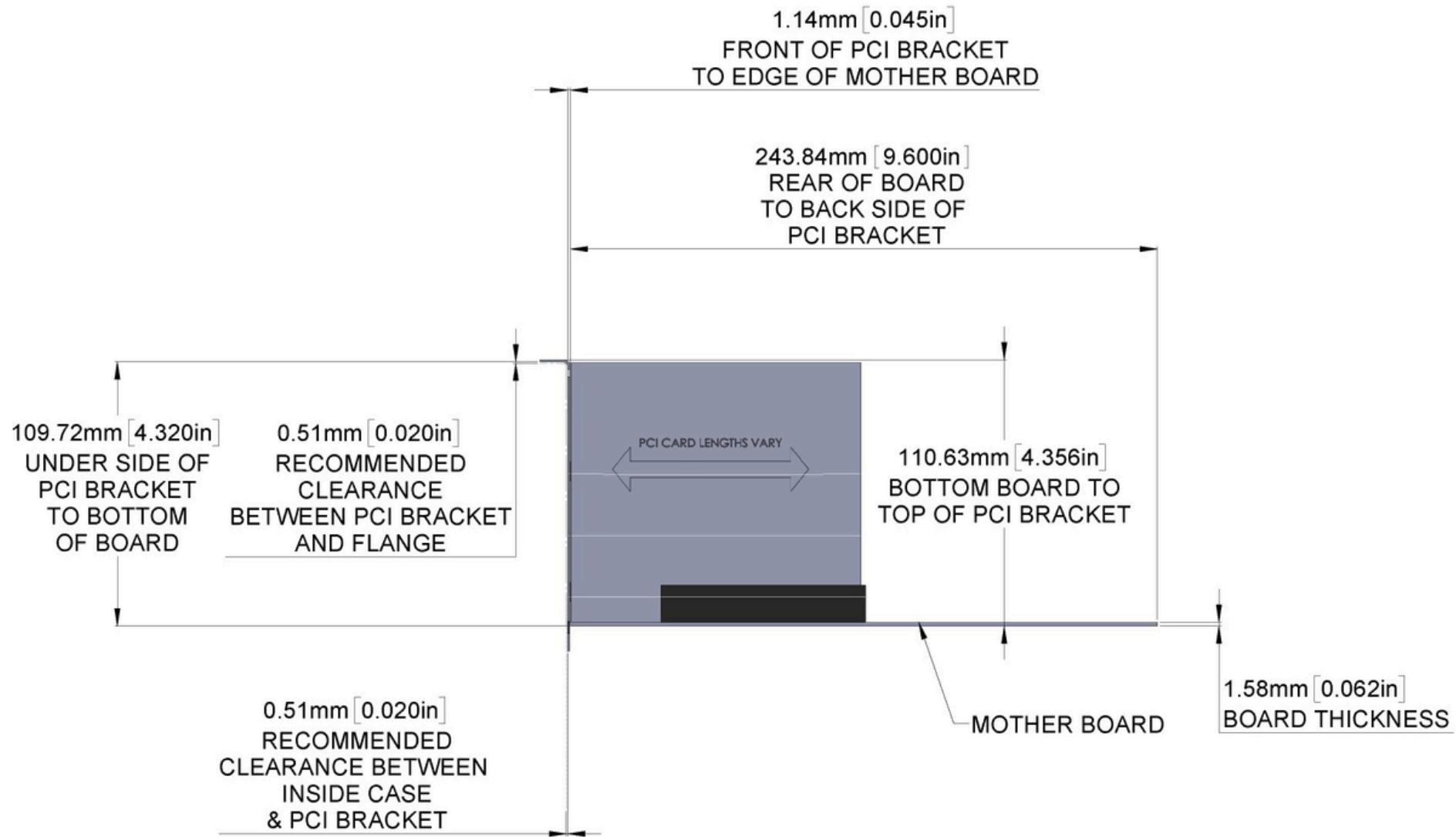
MINI ITX BOARD LAYOUT



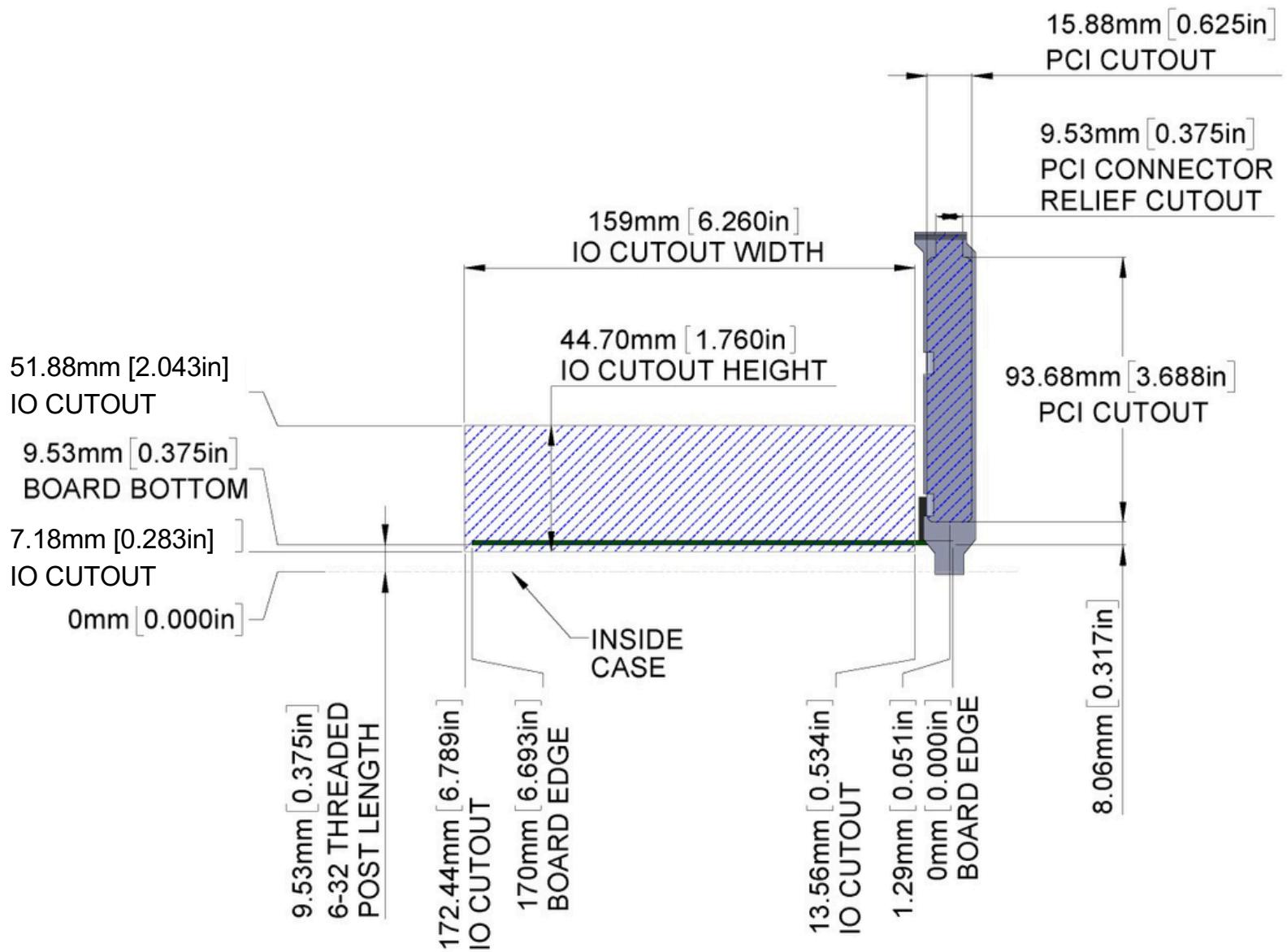
Mini ITX Board: Top View



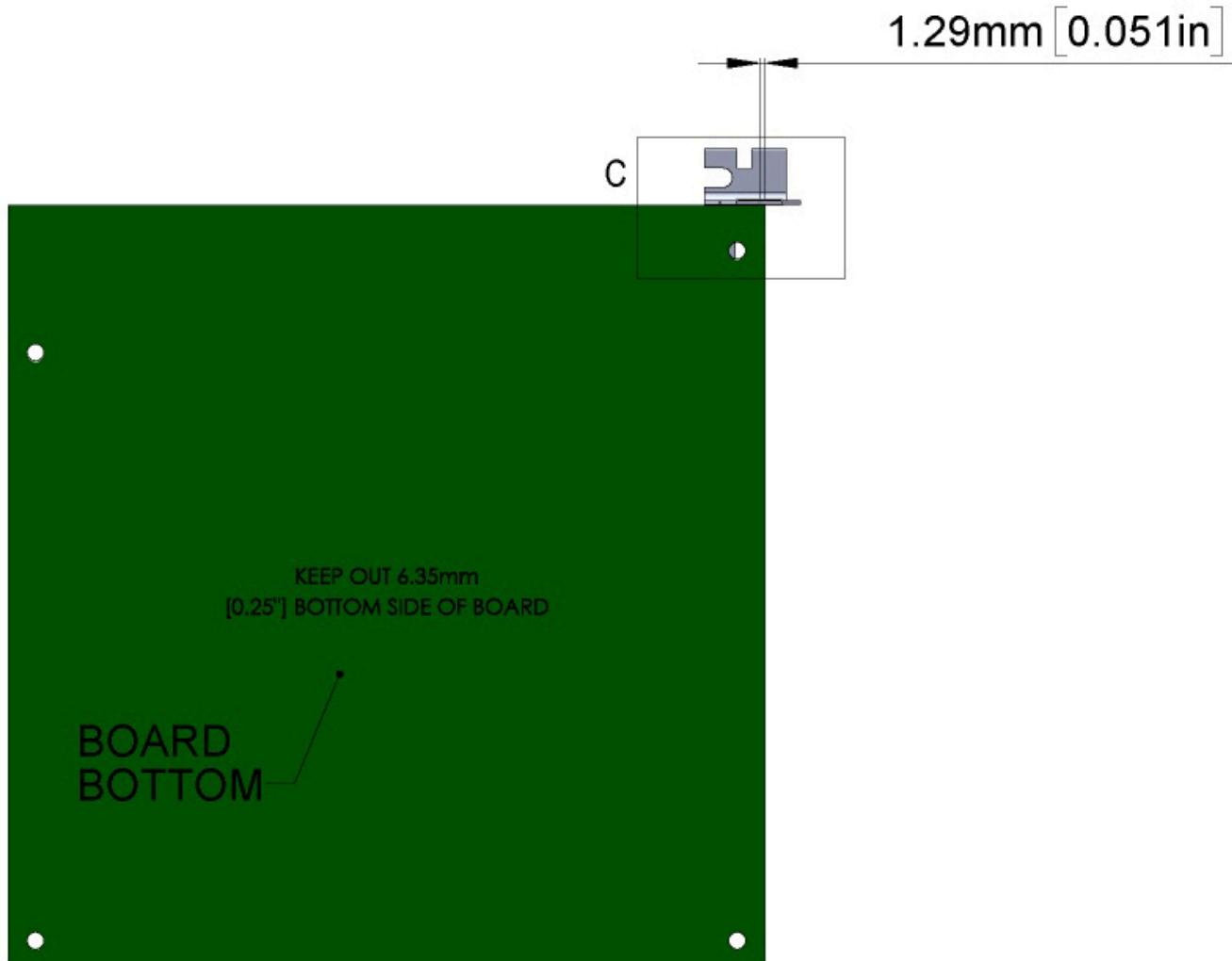
Mini ITX Board: Left View



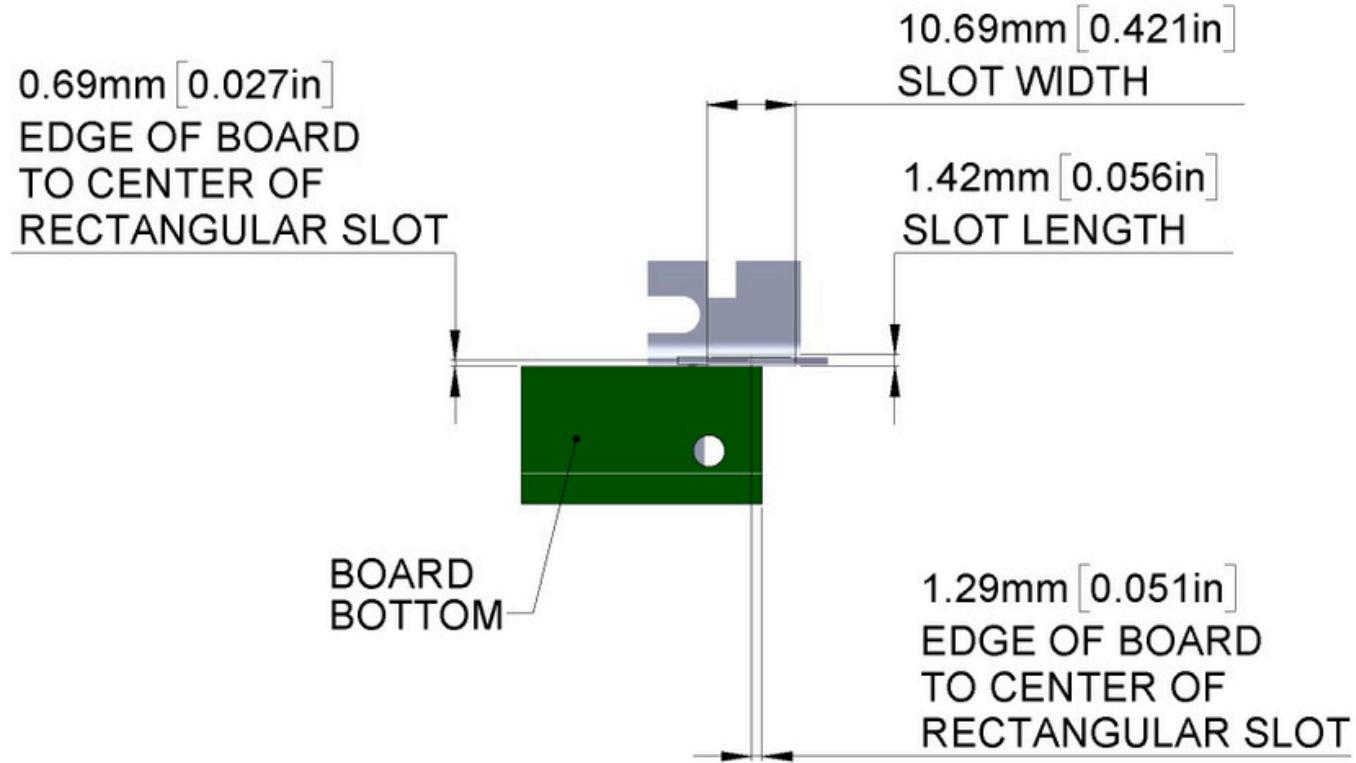
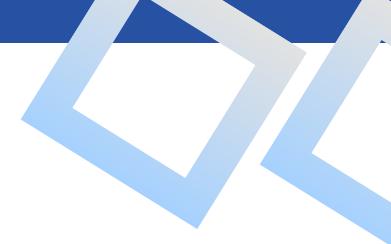
Mini ITX Board: Front View



Mini ITX Board: Bottom View



Mini ITX Board: Detail View



DETAIL C
SCALE 2 : 1
USED TO ILLUSTRATE THE PCI SLOT CUTOUT
IN THE BOTTOM OF THE CASE

ABOUT PROTOCASE



Long lead times stifle projects. They let your focus and momentum drift away.

Latencies complicate production runs and encourage inventory buildup. But it doesn't have to be this way.

At Protocase, we've developed a unique mass custom manufacturing process that's ultra-fast, flexible and easy.

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info@protocase.com