



How to Design Custom Enclosures for Motherboard-Based Systems

If you're looking to integrate a standard form factor motherboard into your custom enclosure, the common [ATX motherboard](#) is universal, powerful, and cost-effective. Also, [micro-ATX](#) and [mini-ITX motherboards](#) have been developed specifically for applications where small size, low power consumption and minimal noise is desired. This resource will cover the key elements of designing custom enclosures that accommodating 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.

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.

For simplicity, in this resource, we will assume the board is being mounted horizontally, on the base of the enclosure and the I/O connectors are accessed through the rear of the enclosure. However, if you choose alternate orientations, the same principles and details can be adapted.

CONCEPTS

- Specific dimensions such as mounting hole patterns and I/O connector block locations are standardized on all ATX, Micro-ATX and mini-ITX motherboards.
- Designing the mounting pattern on the base, I/O and (or) card slot openings on the rear are key tasks.
- Clearances between the edges of the motherboard, fans, components, drives, cables, etc., and the sides of the enclosure must be considered when designing enclosures.
- 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 / 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 adaptor and the PCI card brackets. (This equated to .020" between PCI bracket and inside enclosure wall.)
- 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.
 - Some PCI cards are longer than the example used in the motherboard images below, 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 you are in your design.

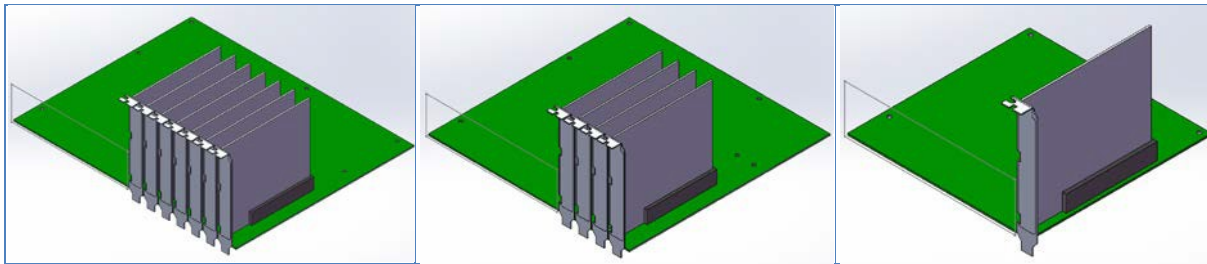
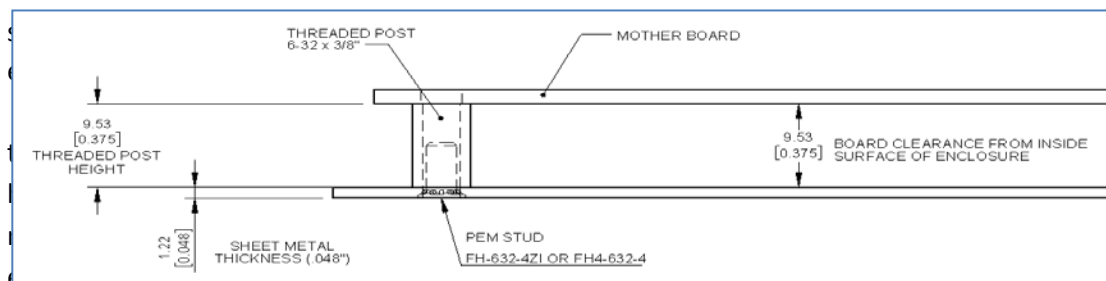


Figure 1 – ATX Board with PCI Cards

Figure 2 – Micro ATX Board with PCI Cards

Figure 3 – Mini ITX Board with PCI Card

- U

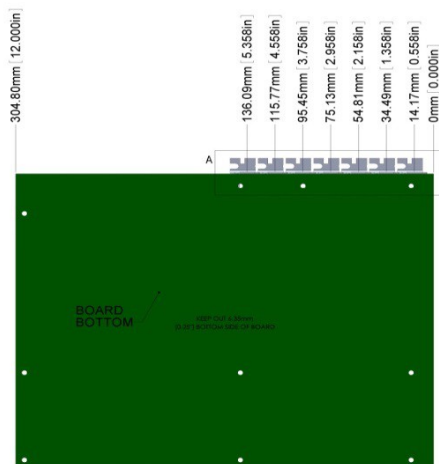


aded posts to raise the board above the floor of the enclosure to avoid contact of parts on the underside with the metal casing (see Figure 3 below).

- Standard motherboard mounting holes will accept a 6-32 thread size.
 - A PEM style self-clinching stud has an external thread; a ¼" (6.35mm) long PEM stud and 3/8" (9.53mm) threaded post should be suitable for most enclosure thicknesses.

Figure 4 – 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. (Refer to bottom view image below for clearances). In the image above we allow .375" clearance.



Bottom View

- 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.

Note: If you intend to use a fan-cooled processor in a situation with little clearance between the fan and the enclosure wall, we recommend fans that pull air directionally across the processor heat sink rather than down onto the top of the sink.

VENT CUTOUT PLACEMENT

Consider the orientation of fans carefully. Align intake and exhaust outlets so you can take advantage of the current they create, and make sure they don't conflict with 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.

See Figure 5 below for some examples of ventilation cutout placements.

To maximize the effect of ventilation airflow, ensure the only openings in your enclosure are the ventilation cutouts or openings that will be filled by switches, connectors, or panel display features.

Unnecessary holes in the enclosure panels can cause disruption of natural convection currents, resulting in less effective cooling of the processors. When in doubt - use a fan or fans to move air in and out of your enclosure.

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 of its support surface. Avoid placing cutouts directly beneath the motherboard which may allow objects to accidentally poke up through the spaces and contact the board, causing unwanted damage. It is better to place bottom panel cutouts outside the perimeter of the motherboard.

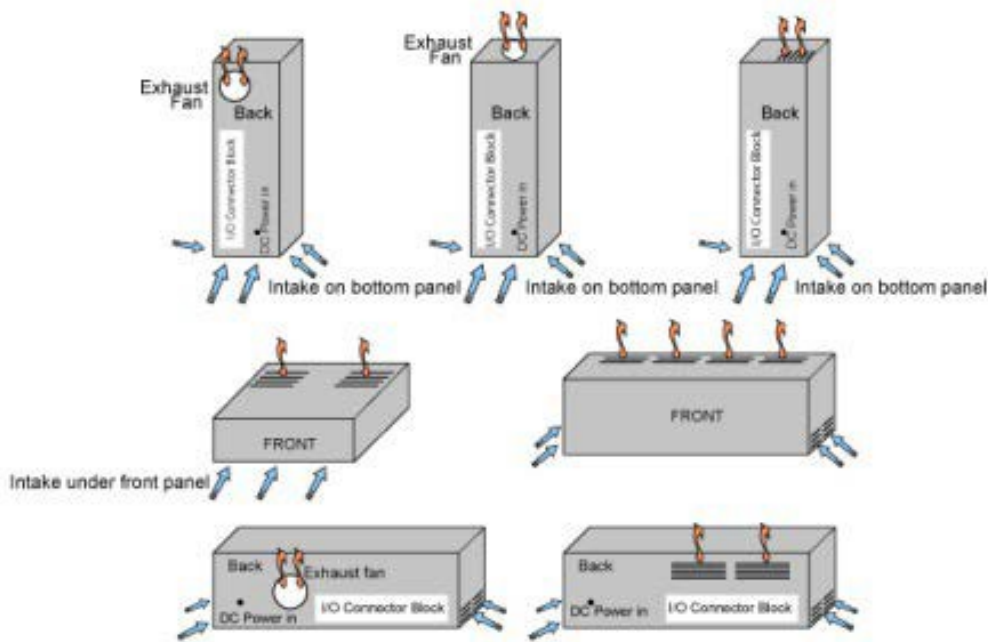


Figure 5 – Suggested placement of ventilation cutouts and enclosure exhaust fans. (Example uses ITX enclosure)

DESIGNING THE BASE

ATX, Micro ATX and Mini ITX motherboards are available in a wide range of configurations, but they use standard overall dimensions, mounting points, PCI card details, and I/O connector block areas.

Mounting holes, standoffs, and offsets

- To locate the board correctly within your enclosure, offsets must be added to these coordinates so that there is sufficient clearance between the edges of the board and the enclosure walls.
- This edge should be offset 0.065" (1.65mm) from the inner face of the enclosure wall.
- 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 be mounted.
- The remaining sides of the motherboard should be offset a minimum of 1/4" from the inner face of enclosure walls.

Figures 6, 7 and 8 below are board views to show the mounting hole patterns with dimensions referenced from the lower right corner of the motherboard.

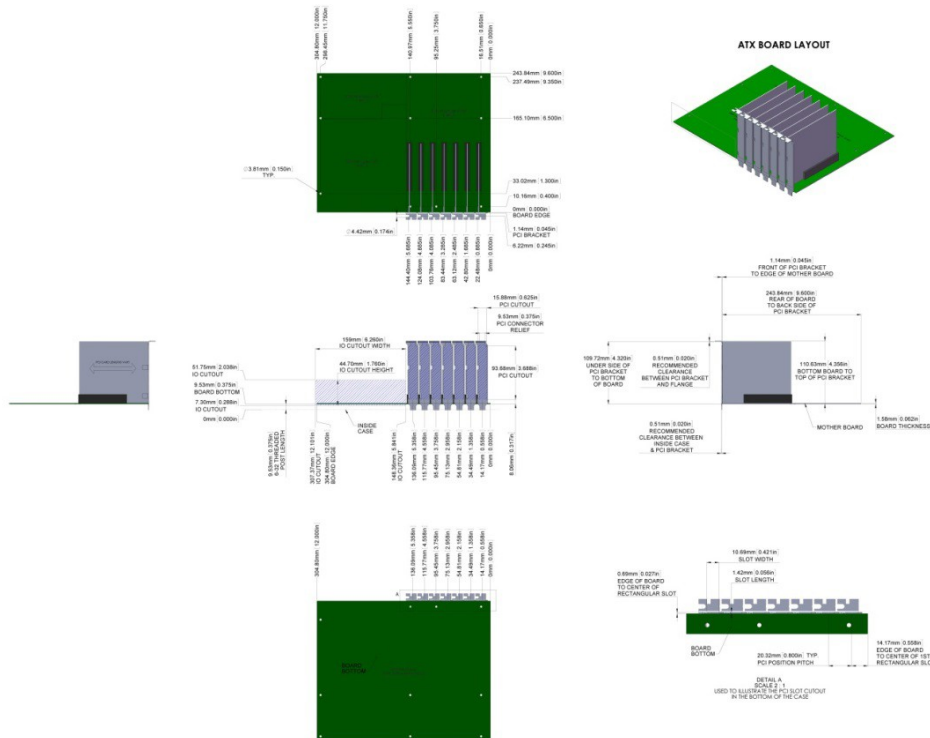


Figure 6 – ATX board all views

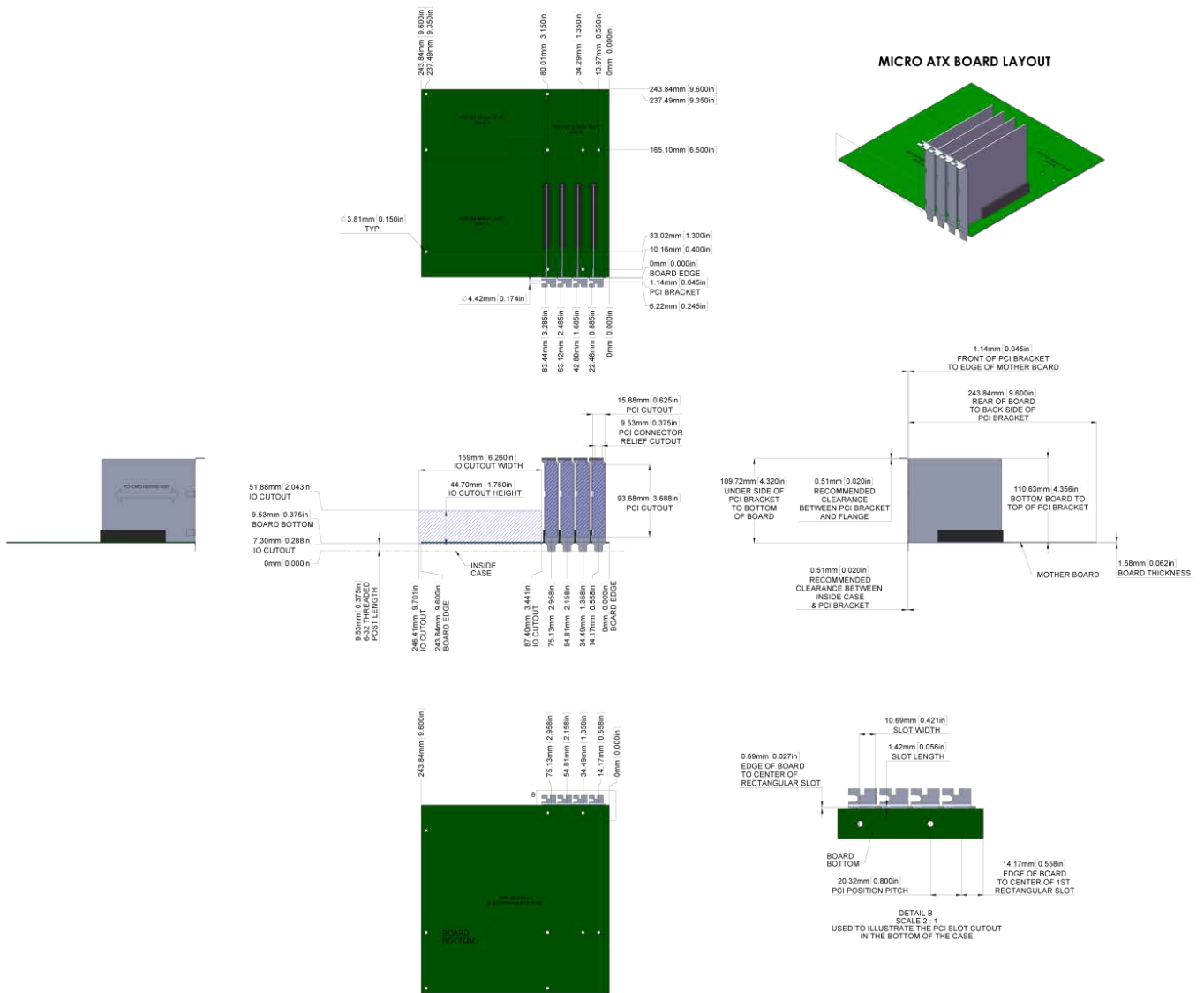


Figure 7 –Micro ATX board all views

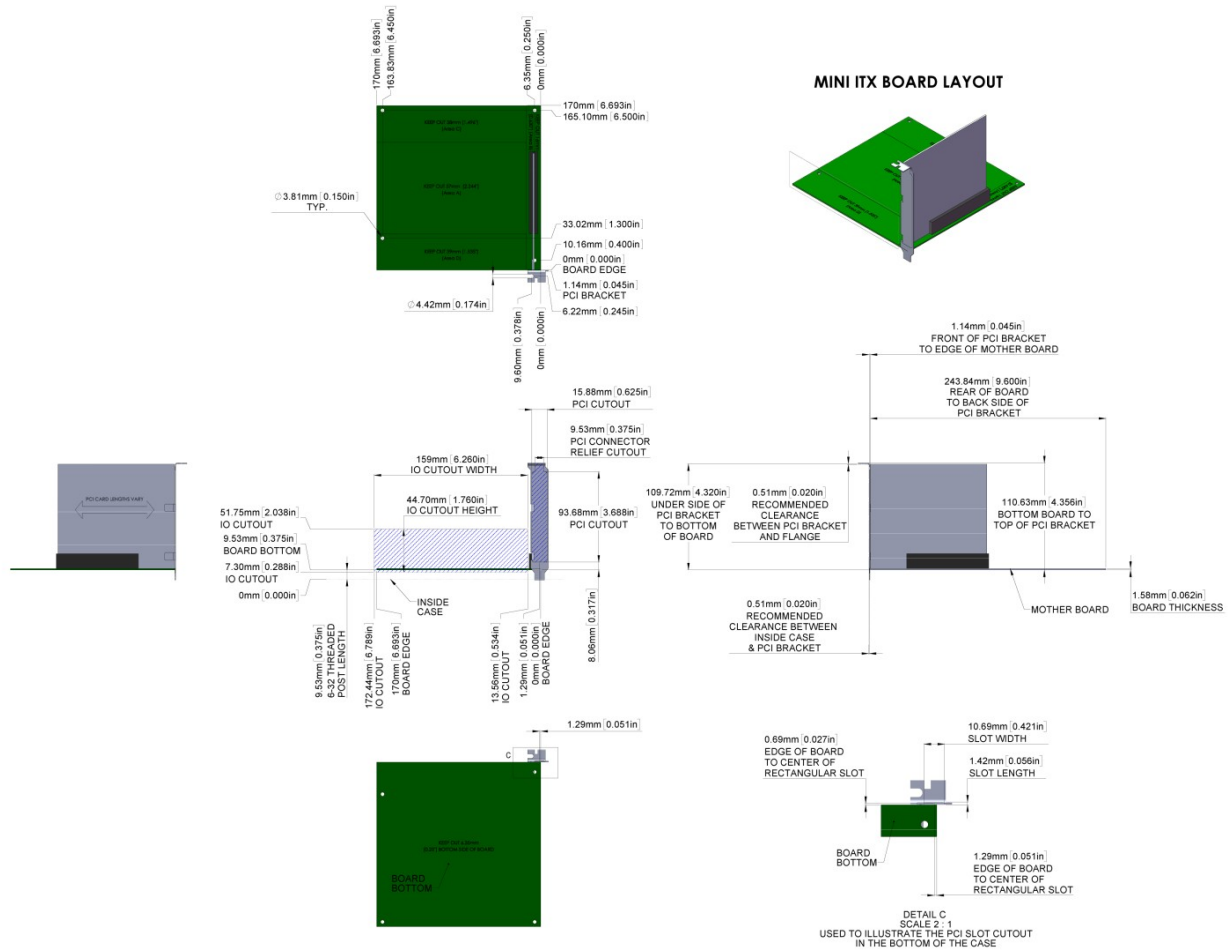


Figure 8 – Mini-ITX board all views

PCI CARD TABS

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 PCI Card Brackets. These tabs are designed to fit into a slot in the base of the enclosure, in order to help secure the card.

Figures 9, 10 and 11 (see below) 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.

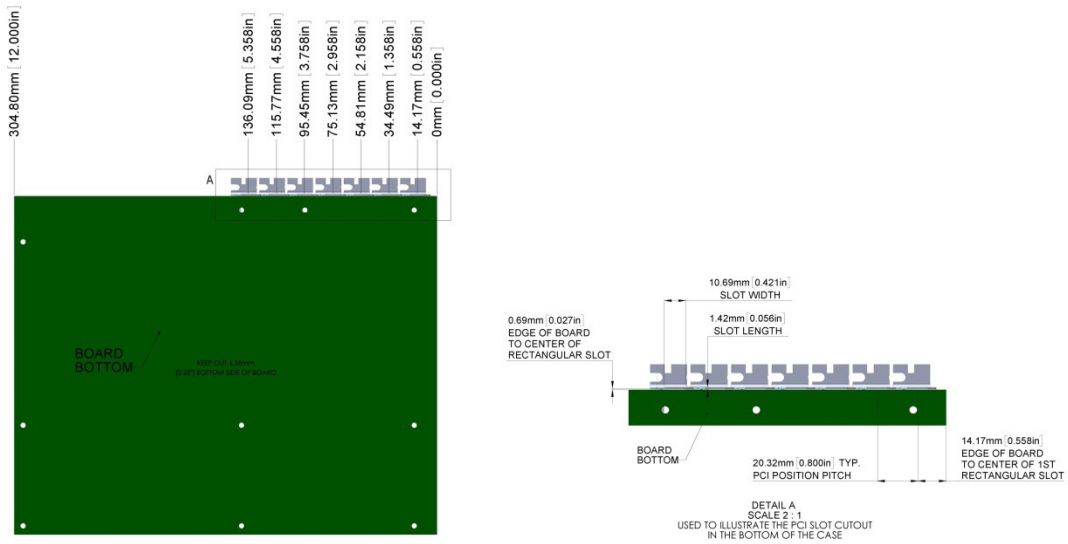


Figure 9 – ATX board bottom view, with dimensions for rectangular slot for PCI tab.

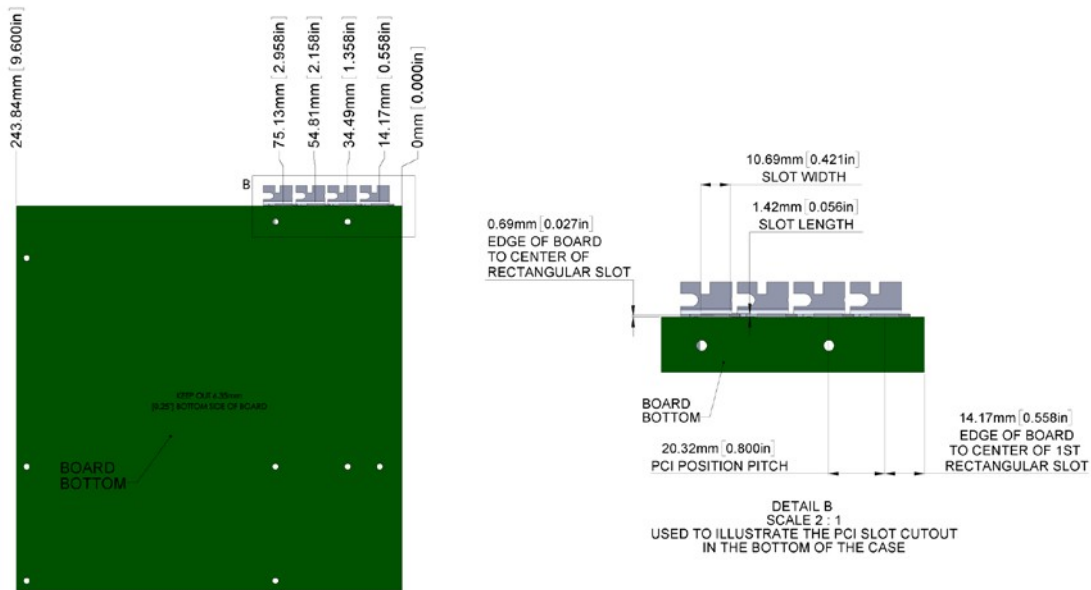


Figure 10 – Micro ATX board bottom view, with dimensions for rectangular slot for PCI tab.

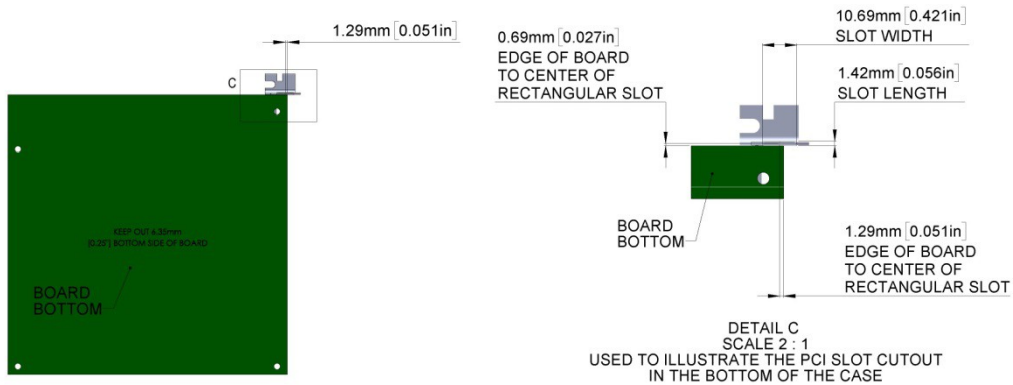


Figure 11 – Mini ITX board bottom view, with dimensions for a rectangular slot for PCI tab.

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

ATX, Micro ATX and Mini ITX boards have a standard size I/O connector block and PCI area. The standard cutout for PCI slot access is shown in **Figures 12, 13 and 14**. These drawings use of a 6-32 x 3/8" threaded post, which positions the bottom of the board 0.375" (9.53mm) from the inside of the base. If you are using standoffs of different length - you must adjust the vertical position of these cutouts accordingly. Another thing to remember is that horizontal dimensions are from the corner of the motherboard. Therefore, be sure to horizontally offset the pattern by an appropriate amount to match the offset you chose when designing the base.

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)

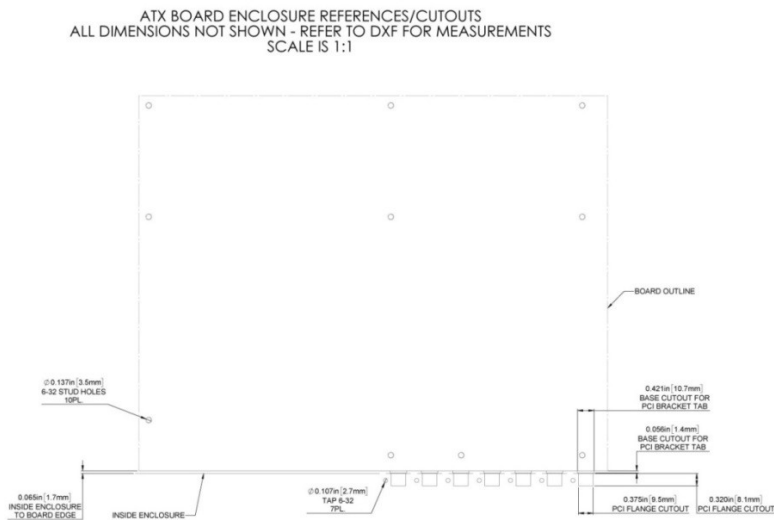
PCI Slots

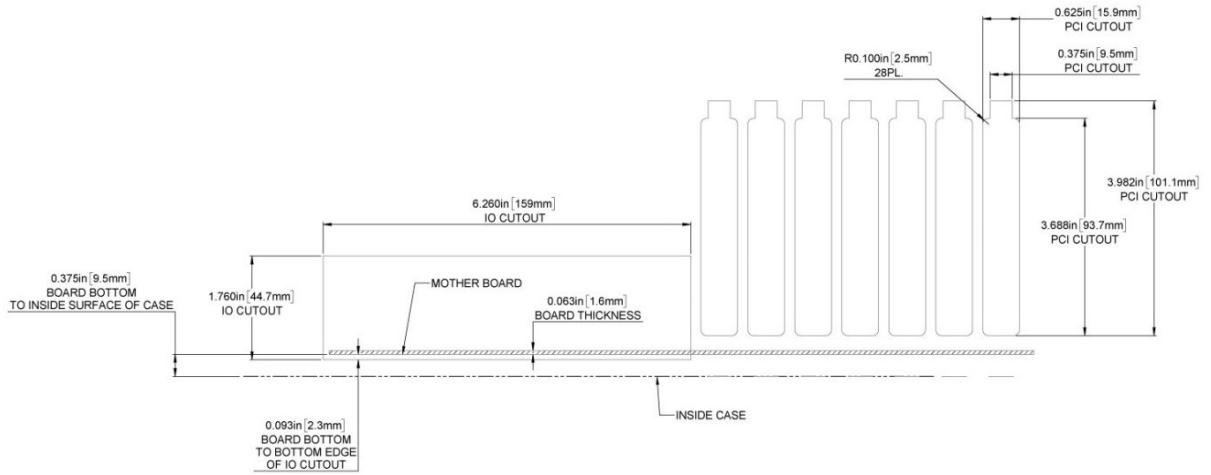
- The standard slot-style cutouts for PCI card access are shown in **Figures 12, 13 and 14**.
- Adjust vertical and horizontal offsets as per I/O area cutouts.
 - If you do not anticipate using all the PCI slots you can either omit cutouts as required or specify '**knockouts**'. For knock outs, we leave several very small metal 'bridges' or 'tabs' that keep the center in place until the user decides to physically remove it.



Figure 12 – PCI cutout Knockout example.

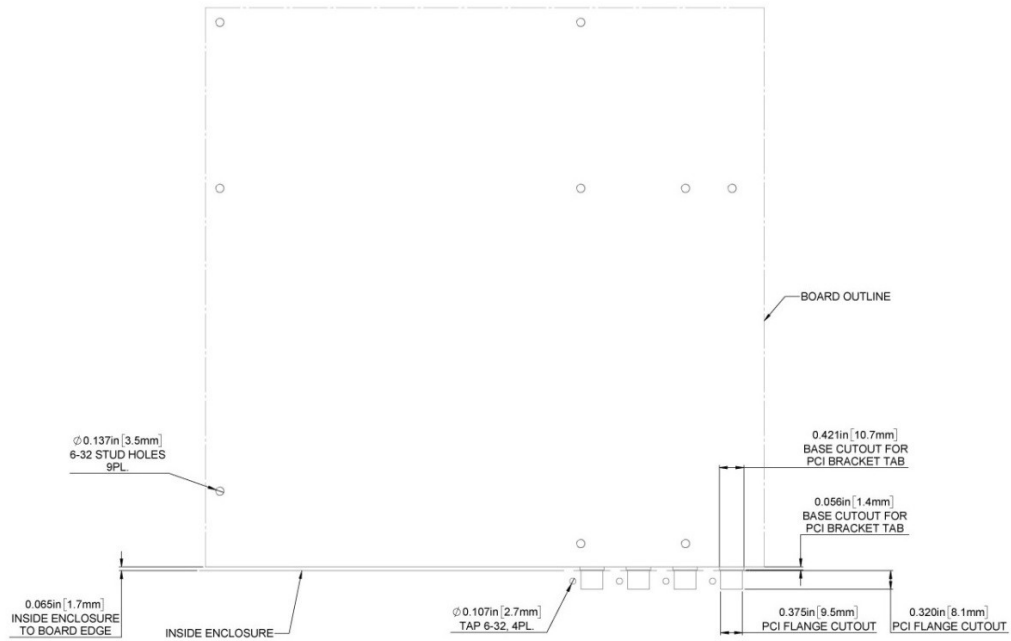
- Use caution with knockouts if using cold rolled steel in damp or corrosive environments, as small bare metal patches will be left once the centers are removed.
- If using PCI cards, a flange should be designed into the back panel to allow PCI card brackets to be fastened.
 - Place screw holes at the dimensions shown for the screw opening on the top of the PCI card brackets, as shown in **Figures 6, 7 and 8.**
 - 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.





ATX enclosure back panel I/O and PCI cutouts

MICRO ATX BOARD ENCLOSURE REFERENCES/CUTOUTS
 ALL DIMENSIONS NOT SHOWN - REFER TO DXF FOR MEASUREMENTS
 SCALE IS 1:1



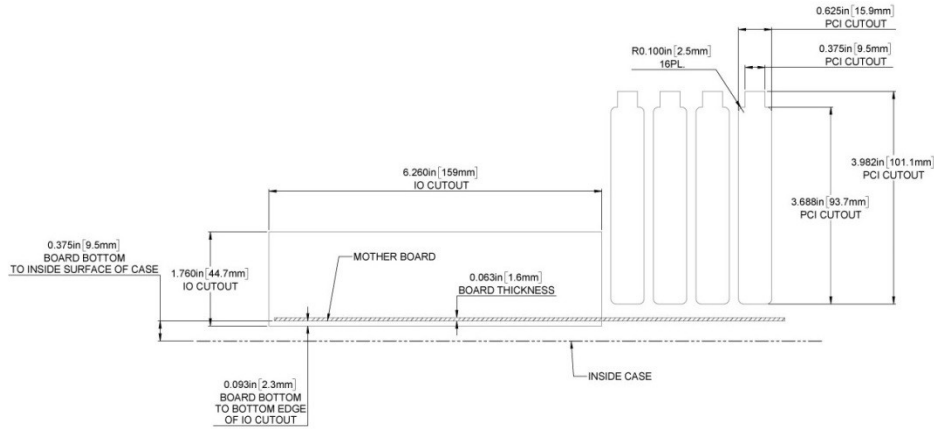


Figure 13 – Micro

ATX enclosure back panel I/O and PCI cutouts

MINI ITX BOARD ENCLOSURE REFERENCES/CUTOUTS
 ALL DIMENSIONS NOT SHOWN - REFER TO DXF FOR MEASUREMENTS
 SCALE IS 1:1

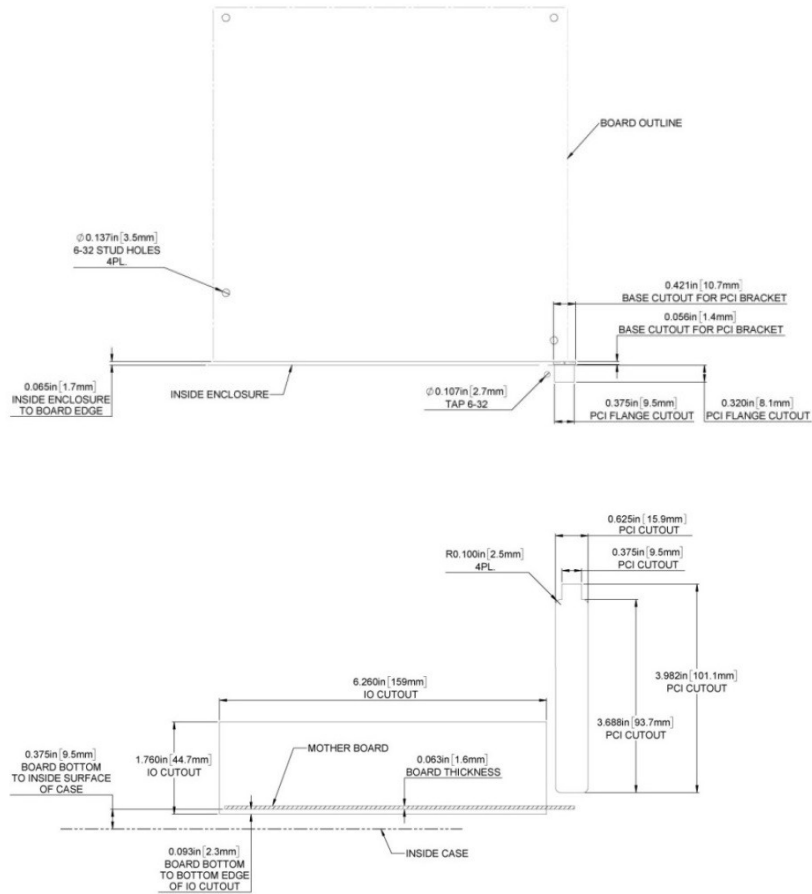


Figure 14 – Mini ITX enclosure back panel I/O and PCI cutouts

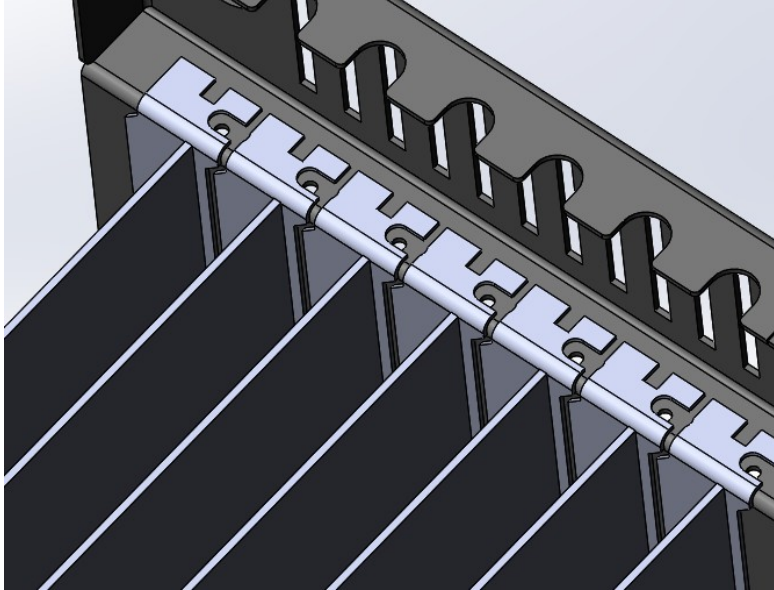


Figure 15 – PCI Bracket Mounting Flange

USING PROTOCASE DESIGNER® 3D CAD FOR ENCLOSURE DESIGN

Procase Designer is 3D CAD software that enables users to quickly design customized electronic enclosures, get instant quotes and buy online. Our software is easy to navigate, quickly learned and available [here](#).

If using Procase Designer, remember it uses the lower left corner of the front face of the enclosure as the origin.

Other things to remember:

- We have created templates that have the IO/PCI cutouts and mounting PEMS included.
- The templates mentioned above use a combination of a stud and an aluminum threaded post (Aluminum Female Threaded Round Standoff 1/4in OD, 3/8in Length, 6-32 Screw Size 93330A443 (6-32)) to mount the board.
- The outside face of the rear of the enclosure - where you will most likely be placing the I/O connector block, will be at the maximum depth dimension of your enclosure.
- Since the connectors must project from the rear panel, calculate the standoff positions from the rear of the enclosure, allowing for the thickness of the metal

LIMITATIONS AND WORK AROUND

If using Procase Designer, please note that it will not accept PCI card tab slots, as they fall on a bend radius. Also, the templates do not include the flange for fastening the top of PCI card brackets. These

limitations will be addressed in future releases. For now you'll need to work around this limitation as described below:

At the present time, if you require PCI card tab slots, simply design without them, and inform Protocase technical staff at the time of order so they can add these details for you, free of charge. If there is anything you are unsure of (measurements, cutouts, placement, etc.) just give us a call and we will be happy to check it out and get you your design as quickly as possible.

ADVANCED DESIGN TOOLS AND MANUFACTURING

The resources listed below are extremely useful for anyone who designs custom electronic enclosures.

- Protocase online [template generator](#) - This will automatically create basic enclosure designs (Rack mount, L-Shape, U-Shape, Consolet, Machined Enclosure) for you in a CAD format of your choice - saving you the effort of designing from scratch.
- [Protocase Designer](#) downloadable 3D CAD software (For enclosure design) - Utilizes a time-saving template based approach, and offers instant online quotes and online ordering.
- All of the CAD files/drawings shown in this document, as well as other details related to enclosures for motherboards can be downloaded [here](#).
 - They are available in Solidworks .sldprt, 2D .dxf, and .pdf formats. The .sldprt file also contains details for other boards in addition to mini-ITX and ATX.
- [Formfactors](#) is a great source for information on motherboards. See links below for more information.
 - [ATX Specification](#)
 - [MicroATX Motherboard Specification](#)
 - [Mini-ITX Specification](#)

Save time and hassle by choosing Protocase for custom enclosure manufacturing. We build your enclosure from your design, exactly to your specifications in 2-3 days, with no minimum order.

Request a [Quote](#) to get started, or [contact us](#).