ZHL-2425-250X+
Heat Sink Mounting Instructions

AN-60-110

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Introduction

Depending on the end system design or architecture, the ZHL-2425-250X+ power amplifier module can be either water cooled or air cooled. Water cooled systems have superior cooling capabilities, but the requirement of a water chiller can be a large and expensive proposition for the evaluation of a single unit. Instead, a heat sink and attached fan can provide a more economical and less bulky cooling solution for single unit evaluation.

Mini-Circuits provides the ZHL-2425-250X+ as an amplifier pallet “without a heat sink” leaving the end-user to decide what type of cooling they want to use.

This application note describes how to mount the ZHL-2425-250X+ to the Mini-Circuits heatsink (HSK-2425-250+). This is a heat sink that is designed specifically for the ZHL-2425-250X+ amplifier and includes mounting holes for attaching a 60mm DC Fan to one end for forced-air cooling. Recommendations are provided for all commercially available tools and accessories not currently provided by Mini-Circuits.

Importance of the Heat Sink

The ZHL-2425-250X+ can generate and dissipate a significant amount of power. At the nominal operating mode of 250W output and assuming 50% efficiency, 250W is dissipated in the amplifier and up to 200W (max reverse power limit) of reflected power is dissipated in the load for a max total of 450W dissipated power. The max operating temperature (65°C) allows for a 40°C temperature rise from a room temperature of 25°C. By making a few simplifying assumptions, we can calculate that the effective thermal resistance of the heat sinking solution from base plate to ambient must be less than 40°C/450W or 0.089°C/W. This thermal resistance cannot be achieved by any reasonably sized heat sink by the passive effect of convection alone. Indeed, some powerful fans are needed in order to cool the amplifier sufficiently in its max dissipation state. The thermal resistance requirement can be relaxed slightly if the amplifier load is well matched or if the amplifier is not operating at full power. In any case, it is critical that the amplifier is always mounted to a heat sink with a fan and its airflow adjusted to keep the amplifier below 65°C at full RF power when operating. Otherwise, the amplifier will get too hot, the built-in protection alarms will be activated, and the power amplifier will shut itself down.

Amplifier Mounting Holes

There are 9 mounting holes on the ZHL-2425-250X+. Eight holes are located beneath the shield and one hole outside the shield, see Figure 1. These can be used to mount the amplifier module to the HSK-2425-250+ heatsink shown in Figure 2. The following instructions describe how to do this.

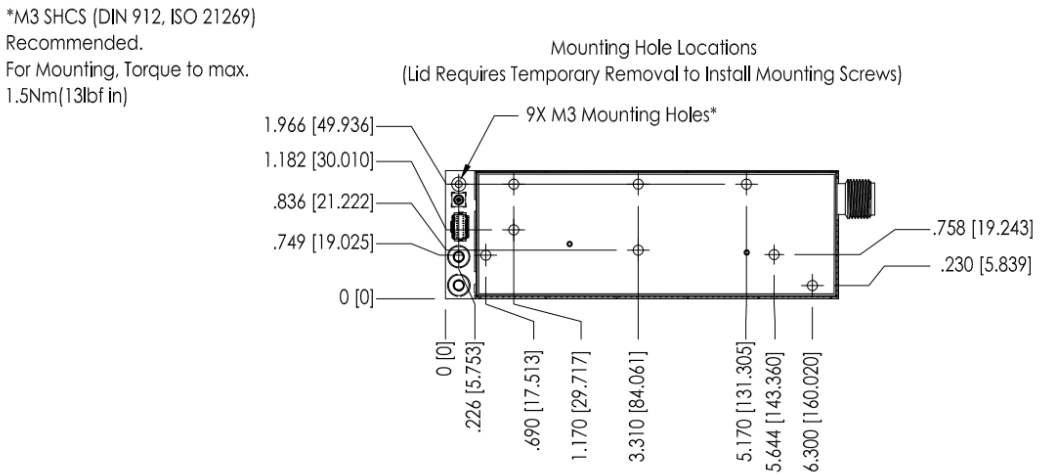


Figure 1: Outline drawing showing the locations of the 9 mounting holes on the ZHL-2425-250X+ (.124in. Dia.), 8 under the cover, sized for M3 socket or pan head screw with head Diameter 5.4 - 5.6 mm

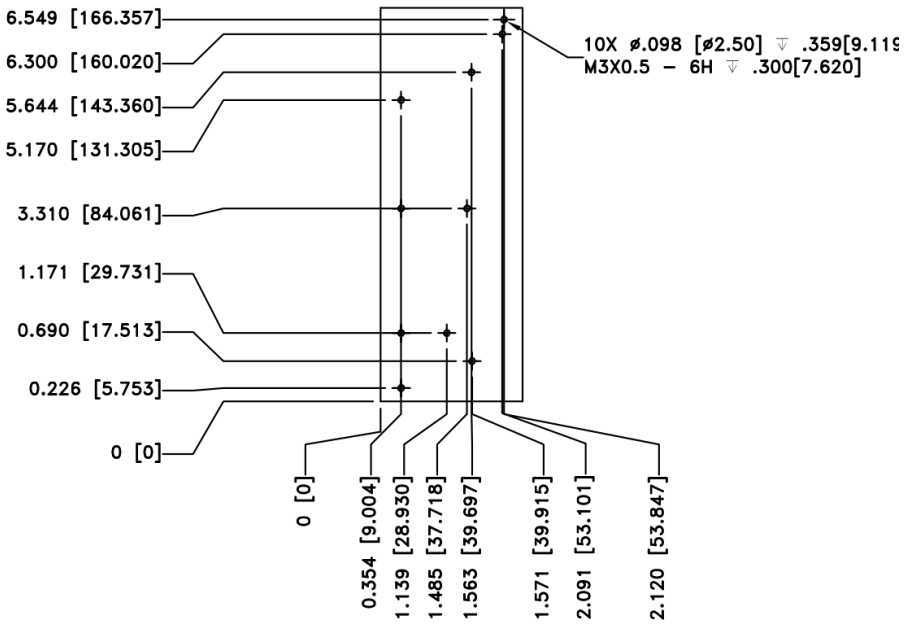


Figure 2: Outline drawing of the HSK-2425-250+ heat sink, the exact locations of the screw holes are shown

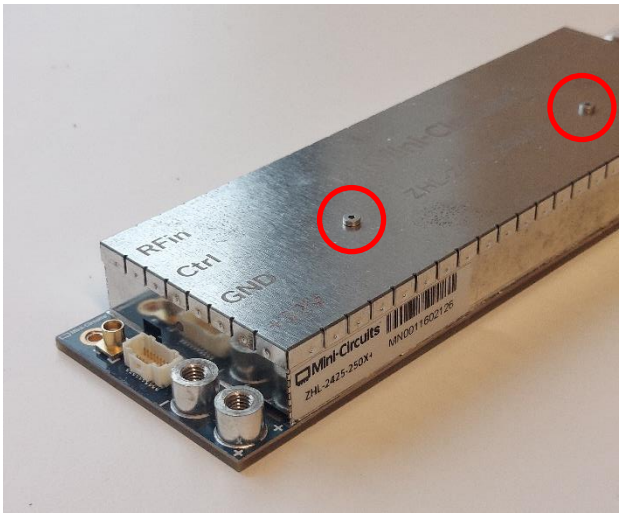


Figure 3: ZHL Amplifier module with shield screws shown.

Heat Sink Mounting Instructions

Step 1:

The ZHL-2425-250X+ is delivered fully tested and calibrated with the shield attached. First, remove the two shield screws shown in Figure 3. The shield screws can be removed using a 0.05" or 1.3mm hex key. Once the screws are removed, pop off the cover by starting from the corner and working your way along the sides.

Step 2:

Apply a layer of electrically non-conductive thermal compound to a ~3x4" area of a plate. Roll the roller in the paste to get the roller covered. Now roll the roller over the bottom of the amplifier module to create approximately a 2-5 mil uniform layer of thermal grease. The thermal compound is used only to fill in air gaps between the heat sink and the base of the amplifier pallet. Thickness should be kept to a minimum. A roller and thermal compound similar to what we use in our lab is shown in Figure 4:

Thermal Compound:

Description: Silicone Grease 2 oz Jar
Manufacturer: Wakefield Vette
Manufacturer P/N: 120-2

Roller:

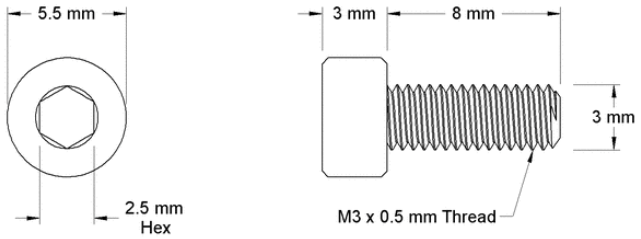
Description: Soft Rubber Brayer
Manufacturer: Speedball
Manufacturer P/N: 4717

Figure 4: Recommendation for thermal compound (left) and roller (right). A roller is used to apply a thin even layer of thermal paste to the interface between the amplifier and the heat sink. Any electrically non-conductive thermal compound with at least the same thermal conductivity as the one listed should be ok to use.

Step 3:

Now align the amplifier on the heatsink and insert the 9 mounting screws. Torque the mounting screws to a maximum of 1.5Nm (13lbf in). The recommended screw length is 8mm, but it is possible to use as short as a 6mm screw. See the recommended screw in Figure 5:

Mounting Screw:



Description: Socket Head Screw, M3 x 0.50 mm Thread, 8 mm Long
Manufacturer: McMaster-Carr
Manufacturer P/N: 91292A112

Figure 5: Recommendation for the screw to mount amplifier to heat sink

Step 4:

Replace the shield cover and fasten the shield cover screws.

Fan Recommendations

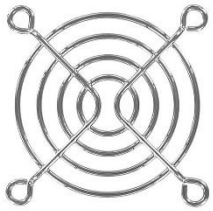
The Mini-Circuits heat sink has been designed with mounting holes for end-mounting 60mm fans. The bottom of the heat sink is covered leaving one inlet and one outlet for air at either end. Our recommendation is to use a single fan on one end of the heat sink oriented so that the direction of airflow is going into the heatsink. The recommended fan assembled with the 4x mounting screws and protective grate are shown in Figure 6 and Figure 7. It is important to size the fan according to the worst-case power dissipation condition that you will see in your application. The recommended fan has a max air flow of 76.16 CFM and is sized for 50% reflection back into the load at full rated 250W forward power. The recommended fan is rated for 2.3A @ 12VDC. Fan speed can be modulated by either the DC supply voltage (6-12V) or through the PWM control input (yellow wire).

Figure 6: ZHL Amplifier module with fan attached to the heat sink. A DC Barrel Jack for easily suppying 12V to the fan is also shown.

Cooling Fan

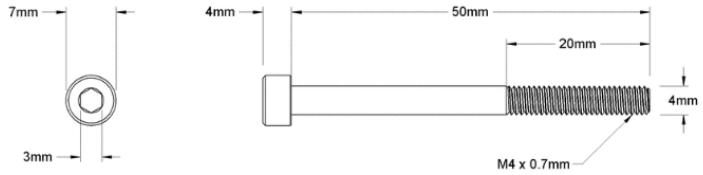
Description: Fan Axial, 60x38mm 12V, 4 wire PWM
Manufacturer: Delta Electronics
Manufacturer P/N: PFR0612XHE-SP00

Fan Finger Guard



Description: 60mm Sq Fan Finger Guard
Manufacturer: Qualtek
Manufacturer P/N: 08147

Fan Mounting Screws



Description: 50mm M4-0.7 6H socket screw
Manufacturer: McMaster-Carr
Manufacturer P/N: 91292A140

Figure 7: Recommendations for the cooling fan (top left), fan finger guard (top right), and fan mounting screws (bottom). The recommended fan shown is a 4-wire version. 3-wire and 2-wire versions are also available if PWM control is not needed.

Fan Controller Recommendations

While it is possible to always run the cooling fan at full speed, there are a few drawbacks to this approach. For applications that require the amplifier to be on standby, biased with no input power, a fan that is operating at full speed would be both loud and inefficient. In this case, an additional controller could be used to modulate the fan speed proportionately to dissipated power or sensed temperature. PWM fan controllers for 4-wire, 12V DC fans are commercially available and a recommendation for the fan controller that has been tested with our recommended fan and heat sink is provided in Figure 8. The housing and four crimp terminals shown in Figure 9 are required to connect the 4-wire fan output to the recommended PWM controller.

PWM Controller

Description: DC 12V, 3A, 4 pin PWM Fan temp. control, thermostat speed controller and thermal probe included.
Manufacturer: Cold and Colder
Manufacturer P/N: PFR0612XHE-SP00

Figure 8: Recommendation for the PWM controller. The temperature sense probe shown in the image can be affixed onto the side of the heat sink with an M2.5 screw

Molex Housing (for fan wiring)

Description: KK 254 Housing with Polarization Rib, 4 Pin
Manufacturer: Molex
Manufacturer P/N: 0470541000

Crimp Terminal (for fan wiring)

Description: KK 254 Crimp Terminal, 22-30 AWG
Manufacturer: Molex
Manufacturer P/N: 08500113

Figure 9: Connector housing an terminal to interface 4-wire fan with PWM controller

Final Notes

The intended location of a temperature probe mounting point is on the side of the heat sink. There are 4 mounting holes on the side of the heat sink as shown in the heat sink case style drawing as well as Figure 10 below. The top left hole is used as the temperature reference point as it is physically closest to the output stage transistor and will follow the temperature reported by the internal temperature sensor most closely.

The fan wire color of the functioning demo system is also shown in Figure 10 for reference.

The right two mounting holes have been used to mount the PWM controller to the heat sink itself for a clean-looking appearance.

The PWM Controller from cold and colder is a nice solution for standalone operation, but it is only one example of what might work to cool the amplifier. When more than one amplifier is used in a system, it may be desirable to control all fan speeds from a central master controller using feedback from the ADC readings on board the amplifier. As the number of amplifiers in a system increases, water quickly becomes a more attractive option for cooling as it offers more efficient and effective implementation options.

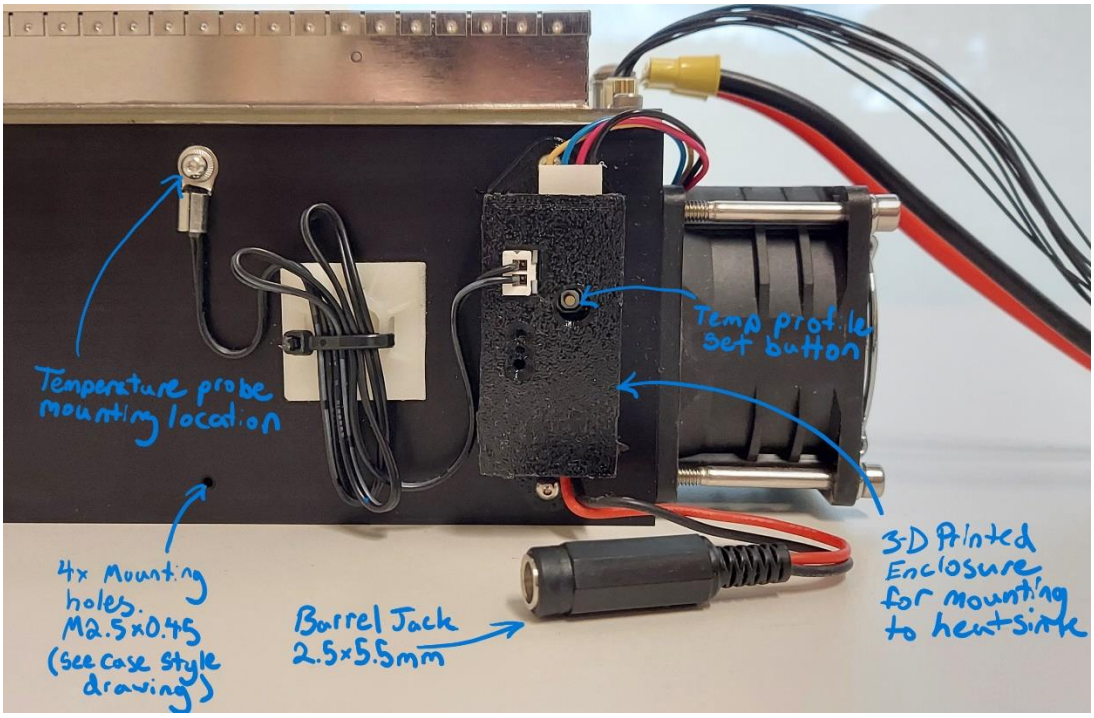


Figure 10: Completed example assembly of temperature feedback cooling system for the ZHL with 3-D printed enclosure for the PWM controller board, barrel jack added for easily interfacing with a standard 12V power supply, and zip ties for cable management.

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