Key Factors and Guidelines for Designing SFP Cage Cooling Systems

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Sealed Small Form-factor Pluggable (SFP) optical and electrical integrated assemblies play an important role on printed circuit boards by maximizing valuable space, while also providing an environmentally rugged interface. Designers currently have two choices when it comes to SFPs: Regular SFP interconnects support 1.125 Gbps Fibre Channel and 2.5 Gbps Gigabit Ethernet applications, while the more advanced SPF+ interconnects support applications for 8 Gbps Fibre Channel and 10 Gbps Gigabit Ethernet. Both interconnect types use the same space-per-port.

Featuring a panel feed-through design, SFP assemblies typically incorporate an internally mounted cage and related electrical circuitry. One of the key considerations when it comes to the cage is whether or not cooling is necessary. There is no clear answer to this question so it’s critical for design engineers to consider several factors:

• The heat dissipation of one SFP insert: This can range from zero (passive copper cable) to approximately two watts when using twin bi-directional LC inserts.

• The equipment practice: This may be a rack with vertical daughter cards, but it could also be a pizza box with only a main board or with additional mezzanine cards on top.

• The number of ports on the daughter card/mezzanine board.

• The density of the ports: This can be single cages with space in between, ganged cages or stacked and ganged cages.

• The airflow in the system: Always occurs bottom-to-up in a rack but may be different in a pizza box, such as east-to-west or front-to-rear.

• The ambient temperature (fan supported approximately +40°C), the maximum allowed temperature for the insert (typically +70°C) and the air flow speed.

Dissipated Heat Guidelines to Consider

At Molex, we conducted many simulations in our thermal labs to understand the results of the above factors. We do not have a universal recipe to offer a clear-cut solution for the problem, but for single cages with spaces in between, engineers are on the safe side if the dissipated heat is below one watt per insert. When ganging cages, there is still no heat problem—assuming there’s a copper ground plane underneath the inserts that distribute the heat.

If dissipated heat rises above one watt per insert, care should be taken—especially when ganged SFP cages are preferred or required. Configuring a fully SFP-loaded front panel with inserts above 1.5 watts heat dissipation for each insert requires cooling.

When addressing the cooling issue, the first hurdle is to find a good thermal connection between the insert and the heat sink. Only Quad Small Form-factor Pluggable (QSFP) inserts have a flat and smooth surface on top for close contact to a heat sink. SFP inserts do not always have this and, even worse, some are manufactured with the label on top, which does not conduct heat well. Design engineers can improve the situation by installing conductive heat cushions like the one shown above.

Using a defined insert with a defined heat cushion, the second hurdle is to select the right heat sink in the given environment. Molex tested an environment using a rack with vertical daughter cards and 24 ganged SFP ports (four cages for each of the six ports). Given the height of only 15.2 mm above the board, it was clear that a heat sink on top of the SFP cages would block the airflow. This situation is actually worse than using no heat sinks.

Heat Sink and Baffle Recommendations

Heat sinks should have fingers (no ribs) to create turbulence and generate better thermal conductivity to the air. In our testing, we thus tried “rucksack” heat sinks since a lower profile with a rucksack is more efficient than a higher heat sink just above the cages.

We tested several heat sink configurations and found the lower-profile, longer rucksack as the best performer. However, even with the extended rucksack, we had to apply a baffle in order to squeeze the airflow onto the rucksack area.
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We then created a heat sink comparison matrix that clearly shows some interesting findings:

- Installing heat sinks is sometimes worse than installing no heat sinks
- Without a baffle, airflow bypasses the heat sink area and thus the airflow is in vain
- More baffles do not improve the cooling effect
- Most critical is the swelter effect—the lower SFPs heat up the upper SFPs when airflow is not controlled

We also simulated and verified thermal issues with stacked and ganged configurations of SFP and QSFP as we foresee a wider usage of cages in the industry—not only with heat dissipation from fiber optic transceivers, but also with dissipated heat from active copper cables where equalizers are integrated into the cable plugs.

Molex tested heat sinks using no rucksack and a short rucksack but found the lower-profile, longer rucksack to work most effectively. Testing revealed that even with an extended rucksack, designers should apply a baffle to squeeze the airflow onto the rucksack area.

Determining the correct SFP cage cooling system is important because of the many benefits an SFP that functions well can provide when designed properly. For example, SFP transceivers can not only be installed into the front to allow for convenient factory pre-installations, but also removed and replaced for easy field upgrades. An SFP that is compatible with ODVA-compliant optical or copper assemblies can also accommodate industry-standard interface connectors and cable assemblies. Integrated solutions can contain copper or optical SFP devices, which allow for future upgrades and backwards compatibility.

When generating your SFP designs, following the guidelines mentioned above will ensure engineers are on the right path.