

HOT MATING AND MATE-FIRST, BREAK-LAST (MFBL) SOLUTIONS FOR POWER AND SIGNAL CONNECTORS



WHAT IS HOT MATING?

Hot mating, also known as hot plugging and live mating, is the act of plugging in a connector or component to a system while at least one circuit in the system is energized. In this document, we will consider the effects of “current interruption,” which refers to disconnection of circuits while still energized. Since arcing can occur during the process of both plugging in and un-plugging a component, for simplification, both actions will be considered hot mating.

Hot mating mainly occurs when testing, troubleshooting or signal adjustments are performed without stopping or shutting down the system. An example of a scenario would be in data centers in which a power supply can fail and needs to be replaced without shutting down the entire server network. Another example is in the case where external peripherals (e.g., laser markers, scanners or other monitoring equipment) need to be plugged into factory machines without shutting down and rebooting the entire assembly line.

DANGERS OF HOT MATING

There are two main problems that can occur during hot mating: a short during connection and arcing during either connection or disconnection. The negative effects of hot mating can vary from signal interference to destruction of components and input/output (I/O) pins. Damage may occur when an inrush of current proceeds through a system that is designed for a much lower current rating and has no proper grounding established.

The most destructive problem for circuit boards occurs when pins are connected in the wrong order causing a short and possibly damaging I/O pins and potentially the system.



Burned Circuit Board

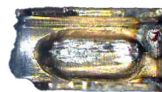
The picture above shows the negative effects of what hot mating can do to circuit boards.

The second problem is what happens when the connector arcs with the live system. Arcing occurs when the connector is plugged in or unplugged, and an electrical discharge is produced between the pins of the connector and electrically active components. This mainly results in damage to the connector housing and terminals and structurally weakens the integrity of the connection.

Something to consider is that the size and duration of the arc is dependent on the power supplied to the system. Systems with higher voltage and current will sustain an arc greater than those of lower voltages and current. This does not mean that arcing does not occur with a lower power system, just that it is less prominent and less damaging.



New Undamaged Contact



Damaged Contact due to Arcing

HOW POLARIZATION CAN PREVENT DAMAGE WHEN HOT MATING

Polarization on a connector refers to a specific keying or layout of the male and female ends and helps ensure a proper connection and prevent incorrect pin alignment.

A connector with polarization keys does not necessarily mean that it is designed to be hot mated, however it does sufficiently protect a connector terminal from being plugged in a way that can cause damage to the system. Polarization is just one way to confirm that the proper pins are mated correctly.



Example of Molex Mini-Fit Connector with Polarization



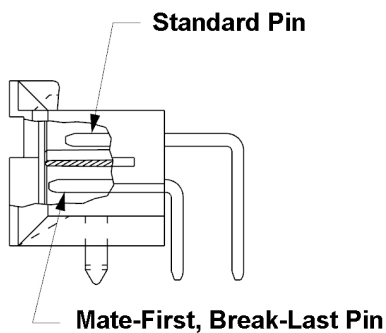
Example of a Connector without Polarization

The safest way to swap out components is to shut down the system, but often this is not possible. However, with proper connector and component selection based on the design requirements, shorting and arcing issues can be avoided.



HOW MFBL CONNECTORS CAN HELP ALLEVIATE ISSUES OF HOT MATING

MFBL is also known as FMLB (first mate, last break), which means that the connector is designed so that certain pins connect in the order desired and disconnect in the opposite order. Compared to FMLB connectors, MFBL connectors usually have longer pins for grounding and shorter pins for power and signal purposes. This protects large equalizing currents from flowing through the signal circuits, which are more sensitive and can permanently damage many electrical components. However, MFBL connectors do allow the ground and power connections to be made that can allow high equalizing currents to flow once the component is initially plugged. MFBL connectors are rated differently than typical connectors. Product specifications should be reviewed for any additional information related to the rating of the connector.



MFBL Mini-Fit Connector Schematic

MFBL connectors have many other advantages outside of hot mating, such as reverse polarity protection, improved electrostatic discharge (ESD) protection and signal status connection activations.

HOW MFBL CONNECTORS WORK TO HELP PREVENT DAMAGES OF HOT MATING

One example of how to hot mate components is with a 2-stage connector. In a 2-stage connector, the contacts connect in the following order and disconnect in the opposite way, as listed below:

1. Connect ground first—this safeguards the discharge of any static electricity in the system and establishes a proper ground for the electricity to flow through once connected.
2. Connect the power and signal second—after the ground is established, the power and signal can flow through the proper channels, as desired.

Note: This is not the only order of operation that will work with a 2-stage connector, and some designers may wish for the power and signal to be established first. MFBL connectors can also help achieve this goal.

EXAMPLE OF PROPER MFBL CONNECTOR FOR HOT MATING:

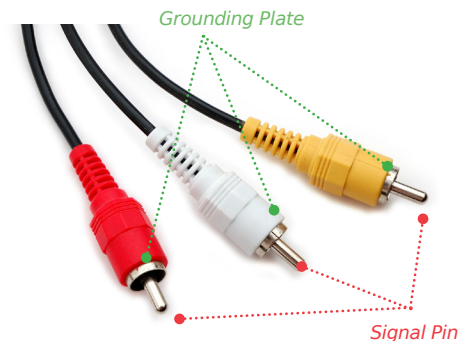
A very simple example of a proper hot-mating connector used in everyday life is the 3-prong outlet plug shown here.



As seen in the photo, the grounding pin extends beyond the power plugs to help ensure that grounding occurs first when someone is plugging in the cord.

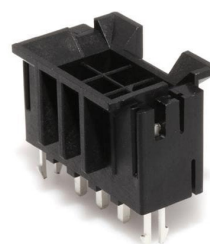
EXAMPLE OF CONNECTORS NOT DESIGNED FOR HOT MATING:

An example of improper hot-mating connectors is the RCA cable connectors shown here.

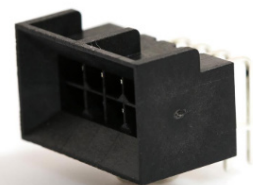


As shown in the figure, the signal pins extend past the grounding plates; this causes distortion in both audio and video signals when they are plugged in until they are fully grounded. This technology was suitable for low-power analog signals, but in most industries today, this type of connector would cause major damage to components.

MFBL connectors that utilize this technology to suit the specific needs of the user include both the Mini-Fit and Micro-Fit Connector product lines as shown below:



Molex Mini-Fit Connector
BMI VERT MFBL 44068



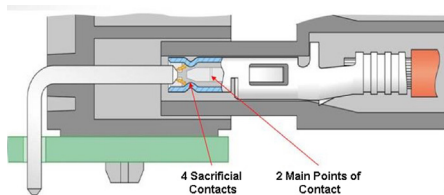
Molex Micro-Fit Connector
BMI RA HDR MFBL 44428



OVERCOMING ARCING WITH SACRIFICIAL CONTACTS

One way to address the issue of arcing caused during hot mating is to use connectors with sacrificial contacts to attract arcing when connecting. While arcing is very destructive to a connector, the sacrificial contacts are designed to take the brunt of this damage, keeping the main point of contact safe from degradation until the connector is fully mated.

An example of this is shown in the figure below:



Connectors like these are designed so that even if the sacrificial contacts on the connector are damaged, the component will still function properly. However, one thing to consider is that connectors with sacrificial contacts are not intended to be used with high mate-and-unmate cycles, as repeated mating and un-mating can degrade the sacrificial contacts. For example, a Gold-plated Mega-Fit Connector will have a durability of several hundred mate-and-unmate cycles; however, when hot mating, this durability will be significantly less.



*Molex Mega-Fit
Power Connector*



*Molex Ultra-Fit
Power Connector*

It is important to refer to the product specifications to determine the maximum voltage (based on UL 1977) allowable for any connector used. The maximum voltage allowed may vary depending on end-use application. Connectors used for hot mating have a voltage rating that is far less than the nominal voltage rating of the connector. This hot-mating voltage rating should be confirmed in the product specifications before the connectors are used in a hot-mating scenario.

SUMMARY

To properly connect a component to a live system, special connectors need to be used to help ensure that both the connector and the components will not be damaged. MFBL connectors work well for this situation, as do connectors designed with sacrificial contacts. If a system requires hot mating, these solutions should be considered in order to meet the needs of the design.