

# LEADFORM FOLLOWS FUNCTION

## IN RF REED RELAY DESIGN

A critical component for good RF performance in a reed relay is optimized leads. Relays are widely used in electronic test equipment to switch signals between different paths. A while ago when 30 MHz was thought to be a high frequency, optimizing relay lead design wasn't a high priority. Simple through-hole signal pins worked fine. But the advent of high speed serial data transmission has raised test signal rates to billions of bits-per-second, and, when switching these signals, more sophisticated lead designs are needed. For example, data flows through a USB3 port at up to 5 Gigabits-per-second (Gbps), requiring a bandwidth of at least 10 Gigahertz (GHz) to transmit all those binary on's and off's correctly.

**Modern high-frequency reed relay design focuses on getting the impedance as close to 50 ohms as possible**

Here's the reason why the leads matter. At high frequencies, electrical signals behave differently than they do close to DC. High frequency signals are degraded if they are sent down a conductor with sharp bends, because bends are inductive and present an electrical resistance that increases with frequency. As a result, energy bounces back to where it originated, is lost as heat, or radiates away into space, resulting in losses and signal distortion. To transmit such high frequency signals without corrupting them, a multi-conductor transmission line with the right ratio of capacitance-to-inductance per unit length is needed. The capacitance-to-inductance ratio defines an electrical impedance, usually designed for 50 ohms. When all the components in a signal chain have the same impedance, the energy transfer between them is maximized and high speed digital data passes through intact. So, for a reed relay to function as an efficient component in a 50 ohm transmission line, it must have a correctly matched impedance.

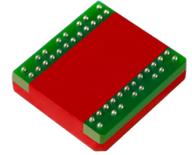
Modern high-frequency reed relay design focuses on getting the relay's impedance as close to 50 ohms as possible through its entire signal path, including its leads. The challenge in designing the leads is to avoid impedance discontinuities as the signal is launched from the typically planar signal transmission lines on a printed circuit board, into and out of the 3-D structure of the relay. Electromagnetic software simulation tools are used to optimize the lead geometry for minimized impedance discontinuities.

How do we know how successful we've been in this design effort? A common benchmark for describing RF relay performance is its bandwidth, defined as the lowest frequency where the RF power throughput drops to 50%, corresponding to a 3 dB power loss. Coto's surface-mount relays generally have bandwidths in the 6 to 9 GHz range. Within this surface mount group there are 4 lead styles:

J-bend, gullwing, axial and ball-grid-array (BGA), shown from left to right in the figure below.



**Leaded relays**  
(from L to R: J-Bend, Gullwing, Axial)



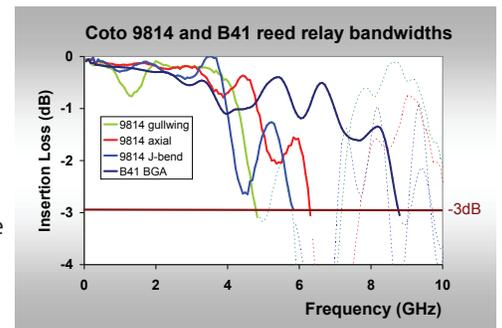
**B41 ball grid array relay**

The graphs below show the RF insertion loss curves for Coto's 9814 Form-A relay, for the three different lead styles. The insertion loss of the B41 relay with its leadless BGA form is also shown. Because the axial relay has no bends in its leads they have very low inductance. As a result, it gives the best high frequency performance and transmits to about 6.3 GHz at its -3 dB point. The gullwing and J-bend relays, with their somewhat more inductive leads, reach -3 dB between 5 and 6 GHz.

For raw high speed performance, the best solution is to do away with inductive leads altogether and replace them with signal waveguides, as is done in the BGA relay. This patented design maintains very close to 50 ohms throughout its entire signal path, and transmits to about 9 GHz at -3 dB.

Some tradeoffs to consider during your design-in phase are these: axial relays have the highest RF bandwidth of the leaded relays but require a cutout in the circuit board to accommodate them; gullwing relays are easy to rework; and J-bends take up slightly less board space but are more difficult to rework. Leadless BGA relays have the highest RF bandwidth of all, but are somewhat more expensive per switching channel. The choice is yours, depending on the high frequency demands of your application.

To find out how Coto can aid you with your design efforts, please contact us at [appsupport@cotorelay.com](mailto:appsupport@cotorelay.com).



9814 Datasheet



B41 Datasheet