



WHITE PAPER

ReliaGear[®] neXT and ReliaGear[®] SB plug-in connections



The new ABB ReliaGear neXT power panel and ReliaGear SB switchboard offer end-users and contractors a choice of proven technologies. Combined with a modular distribution panel board structure and the advanced ABB SACE[®] Tmax[®] XT circuit breakers, the result is faster, more reliable power installations with higher quality.

Historical connection methods

Connections between electrical devices within equipment play a critical role in the efficiency and longevity of an installation. A poor connection results in a higher resistance, which prevents the efficient flow of current and creates heat. Heat means wasted energy and higher risk of failure. A strong connection reduces resistance and heating and, most importantly, increases longevity and enhances safety.

Plug-in connections are — and have been for decades — commonplace in heavy-duty equipment targeted at industrial applications. Busways, motor control centers (MCCs) and switchgear, for example, all use some style of flexible connection between removable devices and the fixed bus within the assembly. These connections facilitate ease of installation and removal of devices while still providing a strong, secure, low-resistance connection.

Longevity and loosening

Bolted connections are susceptible to loosening over time, which, if ignored, can lead not only to high resistance and heating, but also to arcing and possible short circuit failures. The current flows through surfaces in contact not through the entire surface, but through A-spots, which represent only a portion of the contact area. If not enough area is in contact, fewer or smaller A-spots are carrying current, resistance is increased and excess heating is the result. This can be particularly problematic in larger current joints or connections made in the field.

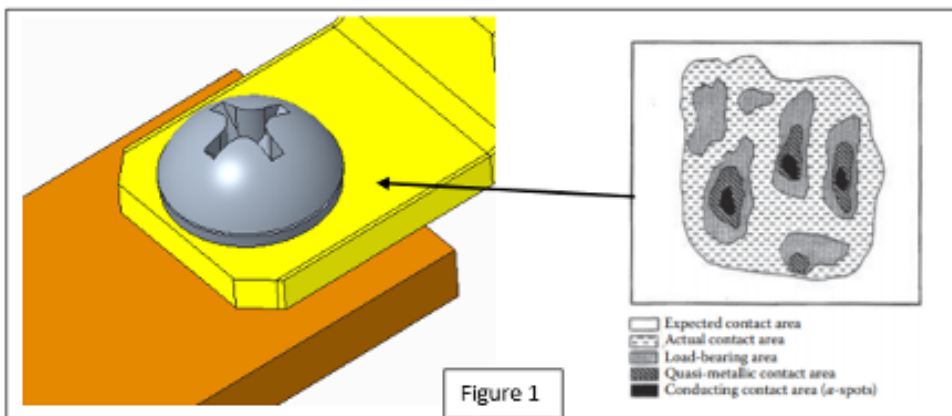


Figure 1

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Assembly

The assembly of classic bolted connections requires attention to the condition of the threaded fasteners and any locking hardware, the surface condition of the joined materials as well as any misalignment between parts. A successful installation requires a certain level of skill and qualifications. To achieve successful continued performance, periodic inspection and/or maintenance of components, including locking or Belleville-type washers, is important and is also typically performed by skilled and/or qualified personnel.

The ReliaGear plug-in design represents a significant improvement over the classic bolted-joint method of device installation and connection. The neXT and SB design uses a fixed (vertical) panel board bus that incorporates slots into its geometry. In addition, the circuit-breaker connectors (line side connectors) feature a clip with matching geometry that engages the slots in the vertical bus assembly.

ReliaGear plug-in breaker assemblies incorporate the circuit breaker and the line side connector assembly into a single, factory-assembled item. There is no strap kit with multiple conductors and no hardware kit; the line side connector is pre-assembled in a single unit. With no field assembly required and no complex kit of parts for connection, installation is straightforward and simple.

Mounting

The ReliaGear neXT panel board's modular design is the key to faster installations. The steel mounting bracket, affixed to the circuit breaker, allows the circuit breaker to be levered into position, engaging the plug-on fingers with the vertical bus. The circuit breaker is then secured in position by easily accessible mounting screws, again attached through the steel mounting bracket. There is no torque to check on the electrical connection and no special tools are required. The line side connector design helps to ensure proper alignment and supports the clips during installation and removal.

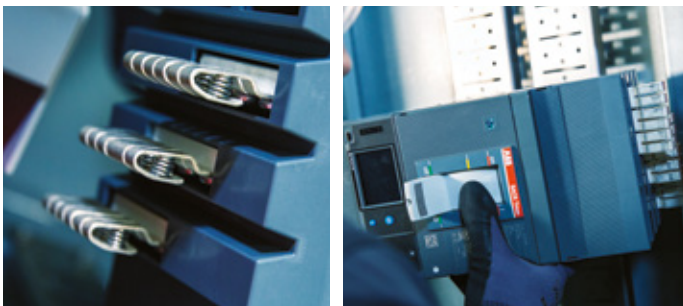
An internal study revealed that, on average, installation of a circuit breaker and strap kit, completed by an experienced technician, can take 10 minutes or more to complete and requires the proper torque wrench to ensure a suitable connection. Adding a similar circuit breaker to the ReliaGear neXT panel board took fewer than 30 seconds, left adjacent devices unaffected and required only basic hand tools. As a consequence, downtime is drastically reduced, increasing the final user's efficiency. A recent study suggests that on large projects, an 8 percent reduction in labor costs can mean a 133 percent increase in profits.*

The neXT rail system allows easy and straightforward installation of devices of various widths and lengths due to its equally spaced slots. Any device with back-bracket slots that fit into the openings on the rail and install into the bus stack may be positioned there. Conversely, and by design, the largest devices will not engage the slots or vertical bus if the panel cannot accept the device.

The slots are designed for the "X" spacing to accommodate the various circuit breaker widths. The frame also accommodates blank spacers when a breaker is not used or to fill in gaps.

When a device is installed fully and properly into the rail system, the underlying frame hole will align with the bolt hole at the back bracket, allowing installation of the screws. This efficient design ensures that the devices being installed are positioned correctly and fully engaged.

The ReliaGear neXT and SB system has been thoughtfully designed so that insertion is as easy as possible while helping to achieve contact integrity. Given the plug-in nature of the design, the insertion forces scale with the current-carrying capacity of the device being installed. For low-ampacity breakers, the insertion will be an easy operation requiring minimal hand force and support. For larger-frame circuit breakers, the ReliaGear neXT power panel is designed so that the breaker's weight is supported until final insertion.



*From "How to Make a Good Estimate Even Better" by Don Kiper, EC&M, 2017.

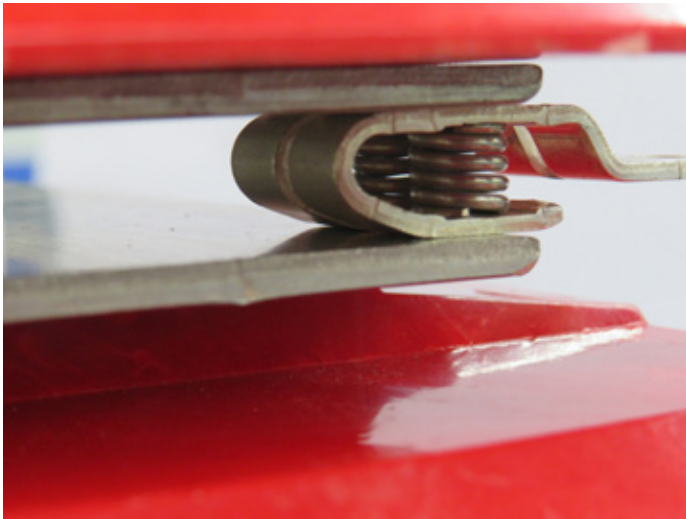
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Performance at rated load

The circuit-breaker line side connector includes a compression spring inside the clip, secured via features in the clip itself, that achieves required contact pressure during typical operating conditions. As a spring-loaded connection, this joint does not loosen over time; there are no threaded connections to inspect or maintain; and the contact pressure is maintained by the spring.

The ReliaGear clip assembly is a patented solution that provides a repeatable and reliable force to the connection, helping to ensure a secure and robust connection.



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ReliaGear neXT clip assembly and vertical bus detail

When examining the contact area of electrical connections, it is important to recognize the difference between apparent contact area and true contact area. While common sense might suggest that surface contact on a theoretical perfect surface creates higher true contact area, experimentation and calculation reveal that line contact can provide a higher ratio of true contact area to apparent contact area.

For comparison, we will use an example of a connection made by two 6 mm threaded fasteners, torqued to 7.3 Nm on a 5.7 cm x 3.4 cm bolted joint. The hardness of the bus bar used is 89 HRF (258 MPa).

Using the formula:

$$T = K.F.D$$

T = Torque applied
F = Applied force due to tightening torque
D = Bolt nominal diameter
K = Constant relating the portion to torque used in producing the contact force. It depends on the condition and how the bolt is used. For dry (unlubricated) condition, use K = 0.2

The contact pressure is calculated as 7 MPa.

Using the formula:

$$A_c = F/H$$

A_c = Area of contact
F = Normal force applied
H = Hardness

The area of true contact is calculated as 0.47 cm², a true-to-apparent contact ratio of 2.7%.

A visual representation of this true vs. apparent contact area is obtained by using pressure-sensitive material, as shown below. Although the theoretical contact area (total area of the white square cross-section) is large, the area affected by the compressive force of the connection (made red by the compressive force) is much smaller.

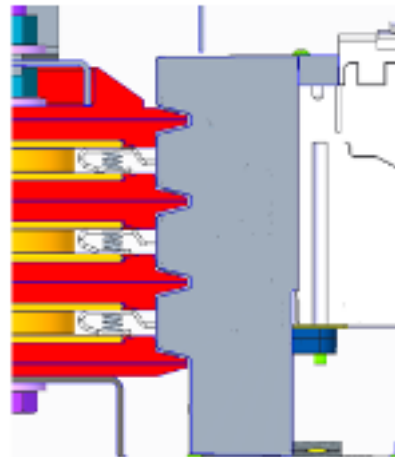


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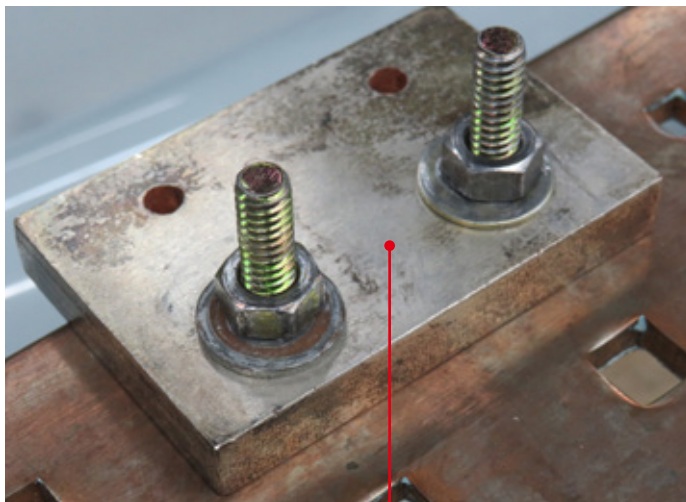
As an example, the same connection made by a ReliaGear neXT clip assembly and held by the embedded compression spring yields a much higher true vs. apparent contact area ratio. Similarly, as above, using the nominal spring force of 6.7 kg and the 0.77 cm x .01 cm dimensional information, one arrives at an apparent contact area of 0.046 sq. cm. Using the same formulas as above and the same material properties, one arrives at a 5.5% true-to-apparent contact area ratio.

For a similar current rating, the contact pressure required to have a better true contact area is much greater (resulting in higher torque values, requiring higher-strength fasteners and more torque verification) in a bolt-on style connection than for a similar plug-in style connection. Classic bolt-on connections made in the field are particularly vulnerable to inadequate assembly.

This distinction is reflected in the comparison of joint resistance values. More true contact area means less resistance.

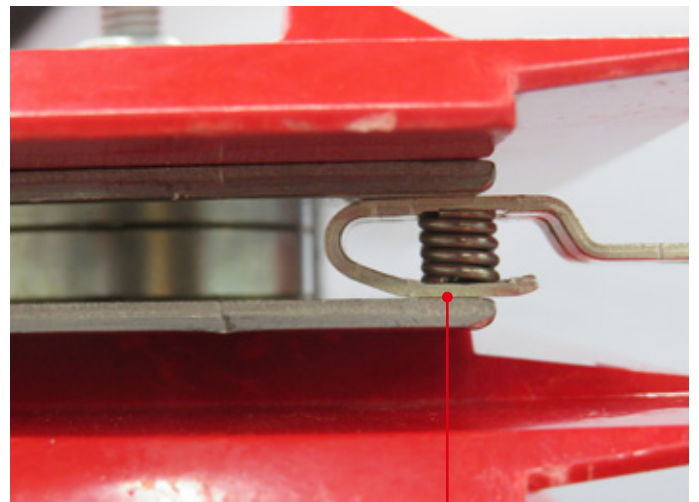


ReliaGear neXT and SB line side connector assembly, showing three-phase connection to vertical bus stack



Typical bolted joint showing theoretical contact area

Surface contact

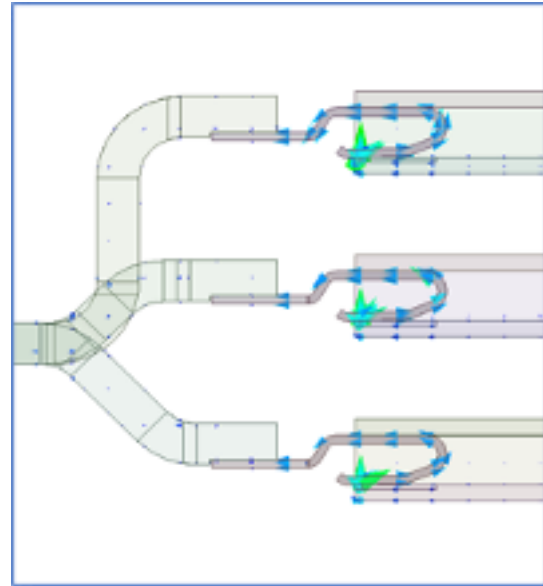


ReliaGear neXT and SB finger assembly, showing line contact area

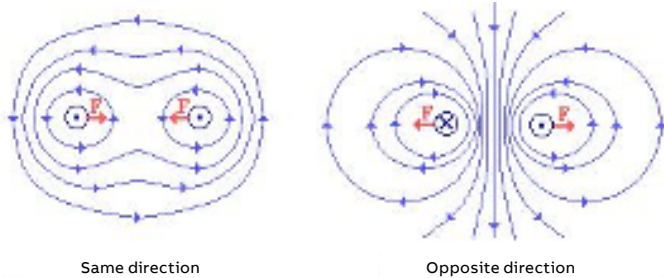
Line contact

Performance at short-circuit conditions

During fault currents, due to magnified electromagnetic forces, parallel current paths repel one another, a phenomenon that causes bolt-on connections to tend toward loosening or even blowing apart. The ReliaGear design and the plug-in clip uses this resistance effect to create a reverse loop. In this reverse loop, the repulsive forces between the clip and the panel board bus are overcome by the repulsive forces generated in the arms of the clip itself. What might be described as “blow-off” forces are harnessed and translated into “blow-on” forces. Through this arrangement, the contact force is intensified proportionally with the magnitude of the current, allowing the clip assembly to remain intact during faults and short circuits.



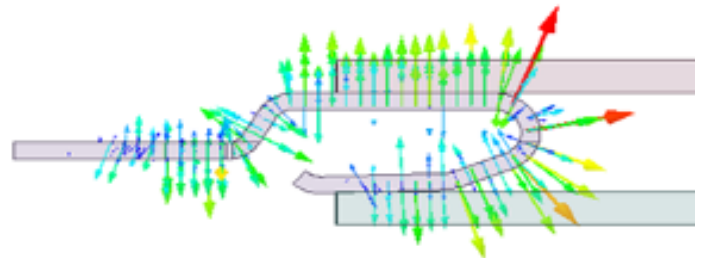
Direction of current flow in ReliaGear neXT clip



Same direction

Opposite direction

Two parallel conductors, each carrying a current in the same direction, will attract one another, while two such conductors that carry current in opposite directions will repel each other.



Force vector diagram showing repulsive forces within the ReliaGear neXT and SB clip impinging on the vertical bus and creating compressive force during high current / short-circuit event. Resultant compressive force creates a stronger connection than during nominal operation.

Vibration testing OSHPD

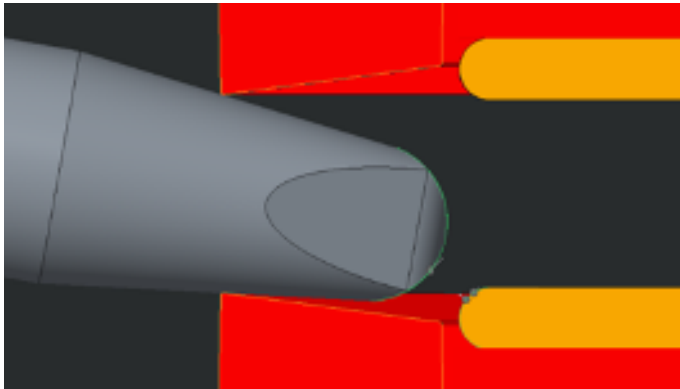
Vibration testing conducted on the ReliaGear neXT assembly system validated the structural and functional integrity of the connection. The test was conducted by rigidly mounting a neXT assembly to a vibration table and subjecting the assembly to values that meet or exceed those required by the relevant code. According to this code, input motions are required to be at least 30 seconds in duration with a broad range of frequencies. Following the vibration event, functionality of the ReliaGear panel and switchboard were verified.

ICC-ES AC156 (International Code Council - Evaluation Services Acceptance Criteria 156) has been met or exceeded during this testing.

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Ingress protection

Ingress protection (IP) code per IEC standard 60529 defines a mechanical housing's degree of protection against the intrusion of dust, accidental contact and water. The patented IP20 finger-safe ReliaGear neXT design incorporates a molded-in mechanical barrier that protects certain configurations of the main bus stack against accidental contact of solid objects of sizes larger than 12.5 mm. This complies with an IP20 level of protection, generally recognized as "finger safe." In addition to finger safe, the design minimizes risk of a forgotten tool or a disconnected wire coming in contact with the bus system. Testing was completed and compliance verified using properly calibrated equipment.



— IP20 compliance for "finger-safe" vertical bus stack assembly as determined by testing with calibrated probe.

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Conclusion

When selecting distribution equipment, there are several factors to consider, but safety and reliability are the most important. The ReliaGear neXT panel board has been thoughtfully designed and tested under myriad conditions to help ensure suitability and reliability. In this white paper, we have outlined several design features that help enhance safety when using ReliaGear panel boards and switchboards. Consider these benefits when selecting your next panel board or switchboard: Plug-in connections have a long history of use in power distribution and controls equipment. These designs have better true contact/apparent contact ratio at rated current than bolted equivalents. During short-circuit conditions, magnetic forces within the line side connector clip serve to improve the electrical connection. These line side connectors and the bus are well suited for ingress protection. The ReliaGear design makes installation easier and faster while ensuring long term performance.

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