

Examples of Key Interlock Systems

A White Paper by Kirk Key Interlock Company

Introduction

The fundamental principle of interlocking – disabling one electrical or mechanical function unless some other function (or functions) is in a particular state – can be achieved in many ways. Key interlocks avoid the limitations of electrical interlocking and the restrictions of mechanical interlocking by making use of easily portable keys, carried in sequence from one interlock to the next. The use of keys imparts a human factor and provides physical evidence of equipment status.

Developed during the 1920's, key interlocking was first utilized on circuit breakers and switches to reduce the hazards caused by improper switching operations. As electrical safety standards evolved during the 20th century, the application of key interlocks has greatly expanded.

Key Interlocks vs Lockout/Tagout

Interlock systems go beyond the well-known lockout/tagout procedures common in industry today. As important to worker safety as those procedures are, lockout/tagout procedures can be defeated intentionally or through forgetfulness. A lock omitted from one switch, a missing tag, or the premature removal of a lock before the associated circuit can be safely re-energized, may result in a serious accident. But with key interlocking, operation is not possible – the key is unavailable for that purpose – until the condition of the associated equipment renders that operation safe.

Typical Interlock Systems

An interlock system is a group or series of interlocking devices applied to associated equipment in such a manner as to allow operation of the equipment, in a predetermined sequence only. A properly applied interlock system will prevent operation of equipment outside of the prearranged sequence.

Consider the simple circuit of Figure 1 shown below. The fuse compartment contains fuses for a non-load break disconnect switch. Checking or replacing the fuses necessitates opening the fuse compartment's locked door. Safety practices dictate that the fuse compartment door remain locked closed unless the circuit has been de-energized.

That imposes two conditions. First, the downstream circuit breaker must be opened, to remove the load current from the switch itself (which is not designed to interrupt such current). Second, when the fuse compartment is unlocked, and accessible to personnel, the disconnect switch must

be open and prevented from reclosing. Figure 2 shows how a key interlock system accomplishes this task.

When the circuit breaker is in the closed position, the key to its interlock is held within the lock and cannot be removed. To initiate the sequence of operations giving access to the fuse compartment, the circuit breaker is manually opened. Turning the key in the breaker interlock then moves the bolt such that the circuit breaker cannot be reclosed and allows the key to be withdrawn from the interlock. The circuit breaker is now safely locked open. Removal of the key ensures that it cannot be unlocked and reclosed by anyone except the person holding that key.

The key is then taken to the switch, which is in its normally locked closed position. The switch has two interlocks – lock 1 which locks the switch in either the open or closed position and lock 2 which is keyed differently and is utilized to lock the switch open (the key in lock 2 is held whenever the switch is closed). Using the first key to unlock lock 1 frees the switch for manual opening and traps that particular key.

Turning the key in lock 2 now locks the switch open and frees that key making it available to unlock the fuse compartment door. Unlocking the fuse compartment door will trap this second key in the door interlock. Only after that door has been physically locked closed once more can key withdrawal be made to reverse the entire process and restore power to the circuit.

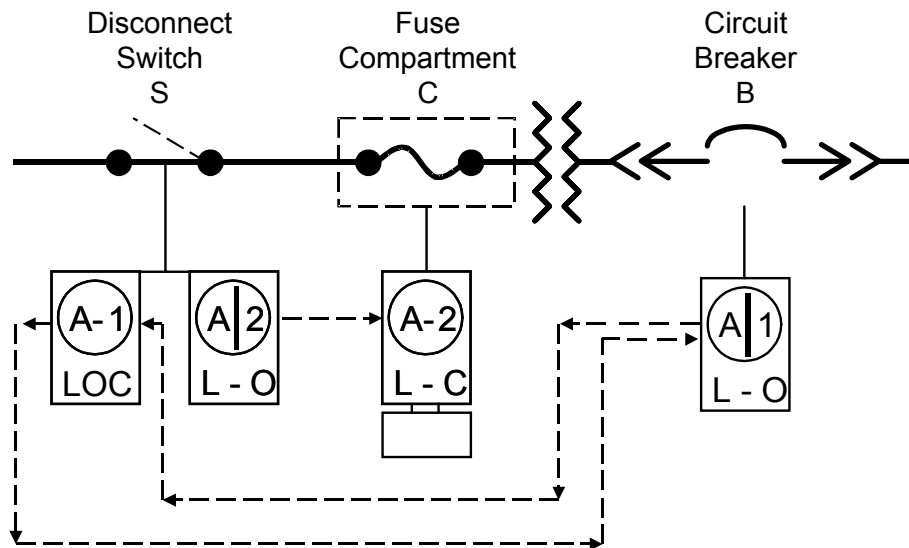


Figure 1. A simple power circuit in which test or servicing operations May dictate key interlocking between several controlling devices.

In Figure 2, shown below, we illustrate four circuits with tie connections between each circuit. The proper application of interlocks can prevent paralleling of the lines A, B, C, and D. Note that the main circuit breakers (A, B, C, & D) are normally closed and have interlock keys which are held until the breakers are opened and locked in the open position. Only after a main breaker

is locked open, can the key can be removed and taken to the proper tie circuit breaker (E, F, or G which are normally locked open and do not contain keys) so that it can be unlocked and closed.

Note that four keys, and only four keys, are required to ensure proper operation of the overall interlock scheme. Each main breaker is keyed uniquely and each tie-breaker is keyed to accept only the correct main breaker keys. Key interchange designations such as A1, B1, and C1 clearly show the allowable paths for main breaker keys. For example, key A1 from main breaker A will only unlock tie-breaker E (after locking open breaker A, of course), and key B1 will unlock tie-breaker E or tie-breaker F only after locking open breaker B.

In this manner, all circuits are protected from paralleling. Note that the interlocks on circuit breakers E, F, and G are supplied with “apartment” lock cylinders, which will allow either of two keys to operate the interlock. For example, key A1 (from circuit breaker A) or key B1 (from circuit breaker B) will operate the interlock on tie circuit breaker E. But key A1 will not operate the interlock on circuit breaker B, nor will key B1 operate the interlock on circuit breaker A.

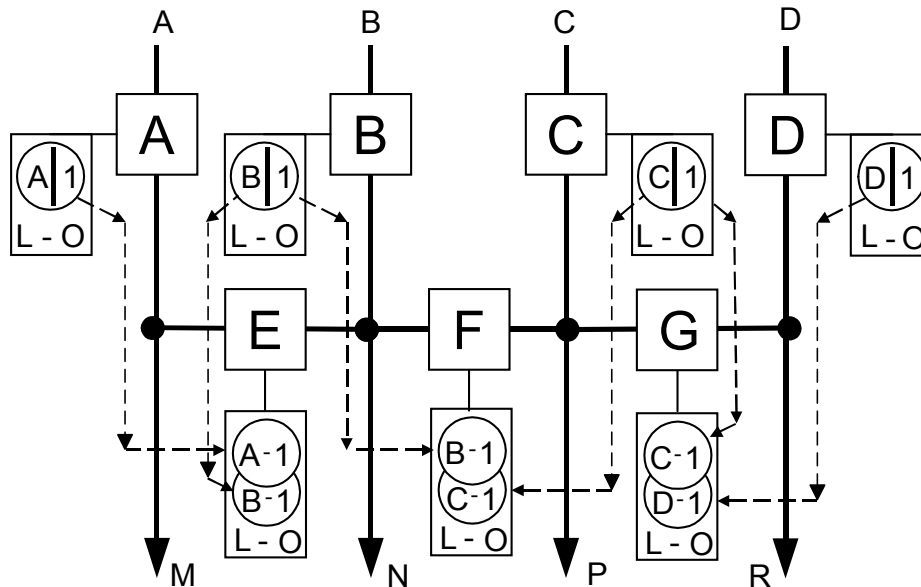


Figure 2. Switchgear line-up with 4 main breakers and 3 tie-breakers.

Figure 3 is similar to the scheme shown in Figure 2 except that this example shows how to interlock the rear access doors of the switchgear line-up. So, in addition to protecting all circuits from paralleling, certain rear access doors can be opened only when the correct circuit breakers have been locked open. Nine doors are shown on this example, but any number of rear access doors could be incorporated.

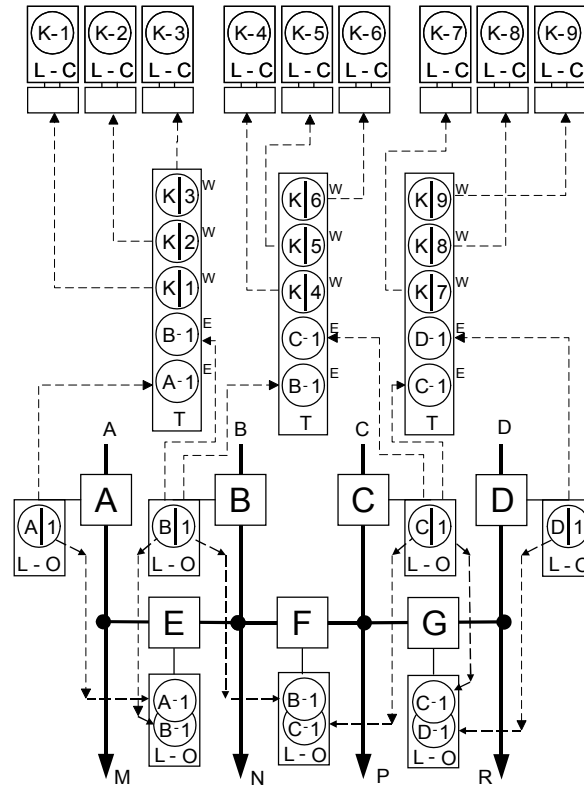


Figure 3. Illustrates how to interlock the rear access doors of the switchgear line-up.

The examples above pertain to electrical switchgear but key interlocks are utilized to interlock practically anything that is operated in a predetermined sequence. A few more examples of the various uses of interlocks are as follows:

- a) Prevents opening of a guard when a motor is energized.
- b) Enclosed Areas – to prevent entrance into enclosed areas containing high voltage electrical equipment except when sources and back-feeds are locked open.
- c) Valves – to provide control of sequential operation of valves.
- d) Tank Car Loading – to prevent movement of railway cars and locomotives onto spurs while tank cars are being loaded or unloaded on the spur.
- e) Ladders – to ensure their being returned to the proper storage cubicle, and to indicate who has removed those not returned.
- f) Panelboards – to block the trip lever of molded case circuit breaker in the off position.

When determining the interlocks that should be employed in any key interlock system, it is necessary that someone establish the normal state of the controlled devices, all of the possible scenarios, and just what is to be achieved with the interlock system. When required, extremely complex interlock systems can be built from basic interlocking principles and applications.

For particularly sensitive operations such as when work needs to be performed under more-than-usual supervision, an interlock system may include a “supervisory key”. Inserting the normal

key alone will not operate the interlock to permit further steps. Instead, a second key (assigned to a designated supervisor) must also be introduced for operation in the same interlock. A “supervisory key” can be introduced at any point of an interlock system regardless of the complexity.

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