



Switchgear Application Book

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Switchgear

James Harry Castell

James Harry Castell invented Trapped Key Interlocking and the founded Castell Safety in 1922. Today Castell carry on the legacy left by Harry Castell continuing to innovate and provide safety in industrial applications worldwide.

Switchgear Principals

Interlocking is the process by which two or more process or procedures are tied together so that at any one point in time only one operation can take place. In the case of switchgear the supplies are interlocked to prevent out of phase power being connected to common busbars and ensuring earthing before allowing access



Trapped Key Interlocking

The use of Trapped Key Interlocking ensures that a predetermined sequence of events is followed. In switchgear applications this ensures that supplies are not commoned and that access to switchgear cabinets of transformers is done when equipment has been made safe.

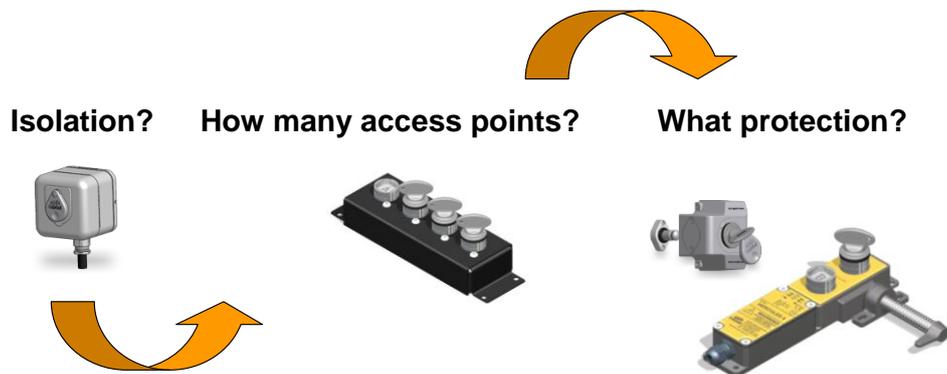
Trapped Key Interlocking works through trapping a key in predetermined positions and using common keys for two or more process. This means that the key is either trapped in process one or is trapped in process two. The sequence of events can be designed using truth tables to ensure only safe operations can occur.

In the simplest form trapped key can be used to ensure access can only be gained to a switchgear cabinet when the switchgear is off. The common key to switch on the switchgear and gain access to the cabinet is either trapped in the isolation lock or is trapped in the access lock. Using Trapped key it is impossible to have the switchgear turned on and have access to the cabinet.



How to Design a System

Through development and experience Castell have a number of methods to isolate switchgear. This can be done mechanically, through control circuitry or through power circuitry. In complex operations a number of isolations may need to occur to ensure that switchgear is safe to work on. The isolation key(s) are then used to either gain direct access, are transferred to a time delay unit or for multiple entry points access through an exchange box.



Access and Personal Protection

Access to the hazardous area needs to be assessed as either part body, arm only, or full body access. Once this is determined an access lock(s) can be selected.

Part Body Access

A part body access lock has only one lock and the isolation key is used to open this. Whilst the access lock is open the key can not be removed and therefore the process can not be started. Only once the lock is closed can the isolation key be removed and the process restarted.

Full Body Access

Full body access locks have two locking mechanisms; the first step in the process is to insert the isolation key. This will allow the personnel key to be removed and then access can be granted by opening the bolt. The isolation key can only be removed once the personnel key has been inserted. Therefore whilst the personnel key is removed and the lock is open the process can not be started. Only once the lock is closed and the personnel key returned can the isolation key be removed and the process restarted.

Coding a System

The coding of the system is an important aspect of the design as this ensures the integrity and safety of the interlocking system. Castell's Trapped Key Interlocks allow for in excess of 50,000 combinations. With this level of available codes entire factories and plants can have trapped key systems with out codes being repeated. It is highly recommended that each site keeps a record of the key codes to ensure that codes are not reused in areas of the site.

The isolation, access and personnel keys all need to be coded differently so the process of safe access is ensured. For example in a simple system code 'A' is used for isolation key, this is then transferred to the exchange box where the code 'B' keys are released for access, 'C' keys are then released from the Access Locks for personnel keys. Coding in this way ensures the access process can not be short cut and the system has integrity.

Applications

Common Switchgear Applications

There are a number of switchgear applications that in Castell's experience appear commonly throughout the world. These are listed within this application book and include:-

- Multiple Incomer Interlocking
- Incomer and busbar interlocking
- Transformer Door Interlocking
- HV/LV Switching
- Earthing

Common Switchgear Symbols



Key Free



Transformer



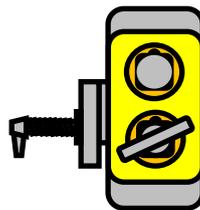
Key Trapped



Breaker

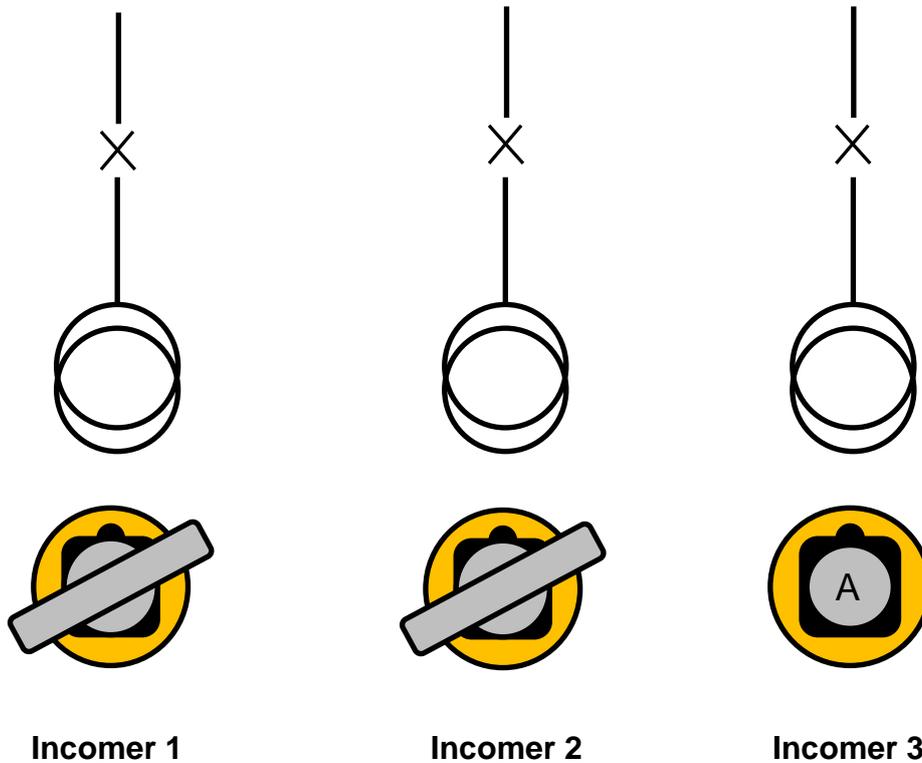


K Lock



AIE Access Interlock

Incomer Interlocking



Operation

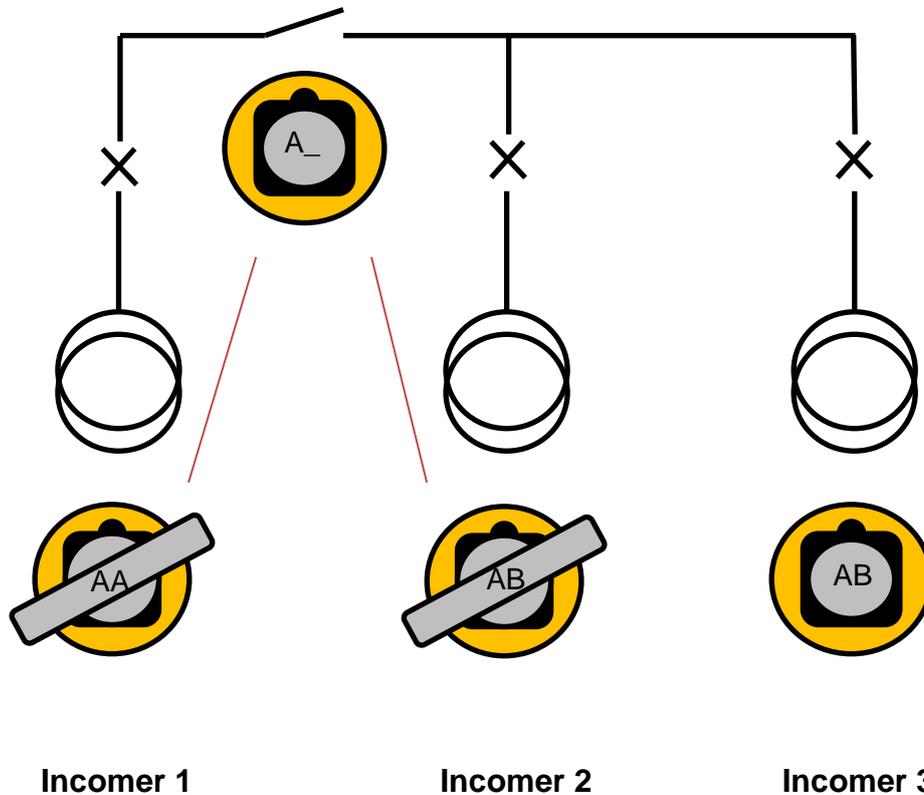
This system will require three locks and two keys. Under normal operation the two keys are trapped with the switches closed so the incomers are supplying.

The system will allow an incomer to be opened (disconnected) and the key released. This key is then transferred to in to the other open incomer which can then be closed.

The system ensures that only two incomers are supplying at any time.

The symbols used here are all symbol A.

Incomer and Busbar Interlocking



Operation

This system will require four locks and two keys. In the situation shown the keys are trapped in incomer one and two with the switches in the closed position.

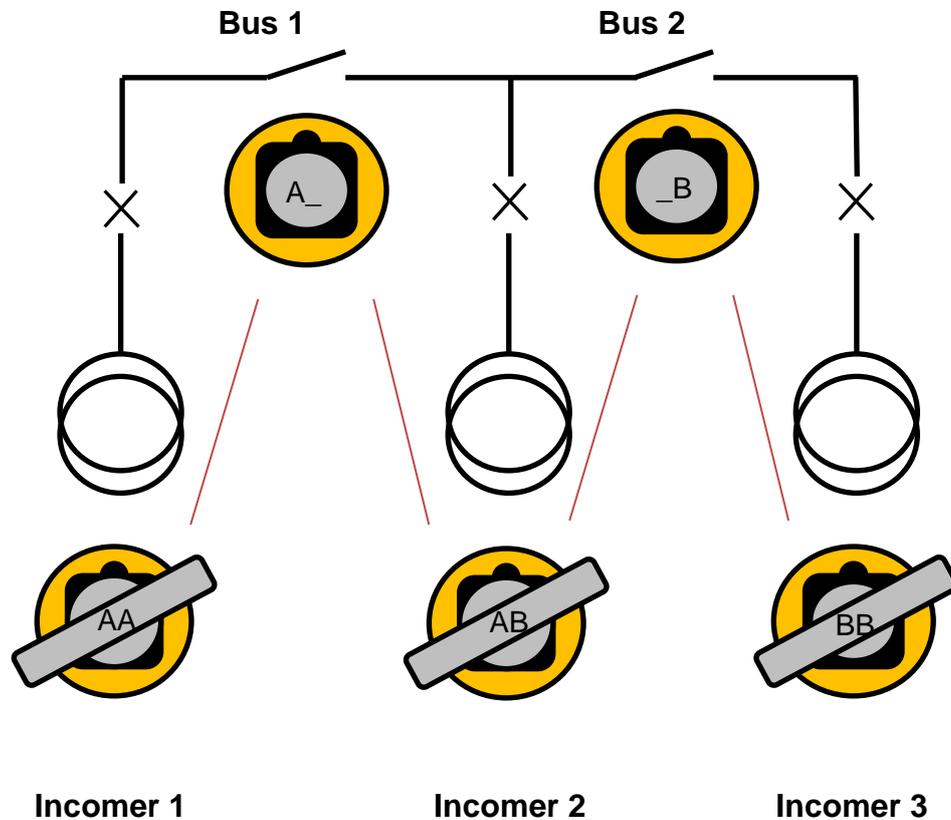
Both the bus coupler and incomer three are open.

The symbol sequence will only allow incomer 3 or the bus coupler to be closed after the appropriate key has been released, transferred and inserted into the bus coupler or incomer three lock.

The system ensures that only two incomers are supplying at any time.

The symbols used here are AA and AB for the incomers and A BLANK for the bus coupler.

Incomer and Busbar Interlocking



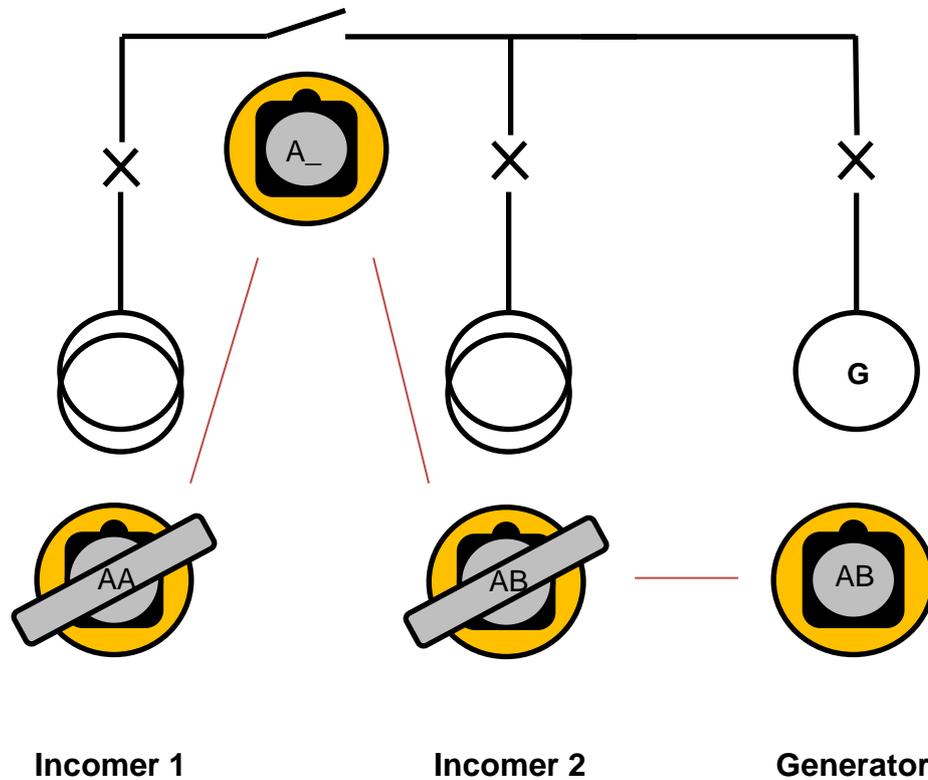
Operation

This system requires five locks and three keys. In the normal operation the keys are trapped in the incomers in the closed position and both bus couplers are open.

The symbol sequence will allow appropriate incomers to be open allowing the key to be released, transferred and inserted and trapped to the associated bus coupler allowing it to be closed.

The symbols used here are AA, AB and BB for the Incomers and A BLANK and BLANK B for the bus couplers.

Incomer, Generator and Busbar Interlocking

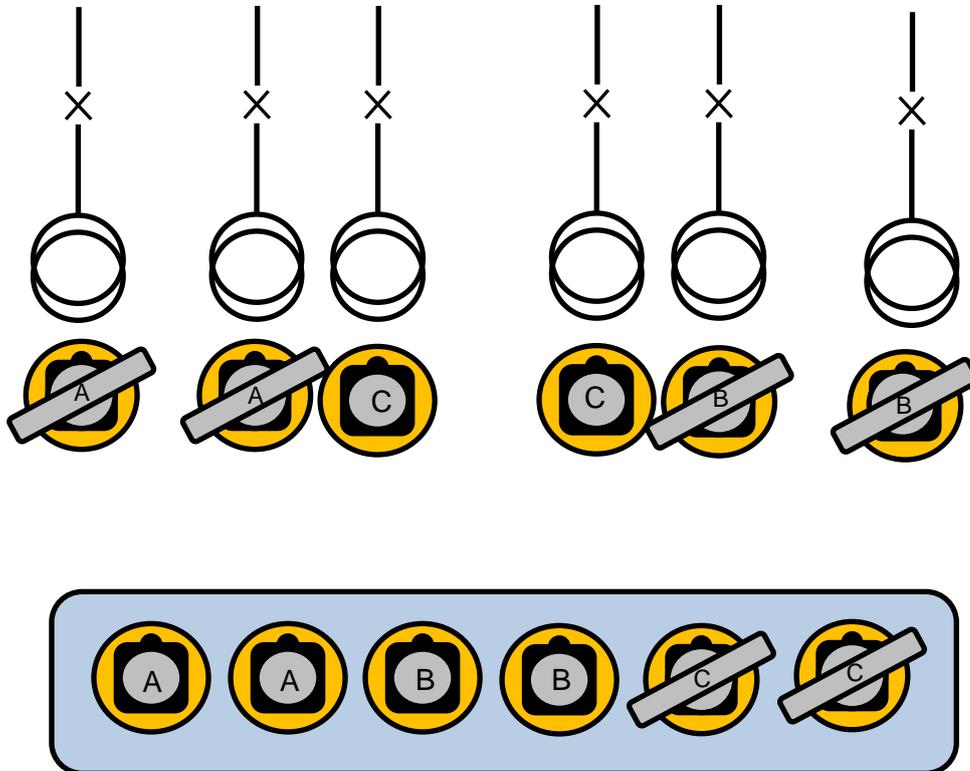


Operation

The normal operation is the 2 incomers are closed with bus coupler and generator are both open. The symbol arrangement using key symbols AA, AB, A BLANK on locks with just keys AA AB will ensure safe switching operation. It will not be possible to have Incomer 2 and Generator closed at the same time to avoid paralleling.

The symbols used here are AA and AB for the incomers and A BLANK for the bus coupler.

Incomer Interlocking



Operation

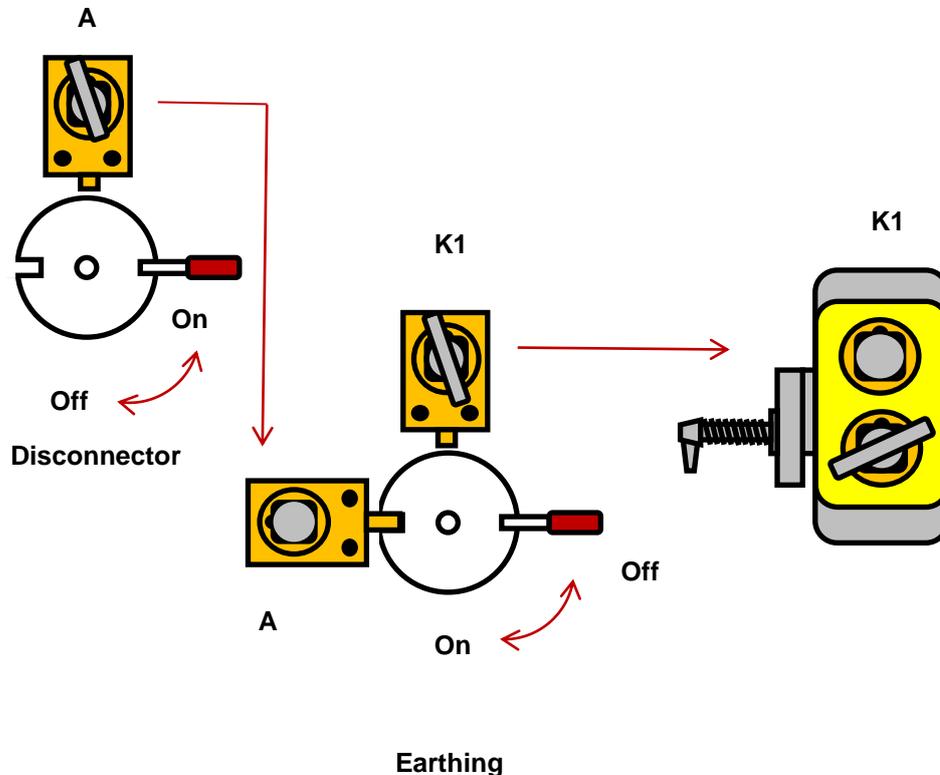
This system will require six locks depending on the breakers. One key exchange box and six keys.

Breakers A and B are closed and the keys are trapped. Keys A and B are removed from the breakers when they are opened and inserted into the key exchange box releasing the C keys.

The C keys are then inserted in the C locks, closing breakers C.

The symbols used here are A, B and C for the incomers.

Transformer Interlocking



Operation

Whilst the disconnector is on the A key cannot be removed. Switching the disconnector to the off position will allow the A key to be removed from the K Lock.

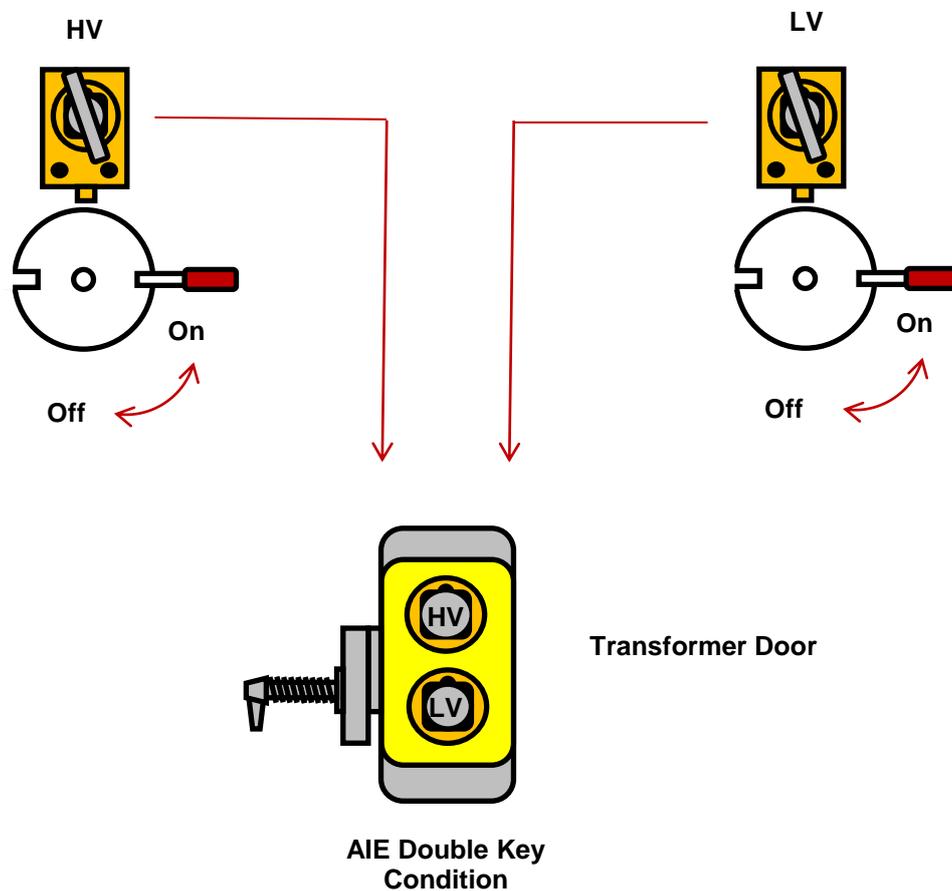
This A key can then be inserted into the K Lock which will retract the bolt and allow the earthing to be switched on.

This will in turn allow the key K1 to be removed extending the bolt and locking the earthing in to the on position.

The K1 key can now be used to gain access through AIE. A personnel key will be released to ensure that the operation cannot be reversed whilst personnel are in the transformer housing.

The symbols used here are A for the disconnector and earthing and K1 for the earthing and the access lock.

Transformer Interlocking - Alternative

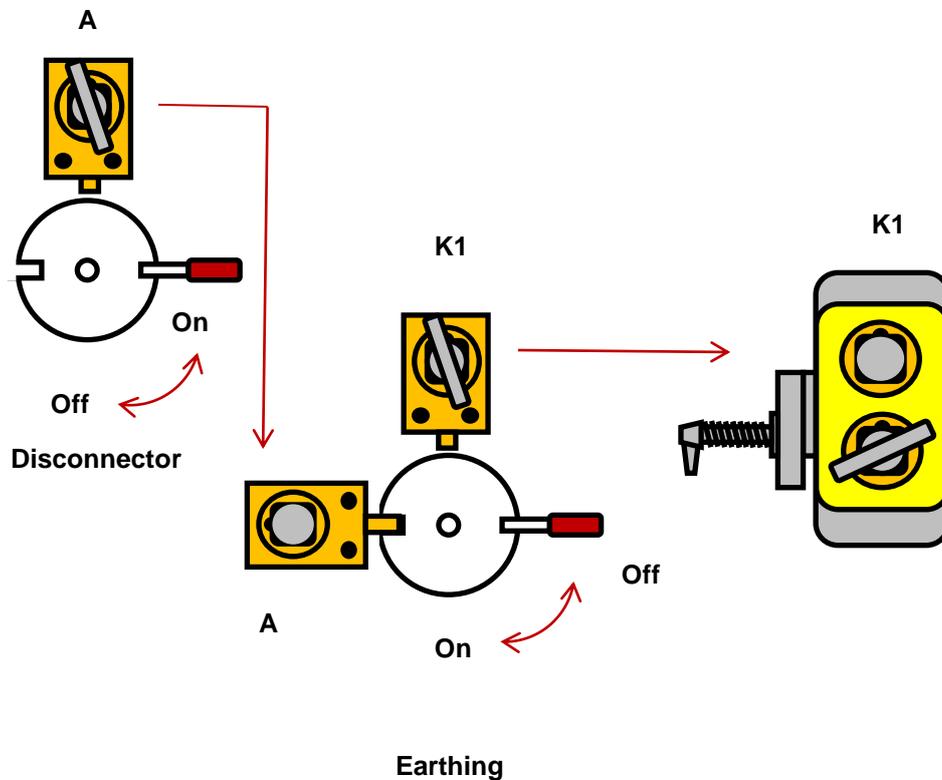


Operation

The HV and LV Isolators are both closed with their respective keys trapped and the transformer door is closed. Both the HV and LV isolators are opened releasing the keys. These keys can then be used in the AIE to give access to the transformer.

The symbols used here are HV and LV for both breakers.

Capacitor Bank Interlocking



Operation

Whilst the disconnector is on the A key cannot be removed. Switching the disconnector to the off position will allow the A key to be removed from the K Lock.

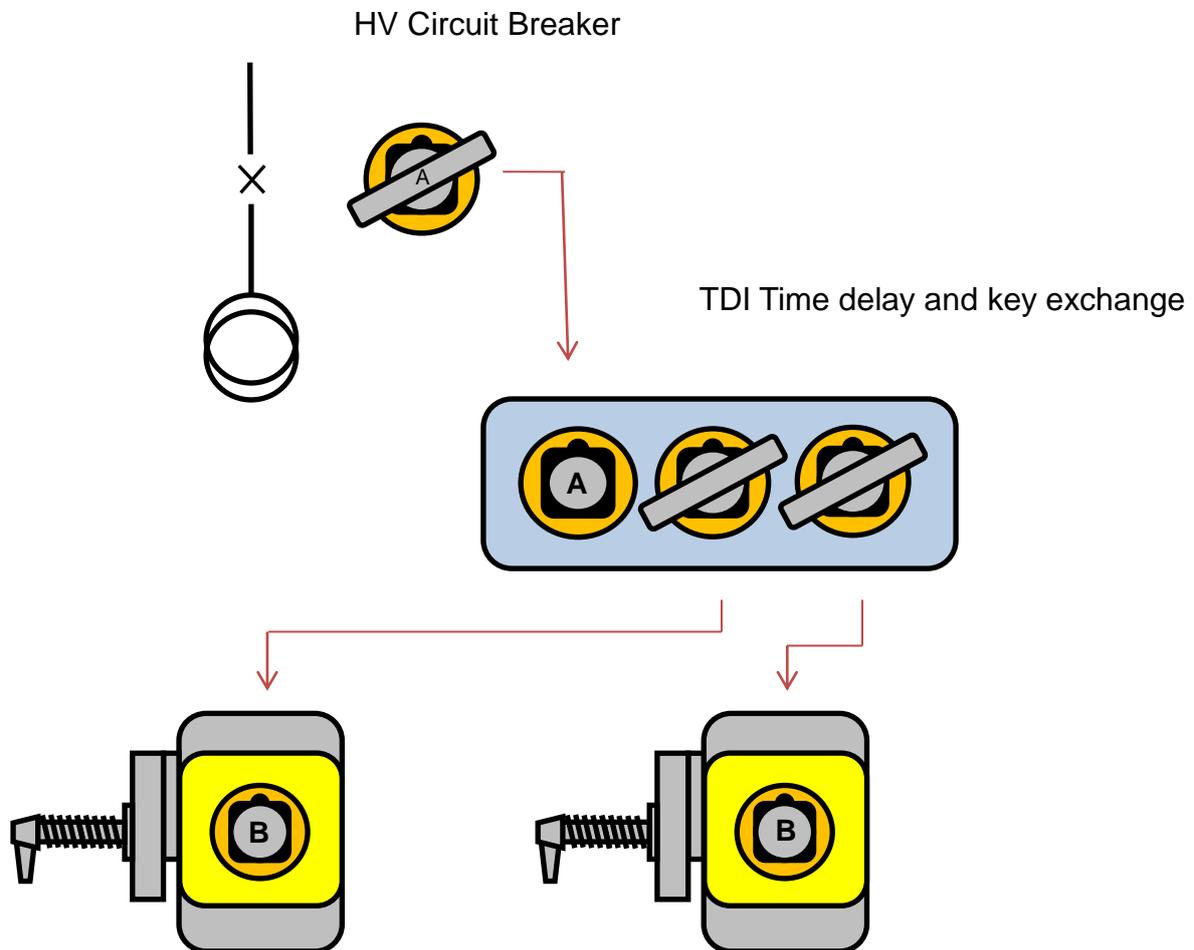
This A key can then be inserted into the K Lock which will retract the bolt and allow the earthing to be switched on.

This will in turn allow the key K1 to be removed extending the bolt and locking the earthing in to the on position.

The K1 key can now be used to gain access through AIE. A personnel key will be released to ensure that the operation cannot be reversed whilst personnel are in the capacitor bank.

The symbols used here are A for the disconnector and earthing and K1 for the earthing and the access lock.

Power Factor Correction Equipment



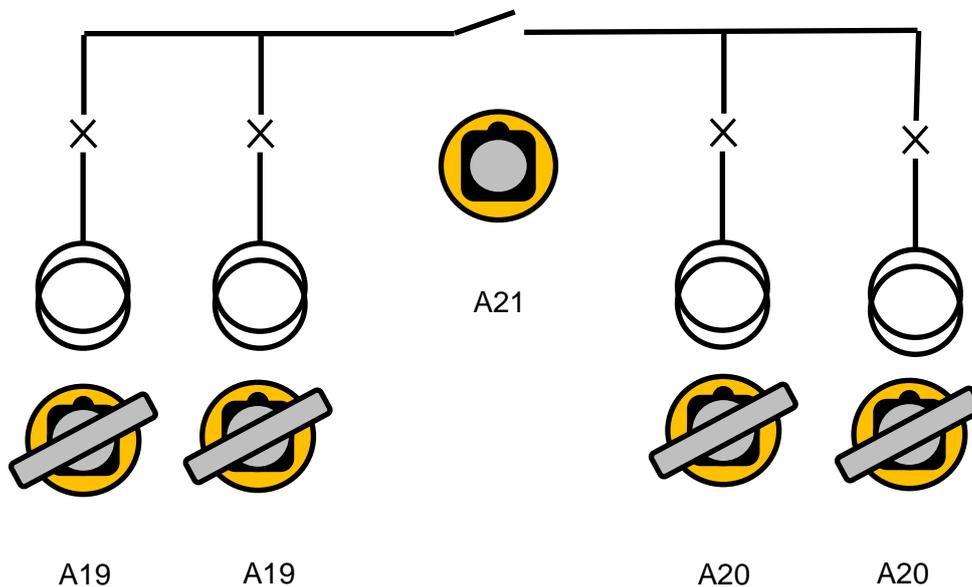
Operation

When the HV circuit breaker is closed access can not be gained to the PFC equipment as the A key remains trapped.

When the HV circuit breaker is open the A key can be removed and inserted in to the TDI time delay unit. After a preprogrammed time the B keys are released and these can be used to gain access to the PFC equipment.

The symbols used here are A for the circuit breaker and B for the access locks.

Incomer Interlocking



Truth Table

W Selector Box

| Position | Inc 1 A19 | Inc 2 A19 | Inc 3 A20 | Inc 4 A20 | BC A21 |
|----------|--------------|--------------|--------------|--------------|-----------|
| 1 | T | T | F | F | F |
| Normal | F | F | F* | F* | T |
| 2 | F* | F* | T | T | F |

* In neighbouring positions only where the key is free in both positions the key does not need to be returned to the key exchange box.

Operation

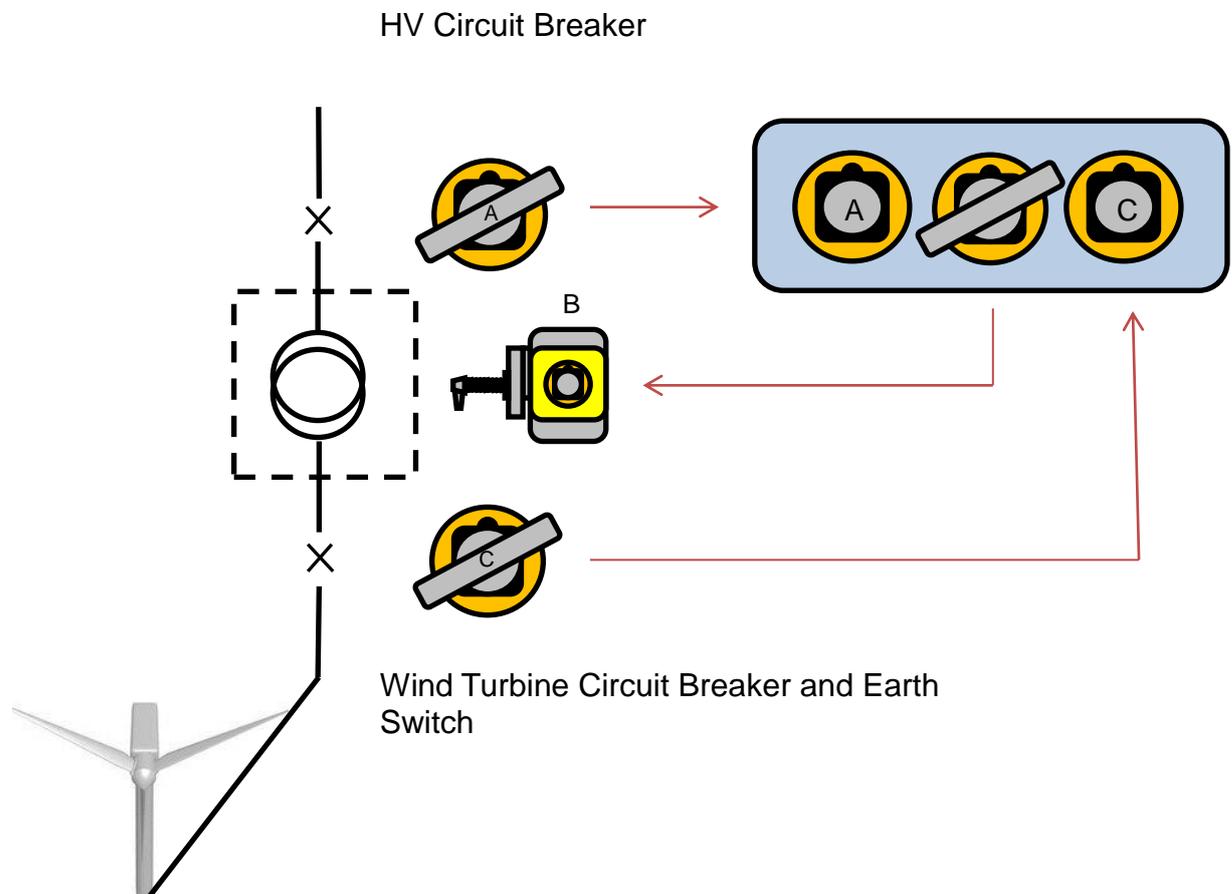
The operation is shown will all incomers closed, the bus coupler open and its key A21 trapped in the W Selector Box.

To change to position 1 from normal, incomers with symbols A19 are inserted and trapped in the W Selector Box. The asterisks denote that incomers three and four remain closed and need not be returned to the box. Key A21 can now be removed to close the bus coupler switch.

To change to position 2 from normal, incomers with symbols A20 are opened and their keys are inserted and trapped in the W selector box. The asterisks denote that incomers 1 and 2 remain closed and need not be returned to the box. Key 21 can now be removed to close the bus coupler switch.

The symbols used here are A19 and A20 for the circuit breakers and A21 for the bus coupler.

Wind Farm



Operation

When the wind turbine is running and generating electricity the keys are trapped in the HV and wind turbine circuit breaker and access can not be gained to the transformer housing.

When the wind turbine and HV circuit breakers are open the keys can then be inserted in to the exchange bow releasing the transformer housing key. This is then inserted in to the AI to gain access to the housing.

The symbols used here are A and C for the circuit breaker and B for the access lock.

OEM Equipment

ABB

| | | |
|---|---|--|
| Manufacturer | | ABB <ul style="list-style-type: none"> • EMAX • SACE Megamax Range F1-F2 • OESA/OETL |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | |  |
| Products To Provide Solution | | |
| EMAX | PDS01388(S) |  |
| SACE Megamax Range F1-F2 | PDS00800 |  |
| OESA/OETL | K-FSB-6.4-3 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) D (Part body) Salus (Part body) AIE (Full body) |     |

Eaton

| | | |
|---|------------------------|--|
| Manufacturer | | Eaton <ul style="list-style-type: none"> • Magnum • MEM 315A-800A • MEM 63A-220A • OMA Breaker • Sovereign SMM300 |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| Magnum | PDS02499 |  |
| MEM 315A-800A | K-FSB-6.4-12.7 |  |
| MEM 63A-220A | K-FSB-6.4-3 |  |
| OMA Breaker | FS1B-CW-65 - Brass |  |
| | FS1S-CW-65 - Stainless |  |
| Sovereign | K-FSB-0-1 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) |  |
| | D (Part body) |  |
| | Salus (Part body) |  |
| | AIE (Full body) |  |

GE

| | | |
|---|-------------------|---|
| Manufacturer | | GE <ul style="list-style-type: none"> M Pact Air Cct Breaker |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| M Pact Air Cct Breaker | FS1B-CW-45-9.5-22 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) |  |
| | D (Part body) |  |
| | Salus (Part body) |  |
| | AIE (Full body) |  |

Harvey

| | | |
|---|---|--|
| Manufacturer | | Harvey Hubble |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
| Products To Provide Solution | | |
| Isolator Handle | K-FSB-6.4-4 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) D (Part body) Salus (Part body) AIE (Full body) |     |

Mitsubishi

| | | |
|---|---|--|
| Manufacturer | | Mitsubishi <ul style="list-style-type: none"> • ACB • Moulded Case ACB |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| ACB | FS1B-CW-65-9.5-22 |  |
| Moulded Case ACB | CL1157 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) D (Part body) Salus (Part body) AIE (Full body) |     |

Moeller

| | | |
|---|-------------------|---|
| Application | | Moeller • NZM 7/10/12 |
| Safety Issue | | Danger from electrocution |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| NZM 7/10/12 | K-FSB-12.7-1 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) |  |
| | D (Part body) |  |
| | Salus (Part body) |  |
| | AIE (Full body) |  |

Schneider

| | | |
|---|---|---|
| Manufacturer | Schneider <ul style="list-style-type: none"> • NT, NW Chasis Withdrawable • Masterpact • Compact NS630b-1600 – Chasis Locking • Compact NS630b-1600 • Compact NS100-630 • Compact NS • NW | |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| NT, NW Chasis Withdrawable | CL1062 – Cut Away Key | |
| | CL1019 |  |
| Compact NS630b-1600 Chasis Locking | CL1019 |  |
| Compact NS630b-1600 | K-FSB-0-4 |  |
| Compact NS100-630 | K-FSB-0-4 |  |
| Compact NS | CL1019 |  |
| NW | CL1019 |  |

| Products To Provide Solution (Continued) | | |
|---|-------------------|---|
| Exchange box | X-box |  |
| Access (select) | AI (Part body) |  |
| | D (Part body) |  |
| | Salus (Part body) |  |
| | AIE (Full body) |  |

Siemens

| | | |
|---|---|--|
| Manufacturer | | Siemens <ul style="list-style-type: none"> • 3WT • 3WL • 3VF6, 3VF8 |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| 3WT | FS2BB-ACW-65-9.5-22 (Braised) |  |
| 3WL | FS2BB-ACW-65-9.5-8 (Braised) |  |
| 3VF6, 3VF8 | K-FSB-16-1 |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) D (Part body) Salus (Part body) AIE (Full body) |     |

Socomec

| | | |
|---|-------------------------------|---|
| Manufacturer | | Socomec <ul style="list-style-type: none"> • Fuser Monobloc • S3 • Monobloc 800 |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| Fuser Monobloc | K-FSB-6.4-3 |  |
| Fuser Monobloc 32-400A | K-FSB-6.4-4 |  |
| S3 | K-FSB-6.4-4 |  |
| | FS1B-CW-65-9.5-22 +STD LEV |  |
| Monobloc 800 Type 3620-3121 | FS2B-CW-65-STD |  |
| Exchange box | X-box |  |

| Products To Provide Solution (Continued) | | |
|--|-------------------|---|
| Access (select) | AI (Part body) |  |
| | D (Part body) |  |
| | Salus (Part body) |  |
| | AIE (Full body) |  |

Terasaki

| | | |
|---|---|--|
| Application | | Terasaki <ul style="list-style-type: none"> • RA8240 • XFHA34-RO-3D5 • XS400NJ MCB • AT6-AT40 |
| Solution | | |
| <p>Interlock the switchgear control panel using the correct isolation lock identified below. The isolation key is locked in position when the power is on. Removing the isolation will turn off the power, this key can then be used to gain access through either the access lock or through the exchange box for multiple points of access.</p> | | |
|  | | |
| Products To Provide Solution | | |
| RA8240 | FS2B-CW-90-9.5-22 |  |
| XFHA34-RO-3D5 | K-FSB-13.5-3 |  |
| XS400NJ MCB | K-FSB-13.5-3 |  |
| AT6-AT40 | FS2B-CW-65-STD |  |
| Exchange box | X-box |  |
| Access (select) | AI (Part body) D (Part body) Salus (Part body) AIE (Full body) |     |

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