Greenlining and Bluelining of Ergon Energy Substation Drawings

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PURPOSE AND SCOPE

To outline the requirements for continuity and function testing of Control, Protection, Metering, Communications and Auxiliary Equipment Panels within Ergon Energy Substations.

DEFINITIONS, ABBREVIATIONS AND ACRONYMS

Greenlining Refers to a series of inspections, tests and verifications that are carried out in order to prove that panel construction and wiring has been carried out in accordance with the design drawings, and that the drawings are an accurate record of the completed works. The term 'Greenlining' is used because a green highlighter is used to record works completed.

Bluelining Refers to a series of tests that are carried out in order to prove that each device in a circuit is functioning correctly, and that the functional interrelation between devices is correct and in accordance with the designers' intentions. The term 'Bluelining' is used because a blue highlighter is used to record works completed.

HMI Human Machine Interface

OCC Operations Control Centre

REFERENCES

Nil.

GENERAL

Greenlining and Bluelining drawings are a record of work completed for continuity testing, checking and function testing. It is not the principal record of corrections, deletions or additions to design drawings, although this information is captured on the Greenlined and Bluelined drawings, it must also be transferred to the single Master drawing copy (Drawing Set 1) along with all other mark-ups from all service providers and contractors who work on the substation.

Greenlining - always use Drawing Set 6

- This set is called the "Greenlining Test Copy".
- Drawing Set 6 changes hands as the work progresses from panel builders to site constructors, and finally to testers.
- Each workgroup must use a different colour highlighter from the previous workgroup when doing continuity testing, and clearly identify on the first drawing of the set which colour belongs to them.
- Green is always reserved for the first workgroup. Do not use Blue, so as not to introduce confusion with Drawing Set 12.

Bluelining - always use Drawing Set 12

- This set is called the "Bluelining Test Copy".
- Drawing Set 12 must change hands if the responsibility for function testing changes throughout the project.
- Each workgroup must use a different colour highlighter from the previous workgroup when doing functional testing, and clearly identify on the first drawing of the set which colour belongs to them.

- Blue is always reserved for the last (SIT) workgroup. Do not use Green, so as not to introduce confusion with Drawing Set 6.

Drawing Sets 1, 6 and 12 are not “owned” by any one workgroup - the workgroup doing the relevant work is the temporary custodian before passing the drawings on to the next workgroup. If another workgroup has the drawing set you need, it is your responsibility to transfer the relevant mark-ups / Greenlining / bluelining to the correct set when you receive it.

Refer to Substation Controlled Drawings - 2868827 for more information on the use and control of the different drawing sets during a project.

The method on the following pages is presented as a series of sequential steps, however it is recognised that in order to maximise efficiency some steps may be carried out in a different sequence depending on the details of the equipment being tested. This is permitted providing the final outcome is as described in this document. Similarly, minor variations in test methods are permitted providing that the final outcome is as described in this document and all mandatory requirements are followed.

CONTINUITY TEST

Requirements

Circuit continuity testing is carried out to prove that wiring has been installed as per the schematic. Panel wiring schedules must not be used for continuity testing. Continuity testing must not be conducted by the same person who wired the panel.

Testing Notes

Continuity tests do not need to be conducted on any plant internal wiring, unless the wiring has been modified, because these tests have already been carried out by the supplier. All other circuits, even if they are only short, are to be tested for continuity. Testing continuity of circuits purely by visual inspection is not acceptable.

Normally open contacts are not to be shorted or closed during continuity testing.

Interconnections between different wires, for example through relay contacts or coils, links, fuses, indicating lamps, switches and other components may cause back-feeds and false continuity results. Interconnections must be removed prior to commencing testing, for example by withdrawing relays, removing fuses / links and disconnecting wires. Disturbance of wiring and connections during testing must be minimised by use of correct test techniques as disturbance of wiring and connections may introduce mistakes due to incorrect reinstatement.

Either a multi-meter or buzzer is acceptable to use as a continuity testing device. A multi-meter is the preferred instrument as it allows for a wider variety of test methods – for instance instead of removing a wire from a terminal to prevent back-feed, it may be possible to compare loop resistance values and positively confirm continuity without disrupting wiring.

An earth return path may be used during testing of field cables; however it should not be used on panel wiring.

If schematic wiring is repeated on several drawings, it only needs to be tested once using the drawing that depicts the most detailed representation of the wiring. However, any corrections and alterations must be transferred to all associated drawings. If multiple panels are wired to the same schematic, each panel must be tested.

Switches are only to be considered as passing continuity tests if all positions have been tested and have passed continuity or no continuity accordingly.

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When new circuitry is connected into live circuitry it is not possible to carry out continuity checks on the final connection as described in this document. In this case, an alternative method of test and measurement is required to verify that the final connections are correct.

Method

Confirm the drawing matches the panel you are checking. Once checked, highlight (green) the panel number in the title bar of the schematic.

Remove all fuses, links and components which can be withdrawn, and open all switches and links on the circuits which are to be tested.

Starting at the end termination point on the circuit, visually check the ferrule has the correct label for the terminal, and the wire is secure. At the other end of the wire, visually check the ferrule has the same label, and confirm the wire is secured in the correct terminal. If this is correct, highlight (green) the wire number on the schematic.

Check the circuit continuity by placing a probe at the cable termination point either end of the wire. An audible bell should be heard if continuous. Move one probe to the other side of the removed fuse, link or withdrawn component and check the circuit is not continuous. Return the probe to its initial position, check continuity, and then move the other probe to the other side of the removed fuse, link or withdrawn component and check the circuit is not continuous. If this is correct, highlight (green) the cable on the schematic between and not including the tested terminal points.

Repeat the above until the entire circuit has been checked. The result should represent something similar to the schematic below.

Anything found to be incorrect or missing on the drawing must be marked on the working drawing as well as the Master drawing set. Additions must be written in red then highlighted yellow. Any deletions must be highlighted red.

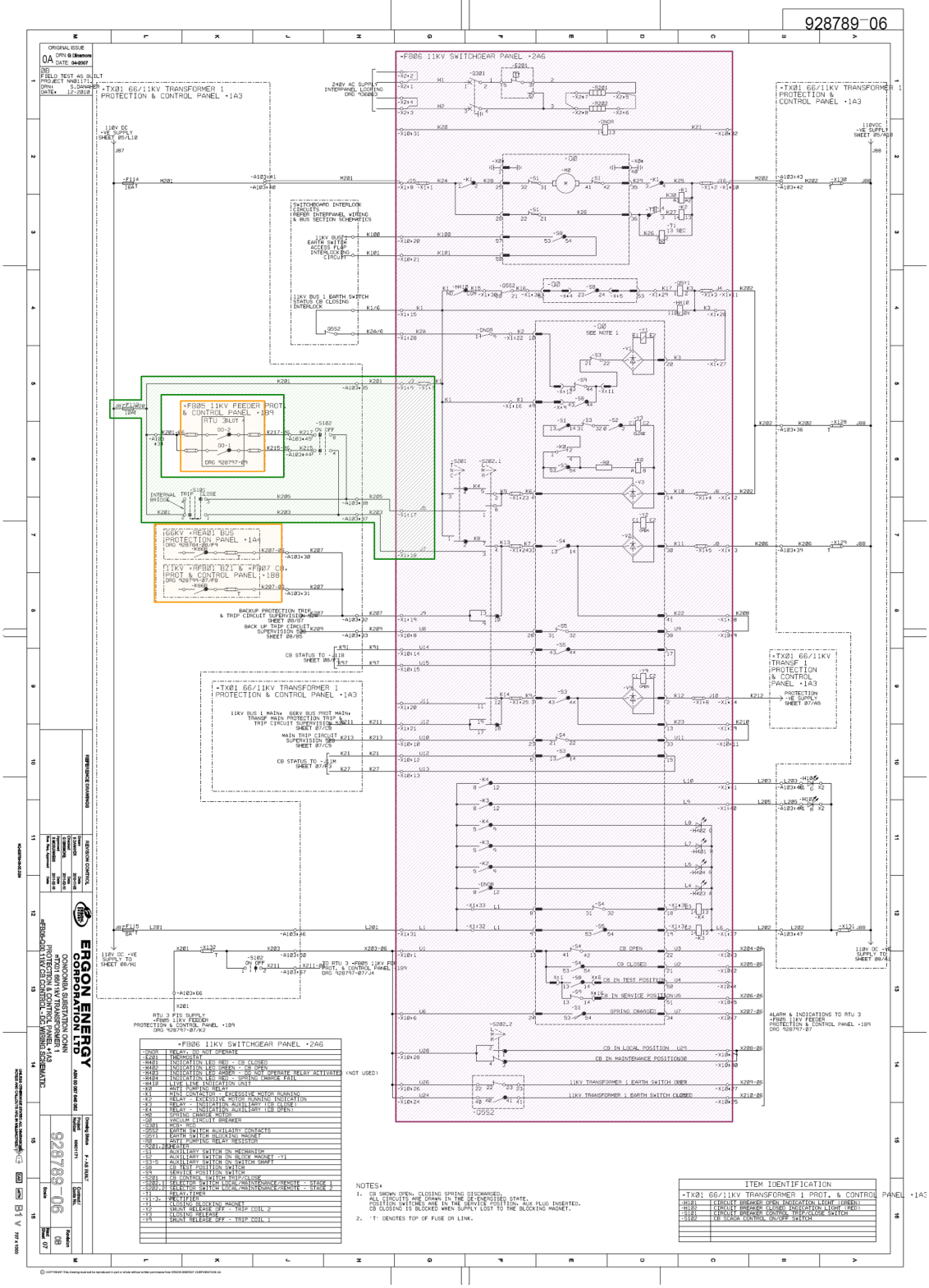
Continuity Test Example

The following schematic will be stepped through as an example of the method expected during testing the continuity of the wiring in this panel.

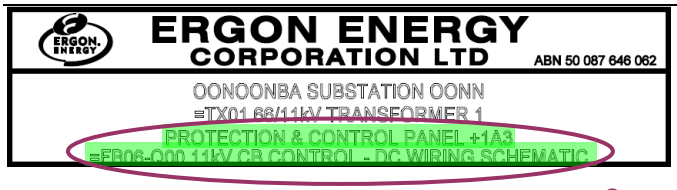
Wiring on another drawing

Wiring already checked by manufacturer

Example continuity test area

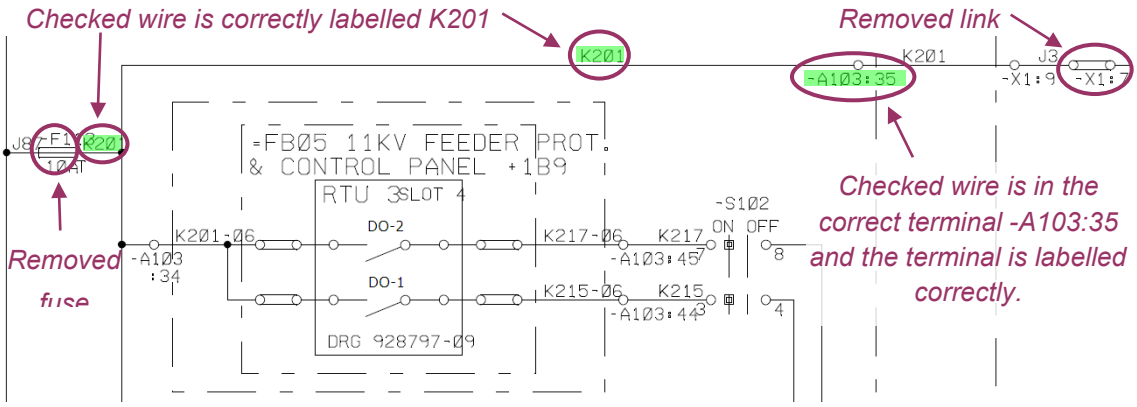


Confirm correct panel is being checked.

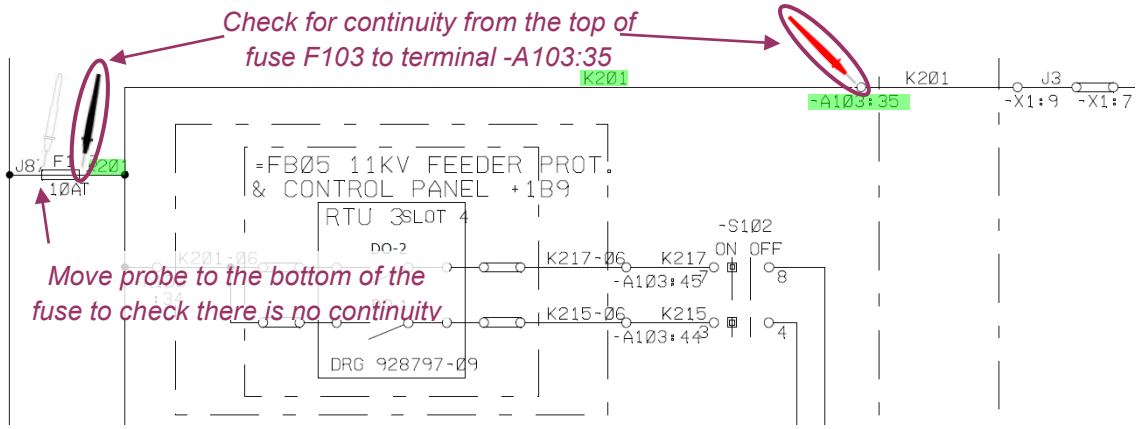


Correct panel is being checked

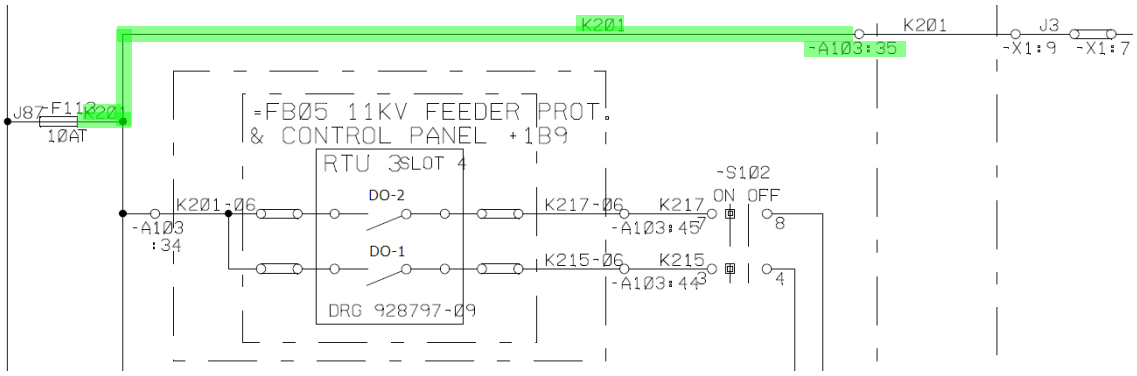
Starting at fuse F113 check terminals and cable are correct.



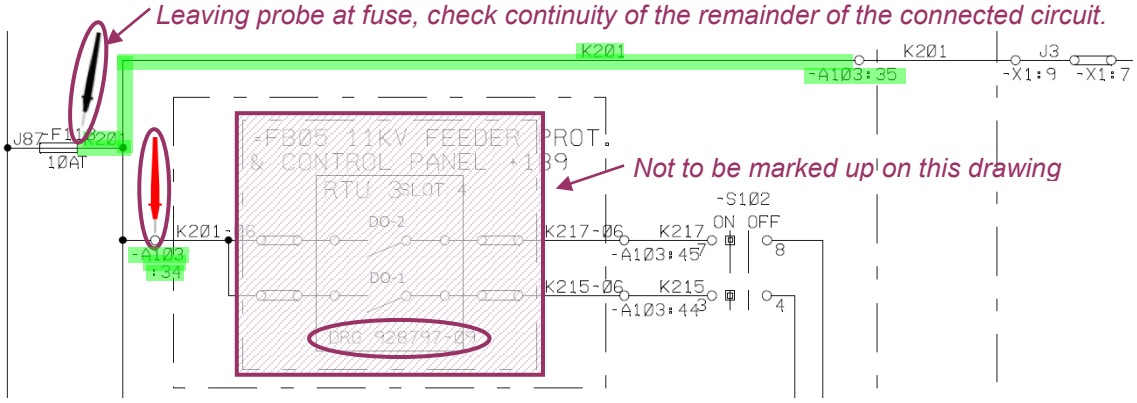
Check for continuity between the connections. First test needs to check for continuity, second test is for no continuity.



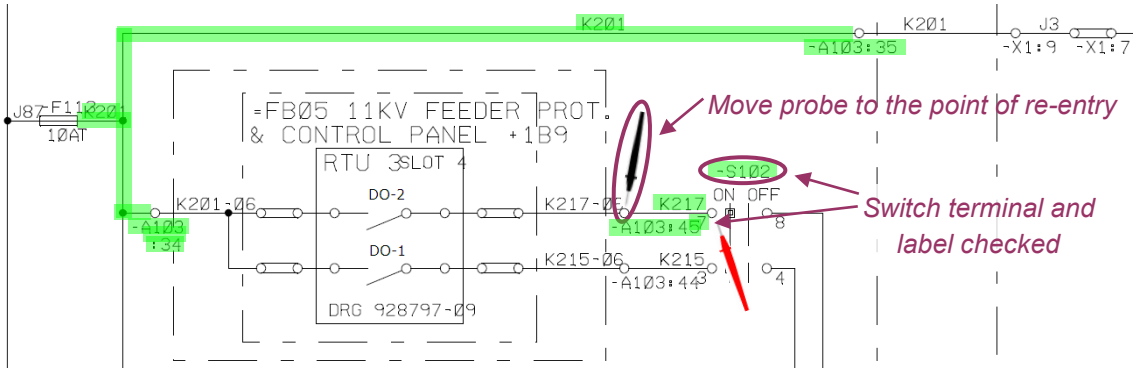
Highlight between tested terminals F113 and -A103:35. Only highlight between the tested points if it passes the continuity test.



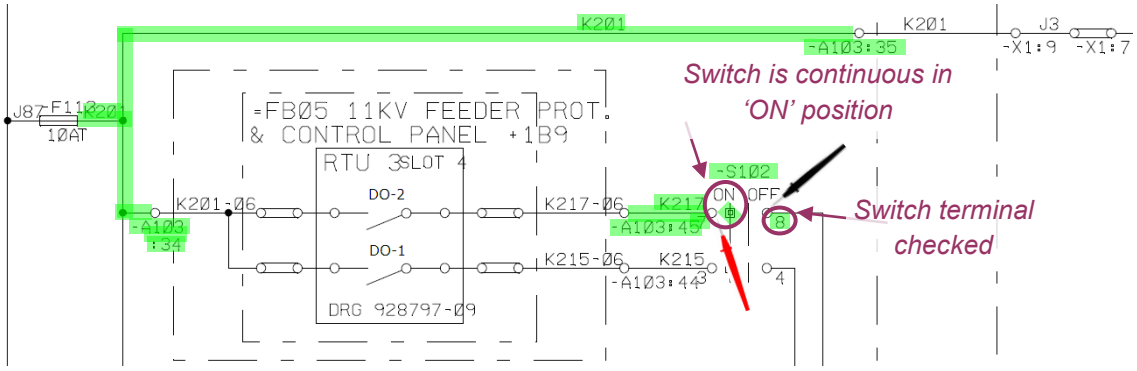
Once the end has been reached for the top branch, move onto the next branch.



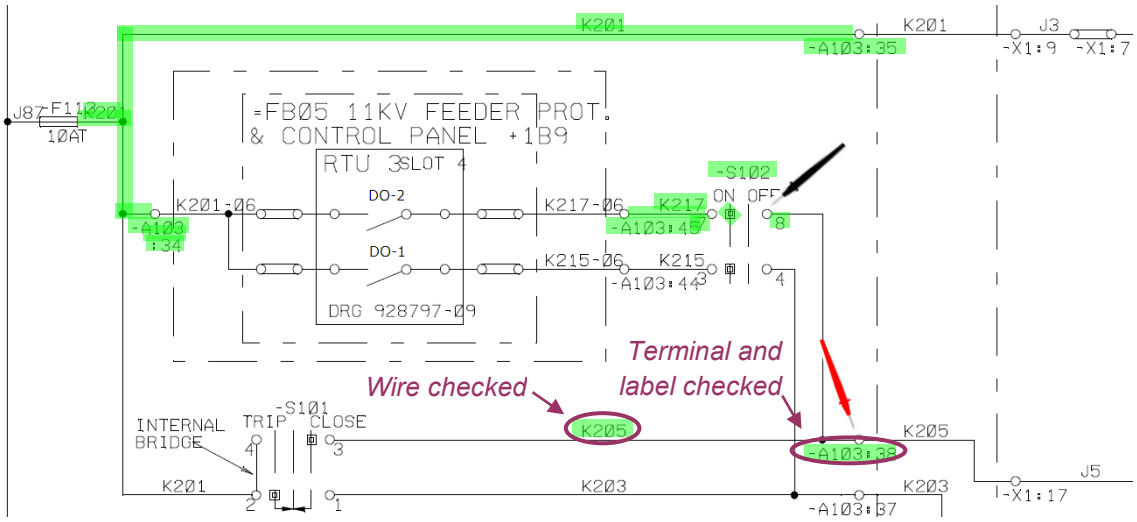
Wiring between panels is checked during control cable continuity testing. Continue circuit continuity checks where the circuit returns to the panel being checked.



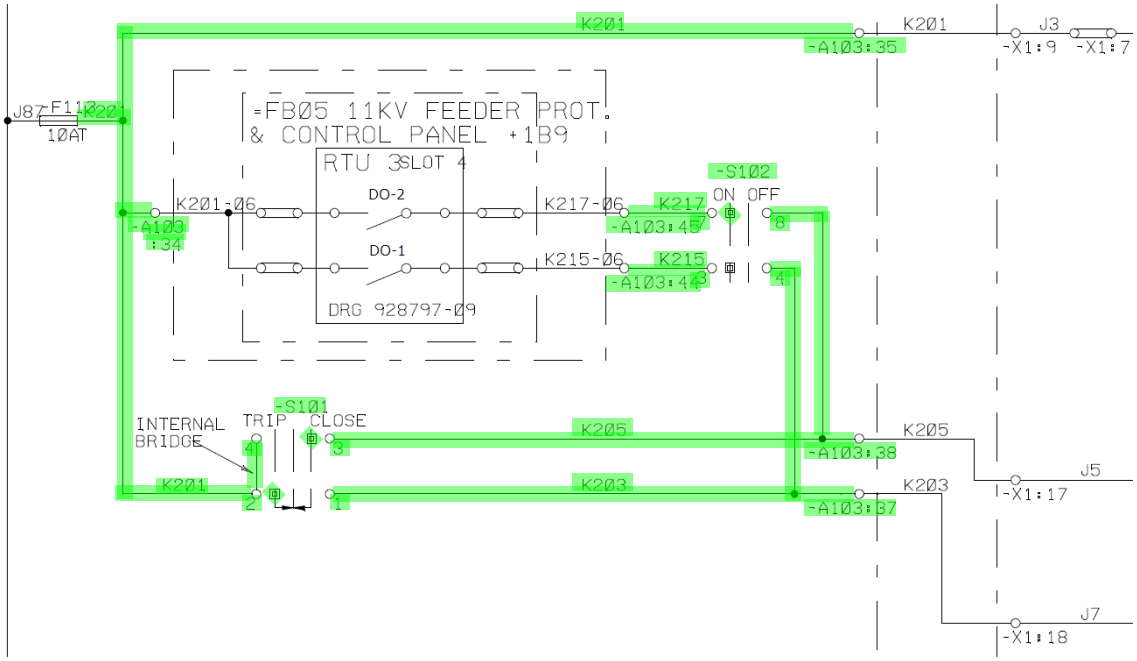
Check for no continuity and continuity across the switch.



Continue checking continuity methodically through the remainder of the circuit.



When the entire branch is completed, it should appear as below.



CONTROL CABLE TESTING

Control cable testing is to be conducted separate to the continuity testing. The control cable schedule is to be used in conjunction with the cable connection diagrams to determine the destination of the control cables and the location for each core. Each core is to be tested for continuity.

Cable Schedule

Visual inspection needs to confirm the following cable information for each cable:

a. Origin.
b. Destination.
c. Cable number.
d. Type of cable.

Continuity of at least one core must be checked before the cable information in the cable schedule is to be highlighted (green).

Cable Connection Diagram

Visual inspection needs to confirm the following cable information for each cable:

a. Terminal number.
b. Wire number.
c. Core number.
d. Cable number.
e. Terminal bridging.

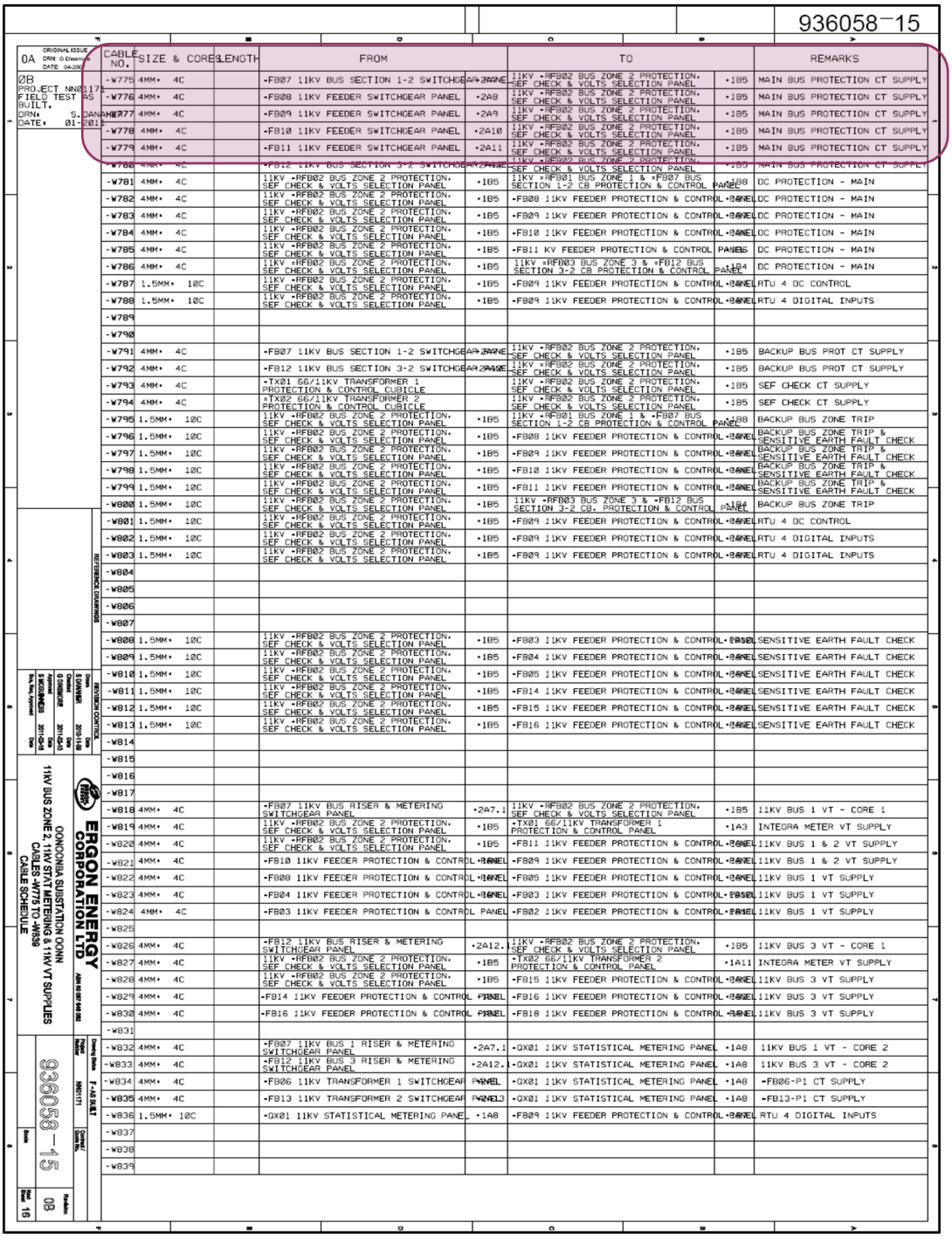
Testing Continuity

1. The wire to be tested must be isolated at each end from the panel circuits. The wiring schematics might need to be used to determine the best isolation point. If isolation cannot be achieved by removing a link or fuse, or opening a switch, the wire may need to be removed from the terminal.
2. One end of the control cable core is to be shorted to ground, with the other end connected to the continuity testing device.
3. The wire as shown on the schematic is to be highlighted (green) if this passes the continuity test. The circuit must be returned to normal operation.

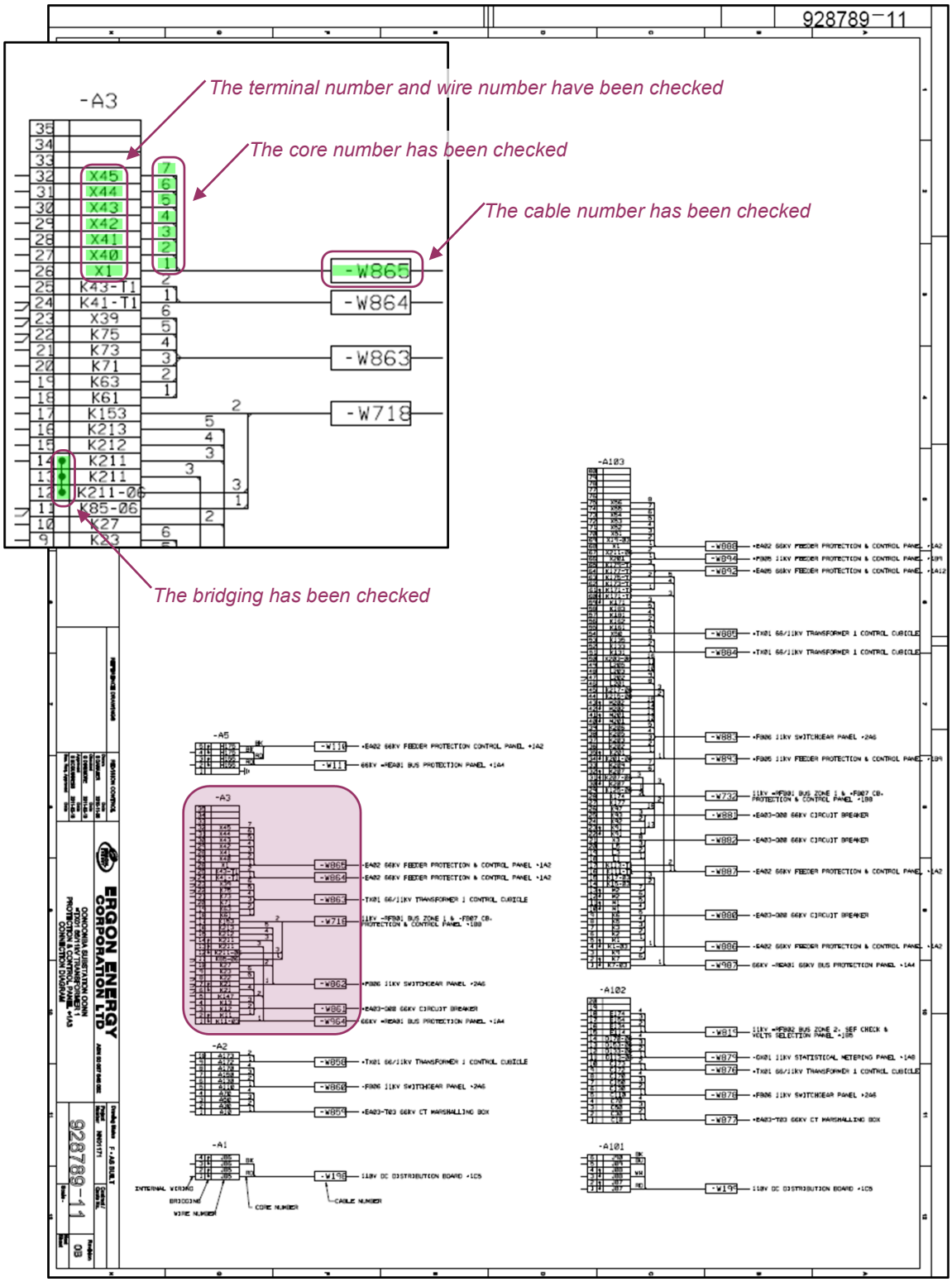
Cable Schedule Example

Cable number has been checked at both ends of the cable / *The start of the cable has been checked*

CABLE NO.	SIZE & CORES	LENGTH	FROM		TO		REMARKS
-W775	4MM• 4C		•FB07 11KV BUS SECTION 1-2 SWITCHGEAR PANEL	•2A7	11KV •RFB02 BUS ZONE 2 PROTECTION, SEF CHECK & VOLTS SELECTION PANEL	•1B5	MAIN BUS PROTECTION CT SUPPLY
-W776	4MM• 4C		•FB08 11KV FEEDER SWITCHGEAR PANEL	•2A8	11KV •RFB02 BUS ZONE 2 PROTECTION, SEF CHECK & VOLTS SELECTION PANEL	•1B5	MAIN BUS PROTECTION CT SUPPLY
-W777	4MM• 4C		•FB09 11KV FEEDER SWITCHGEAR PANEL	•2A9	11KV •RFB02 BUS ZONE 2 PROTECTION, SEF CHECK & VOLTS SELECTION PANEL	•1B5	MAIN BUS PROTECTION CT SUPPLY
-W778	4MM• 4C		•FB10 11KV FEEDER SWITCHGEAR PANEL	•2A10	11KV •RFB02 BUS ZONE 2 PROTECTION, SEF CHECK & VOLTS SELECTION PANEL	•1B5	MAIN BUS PROTECTION CT SUPPLY
-W779	4MM• 4C		•FB11 11KV FEEDER SWITCHGEAR PANEL	•2A11	11KV •RFB02 BUS ZONE 2 PROTECTION, SEF CHECK & VOLTS SELECTION PANEL	•1B5	MAIN BUS PROTECTION CT SUPPLY



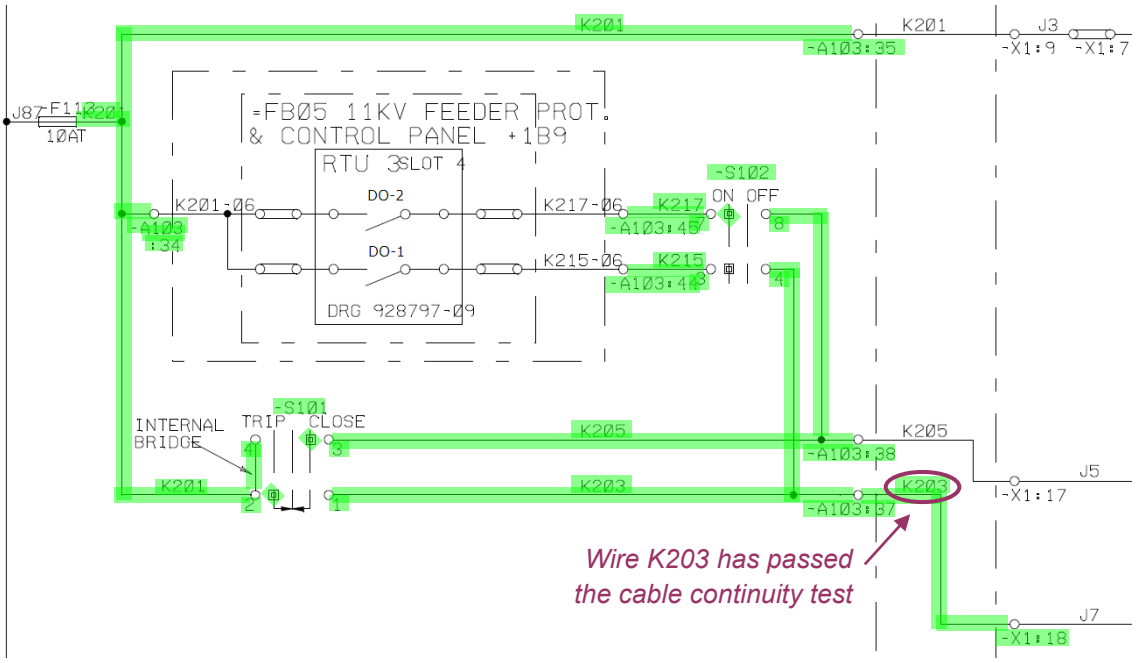
Cable Connection Diagram Example



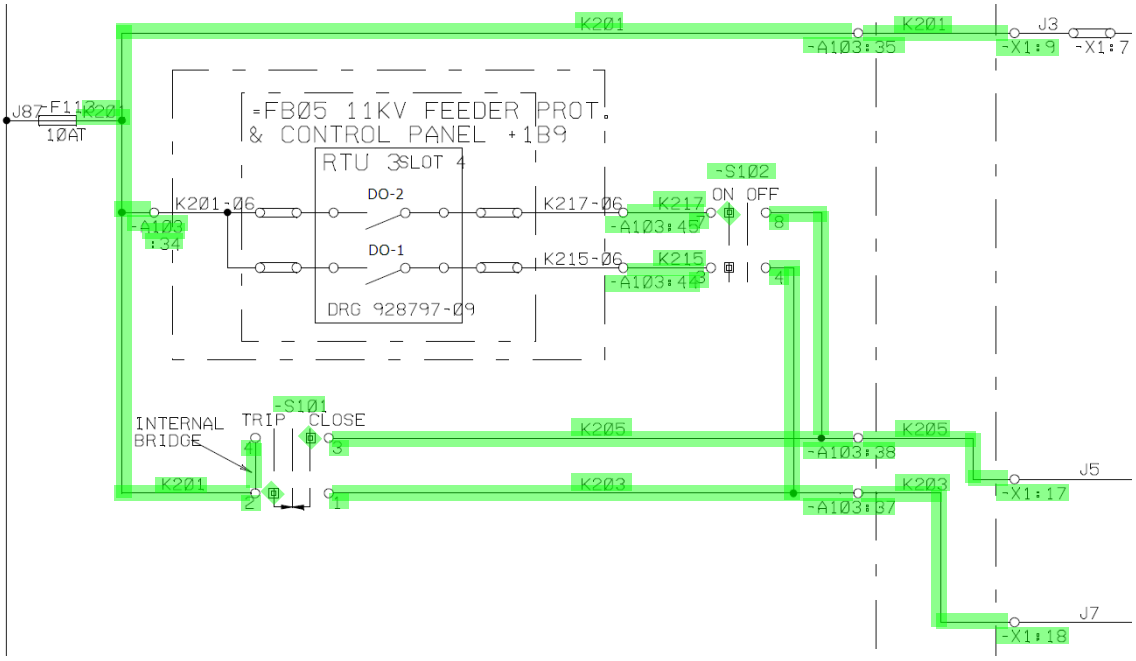
Continuity Example

Each core must be checked for continuity once the Control Cable visual inspections have been completed. This is to be marked up on the wiring schematic.

Once K203 has passed cable continuity test, the schematic is marked up:



When all cables have been checked and have passed:



DRAWING CHECKS

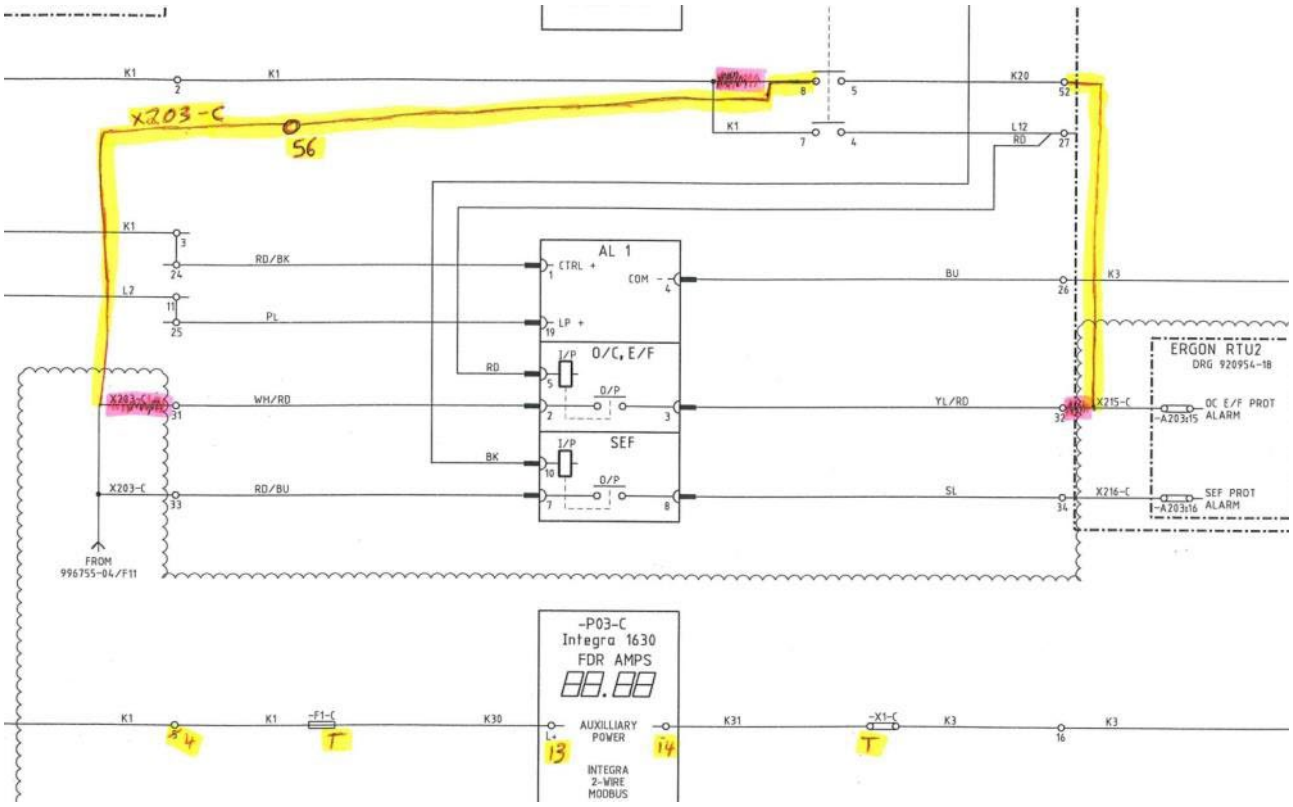
Drawing checks are carried out to confirm the overall accuracy of electrical drawings.

Although this is not a 'testing' function, it is carried out during continuity and functional testing.

The items to be checked include:

1. Drawing number.
2. Cross references to other drawings.
3. Cross referencing where the details of one component are spread across several drawings (for example multi-trip relay contacts on several schematics).
4. Verification that details that appear on multiple drawings are consistently represented.
5. Incomplete or missing data (for example a drawing number shown as "???" or missing contact terminals).
6. Panel component list data (for example control switch part numbers).
7. Panel layout including correct fit-out and location of all components.

Any additions or corrections are recorded as described previously. The drawing below shows an example of minor corrections recorded on a schematic (note that greenlining has not been shown for clarity). In this example, the use of an alternative contact must be approved by the designer prior to implementation.



FUNCTIONALITY AND ISOLATION TEST METHOD

Once continuity has been proven for the panel, functionality and isolation tests need to be conducted.

Functionality Test – Part 1 (Element Level)

Functionality of devices can be tested by:

- Initiating the contacts of the device, or
- Shorting the contacts of the device.

Functionality test Method A is preferred; however Method B can be used where it is not possible to do a Method A test. Where Method B is used, a blue 'B' is to be written near the Bluelined contact.

All settings and configurations must be applied prior to carrying out function testing.

Bluelining an element on a schematic drawing means that the element is operated by the correct upstream device and operates the correct downstream device. It means that the element has been verified as having the correct functional and logical operation in the context of the entire scheme that it is part of. This verification shall be achieved by operating other upstream and downstream elements of the scheme.

Isolation Test

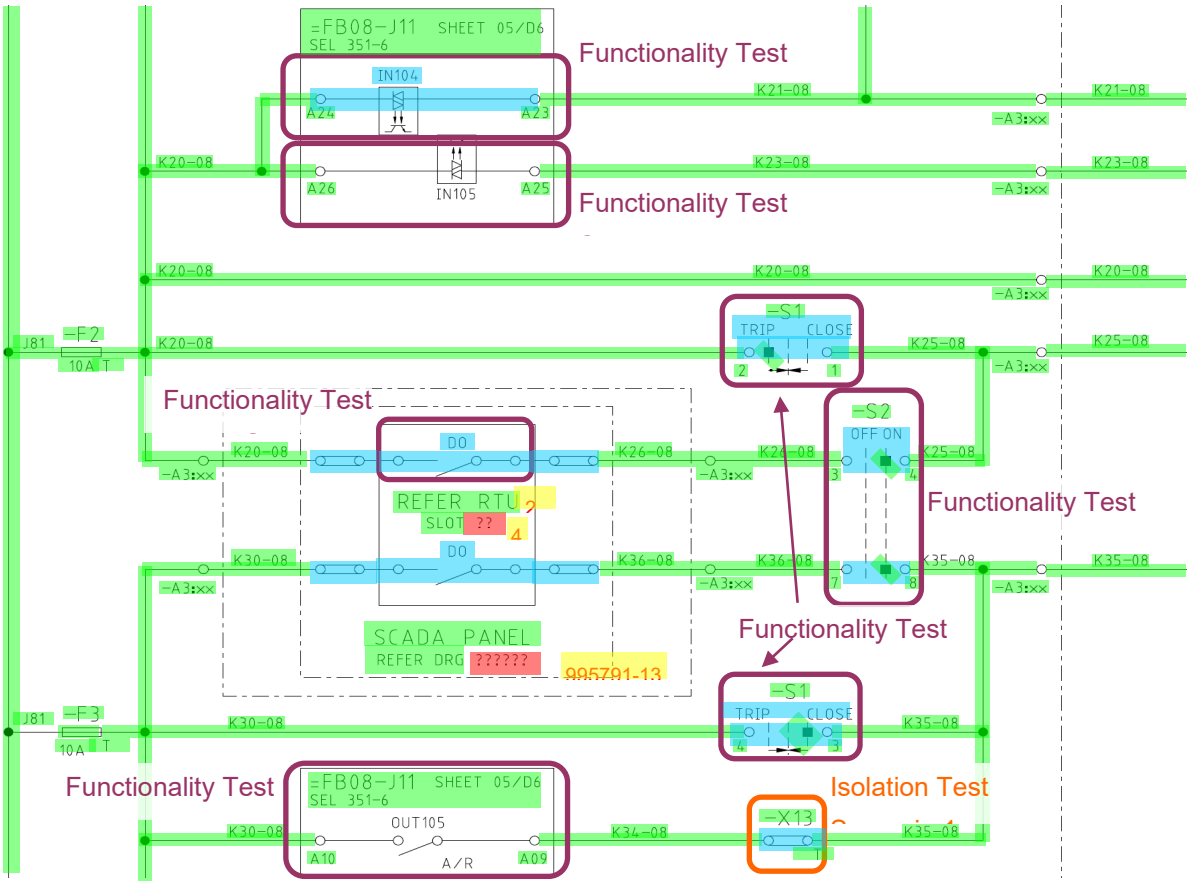
An Isolation Test is carried out after a Functionality Test in order to prove that isolation points have the effect of isolating a function and there is no 'back-feed' into the circuit. An isolation test is carried out by removing only one isolation element at a time.

Bluelining a fuse, link, or isolation element on a schematic drawing means that the element, when removed or open, provides effective isolation.

Functionality Test – Part 2 (Scheme Level)

Once all function and isolation testing at the schematic level has been completed, overall scheme testing from the Metering and Protection single line diagram must be completed. This is done to verify the complete functionality of protection schemes as opposed to testing functionality between adjacent elements only. Scheme testing can only be finalised when all integration of new secondary systems to existing systems has been completed. All trips, initiates and blocks shown on the Metering and Protection single line diagram are tested as a scheme and Bluelined when verified as operating correctly.

Functionality and Isolation Test Example



Functionality Tests Scenario:

1. IN104 sees the correct status of the trip circuit supervision circuit and this status is reflected at the protection relay display and alarm or indication output.
2. In this scenario even though the voltage measured across terminals A25 and A26 correctly reflects the trip circuit supervision status there is no Bluelining of the drawing because the full functionality has not been verified. The operation of the internal relay logic as a scheme must be verified before the input is Bluelined as per Scenario 1.
3. Turning S1 to the 'TRIP' position resulted in opening the circuit breaker. Turning S1 to the 'CLOSE' position resulted in closing the circuit breaker.

   Note: 'TRIP' and 'CLOSE' are both blued in both switch locations on the drawing.
4. S2 set to 'ON' allowed SCADA tripping and closing. S2 set to 'OFF' prevented SCADA tripping and closing.
5. Operating this contact by the local HMI, OCC or a test set had the desired effect of tripping the circuit breaker. Subsequent removal of each link in turn prevented tripping or closing of the circuit breaker.
6. An auto-reclose was successfully initiated when terminal A09 was bridged to terminal A10. OUT105 will not be blued until additional tests have proved that the Auto Reclose Logic correctly operates OUT105. However, this does allow the blueing of link –X13 and downstream close coil.

Isolation Test Scenario:

1. An auto-reclose was successfully initiated, and the subsequent removal of the link prevented an auto-reclose from occurring.