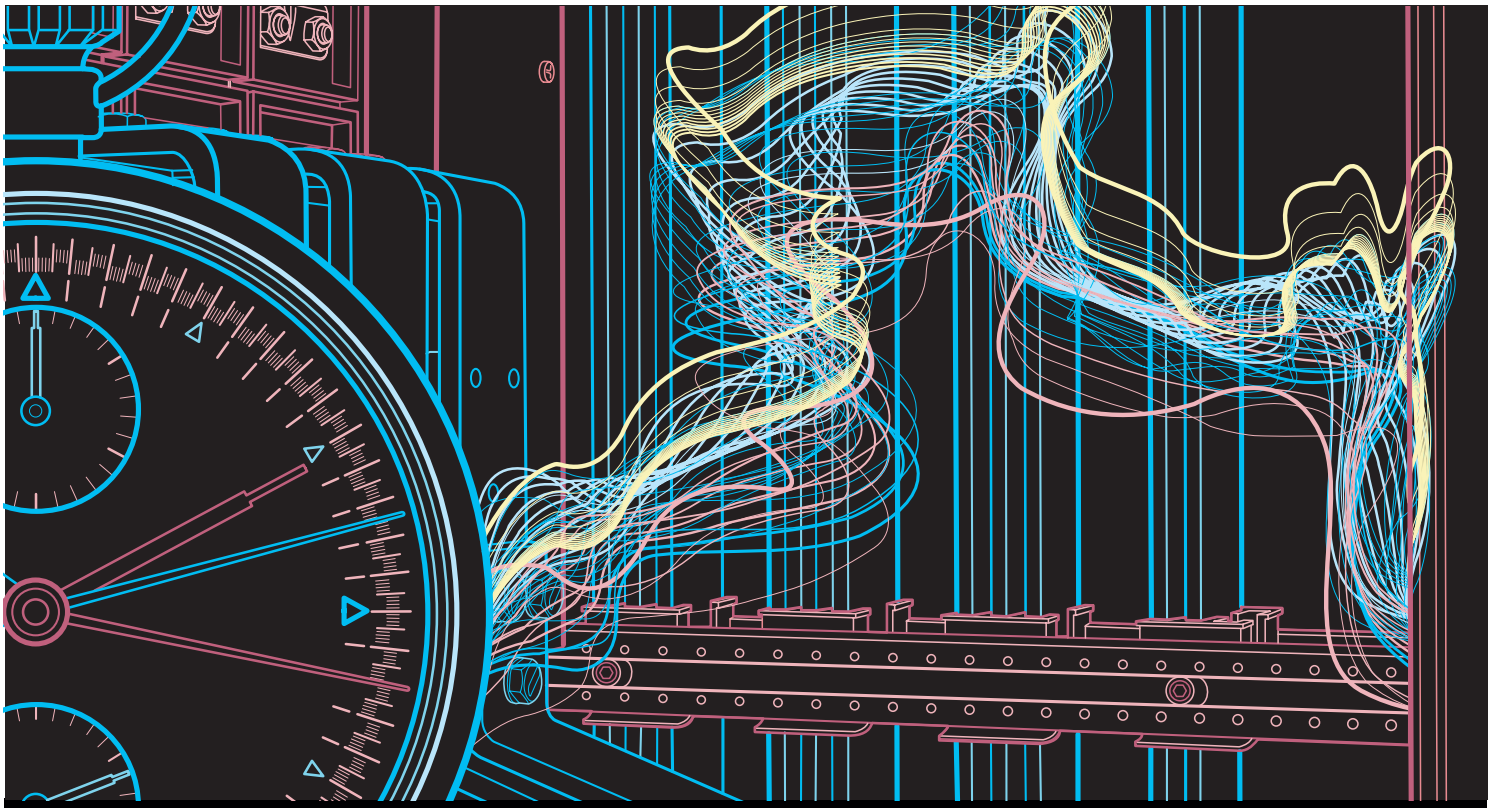

White paper

Arc flash energy reduction using ABB Emax 2 with second I Protection (2I) and Dual Settings

Power and productivity
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Arc Flash Energy Reduction Using ABB Emax 2 With Second I Protection (2I) and Dual Settings

Contents

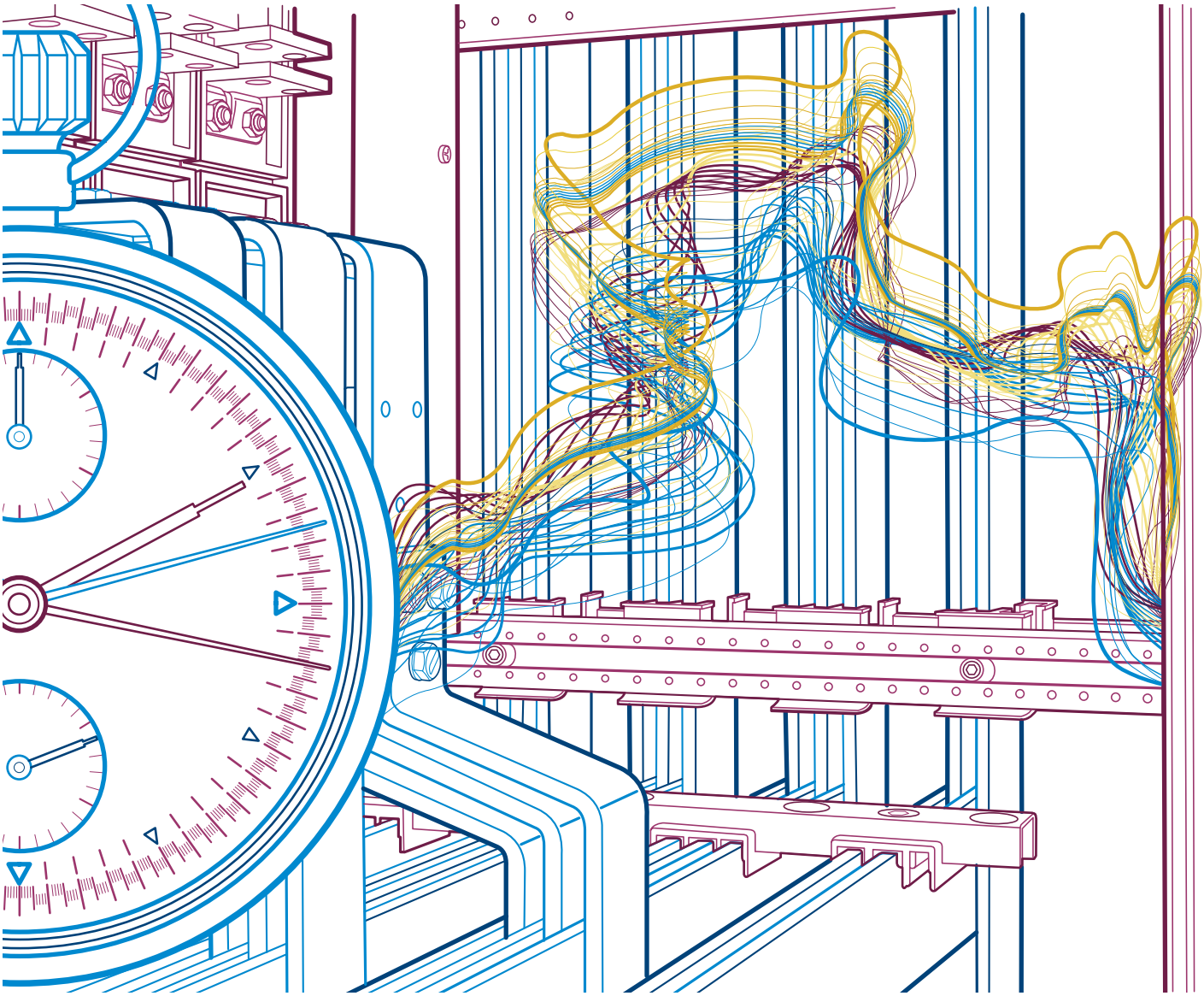
1. Introduction

1.1 Purpose

Selective Coordination often requires upstream circuit breakers to wait in the event of a fault condition to allow downstream circuit breakers time to clear the fault. This increased time delay permits fault currents to flow and increases the amount of hazardous arc flash energy available the longer the fault current is allowed to flow. As you can see an opposing situation can result between Selective Coordination which needs upstream circuit breakers to remain closed during fault conditions, while Arc Flash Energy reduction methods requires these same circuit breakers to open quickly.

While the level of arc flash energy that results in a selectively coordinated system may be fully within acceptable levels to protect equipment from damage, this amount of arc energy is potentially very hazardous to personnel that may be working in the vicinity of the equipment.

[1] OSHA 29 Code of Federal Regulations (CFR) Part 1910 Subpart S requires that employers assess the arc flash hazard. If there is one present or likely in a certain area then the standard requires use of personal protective equipment. This equipment must be worn within specified boundaries given by the standard.



[2] NFPA 70E Standard for Electrical Safety in the Workplace recognizes that there are situations where working on energized electrical equipment is needed. As a result, strict guidelines are outlined in NFPA 70E for the various levels of Personnel Protective Equipment (PPE) that must be worn by personnel within arc flash boundaries.

[3] IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations provides guidelines for conducting a formal arc flash study of the devices in an electrical system. Facility engineers should perform an arc flash study to identify the recommended level of PPE and arc flash protection boundary.

In the 2011 edition, the NEC® added a new set of recommendations for addressing arc flash energy reduction in circuit breaker applications, per Article 240.87

[4] **240.87 Noninstantaneous Trip.**
Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200A or higher, 240.87(a) and (b) shall apply.

(a) Documentation.
Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s).

(b) Method to Reduce Clearing Time.
One of the following or approved equivalent means shall be provided:
(1) Zone-selective interlocking
(2) Differential relaying
(3) Energy-reducing maintenance switching with local status indicator
(4) Energy-reducing active arc flash mitigation system
(5) An approved equivalent meas

Note: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to 'no intentional delay' to reduce the clearing time while the worker is working within an arc-flash boundary as defined in NFPA 70E, 2009, Standard for Electrical Safety in the Workplace, and then to set the trip unit back to its normal setting after the potentially hazardous work is completed.
The idea behind this new NEC requirement is that in cases where the circuit breaker is used without an instantaneous trip function, an alternate means shall be provided to reduce the fault clearing time while a worker may be within the arc flash boundary of that circuit breaker. In this document we will concentrate on method three (3), energy-reducing maintenance switching with local status indicator.

[1] Part 1910 Subpart S. (2011). In OSHA 29 Code of Federal Regulations (CFR). Washington, D.C.: U.S. Dept of Labor, Occupational Safety and Health Administration.
[2] NFPA 70E standard for electrical safety in the workplace (2012 ed.). (2011). Quincy, MA: NFPA.
[3] IEEE guide for performing arc-flash hazard calculations. (2002). New York, New York: Institute of Electrical and Electronics Engineers.
[4] NFPA 70E standard for electrical safety in the workplace (2012 ed.). (2011). Quincy, MA: NFPA.

2. ABB Arc Flash Safety Solutions

With SACE Emax 2's Ekip trip units, a new level of safety during maintenance and operation is achieved. These powerful trip units are equipped with the most innovative technology on the market. Two of these integrated technologies are dual settings and second instantaneous protection which can be used to improve personnel and system safety by adhering to NEC Arc flash energy reduction requirements.

2.1 Dual Settings

With the dual setting feature an extra level of protection against Arc Flash Hazard is provided within the trip unit. Two protective parameter sets are available called set A and set B. When this feature is used it can be set to activate an alternative set of parameters for long-time, short-time, 2nd short-time, instantaneous, ground fault, directional overcurrent, and/or over temperature settings. The alternative set of protective settings provide the ability to establish minimum delays on the protective functions during maintenance activities performed downstream of the breaker. With minimized delays, the potential to reduce the risk of injury to personnel during an arc flash incident is improved.
Set A and set B are completely interchangeable and both can be configured as the default or alternate set.

2.2 Second I (2I) Protection

Instantaneous protective settings are typically sacrificed to maintain selectivity with upstream and downstream protective devices in a power system. In these instances, the lack of consideration for the amount of available arc flash energy can increase the risk to personnel. The 2I feature permits opening of the circuit breaker faster than the standard instantaneous setting when a lower value is applied. It also is completely independent from ANSI 50 protective function, which means it has the capability to be set without affecting the other pre-set protections (ie. LSIG). The thresholds for this protection can be predetermined and stored to be ready for temporary activation. Once maintenance downstream is complete, the 2I setting can be deactivated.

2.3 Activation of 2I and Dual settings

2I and Dual Settings can be activated in four ways:

- Locally, directly on the input on the Ekip display unit
- Remotely, via any Ekip Com module connected to the circuit breaker
- Remotely, via a switch wired through an Ekip Signalling module.
- By a settable internal time, after circuit breaker closing (Dual settings only)

When 2I is active, the Ekip display unit will show a confirmation of the activation and a red LED alarm will flash on the diagnosis bar. For Dual settings, an A or a B will be displayed according to which set is active.

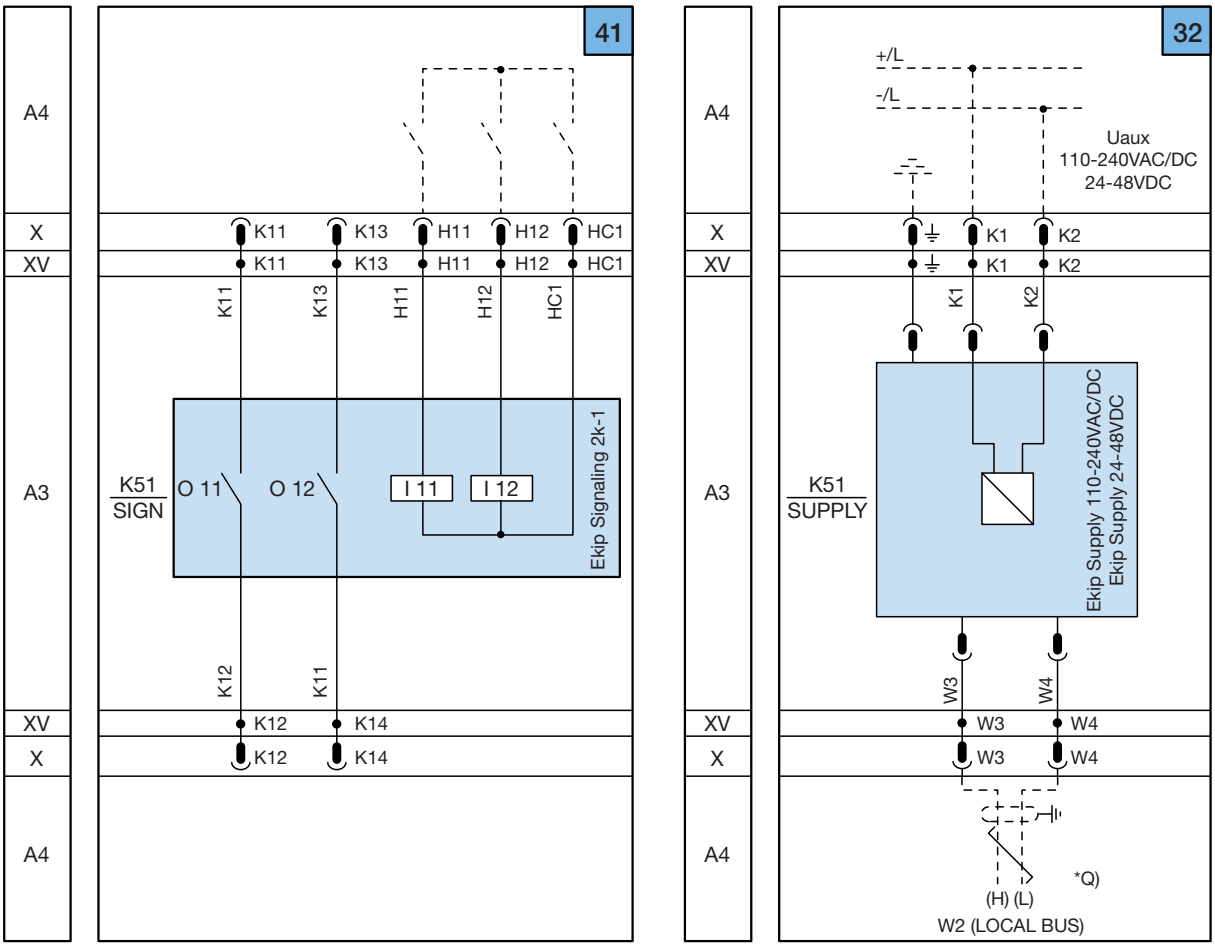
The following pages will explore setting "Second I" protection and dual settings remotely via a switch in order to provide instruction to engineers and designers regarding the requirements in 2011 NEC® article 240.87(3), for energy-reducing maintenance switching with local status indicator. This paper specifically addresses how to implement these requirements using **ABB SACE Emax 2** Low Voltage Power Circuit Breakers (LVPCBs).

3. Implementation of Arc Flash Safety Solutions

3.1 Wiring

1. The digital input that will be used on the ABB Emax 2 Ekip Signalling 2k module is located on terminals H11 and HC1 shown on diagram 41 below of the circuit breaker and should be wired in series with a normally open contact on the maintenance mode switch/selector switch.

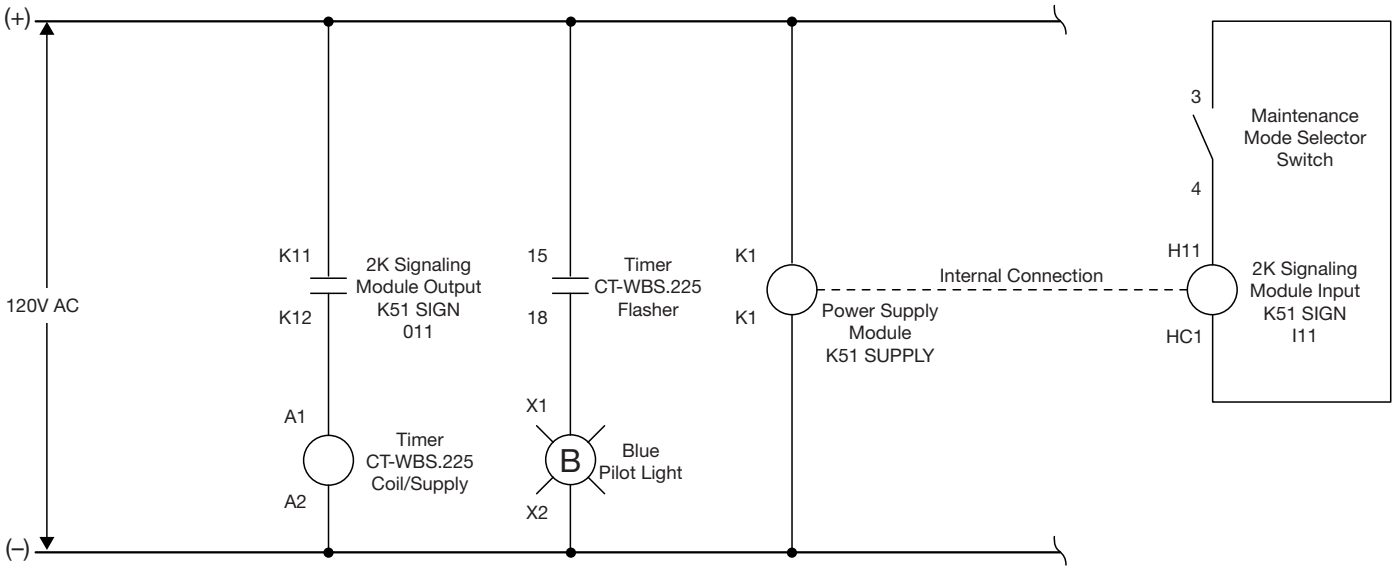
   – Note: The Ekip Signalling 2k module requires the presence of an Ekip Supply module (see diagram 32 below) in the first available slot on the right of the circuit-breaker terminal box. The Ekip Supply module will power the digital input of the signaling module which will trigger the protective parameter "2I" to become active once programed.



Note: Diagram 41 is shown for the 1st installed Ekip Signalling 2k module, however up to a quantity of 3 Ekip Signalling 2k modules may be installed on circuit breaker frames E2.2 to E6.2 and up to a quantity of 2 Ekip Signalling 2k modules may be installed on circuit breaker frames E1.2.
Any one of the Ekip Signalling 2k modules may be program to accommodate the maintenance mode application but adjustments are required to the referenced connection points and programed settings.

3. Implementation of Arc Flash Safety Solutions

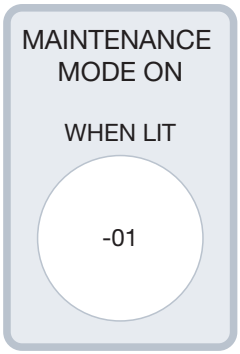
2. Wire the Ekip Signalling 2K module, Ekip supply module, maintenance mode switch, timer, and blue pilot light as shown below



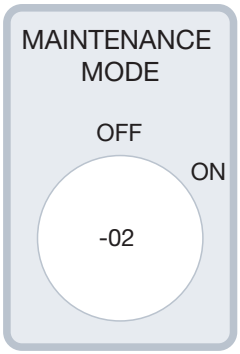
Note: The diagram shown is for a 110-240V AC/DC version of the Ekip supply module. If the 24-48V DC version of the Ekip supply module is used, it should not be included in the control circuit above.

3. Install the custom aluminum engraved nameplates on the deadfront enclosure around the pilot light and selector switch. Part# MP-NPE29-01 is for the blue pilot light. Part# MP-NPE29-02 is for the 2 position selector switch.

Part # MP-NPE29-01



Part # MP-NPE29-02



4. Apply the appropriate control voltage to power up the Ekip Supply module. If the Emax 2 breaker is a withdrawable type, rack the breaker into the test position.

3.2 Programming on Ekip Connect

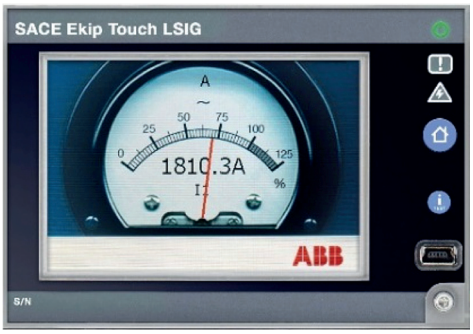
The ABB Emax 2 Ekip Touch trip unit is very sophisticated and has many advanced features; in order to function properly it has to be programmed in a specific way to enable the desired functions. In this section we will outline the steps needed to complete the programming to enable “2I protection” and “dual settings”.

1. Launch the free Ekip Connect software on the customer supplied laptop.

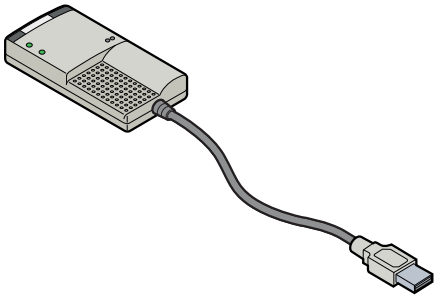
2. Connect one side of the micro USB cable C to the Ekip T&P module B and the other side to the Ekip Touch trip unit A. Connect the USB connection on the Ekip T&P module B to the customer supplied laptop.

   You can confirm the proper connection is made when the green power led is on. Active communication will be indicated via the orange transmission indicator blinking on the Ekip T&P module B.

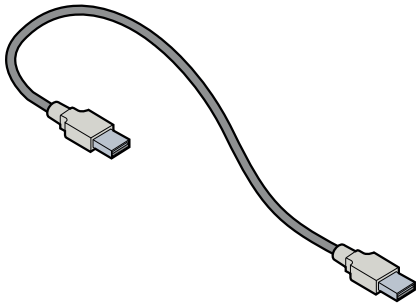
A



B

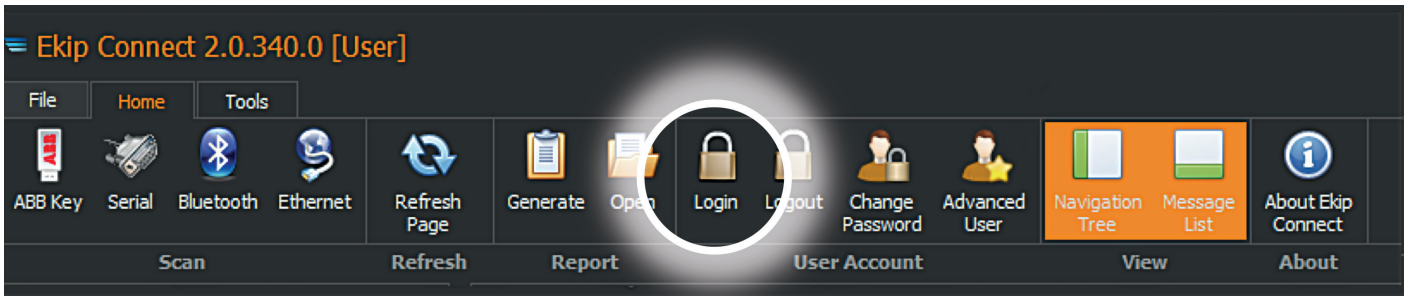


C

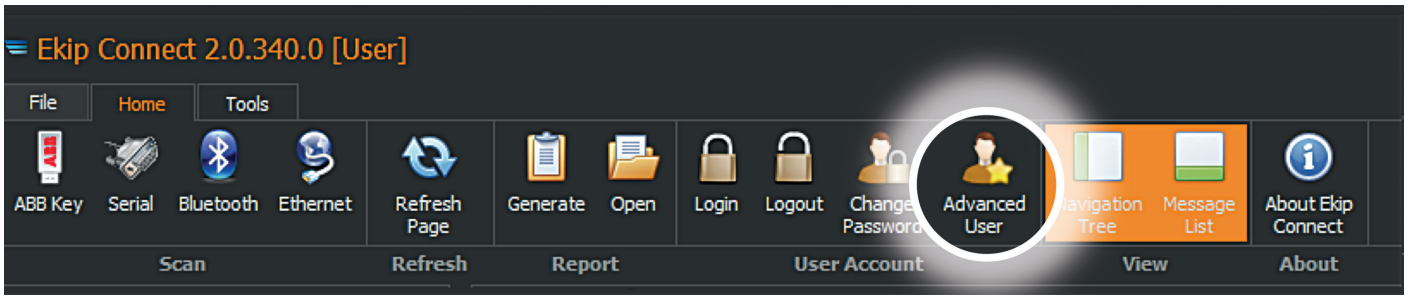


Note: It may be necessary to scan for the trip unit via the ABB Key before the device will appear in the Ekip Connect software

3. “Login” (login password is 0001)



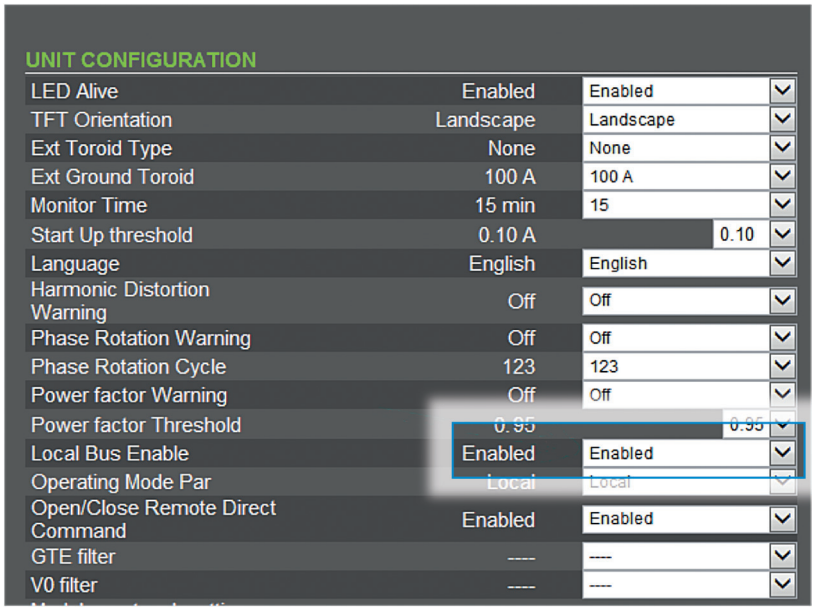
4. Select “Advanced User” so all options are available. Now you are ready to begin programing.



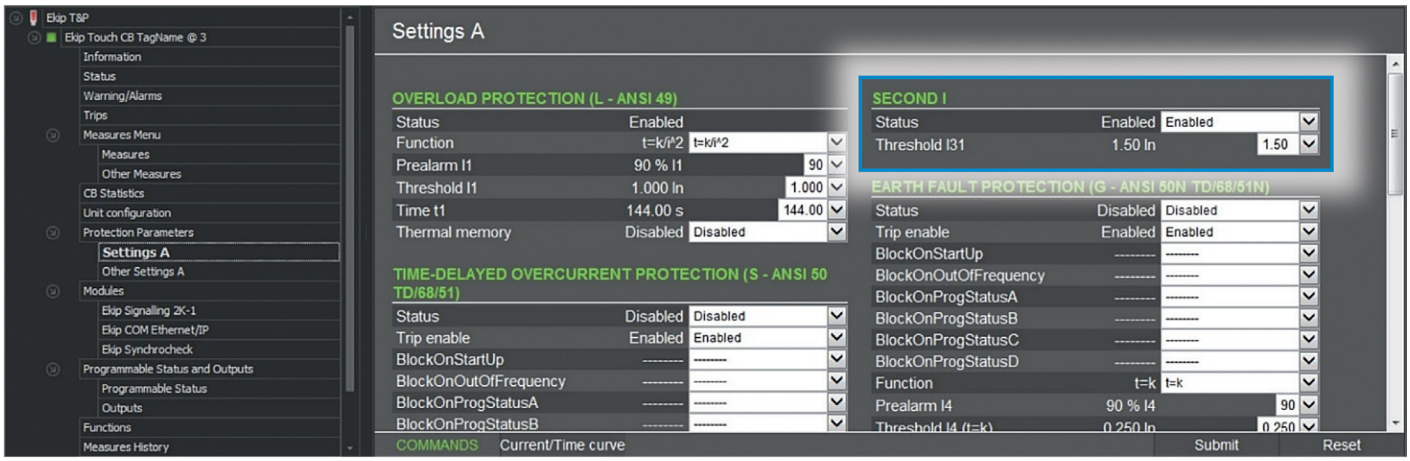
3. Implementation of Arc Flash Safety Solutions

3.3 Programming "2I" Protection with Ekip Connect

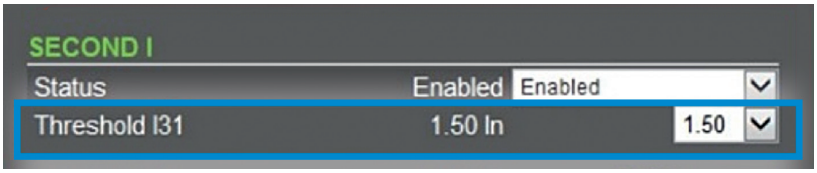
1. Enable Local Bus to see Ekip Signalling module 2K1



2. Turn on the 2I protection feature by selecting "Protection Parameters" > "Settings A" in the left hand column, then under "Second I" select "Enabled" in the drop down menu



3. Next set the 2I protection threshold by selecting from the "Threshold I31" dropdown options. I31 can be set from 1.50 In to 15.0 In at increments of 0.10 In.

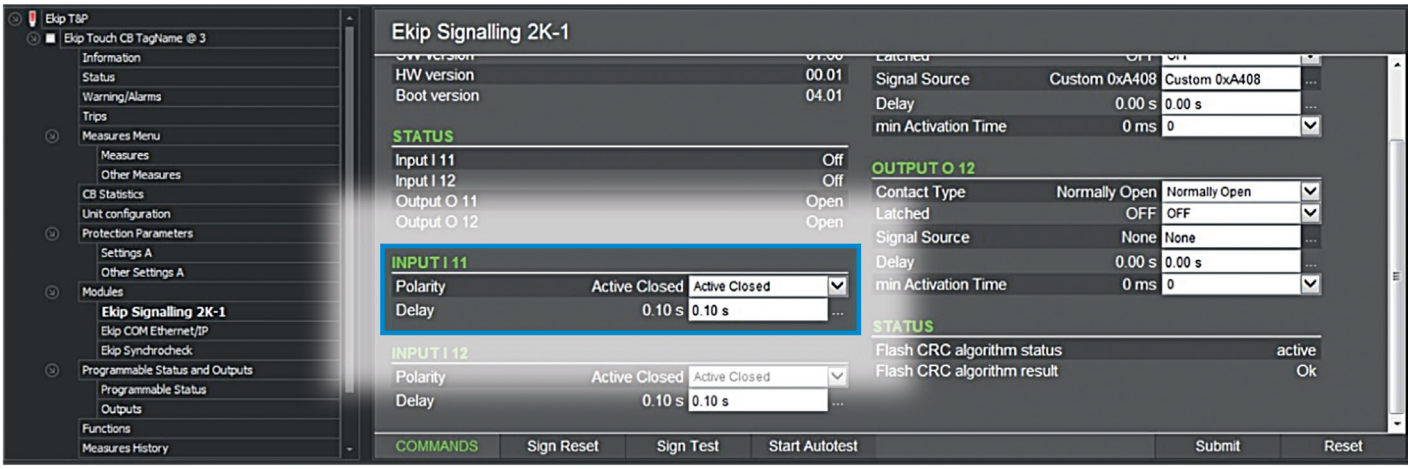


Note: The Threshold I31 setting should be determined by the customer. The circuit breaker will ship with factory default settings. ABB recommends that a short circuit, coordination, and arc flash hazard analysis be performed by the customer to determine all appropriate protective device settings.

4. The next step is to program the signaling input of the 2K to activate the 2I protection mode. In the left column select “Functions” and scroll to “Second I” in the main section of the window. Choose from the Second I Mode dropdown “Function Dependent”. Choose “Ekip Signalling 2K input 1” as the function, and select the desired time delay to be used once the “maintenance switch” is turned on.

5. Click on “Submit” to save the changes. The first time you submit any programming changes you will be asked for a password if it was not entered during login, the password is “0001”.

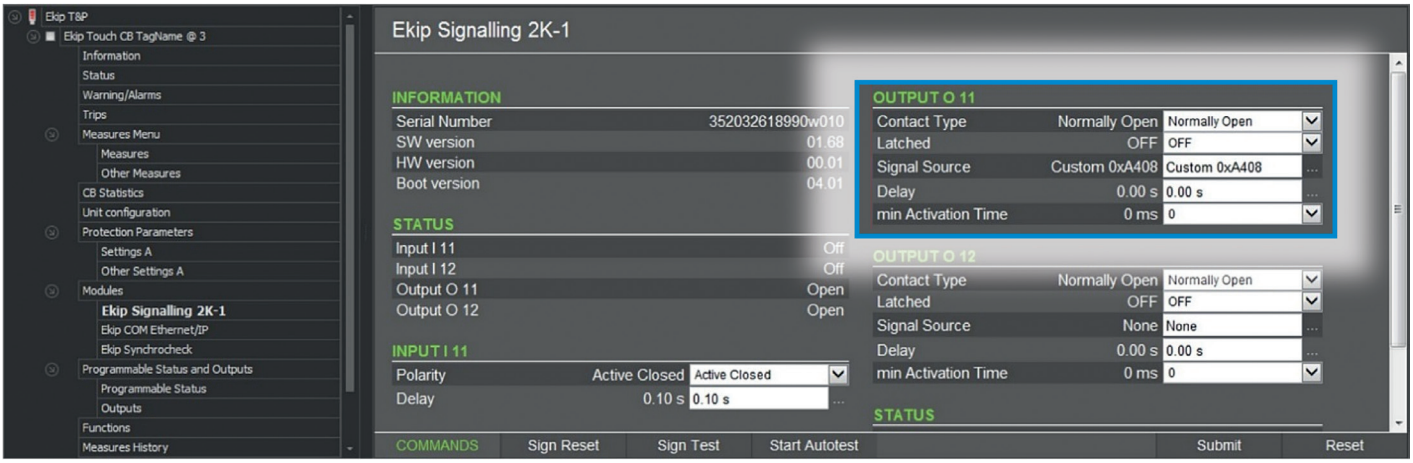
6. Next program the input of the Ekip Signalling 2K to activate the 2I feature and switch it on and off. In the left column select “Modules” > “Ekip Signalling 2k-1”. Ensure that the “Input I 11” polarity is set to “Active Closed”.



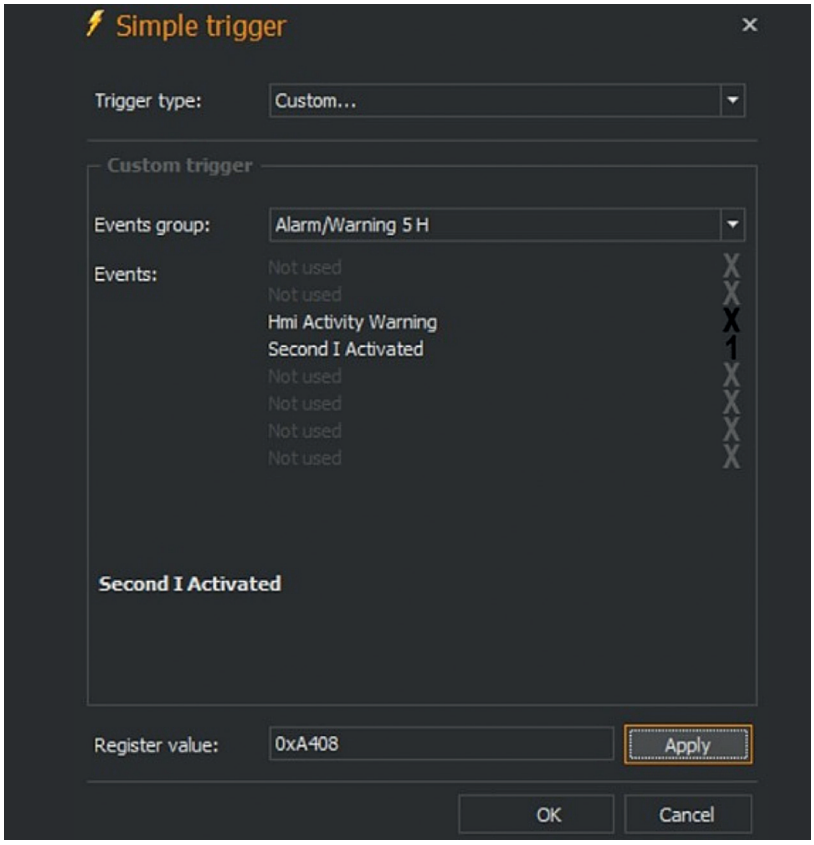
3. Implementation of Arc Flash Safety Solutions

7. Next program the output of the Ekip Signalling 2K. In the left column select “Modules” > “Ekip Signalling 2k-1”.

8. Ensure that the under “Output O 11” the “Contact Type” is set to “Normally Open”. Ensure that the “Latched” setting is set of “OFF”. The “Delay” setting can be left at “0.00s” or adjusted as desired. Ensure that the “min Activation Time” is set at “0 ms”.



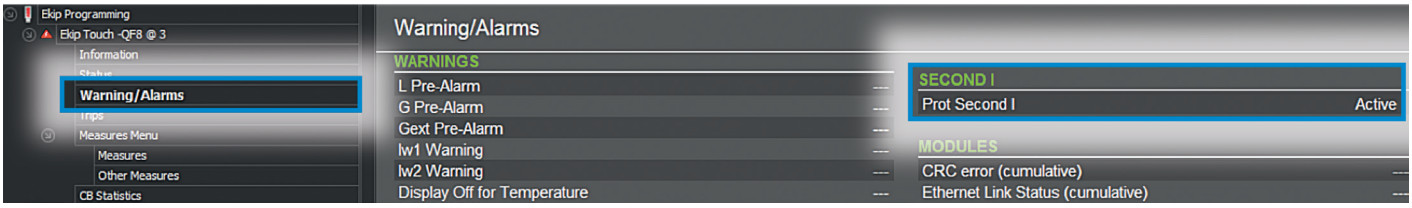
9. Select the “Signal Source”.
10. When the window opens, select “Custom” for Trigger type.
11. Select “Alarm/Warning 5H” for Events group.
12. Select “Second I Activated” until the black “X” changes to a “1”.



13. Click Apply and OK. Then click on “Submit” to save your changes. The signaling module is now programed to activate the 2I protective setting when the maintenance mode switch is in the on position and close the output contact to start the timer.

3.4 “2I” Verification

1. You can verify this by selecting “Warning/Alarms” in the left hand column and under “SECOND I” will indicate an active setting for “Prot Second I” when the maintenance mode selector switch is on.



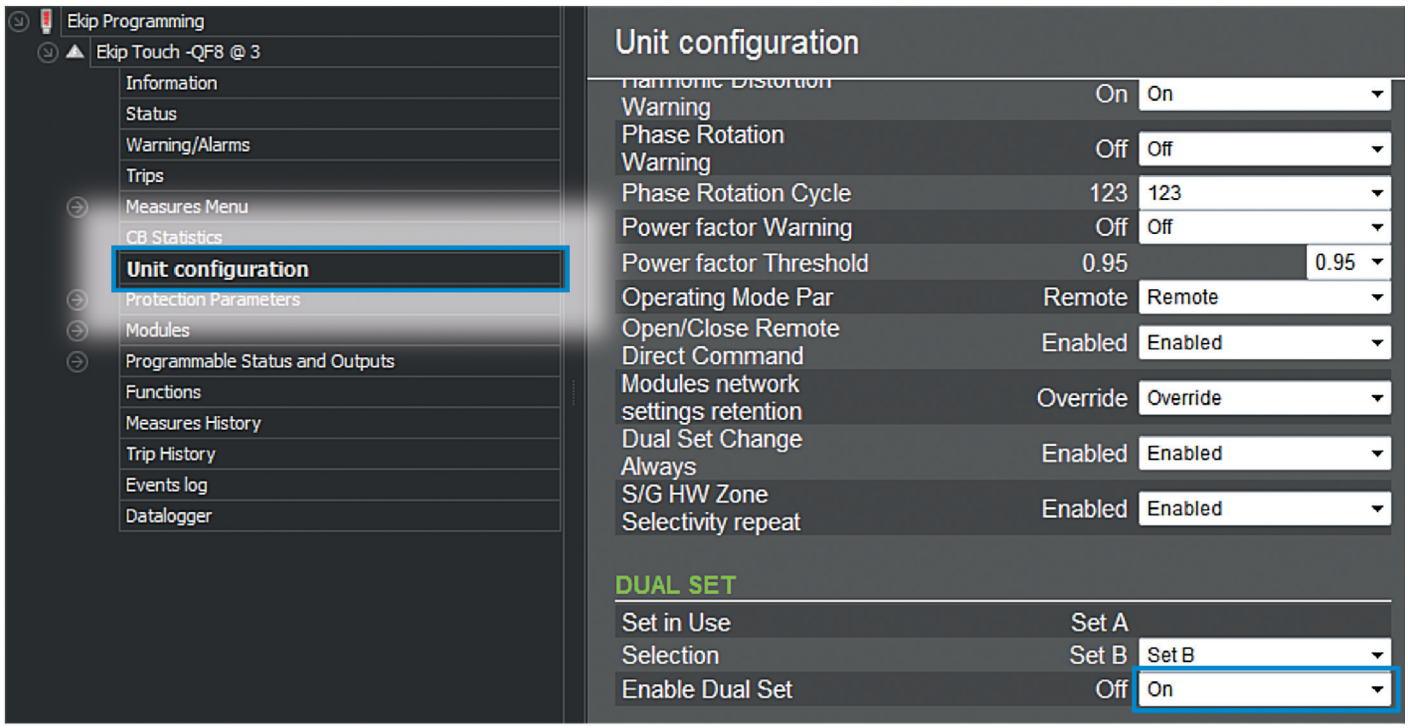
2. You can verify that the output is working by selecting “Outputs” in the left column and identifying that “(2K-1) Output 1” will indicate a closed state and the external blue pilot light should be flashing/blinking when the maintenance mode selector switch is on.

3. The default protective parameter set is “Set A”, when the “maintenance switch” is put into maintenance mode, the Ekip power supply will power the digital input of the signaling module and this will cause the protective parameter to activate “2I”. The display of the trip unit will indicate 2I is activated through an alarm indicator

3.5 Programing “Dual Settings” Protection with Ekip Connect

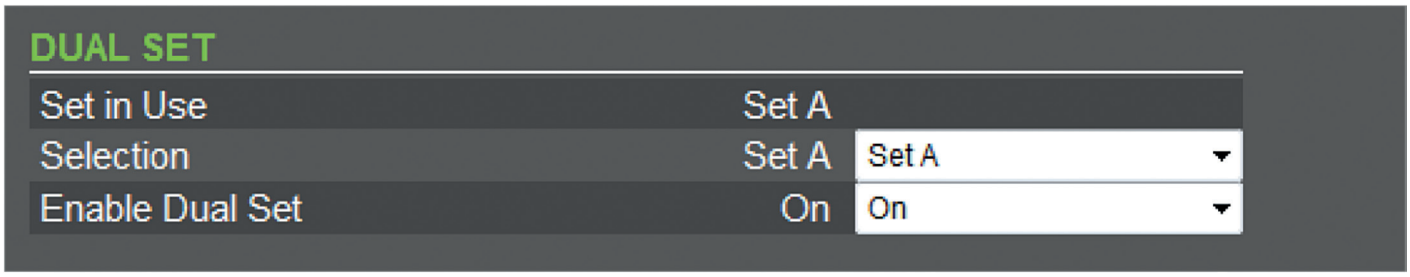
1. Turn on the Dual settings feature by selecting “Unit configuration” in the left hand column, then under “DUAL SET” select “On” in the Enable Dual Set drop down menu.

2. Turn on Dual SET Change ALWAYS, to “Enabled”.



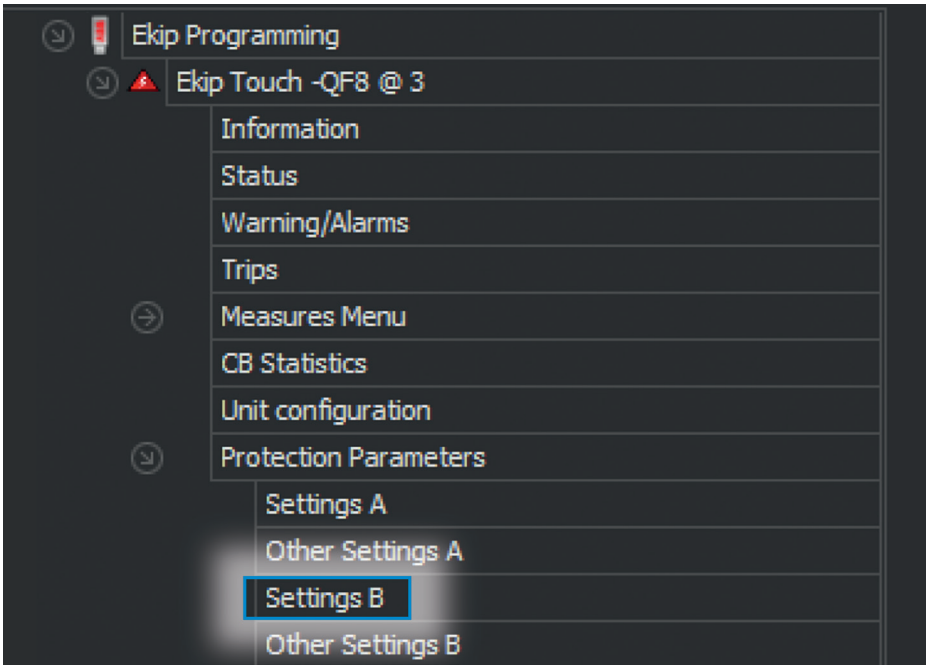
3. Implementation of Arc Flash Safety Solutions

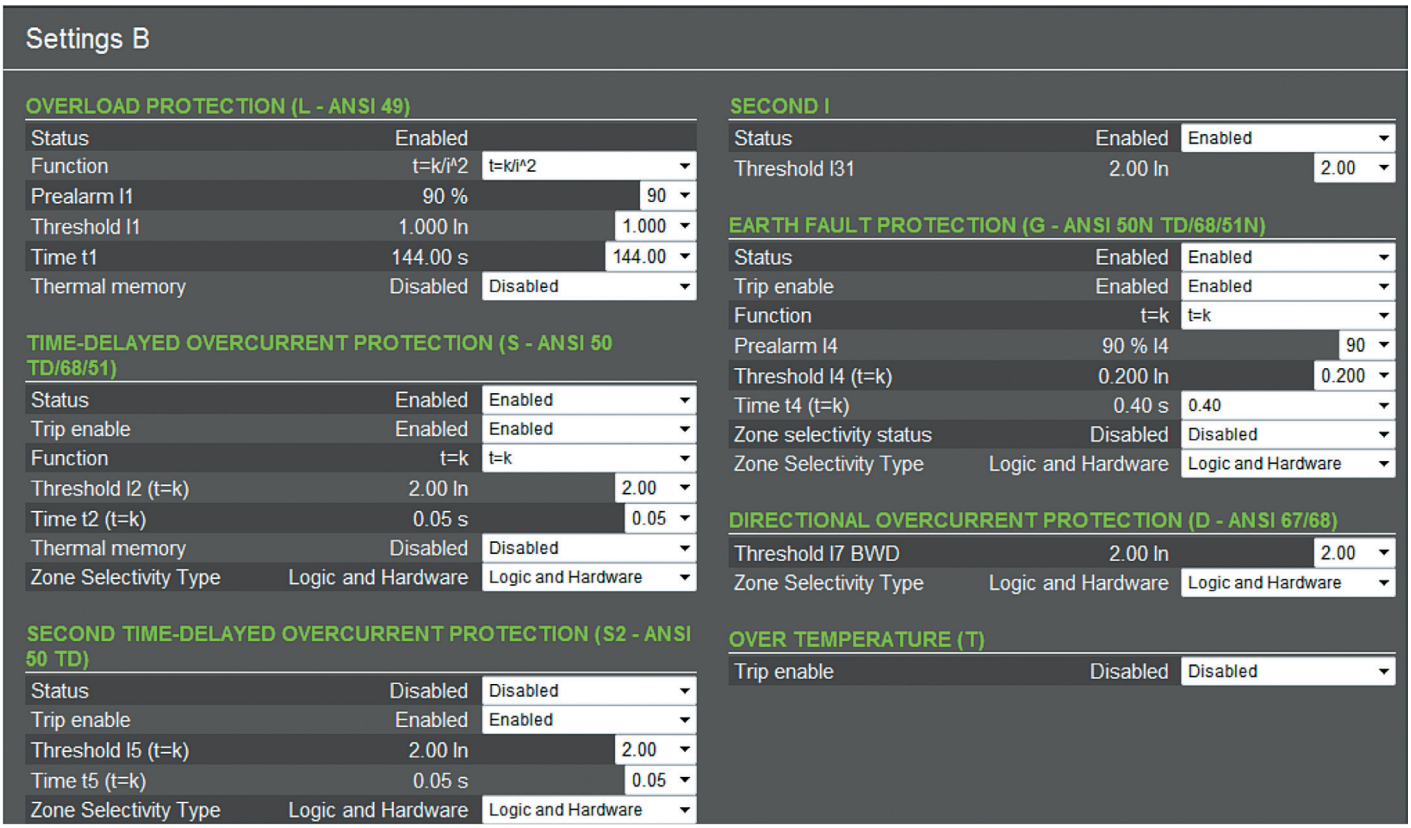
3. Ensure “Selection” is on “Set A”.



4. Now click on “Submit” to save your changes

5. Now click on “Settings B” in the left hand column and enter the set B programming parameters





Settings B

OVERLOAD PROTECTION (L - ANSI 49)

Status	Enabled	
Function	t=k/i^2	t=k/i^2
Prealarm I1	90 %	90
Threshold I1	1.000 In	1.000
Time t1	144.00 s	144.00
Thermal memory	Disabled	Disabled

TIME-DELAYED OVERCURRENT PROTECTION (S - ANSI 50 TD/68/51)

Status	Enabled	Enabled
Trip enable	Enabled	Enabled
Function	t=k	t=k
Threshold I2 (t=k)	2.00 In	2.00
Time t2 (t=k)	0.05 s	0.05
Thermal memory	Disabled	Disabled
Zone Selectivity Type	Logic and Hardware	Logic and Hardware

SECOND TIME-DELAYED OVERCURRENT PROTECTION (S2 - ANSI 50 TD)

Status	Disabled	Disabled
Trip enable	Enabled	Enabled
Threshold I5 (t=k)	2.00 In	2.00
Time t5 (t=k)	0.05 s	0.05
Zone Selectivity Type	Logic and Hardware	Logic and Hardware

SECOND I

Status	Enabled	Enabled
Threshold I31	2.00 In	2.00

EARTH FAULT PROTECTION (G - ANSI 50N TD/68/51N)

Status	Enabled	Enabled
Trip enable	Enabled	Enabled
Function	t=k	t=k
Prealarm I4	90 % I4	90
Threshold I4 (t=k)	0.200 In	0.200
Time t4 (t=k)	0.40 s	0.40
Zone selectivity status	Disabled	Disabled
Zone Selectivity Type	Logic and Hardware	Logic and Hardware

DIRECTIONAL OVERCURRENT PROTECTION (D - ANSI 67/68)

Threshold I7 BWD	2.00 In	2.00
Zone Selectivity Type	Logic and Hardware	Logic and Hardware

OVER TEMPERATURE (T)

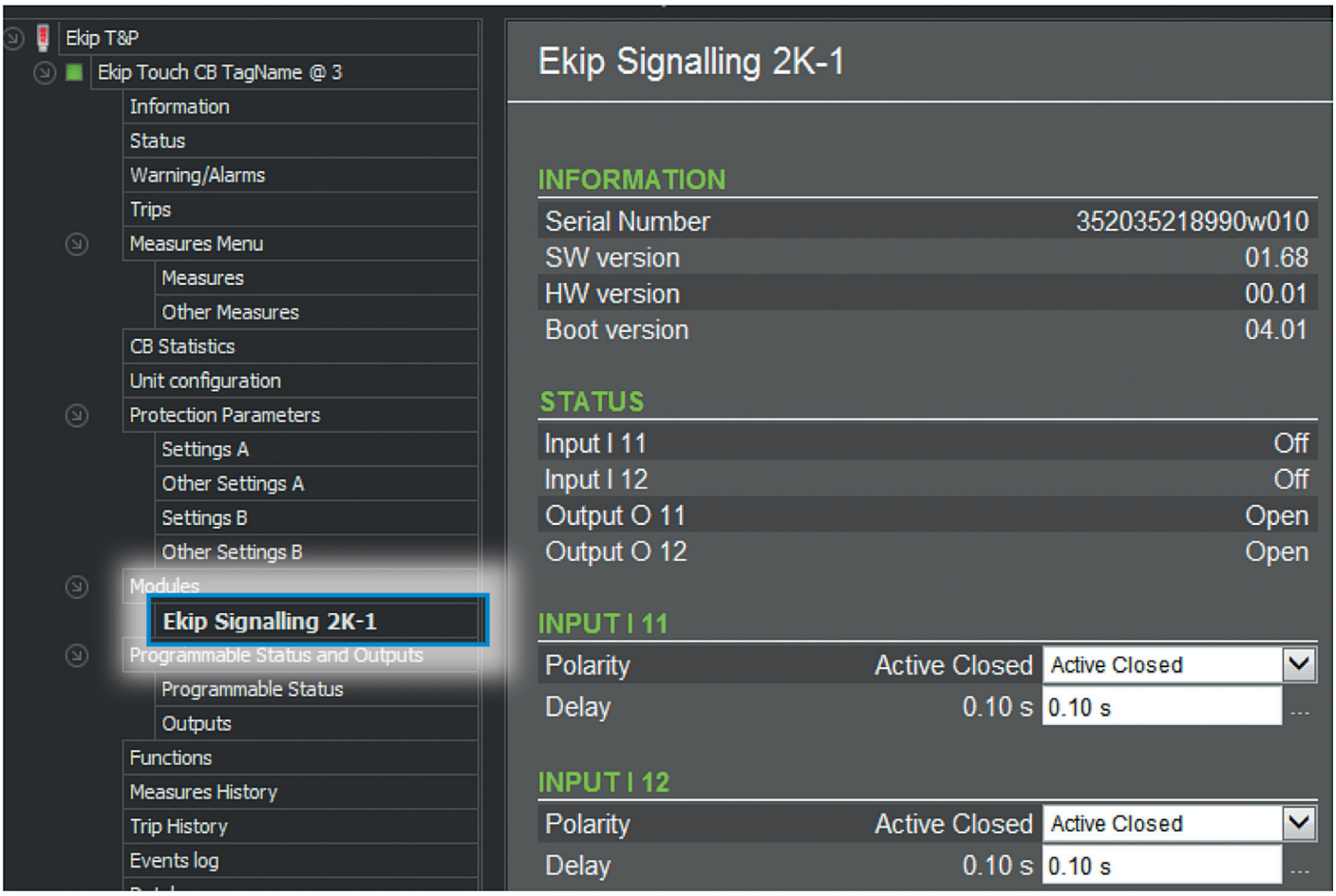
Trip enable	Disabled	Disabled

Note: The settings should be determined by the customer. The circuit breaker will ship with factory default settings. ABB recommends that a short circuit, coordination, and arc flash hazard analysis be performed by the customer to determine all appropriate protective device settings.

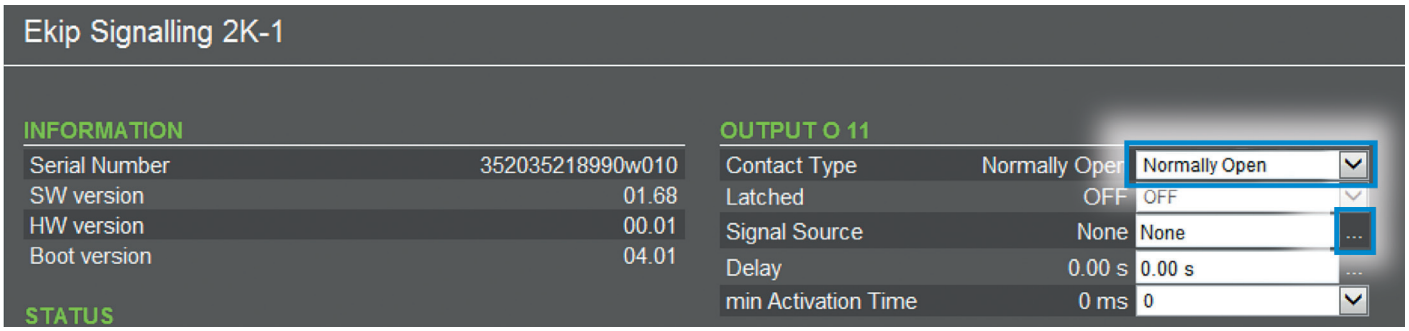
6. Now click on “Submit” to save your changes

7. The next step is to program the signaling input of the Ekip Signalling 2K1 module to activate the dual setting feature and switch between the Set A and Set B programming parameters. Select “Ekip Signalling 2K1” in the menu in the left hand column and set the “INPUT 1 01” to “Active Closed”.

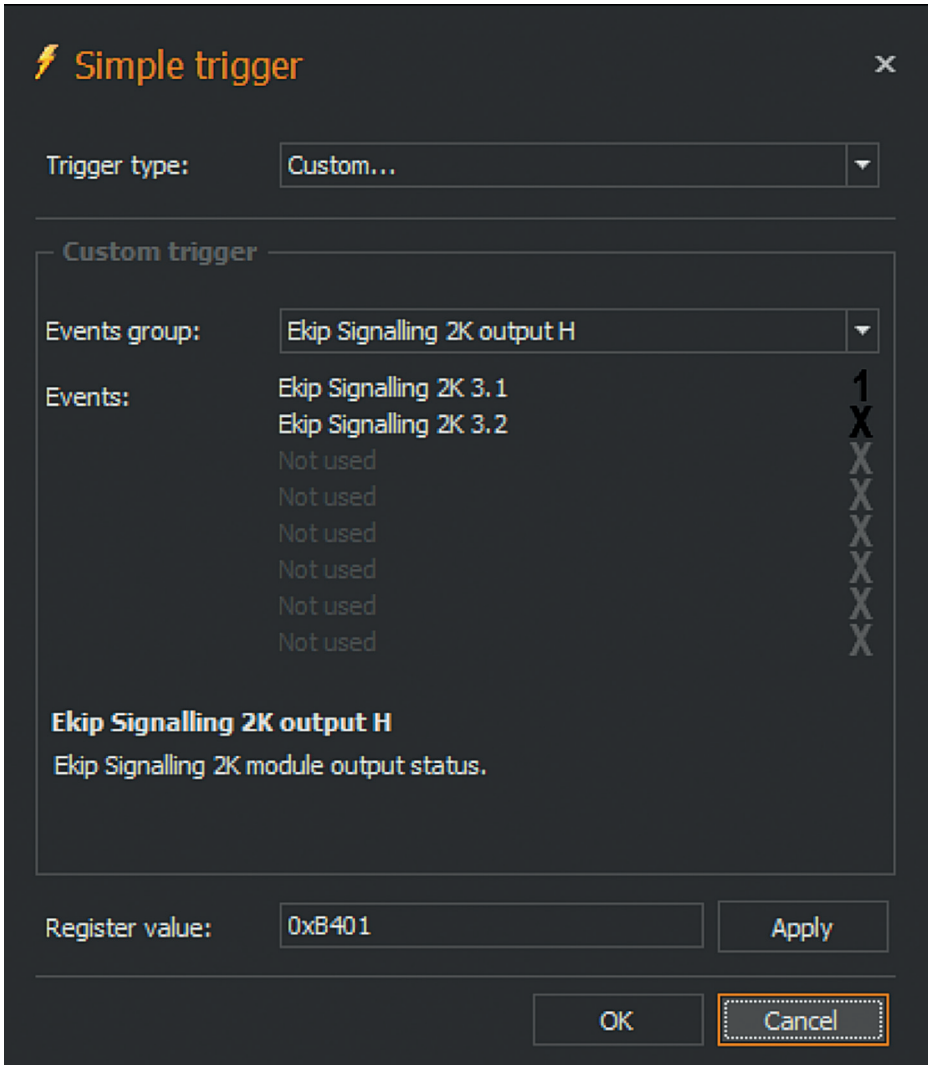
7. The next step is to program the signaling input of the Ekip Signalling 2K1 module to activate the dual setting feature and switch between the Set A and Set B programming parameters. Select “Ekip Signalling 2K1” in the menu in the left hand column and set the “INPUT 1 01” to “Active Closed”.

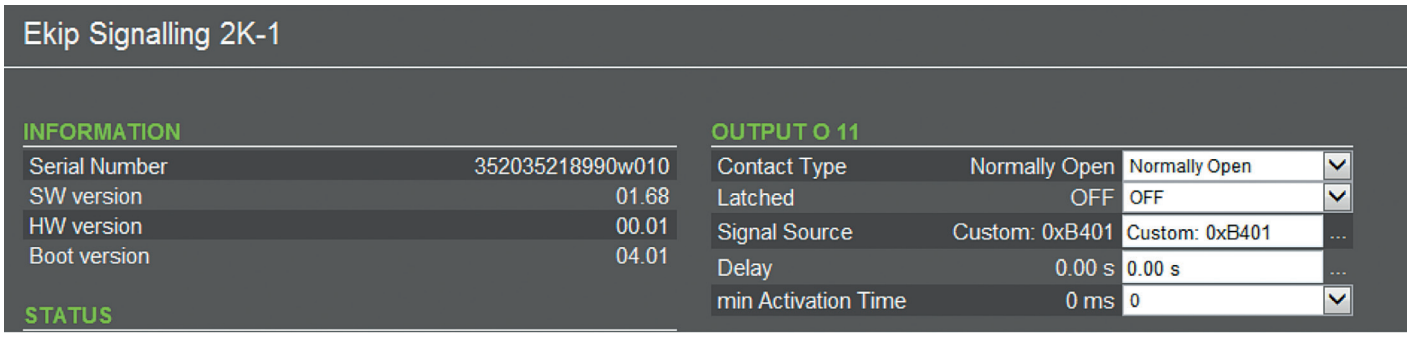


8. The next step is to program the O 01 output relay contact, select “Ekip Signalling 2K1” in the left hand column and set the “Contact Type” to “Normally Open”, and the “Signal Source” to “Custom” by clicking the three dots next to the white square.



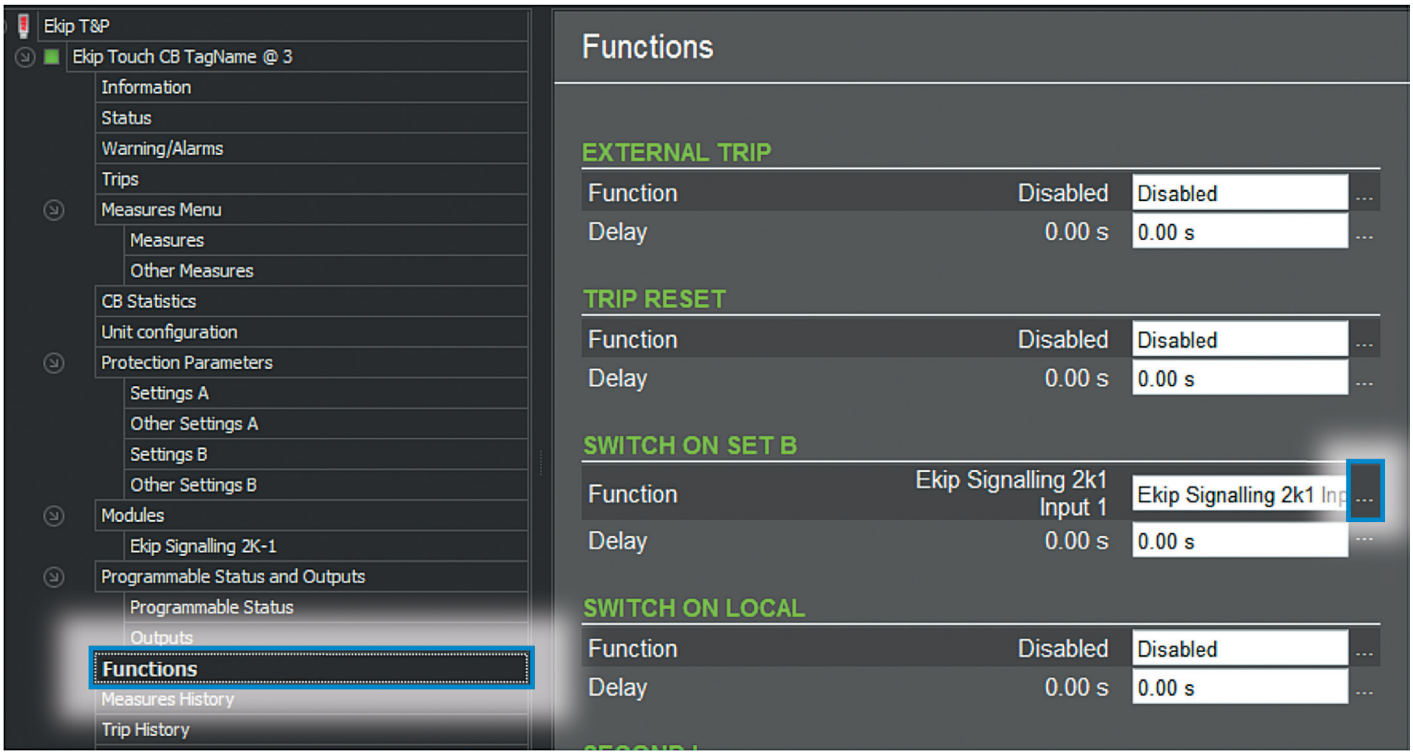
9. Once the three dots are clicked the “Simple trigger” window opens and from the “Trigger type” dropdown choose “custom”. Next from the “Events group:” dropdown choose “Ekip Signalling 2K + Local I/O H” and in the “Events:” list below click “Ekip Signalling 2K Input 1” until the corresponding “X” becomes a “1”. Click “Apply” and “OK” to close the window.



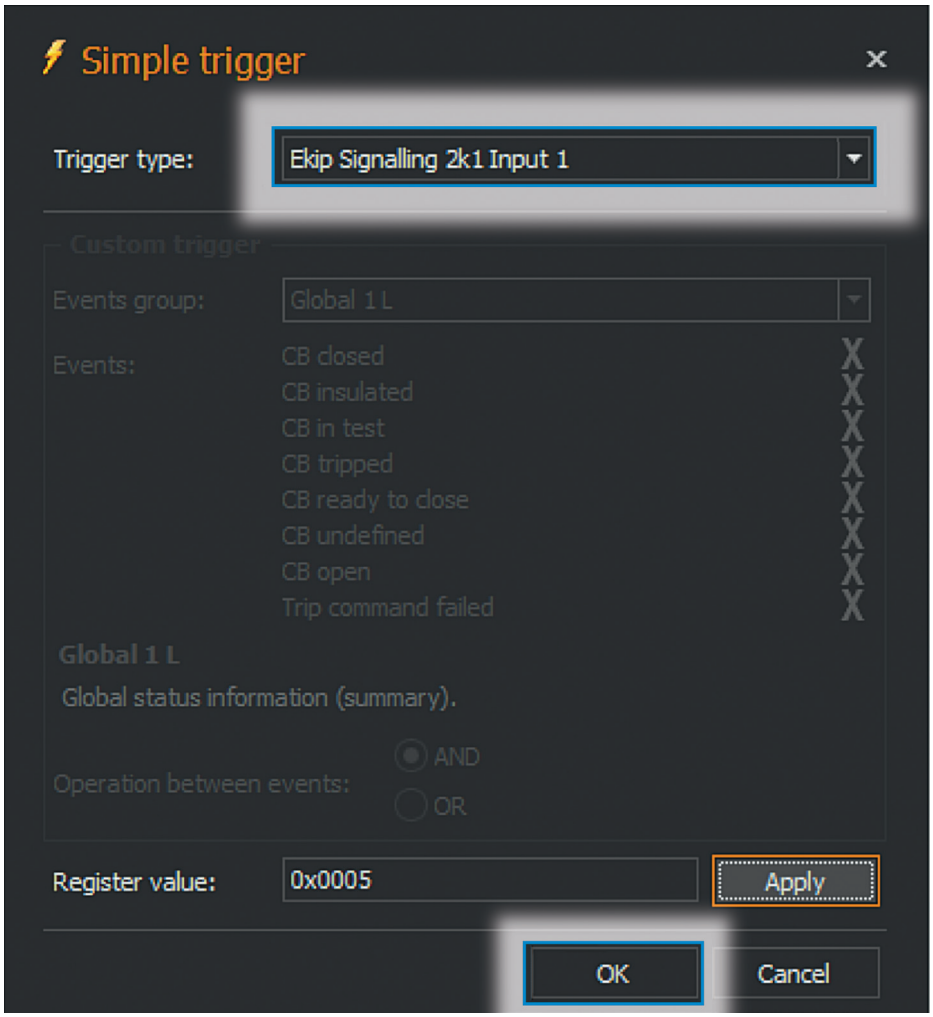


10. Now click on “Submit” to make the changes effective.

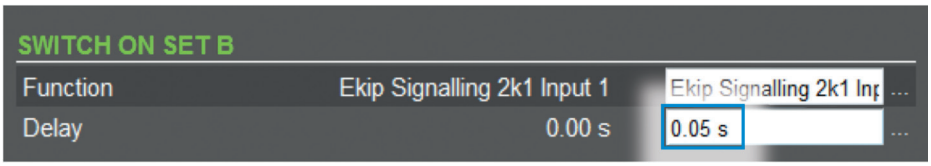
11. Next choose “Functions” in the left hand column and under “Switch to Set B” change the “Function” to “trigger type” “Ekip Signalling 2K1 input 1”. Do this by clicking on the three dots next to the white box corresponding to the “Function” option and the “Simple trigger” window will pop up.



12. Next choose the “trigger type” “Ekip Signalling 2K1 input 1” from the drop down then click “Apply” and “OK” to close the window.



13. Next choose the time delay wanted once the maintenance switch is turned on.



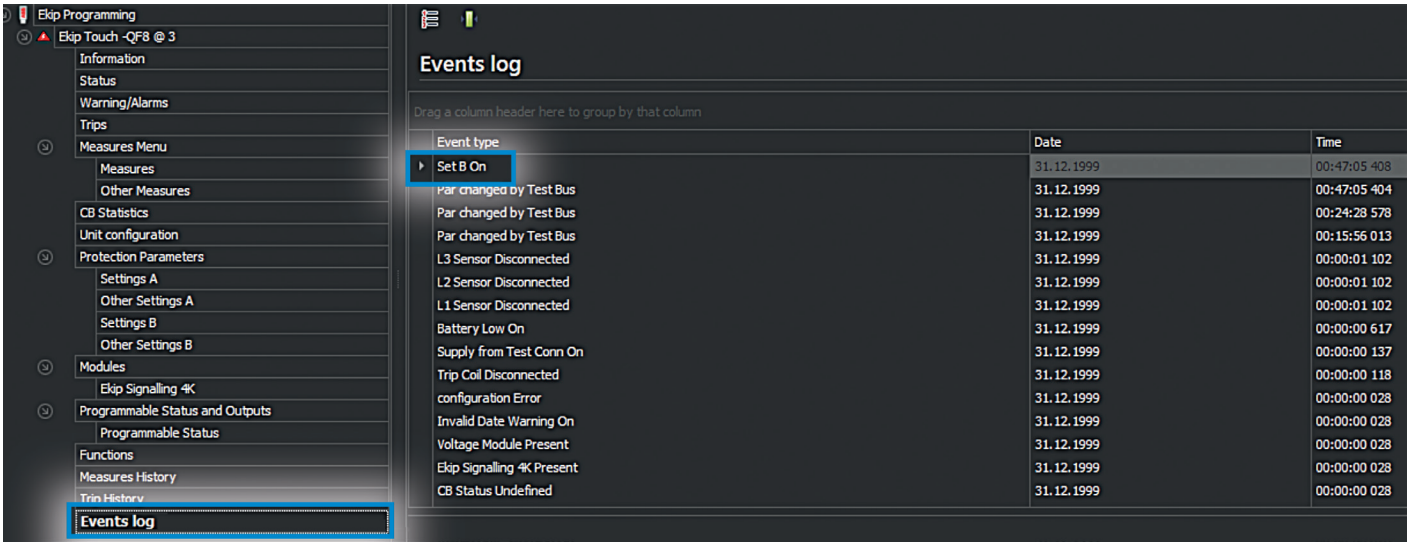
14. Now click on “Submit” to save your changes

3.6 Dual Setting verification

1. The default protective parameter set is “Set A”, when the maintenance switch is put into the maintenance position it will supply 24 Vdc to the digital input of the signaling module and this will cause the protective parameter set to change to “Set B”. The display of the trip unit will indicate if Set A is active or Set B by the presence of this symbol.

   – **A** o **B** if the **Dual Set** function is enabled (see the **Setting** menu), the letter identifies the active configuration.

You can also verify this by looking for the “Set B ON” message, in the “Event Log”



2. The signaling module digital input can be checked to see if it is active by checking the “Ekip Signalling 2K1” in the left hand column. Under “INPUT STATUS” it will show input I 01 as “ON” when the “maintenance switch” is in the maintenance position.

3. The signaling module will have a green “Power” LED illuminated and a green LED to indicate the status of the input relay contacts. To verify if everything is working correctly check to see if the green “Power” LED and the green “I 01” LED are illuminated when in maintenance mode.

4 Protection Benefits

The “maintenance switch” is a simple and effective way to reduce the potential arc flash energy present when workers are in the vicinity of the electrical equipment; this creates a safer work environment and can also reduce the PPE requirements. This method can be implemented with a small amount of wiring and additional parts making it a cost effective option.

[5] Table 1 – 2I protections effect on Personal Protective Equipment (Switchgear, 24 inch boundary, Grounded, 480V system)

Second I	Arcing Current (kA)	Clearing Time (ms)	Incident Energy (cal/cm²)	Hazard Risk Category	PPE Required
Without 2I	30	190	13.1	3	Cotton underclothing plus FR shirt, pants, overalls or equivalent
With 2I	30	30	2.2	1	Flame Retardant (FR) shirt and pants

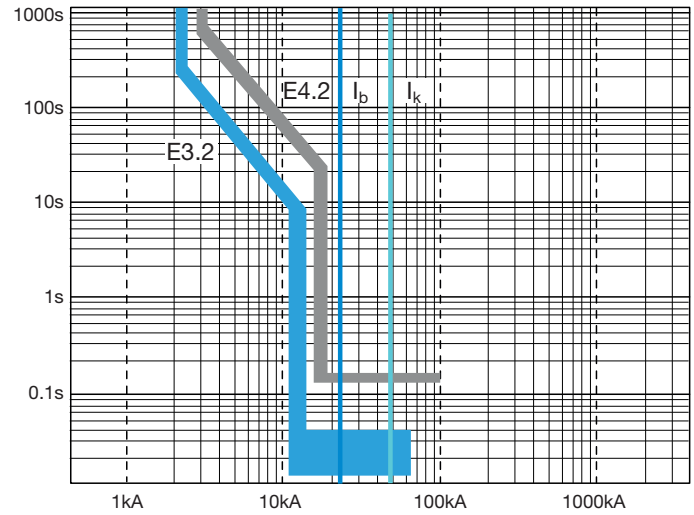
[5] ABB, Inc,. (2009). Arc flash hazards. Wichita Falls, TX USA: ABB. Retrieved from https://library.e.abb.com/public/2b5f3d9051ccdd76852576ac006dc16b/1SXU210204G0201.pdf

4.1 2I Benefits Summary

Table 1 indicates that with 2I protection activated, prior to maintenance, the amount of arc flash energy released during arc fault is significantly reduced. This reduces the risk of injury to the person performing maintenance on the energized equipment because the risk level is reduced by 2. Consequently, less PPE is required which further reduces the risk of injury do to mistakes caused by the oversized equipment necessary at the higher Hazard Risk Category (HRC). Less PPE also means less money needs to be spent on PPE. Furthermore, money can be saved because 2I protection is integrated into the trip unit.
This eliminates the need for an additional component to provide this protection. If implemented correctly, 2I protection is a simple solution that can provide safety, convenience and cost savings.

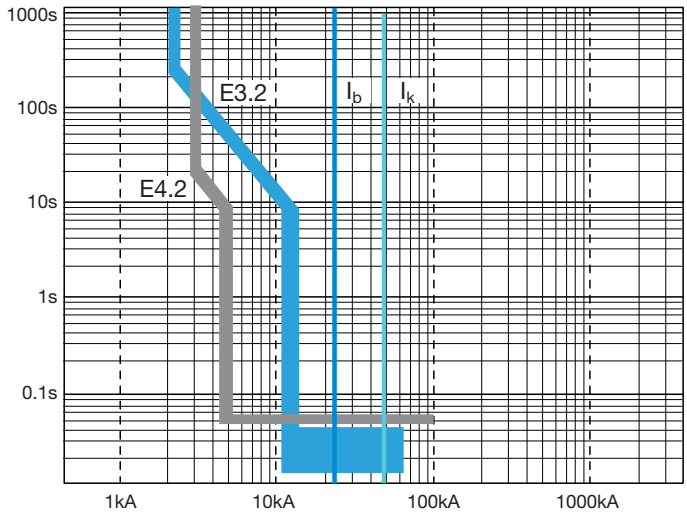
The different HRC and PPE levels can be viewed in the NFPA 70E: Standard for Electrical Safety in the Workplace.

Time current curve - Set A



E4.2H 3200 Ekip Hi-Touch LSI In=3200A 4P
L: I1: 0.85 t1: 102s
S: t=const I2: 5.4 t2: 0.14s
Fault current Ik= 48.11kA
Load current Ib= 23.30kA
I: off

Time current curve - Set B



E4.2H 3200 Ekip Hi-Touch LSI In=3200A 4P
L: I1: 0.85 t1: 3s
S: t=const I2: 1.5 t2: 0.05s
Fault current Ik= 48.11kA
Load current Ib= 23.30kA
I: off

4 Protection Benefits

[6] Table 2 – Summary of Time-Current Selectivity Calculations v Dual Setting Protection Calculations

Summary table

	Time-current selectivity	Dual setting
Flash Protection Boundary	1.29 m	0.77 m
Arc Incident Energy	8.83 cal/cm^2	3.15 cal/cm^2
PPE Category	3	1
Additional wiring	NO	NO
Notes	long trip times for multi-tiered selectivity chains	switching from set A to set B can be automatic and/or remotely operated

[6] ABB, Inc,. (2009). Arc flash hazards. Wichita Falls, TX USA: ABB. Retrieved from https://library.e.abb.com/public/2b5f3d9051ccdd76852576ac006dc16b/1SXU210204G0201.pdf

4.2 Dual Setting Benefits Summary

The above example shows how the two parameter sets A and B can be adjusted so that set A can be used under normal conditions to achieve selective coordination and set B when maintenance operations are carried out on the switchgear to insure a fast trip time under fault conditions.
Set A allows time-current selectivity, whereas Set B adopts the minimum setting values of the protection functions L and S and allows the above calculation.
In this example the flash protection
boundary, arc incident energy, and PPE category are all reduced when switching from set A to set B. While not applicable to every system, this shows that dual setting can be used to reduce the risk of injury to personnel while working on an active system.

Dual settings is a flexible solution which can help its users mitigate Arc flash hazard risks but also can be used to maintain selective coordination within a system.
The different HRC and PPE levels can be viewed in the NFPA 70E: Standard for Electrical Safety in the Workplace.

5 Equipment Selection

5. 1 Circuit Breaker

ABB SACE Emax 2 equipped with one of the following trip units:
For "Second I":
- All Ekip Touch, or
- All Ekip HI-Touch,

For Dual settings:
- All Ekip HI-Touch

5. 2 Circuit Breaker Accessories

For "Second I" and "Dual Settings":

Ekip modules	US ordering code	Global ordering code
Ekip Signalling 2k module	ZEA2K1	1SDA074167R1
Ekip Supply module	ZEAPWRS	1SDA074172R1
Ekip Test & Programming module	ZEAEKPTP	1SDA066989R1

5. 3 Additional Accessories

To complete the installation of the energy-reducing "maintenance switch" function we will need the following:

For "Second I" and "Dual Settings":

Accessory parts	US ordering code	Global ordering code
Timer with adjustable time delays from 0.05 sec. to 300 hrs. in 10 ranges, and 24-48 VDC, 24-240 VAC rated control supply voltage, and control input, and 2 SPDT (c/o) output contacts	1SVR730040R3300	1SVR730040R3300
Blue pilot light 110-130 VAC/DC	ML1-20L10L13	1SFA616920R8005 1SFA616921R2144 1SFA611605R1200 1SFA611400R1004
2 position selector switch with long BEZEL NO+NC (22mm)	M2SS4-40B11	1SFA611203R1006 1SFA611605R1111
Alternative: 2 position key operated selector switch NO+NC (22mm)	M2SSK1-40111	1SFA611280R1001 1SFA611610R1010 1SFA611605R1101
Custom aluminum engraved nameplate for pilot light; use product selector page 7.129 for ordering o Line 1: MAINTENANCE o Line 2: MODE ON o Line 3: WHEN LIT	MP-NPE29-01	SK615541-1 (Custom engraving)
Custom aluminum engraved nameplate for selector switch; use product selector page 7.129 for ordering o Line 1: MAINT. MODE o Line 2: OFF o Line 3: ON (Custom Engraving)	MP-NPE29-02	SK615541-1

- Free Ekip Connect Software – can be downloaded here
- Customer supplied laptop with Microsoft Windows Operating System

Contact us

For more information please contact:

ABB SACE
A division of ABB S.p.A.
L.V. Breakers
Via Pescaria, 5
24123 Bergamo - Italy
Tel.: +39 035 395 111
Fax: +39 035 395306-433
www.abb.com

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