



# Pre-Fix Project

Equipment Settings Philosophy

24/03/2023

**Electricity  
Distribution**

**nationalgrid**

## Version Control

Issue	Date
0.1	20/03/2023
0.2	23/03/2023
1.0	24/03/2023
1.1	17/08/2023

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# Introduction

This document presents the settings philosophy, current recommendations for Category I, Category II and Category III devices feeding into C-DIP.

This document is a draft only.

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# Category I Devices

These are devices that can capture three phase current and voltage waveforms (at a suitable sampling rate) and broadcast the information in operationally useful timescales.

Examples include Protection Relays and Power Quality Monitors.

The minimum sampling rate currently recommended for these devices is 256 samples per cycle.

The settings described below may need to be adjusted based on whether the device is installed on a transformer or on a feeder. There is also a nice-to-have requirement for Category I devices to be able to receive signals from Category II devices in the same geographical location in order to trigger a waveform capture.

## Overcurrent/Current Inrush Trigger Settings

Inrush settings trigger when there is an increase in the current by a threshold amount within the number of cycles defined.

Usage so far in the Pre-Fix trial has shown that the Overcurrent/Current inrush settings have some usability in capturing post fault events, but suffer from disadvantages when being used to capture pre-fault events.

These settings require thresholds tailored to the site the Category I device is installed at. We currently recommend that the Amp threshold is set to either 25A, or 10% of the maximum daily load at the site, whichever is the higher value. There is a trade-off seen between sensitivity in these triggers and the introduction of noise, and this recommendation is subject to changes based on findings during the Pre-Fix trial.

## Voltage Distortion Trigger Settings

Voltage distortion settings trigger when there is a difference between two voltage cycles of a defined percentage of the cycle magnitude for a defined percentage of a cycle or more.

Usage so far in the Pre-Fix trial has shown that these triggers have been less susceptible to noise than the overcurrent/current inrush triggers.

We currently recommend that the magnitude threshold is set to 5% and the duration threshold is set to 25% of a cycle. This recommendation is subject to changes based on findings during the Pre-Fix trial.

## Current Distortion Trigger Settings

Current distortion settings trigger when there is a difference between two current cycles of a threshold amount for a defined percentage of a cycle or more.

More testing required to determine what load is needed before the triggering on noise becomes an issue. An initial setting of 50A distortion for 10% of a cycle has been trialled at Pre-Fix sites but has caused some issues with noise.

We currently recommend that the magnitude threshold is set to 100A and the duration threshold is set to 10% of a cycle. This recommendation is subject to changes based on findings during the Pre-Fix trial.

# Category II Devices

These are devices that can capture three phase current waveforms (at a suitable sampling rate) and broadcast the information in operationally useful timescales.

Examples include Smart Cable FPIs, Smart OHL FPIs, Automation relays, Auto reclose relays and Overhead line monitors.

The minimum sampling rate currently recommended for these devices is 32 samples per cycle for Smart Cable FPIs, and 40 samples per cycle for Smart OHL FPIs.

## Smart Cable Fault Passage Indicators

### Fault Settings

The following fault settings have been applied to Pre-Fix Smart Cable FPIs. Exceeding these thresholds triggers a fault event and a waveform capture. These settings have a post-fault use case. The settings described below are being trialled on devices installed at East Midlands primary substation circuit breakers during the Pre-Fix trial. These will need to be adapted depending on where the device is installed on the network. A nice-to-have feature would be for devices to have the ability to enable adaptive settings, that will scale these values based on the load at the install location.

Threshold Type	Threshold Value
Earth Fault	50A
Earth Fault Duration	50ms
Phase-Phase	500A
Phase-Phase Duration	80ms
Sensitive Earth Fault	20A
Sensitive Earth Fault Duration	1000ms

### CT Ratio Settings

Field testing with Smart Cable FPIs has highlighted issues when the CT ratio of the unit is too high.

Due to this, the recommendation is that CT ratios should be kept between 100/1 and 600/1. Because of this, Smart Cable FPIs should be configured such that the expected input matches the expected output and that sensors are installed in line with this (e.g. 1A sensors on wires that produce 1A nominal).

### Pre-Fault Settings

The following pre-fault settings have been applied to Pre-Fix Smart Cable FPIs. Exceeding these thresholds triggers a waveform capture. These settings are for use in the detection of Pre-Fault activity on the network, and are the standard triggers for the Smart Cable FPIs used in the Pre-Fix project.

Threshold Type	Threshold Value
Earth Fault Pickup Threshold	50A
Earth Fault Pickup Duration	20ms
SEF Pickup Threshold	20A
SEF Pickup Duration Threshold	200ms
PP Pickup Threshold	200A
PP Pickup Duration Threshold	50ms
Cycle Difference Threshold	20A (Phasor)
Wave Difference Threshold	20A (RMS)

The Wave Difference trigger operates based on the difference in current RMS between the current cycle and the previous cycle, whereas the Cycle Difference trigger operates based on the difference in phasor current between the current cycle and the previous cycle.

## Smart Overhead Line Fault Passage Indicators

### Fault Settings

The following fault settings have been applied to Pre-Fix Overhead Line FPIs. Exceeding these thresholds triggers a fault event and a waveform capture if waveform captures have been enabled on the device. These settings have a post-fault use case, but as they are more sensitive than most OHL protections, there has been some evidence of pre-fault captures triggering. The settings described below are being trialled on devices installed across the entire OHL portion of feeders in the South-West during the Pre-Fix trial. In future implementations, these will need to be adapted depending on where the device is installed on the network. A nice-to-have feature would be for devices to have the ability to enable adaptive settings, that will scale these values based on the load at the install location.

Threshold Type	Threshold Value
dI/dT Trip	40A
dI/dT Trip Duration	50ms
Overcurrent Trip	250A
Overcurrent Trip Duration	50ms

The same thresholds are used for fault-pickups. If volts are lost, the fault will trigger as a trip, if voltage are not lost, the fault will trigger as a pickup.

### Waveform Capture Settings

Waveform captures done by some Smart Overhead Line FPIs will have low sampling rate unless the average line current exceeds a certain value. This can lead to discretized data in lower current areas, which could interfere with analysis.

There is also concerns that Smart Overhead Line FPIs installed in low current areas will have their battery drained significantly faster if large quantities of waveform captures are taken and uploaded.

Because of this, the current recommendation is that Smart Overhead Line FPIs should have their waveform capture enabled when the line current is above 15A and may additionally have captures enabled in low-activity areas with an average current below 15A subject to importance.

The must-have function of Smart Overhead Line FPIs is to give a binary indication for defect activity. The nice-to-have function is waveform capture as this can be used to inform distance-to-defect estimations and give insight into the most likely failed component.

### Pre-Fault Settings

The following pre-fault settings are available within the Pre-Fix Smart Overhead Line FPIs. Exceeding these thresholds will trigger a pre-fault event when enabled.

Threshold Type	Threshold Value
I> Enabled?	Y/N
I>> Enabled?	Y/N
I>>> Enabled?	Y/N
I> Threshold	100A
I> Duration Threshold	1s

Threshold Type	Threshold Value
I> Fallback Time	100ms
I>> Threshold	400A
I>> Duration Threshold	100ms
I>> Fallback Time	100ms
I>>> Threshold	1000A
I>>> Duration Threshold	10ms
I>>> Fallback Time	100ms

The current recommendation would be to consider the thresholds desired for these pre-fault settings for Smart Overhead Line FPIs, followed by field testing to ensure they are both effective at picking up pre-faults, and not triggered by noise or spurious activity (such as load pick-up).

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# Category III Devices

These are devices that are sensitive to fault current passage, voltage presence or circuit status, but do not capture waveforms, but can broadcast information in operationally useful timescales.

Examples include LV monitors, Connected FPIs, and HV Auto-reclosers.

## LV Monitors

The must-have status point is volts on/off.

Nice-to-have data points also include pre-event loading, fault current and post-event loading.

## Connected FPIs

The must-have status point is fault yes/no.

## HV Auto-reclosers

The must-have status point is Auto-recloser opened/closed.

Nice-to-have data points also include pre-event loading, fault current and post-event loading.

# Clarifications

Regarding third party integration:

- NGED responsible for working with vendor to deliver C-DIP ready capability.
- Nortech responsible for vendor equipment integration to C-DIP.

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# Appendices

## List of Equipment Types to be integrated within C-DIP (Pre-Fix Scope)

1. Siemens Siprotec Relay
2. SEL Relay (note: proof-of-concept as not yet used by NGED)
3. Schneider T300s &ADVC3
4. S&C Trip Saver

## List of other Equipment Types to be integrated within C-DIP (BaU system expansion)

1. GE Relay Type xx (tbc confirmed by NGED)
2. Lucy Electric Sabre RMU (RTU type in development by Lucy)

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