POWER AUTOMATION TECHNOLOGIES

HORSTMANN NAVIGATOR (& SMART NAVIGATOR) Operating Principle

Overview:

The Horstmann NAVIGATOR and SMART NAVIGATOR are overhead line fault passage indicating devices which operate on the principle of direct connection to the line to monitoring load and fault current.

Unlike fault indication devices which may look at a combination of the rate-of-rise-in-current and voltage conditions to determine if there is a fault, the NAVIGATOR(s) use a simple and effective logic which does not cause false indications. Voltage field sensing is not used due to its poor field performance where this can introduce installation limitations such as preventing use on double lines, being mounted close to metal or concrete poles or poles with LV lines. As the NAVIGATOR mounts around the line conductor, it is not affected by foreign magnetic fields which can cause false alarms on pole mounted type sensors.

This document provides general information on the operation of the NAVIGATOR and SMART NAVIGATOR Series. Please refer to the specific product data sheet, operating manuals and order code specification for unit specific performance. Some specifications, settings and available options etc differ between models.

NAVIGATOR & SMART NAVIGATOR

The NAVIGATOR-LM provides visual indication only. It is available in a Type A, indicating permanent faults and a Type B, indicating permanent and momentary faults. The 'SMART NAVIGATOR' is similar to the 'NAVIGATOR-LM Type B' but the major difference is the SMART NAVIGATOR adds a low power radio to communicate with a pole mounted "SMART Reporter" SCADA interface unit. The SMART Reporter can use GPRS or virtually any customer supplied modem/radio to communicate back to SCADA.

NAVIGATOR-LM Load-Tracking & trip current

The NAVIGATOR-LM can be purchased with either a factory fixed trip current setting, or with a Load-Tracking feature which provides a simple and effective auto setting, adjusting to suit the line load. In both cases an inverse time/current curve is used. Specific curves are referred to using the current threshold at 100 ms, i.e. 100 A/100 ms.

Fixed Trip Setting

At time of order the 100 millisecond point of the desired trip curve is specified, such as 450 A. The NAVIGATOR-LM will indicate if current exceeds the current/time threshold of only that curve. Load-Tracking is disabled.

Load-Tracking

The NAVIGATOR-LM will measure peak load current to set itself to the appropriate trip curve:

- The trip curve used is 4-6 times the peak load current
- The peak load current must be present for 50-60 seconds, to eliminate range changes due to transient loads (Adjusting Delay specification)
- If the measured peak load current is under 25 A, the NAVIGATOR-LM will set itself to the 100 A/100 ms trip curve
- On initial start-up, the unit defaults to a 100 A/100 ms curve (Unlevelled minimum trip specification)

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The NAVIGATOR-LM stores the highest peak load current from the last 72 hours, and uses this to determine the trip current curve. This infers that if the load current increases further (for at least 50-60 seconds) the trip characteristic will move to a higher tripping curve based on the new peak. When a range change occurs, the 72 hour counter is reset. If the 72 hour period expires without a range increase, the peak load current value is reset to the present load level, and the process repeats.

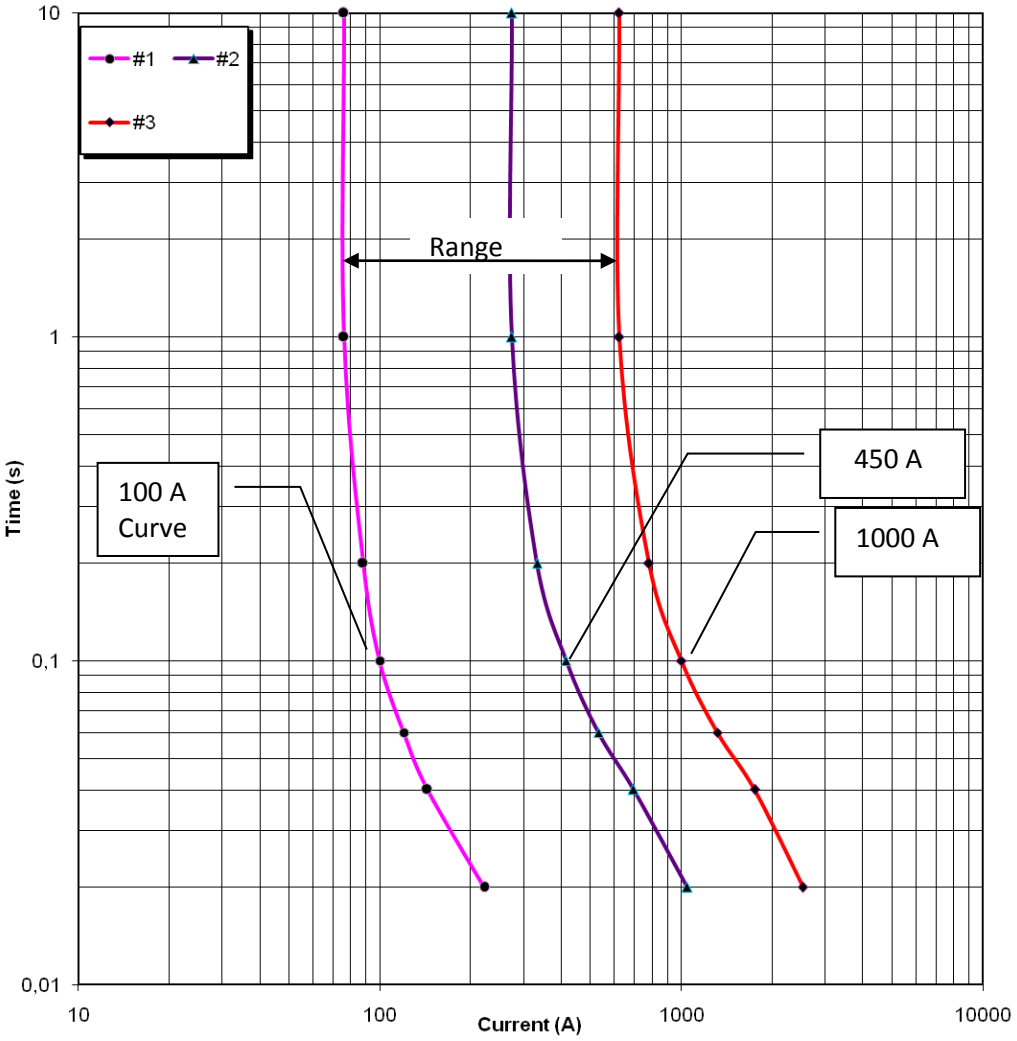

Figure 1. NAVIGATOR-LM Trip Current Curves.

Peak Load Current	**0-25 A**	**50 A**	**70 A**	**100 A**	**170 A**
Trip Current Curve (100 ms point)	100 A	200 A	294 A	450 A	1000 A

Table 1. NAVIGATOR-LM Trip Current Curve examples.

With the NAVIGATOR-LM Load-Tracking feature enabled, the "Level Factor Range" of 4-6 is used to determine the trip current curve. At low load currents a factor of 4 is used, increasing up to 6 for high load currents. The trip current curves ranges available are virtually continuous from 100 to 1000 A (100 ms). *[Note that Aus/NZ product specifications are based on 100 ms point, some other regions use the 200 ms point].*

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SMART NAVIGATOR Load-Tracking & trip current

The SMART NAVIGATOR (and the directional indicating version the 'SMART NAVIGATOR HV DFCI') can be purchased with either a factory fixed trip current setting, or with a Load-Tracking feature which provides a simple and effective auto setting, adjusting to suit the line load. In both cases an inverse time/current curve is used. Specific curves are referred to using the current threshold at 100 ms, i.e. 50 A/100 ms. *[Note that Aus/NZ product specifications are based on 100 ms point, some other regions use the 200 ms point]*

Fixed Trip Setting

At time of order the 100 millisecond point of the desired trip curve is specified, such as 200 A. The SMART NAVIGATOR will indicate if current exceeds the current/time threshold of only that curve. Load-Tracking is disabled. (800 A is typical, other values on request)

Load-Tracking

The SMART NAVIGATOR will measure peak load current to set itself to the appropriate trip curve:

- The trip curve used is 4 times the peak load current value. If for example the peak load current value is 75 A, the trip curve will have a 100 ms point of 300 A
- The peak load current must be present for 50-60 seconds, to eliminate range changes due to transient loads (Adjusting Delay specification)
- If the measured peak load current is under 15 A, the SMART NAVIGATOR will set itself to the 50 A/100 ms trip curve.
- On initial start-up, the unit defaults to the 50 A/100 trip curve (Unlevelled Minimum Trip specification)

The SMART NAVIGATOR stores the highest peak load current from the last 72 hours, and uses this to determine the trip current curve. This infers that if the load current increases further (for at least 50-60 seconds) the trip characteristic will move to a higher tripping curve based on the new peak. When a range change occurs, the 72 hour counter is reset. If the 72 hour period expires without a range increase, the peak current value is reset to the present load level, and the process repeats.

With the SMART NAVIGATOR, the trip value range (at 100 ms) ranges from 50 A to 1000 A. Load-Tracking features starts with load currents above 15 A shifting the trip current from 50A (100 ms) to a maximum trip current curve of 1000 A (100 ms) which is reached at 250 A load current (i.e. 1000/4)

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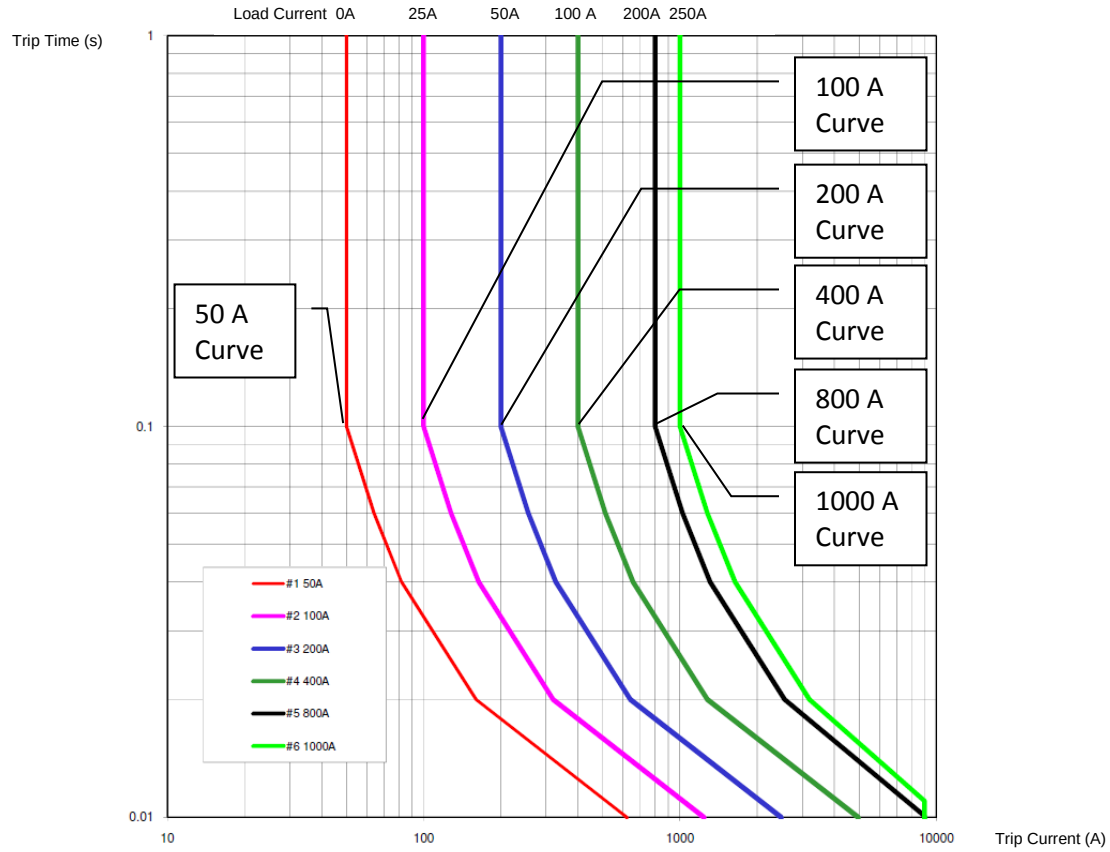

Figure 2. SMART NAVIGATOR Trip Current Curves examples (not all curves shown).

Peak Load Current	**0-15 A**	**50 A**	**100 A**	**250 A**
Trip Current Curve (100 ms point)	50 A	200 A	400 A	1000 A

Table 2. SMART NAVIGATOR Trip Current Curve examples.

Setting

For reliable indication the goal is to select the trip current curve just 'below' that of the upstream overcurrent protective device. This is to ensure the overcurrent device does not operate before the NAVIGATOR has had an opportunity to 'trip' (indicate). However, the trip current curve should be selected to be "under", but as close as possible to the overcurrent device, so as false indications do not occur where possibly the NAVIGATOR is 'tripped' but fault is self-clearing and not sufficient to trip the overcurrent device.

Fault identification

Faults that can appear on the network can be classified as permanent or momentary:

- Permanent faults are those isolated from the network by a protective device upstream.
- Momentary faults are those that cause one or two operations of a recloser or upstream circuit breaker, with power being returned to the consumers.

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There are two version of the NAVIGATOR-LM, one indicates only Permanent faults, the other Permanent and Momentary faults.

Type A - Permanent (only) Fault Indication

- 6 x Red LED's flash to indicate permanent faults
- 1 x Yellow LED to indicate low battery status (6 months of operation)

Type C - Permanent and Momentary Fault indication.

- 6 x red LED's flash to indicate permanent faults (actually 4 x red & 2 x orange flash, but due to optical effects, this appears to be 6 x red LED's), or
- 2 x orange LED's indicate momentary faults
- 1 x yellow LED to indicate low battery status (6 months of operation)

The most commonly used NAVIGATOR-LM is the Type C, because it can identify both types of faults. The SMART NAVIGATOR reports to SCADA Permanent or Momentary fault classification, but only provides visual indication of Permanent faults.

LED Reset

Red LED flashing indication of a permanent fault on NAVIGATOR-LM (both Type A & C) and SMART NAVIGATORS is reset by (the first of):

- Use of the reset magnet
- The selected time interval being exceeded (default 4 hours, but 1, 4, 8, 12, 24 hours possible)
- Return of load current (>3 A) [Order option available to disable this]
- For SMART NAVIGATORs, reset via SCADA is also possible

Orange LED flashing of a momentary fault on NAVIGATOR-LM Type C is reset by (the first of):

- Use of the reset magnet
- The selected time interval being exceeded (default 4 hours, but other times possible)
- [Return of load current does not reset orange momentary fault indication flashing]

A current detection of >3 A is used by the NAVIGATOR/SMART NAVIGATOR to determine if the flashing fault indication should be reset due to return of load current to the circuit. This setting is the "Current Reset" value and is 3 A for most products, but can be down to 1 A for some special version. If the restored load current is less than 3 A, then reset would occur via the timer function.

An option for some HV units (110 kV) is to also reset based on an E-Field voltage sensor.

Logic to identify Permanent and Momentary Faults

The NAVIGATOR-LM Type C immediately starts to flash (with all 6 LEDs) upon a fault. After 60 seconds it checks if there is current on the line (current >3 A).

- If there is current on the line, the recloser upstream has opened and reclosed successfully and power is now restored. The NAVIGATOR-LM will then change its flashing indication to that for a momentary fault.
- If there is no current on the line, the recloser may have locked out, and the NAVIGATOR-LM will continue to flash indicating a permanent fault.

This simple logic, results in reliable field indication. The absence of voltage detection, increases the reliability of correct indication, and allows the Horstmann units to be mounted in a wide range of locations, including double circuit poles etc.

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