Low voltage cable fault location using the ***Kehui*** T-P22

Problems of fault location on low voltage cables = [Multiple branches; Single phase services; Access to customers' terminals; Connected loads] + ***Fault behaviour***

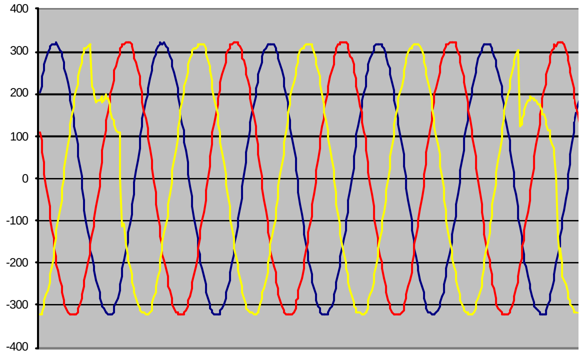
Fault behaviour =

- **Unstable/Non-linear faults** → Transitory, Intermittent, Persistent
- ***OR***
- **Stable/Linear faults** → Permanent

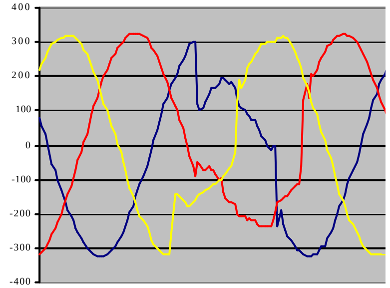
Low voltage cable fault classifications

- ***Transitory*** - irregular voltage dips
- ***Intermittent*** - irregular fuse operations
- ***Persistent*** - repetitive fuse operations
- ***Permanent*** - open circuits and solid welds

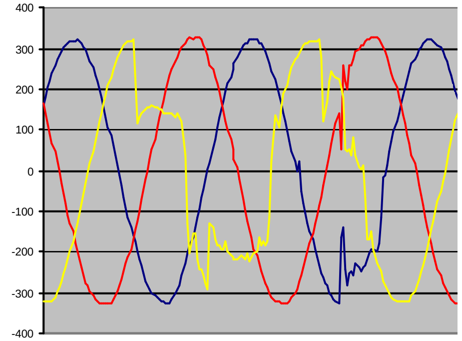
Many faults on low voltage cables begin as ***Transitory*** faults and develop first into ***Intermittent*** faults before becoming ***Persistent*** faults and then, possibly, ***Permanent*** faults



Substation voltage during 2 single phase ***Transient*** faults

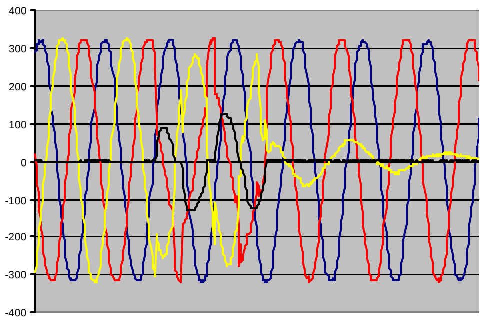


Substation voltage during 3 phase ***Transient*** fault

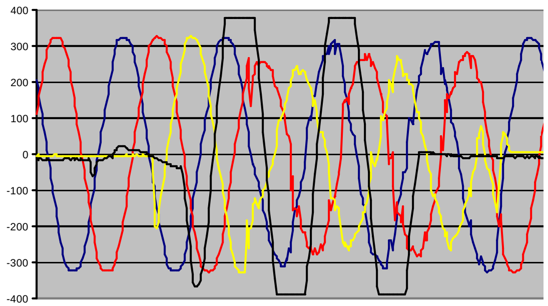


Customer's voltage during 3 phase ***Transient*** fault

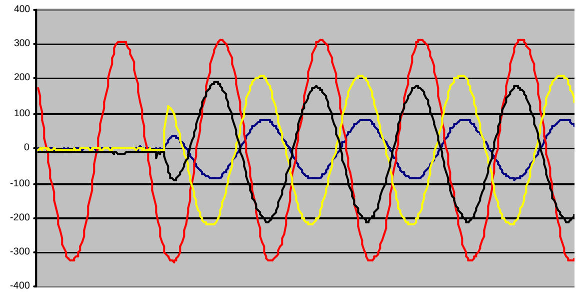
Faults on low voltage cables can involve 1, 2 or 3 phases



Substation voltage and current during ***Intermittent*** fault (current not to scale)



Substation voltage and current re-energising ***Persistent*** fault (current not to scale)



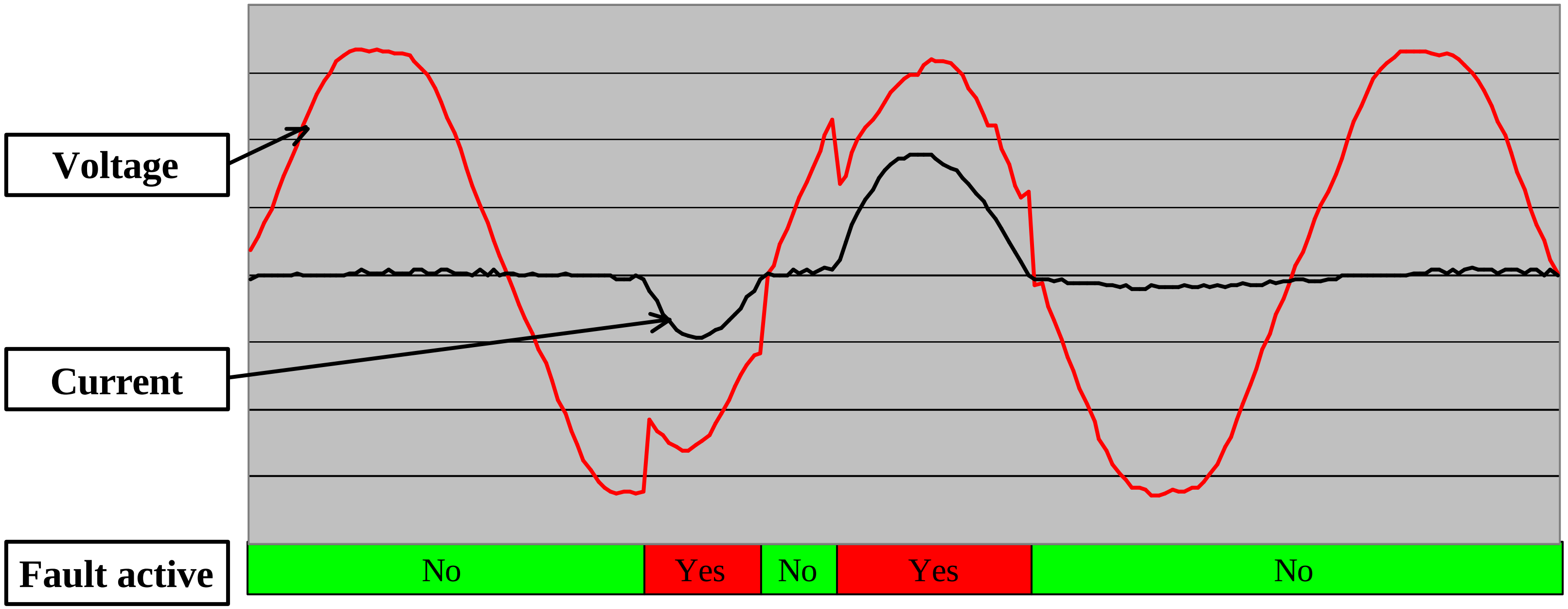
Substation voltage and current re-energising ***Permanent*** fault (current not to scale)

Transient and ***Intermittent*** faults can only be located using **ON-LINE** fault location techniques

Persistent faults require fault location techniques which suit their **UNSTABLE/NON-LINEAR** character

Permanent faults are **STABLE/LINEAR** and can be located using **OFF-LINE** fault location techniques

Unstable faults on low voltage cables produce *non-linear* voltages and currents

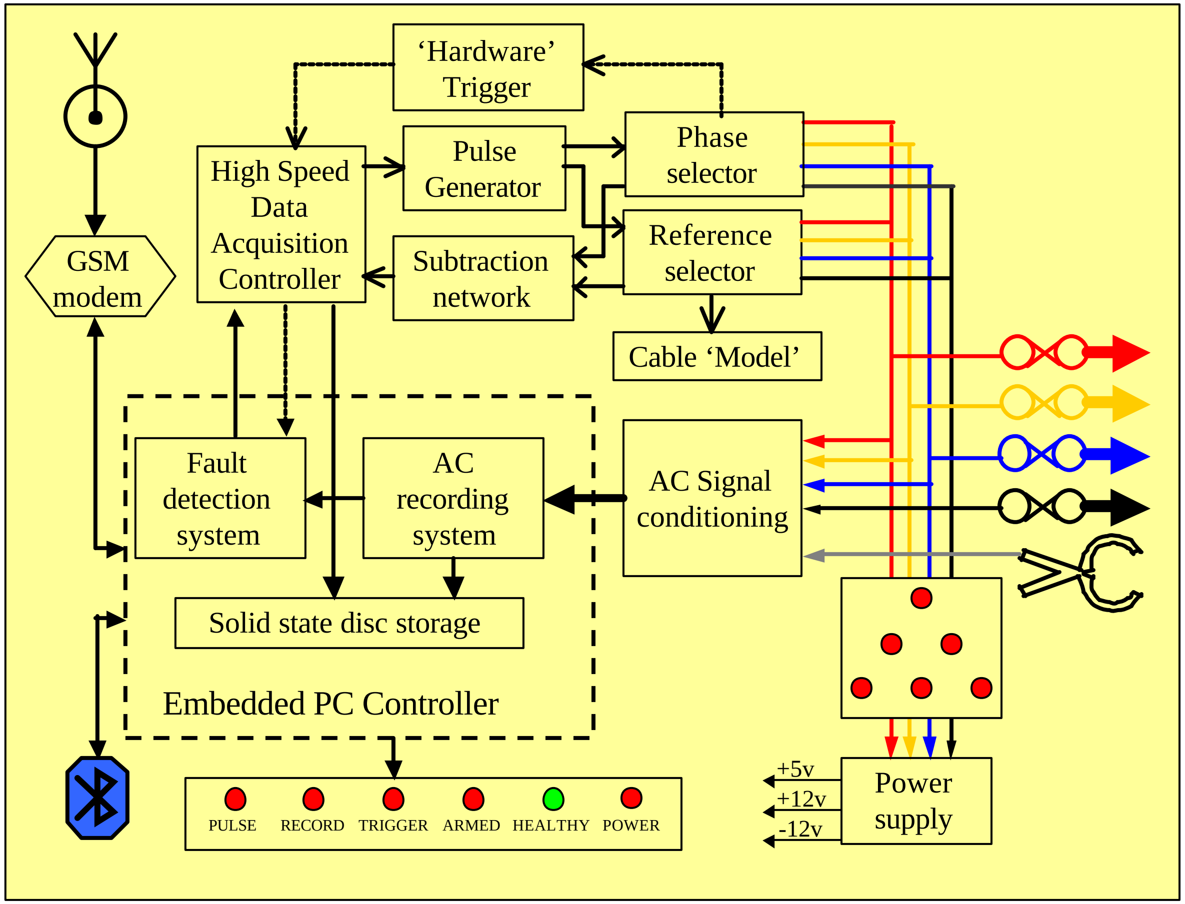


Unstable faults on low voltage cables can be located using 1 or more of the following phenomena:

- Reflections from the transient low resistance of the ***fault arc*** (Time Domain Reflectometry)
- The ***travelling waves*** created by the sudden collapse of voltage (Transient Recording System)
- The ***voltage profile*** along the cable due to the transient fault current (Voltage Gradient System)

T-P22 fault locator

T-P22 fault locator and accessories



T-P22 fault locator design

<u>The T-P22 fault locator consists of</u>:

- **'high speed' data acquisition and triggering**
- **pulse generator**
- **differential TDR output stage with phase selection**
- **'wireless' local and remote communication**
- **status indicators**
- **power supply with automatic phase selection**
- **4 channels of 'low speed' data acquisition and triggering**

<u>The T-P22 fault locator provides</u>:

- ***TDR Fault Location*** **for testing from a <u>single point of connection</u> with minimum dependence on cable records**
- ***Travelling Wave Fault Location*** **by simultaneous testing at <u>two points of connection</u> on a branched network to resolve fault location ambiguities**
- ***Voltage Gradient Fault Location*** **by analysis of the AC data from at least <u>three separate points of connection</u>**

Fault location using ‘on-line’ time domain reflectometry

TDR **methods require that the fault produces a reflection (echo) which can be identified amongst the reflections from joints and other impedance discontinuities**

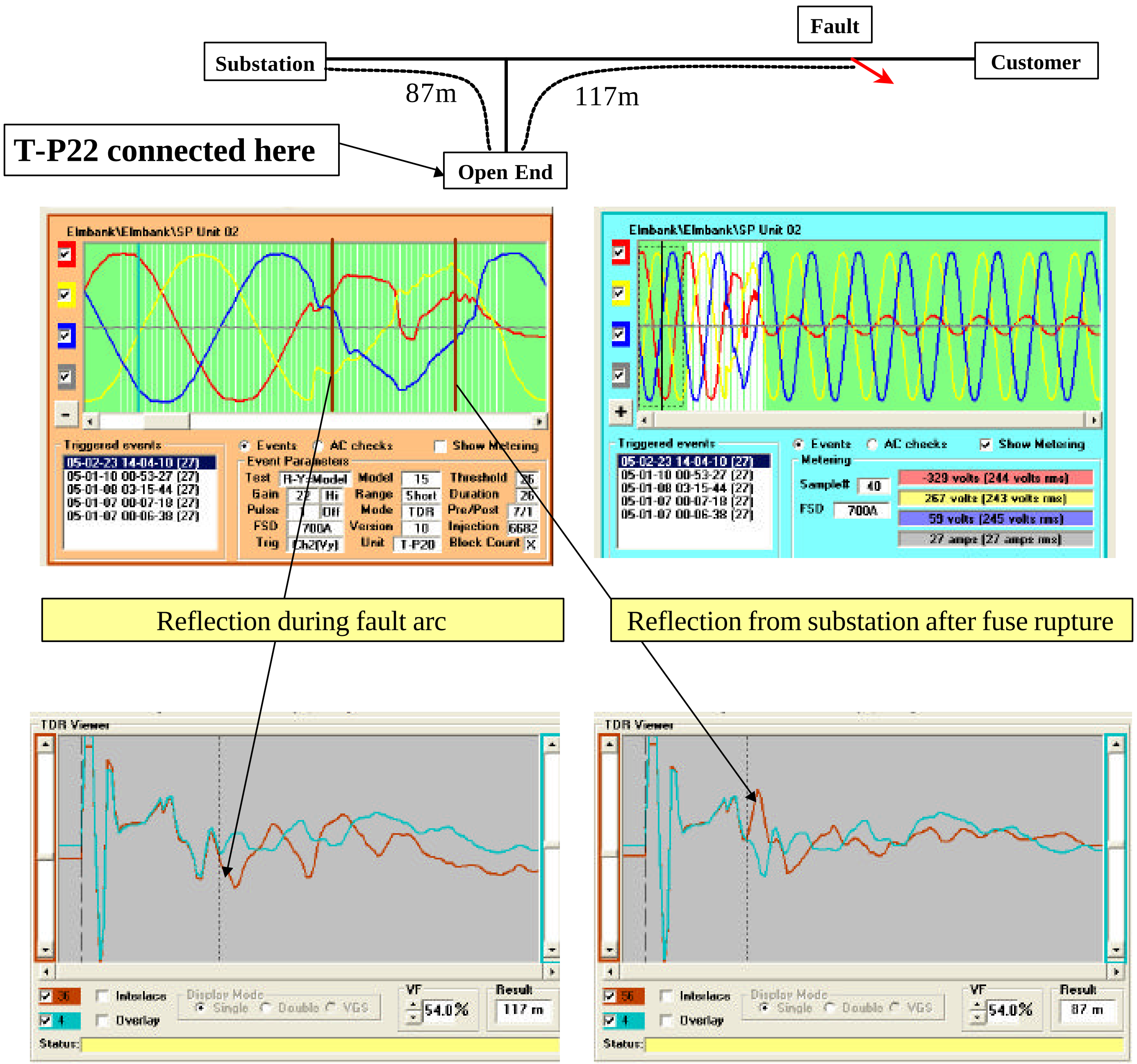
The reflection magnitude varies with the fault resistance - which for an ‘arcing’ fault will be very low producing a near total reflection.

Fault reflection recognition is simplified by comparing TDR traces ***Before and During*** **the arcing**

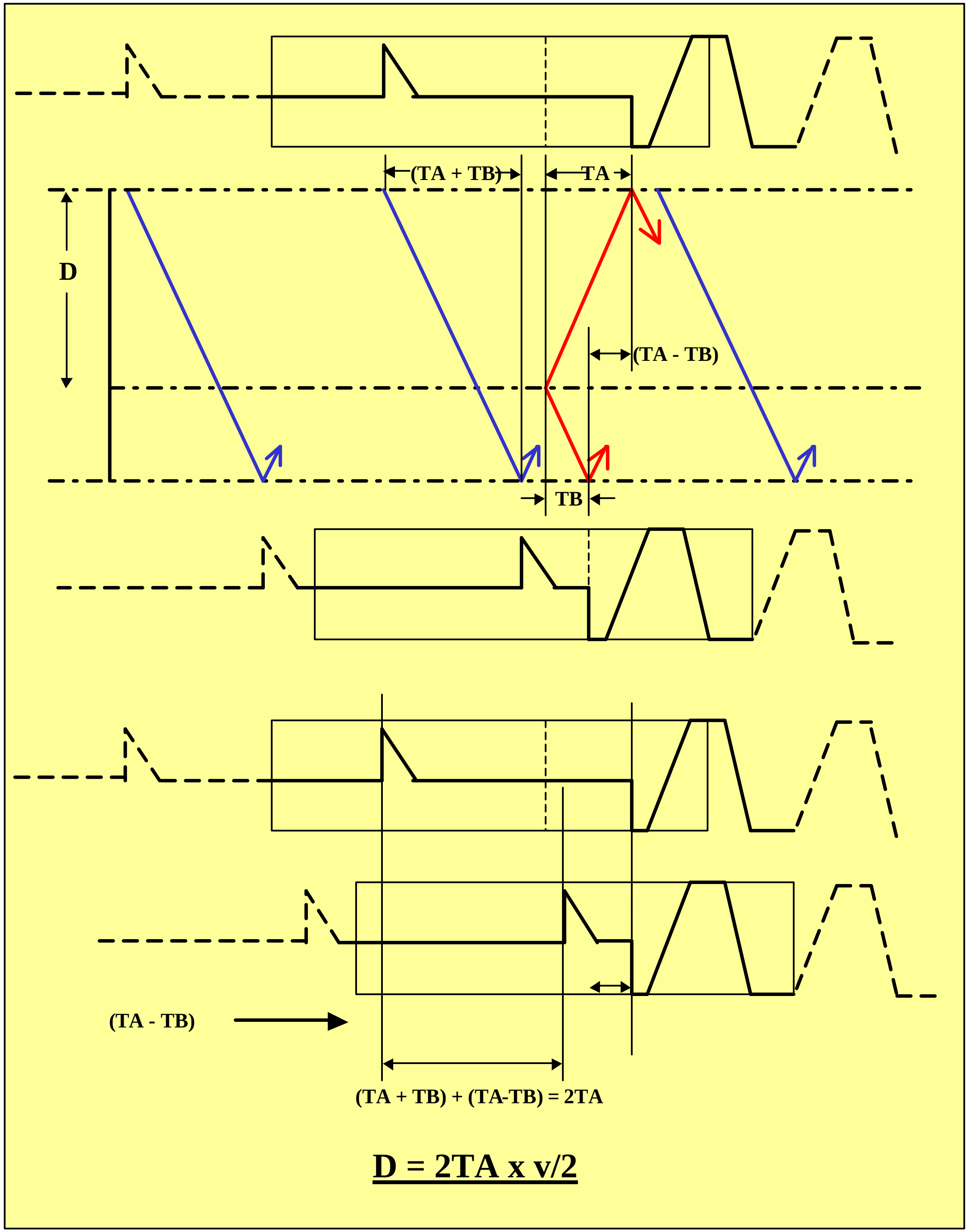
For maximum efficiency of pulse injection into the faulty cable the fault locator should be connected at an open end.

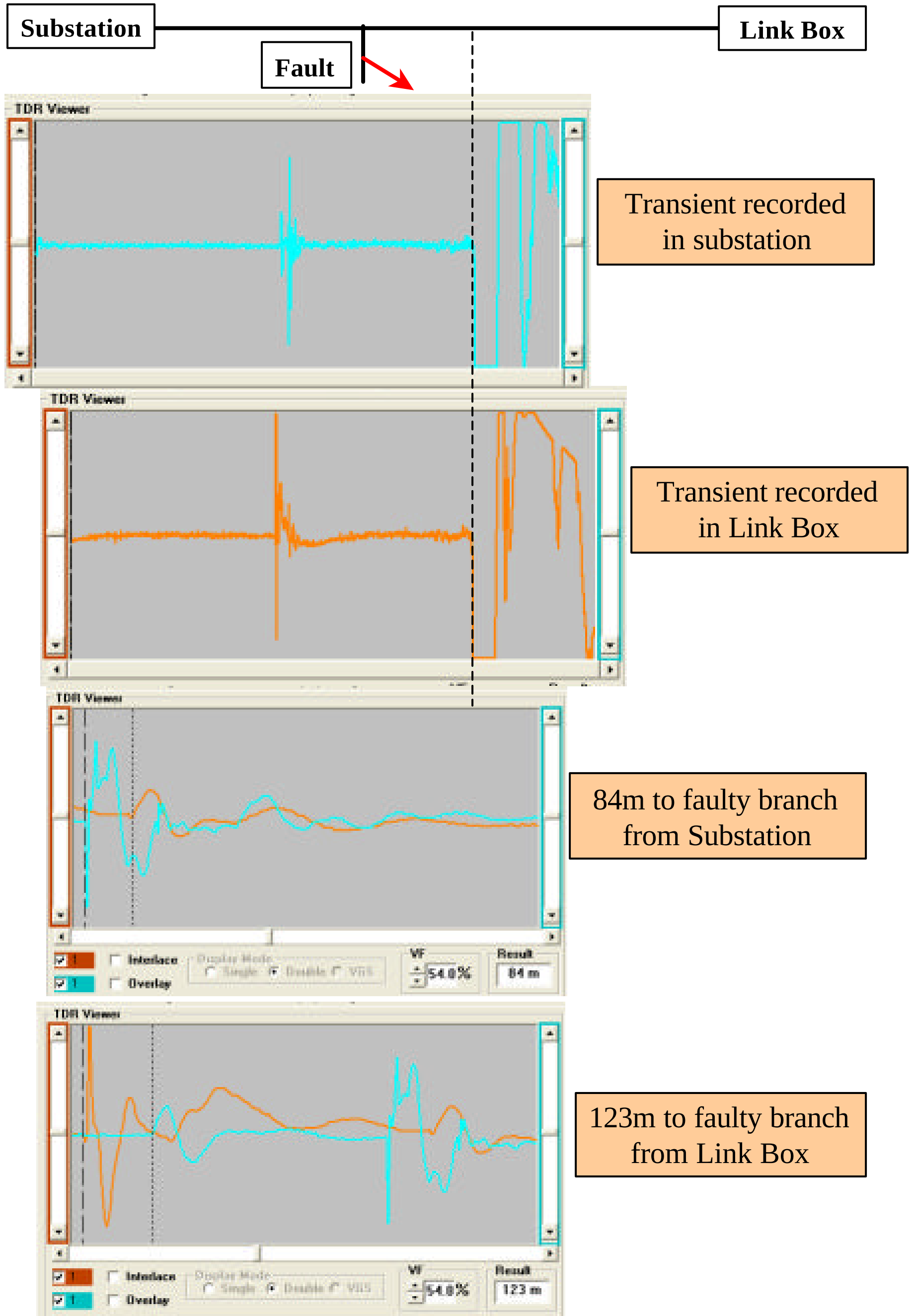
When connecting the fault locator in a substation feeding multiple cables it is normal practice to energise the faulty phase via an automatic re-closer in series with a suitably rated ‘blocking’ coil.

Fault location using 'on-line' time domain reflectometry

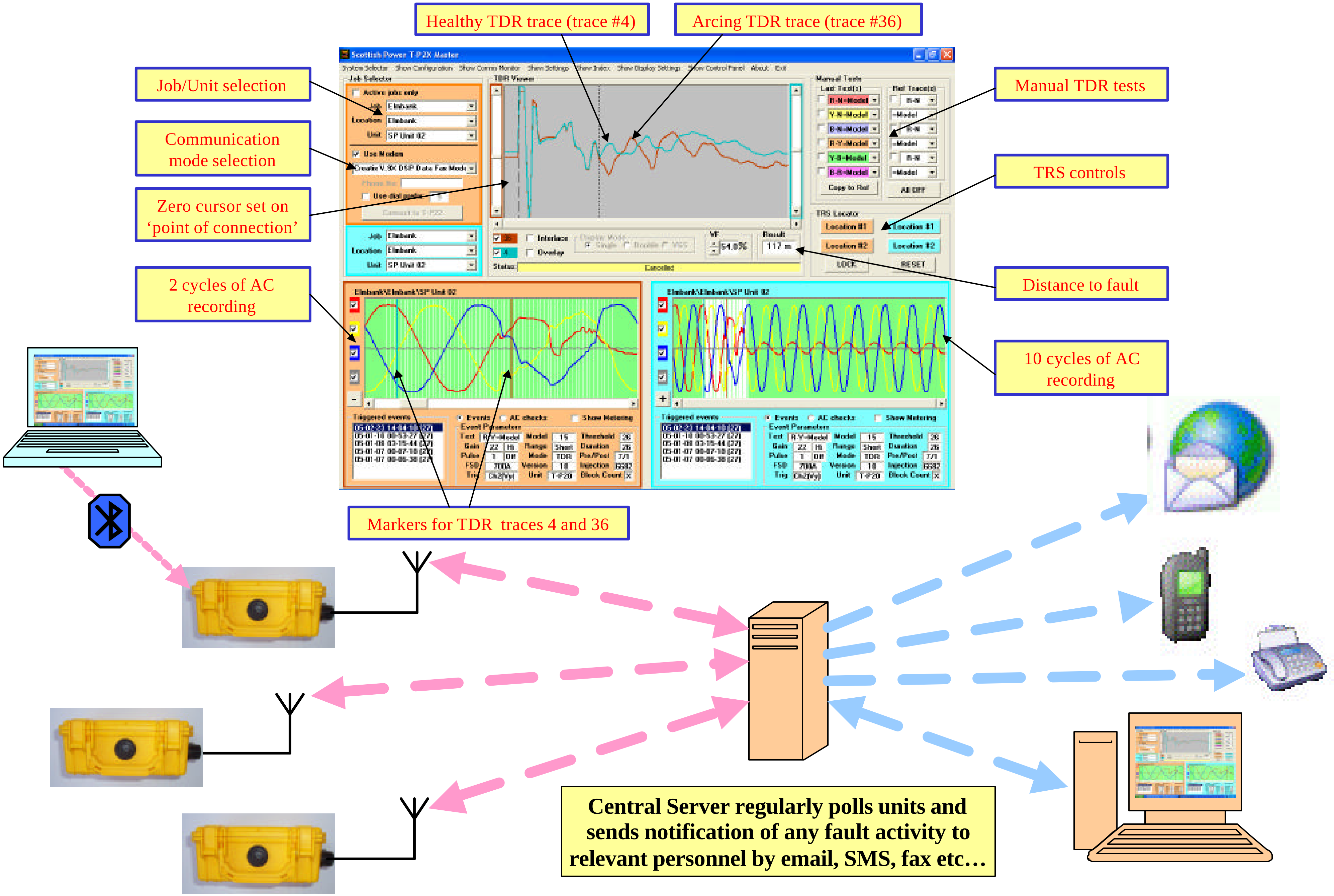


Fault location using travelling waves





Monitoring, data retrieval & control of T-P22 fault locators



Benefits of using T-P22 fault locators

Low voltage cable faults present a greater technical challenge to a DNO than HV cable faults

Incentives imposed by the Regulator have increased the urgency to restore supplies after permanent faults and to maintain supplies by reducing the number of intermittent faults

Re-organisations within DNOs have created a need for simple equipment and procedures which can be installed by field staff

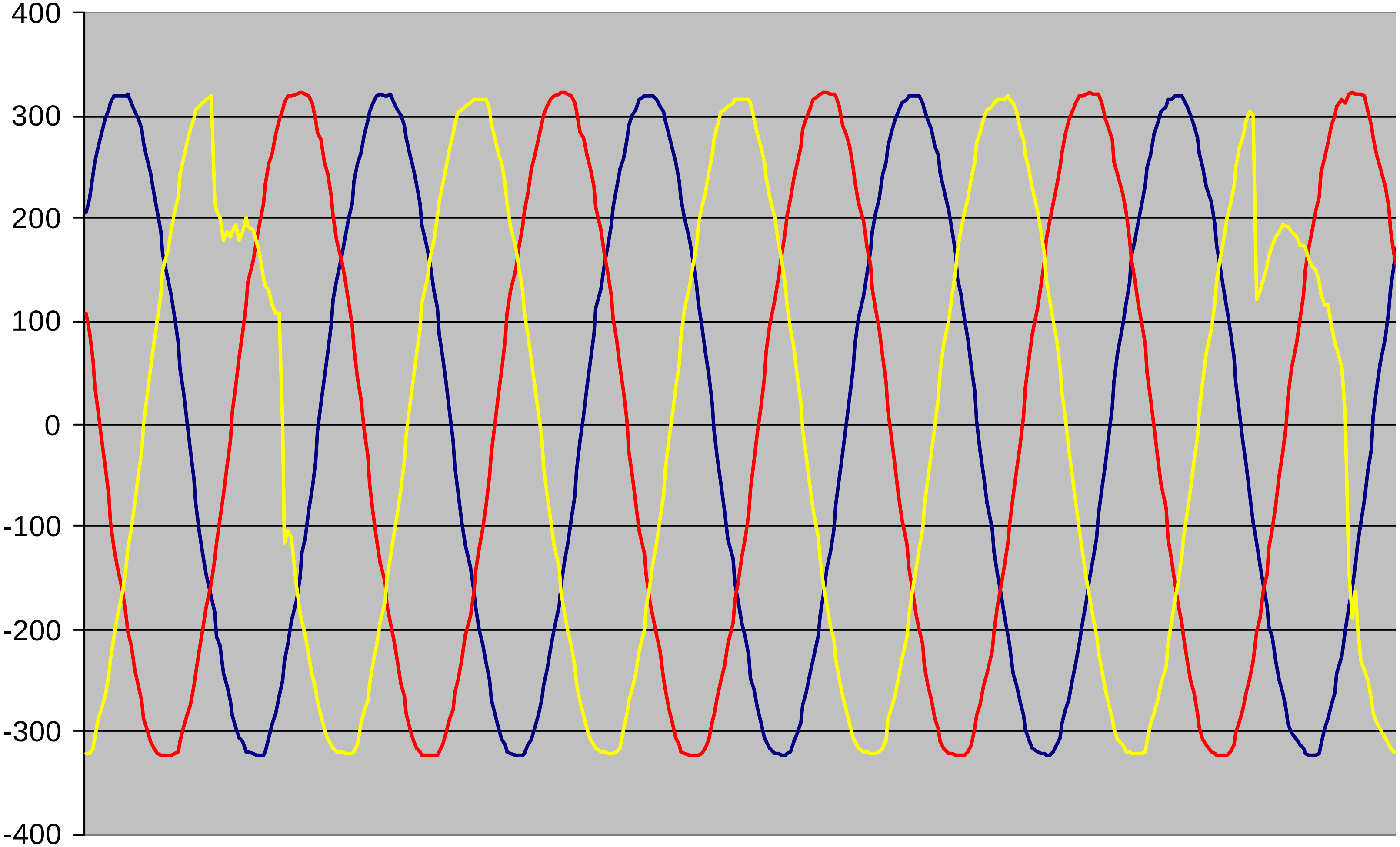
Fault location devices with remote communications allow control and analysis by centrally located specialists

Fault locations can be confirmed by field staff using devices such as the *Fault Sniffer* or acoustic detectors - eliminating unnecessary excavations, reducing costs, expediting restoration and meeting customers' expectations

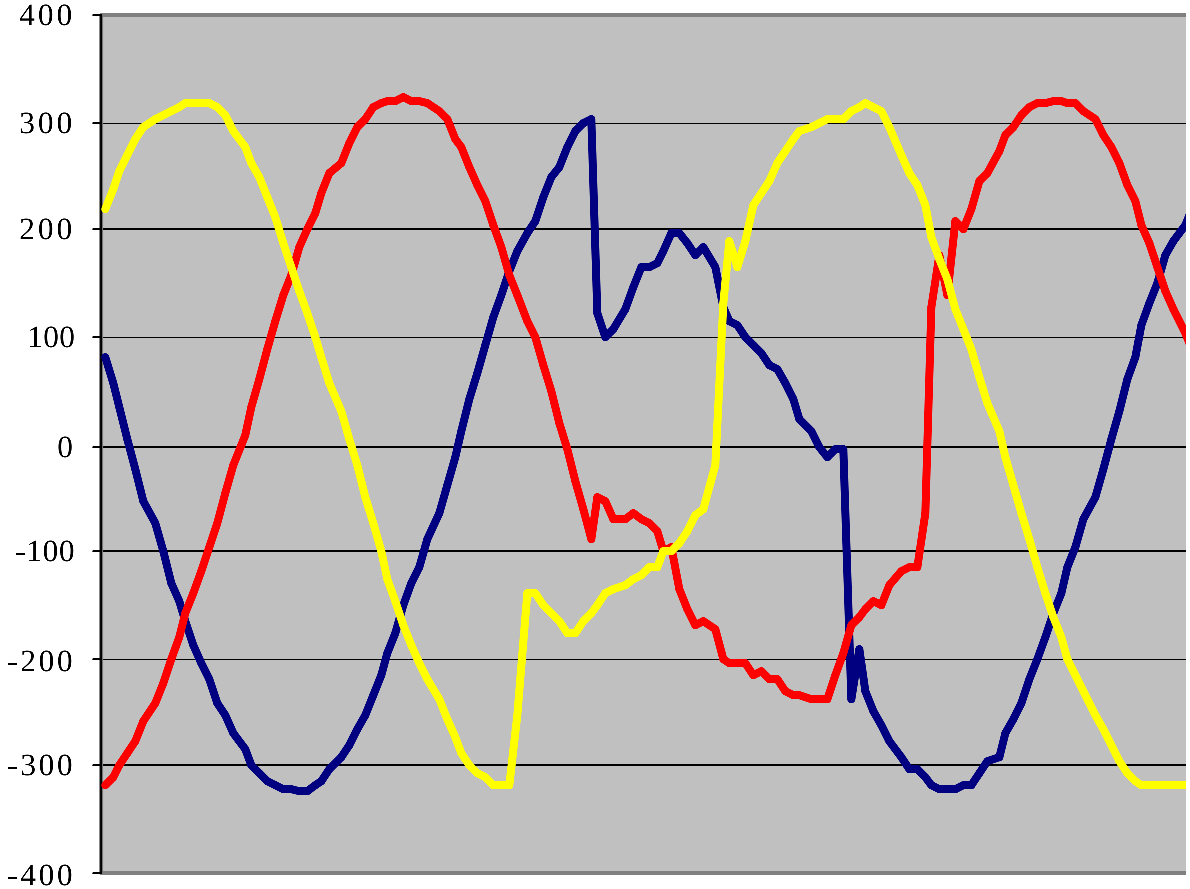
Capturing the power frequency transients produced by low voltage cable faults is essential to understanding their character and hence to the selection of the most appropriate technique(s) to determine their location

***Transitory* faults degrade PQ and are a major cause of *flickering lights* – often as precursors to developing into *Intermittent, Persistent* or *Permanent* faults**

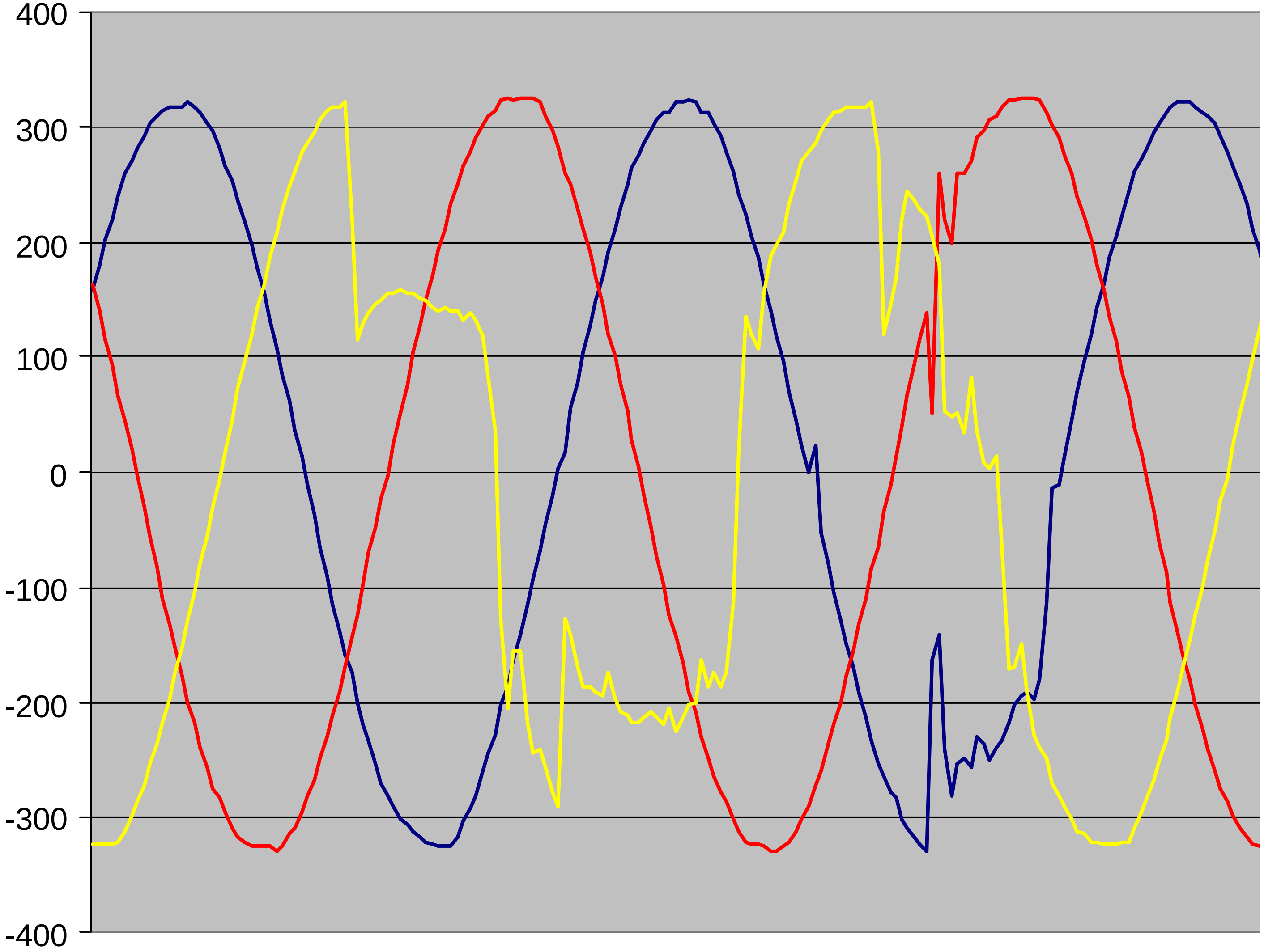
***Transitory* fault phenomena can be used for condition monitoring to provide *early warning* of pending problems to prevent consumer interruptions and power quality complaints**



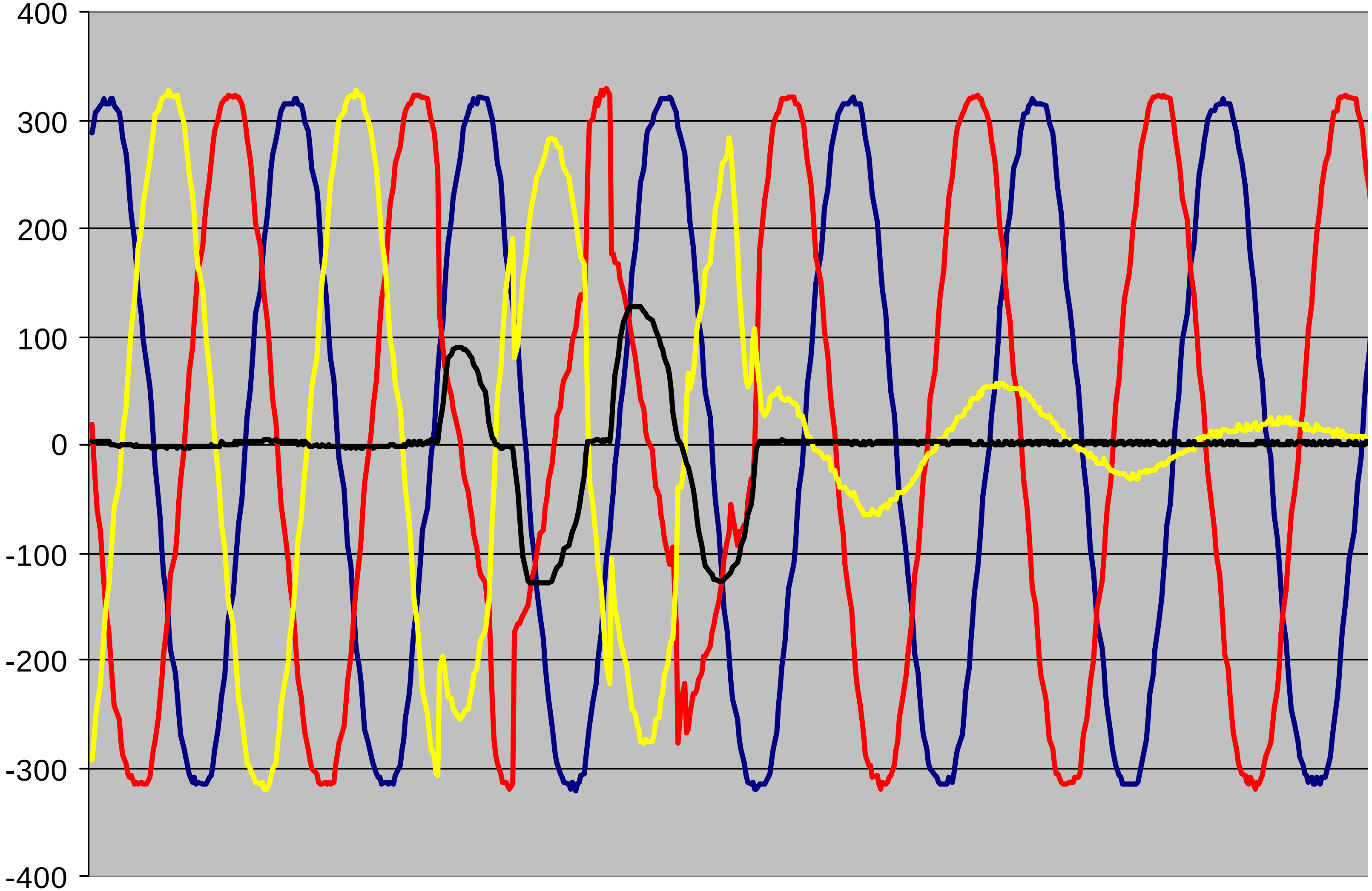
Substation voltage during 2 single phase ***Transient*** faults



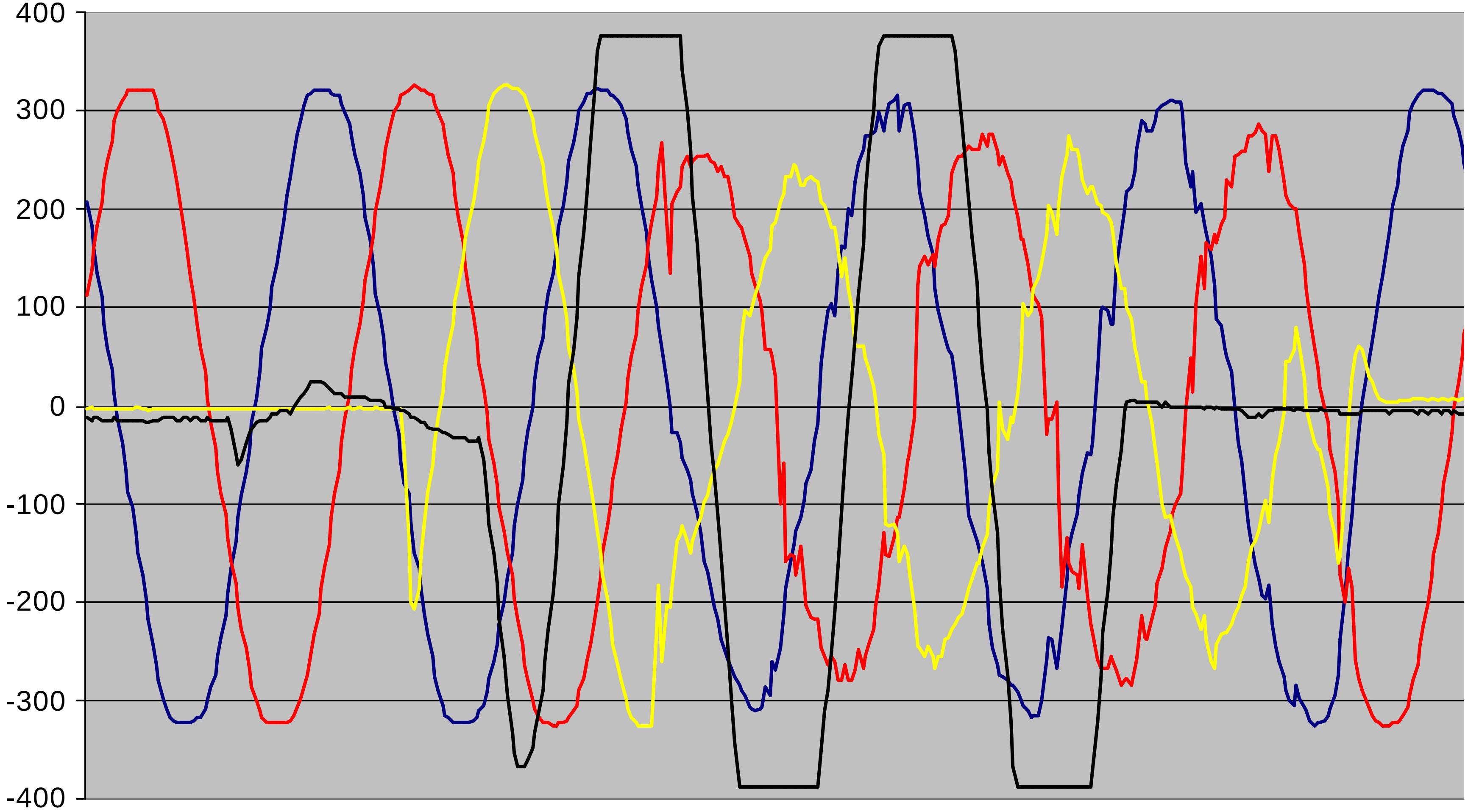
Substation voltage during 3 phase ***Transient*** fault



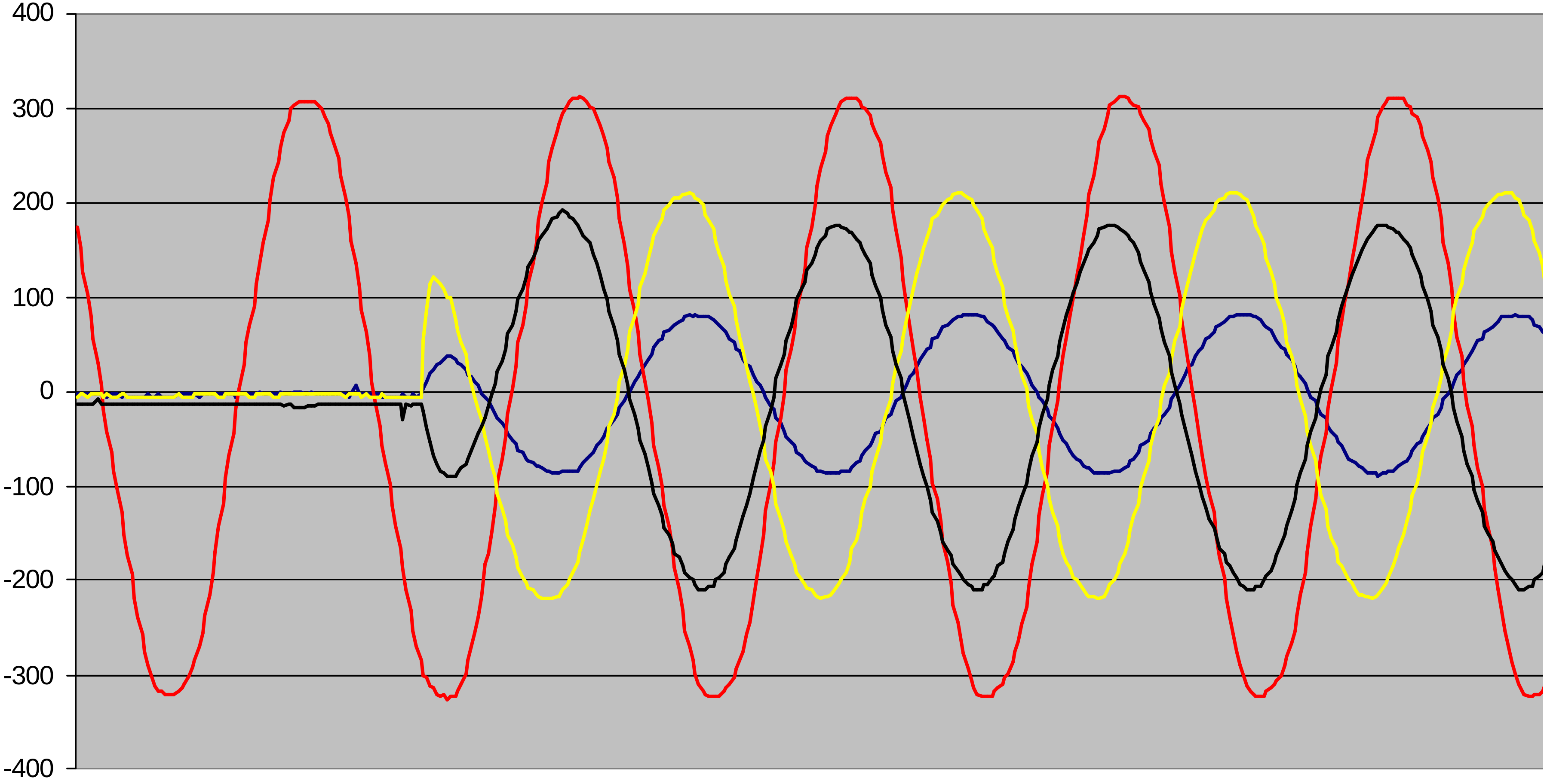
Customer’s voltage during 3 phase ***Transient*** fault



Substation voltage and current during ***Intermittent*** fault
(current not to scale)



Substation voltage and current re-energising ***Persistent*** fault
(current not to scale)



Substation voltage and current re-energising ***Permanent*** fault
(current not to scale)