Fault Diagnosis for a Parallel Transmission Line Using Chromatic Processing

Z. Almajali, Prof J. Spencer and Prof G. Jones

Centre For Intelligent Monitoring Systems, Department of Electrical Engineering and Electronics, University of Liverpool

Introduction

The overhead transmission line is a vital component of the power system, and it has the highest fault incidence rate. Most of the fault sources are beyond man control, and the fault conditions could threaten the stability and the reliability of the power system.

Objective

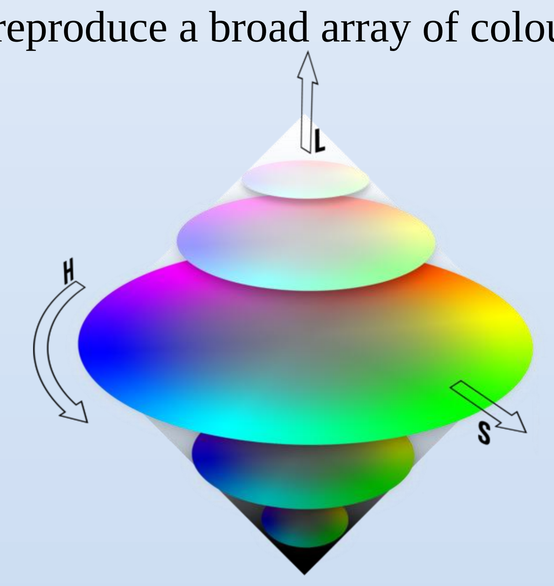
To design a comprehensive protection system, there is a need to include a fault diagnosis of transmission system in the power system protection with the ability of a fault detection, correct type classification and estimate its exact location. An accurate fault locator can assist in the control of the system and enable faulty parts of the system to be efficiently located and isolated for correcting the system and restoring it to its previous healthy condition.

Chromaticity

In colour theory, colour models mathematically describe how colours may be represented.

RGB Colour Model

Based in human perception of colours. In RGB colour model the red, green, and blue light are added together in various ways to reproduce a broad array of colours.



HLS Colour Model

The raw RGB values are transformed to give the colour-making attributes, such as hue H, lightness L, and saturation S.

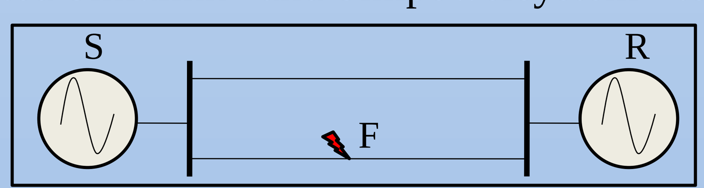
Chromatic Monitoring[1]

Chromatic monitoring is a technique, which is derived from colour science and the photic fields concepts. It has already been applied for monitoring systems with complex conditions

The chromatic methodology is a technique that provides a means of signal recognition for system monitoring applications in terms of parameters which are analogous to those encountered in colour science, but which have been extended to complex data, and it has been proven to be effective in monitoring of complex condition systems.

Simulation Study

A 735 kV, 60 Hz parallel 200 km transmission line is considered using simulation with MATLAB® software and its associated Simulink® and Simpowersystem® toolboxes



Various types of faults were simulated which included the following conditions.

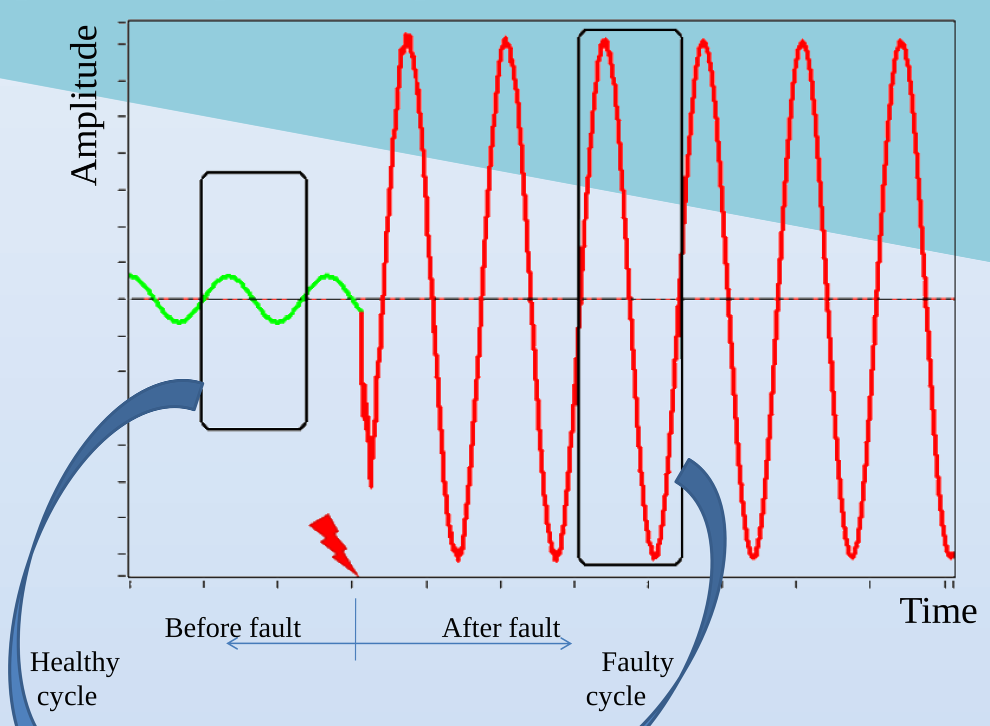
Fault location: 5%, 10%, 15%, …, 90%, 95% of the distance.

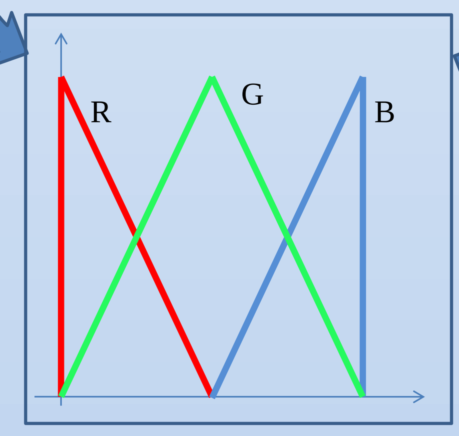
Fault types: line to ground (AG, BG, CG), line to line (AB, BC, AC), line to line to ground (ABG, BCG, ACG), three lines fault (ABC, ABCG).

Fault resistance: 0.001, 100 and 200 ohm.

Method Description

The following waveform is a sample of a fault current positive sequence component at the sender terminal.





Cycle by cycle of the waveform are monitored chromatically by three R, G & B filters. The selected profiles for this purpose is Triangular with overlaps at half heights.

The following relationships[1] are used for calculating of the H, L & S parameters

$$H = 240 - 120 \cdot g/(g+b) \quad r = 0$$
$$= 360 - 120 \cdot b/(b+r) \quad g = 0$$
$$= 120 - 120 \cdot r/(r+g) \quad b = 0$$

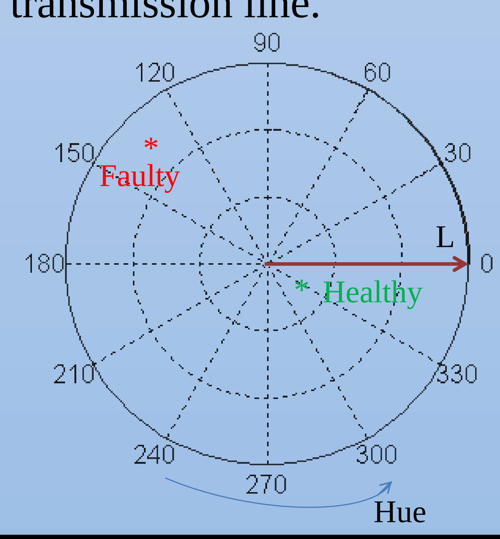
Where

$$r = R - MIN(R, G, B)$$
$$g = G - MIN(R, G, B)$$
$$b = B - MIN(R, G, B)$$

$$L = (R + G + B)/3$$

$$S = \frac{[MAX(R, G, B) - MIN(R, G, B)]}{[MAX(R, G, B) + MIN(R, G, B)]}$$

The chromatic principles is implemented on the time domain of the symmetrical component waveforms of the current at both sender and receiver ends of the double transmission line.



The hue H and the lightness L parameters are plotted as polar diagrams, with H being an angular value and L being radial values, the variation of the monitoring process output reflect information about the changes in the system conditions.

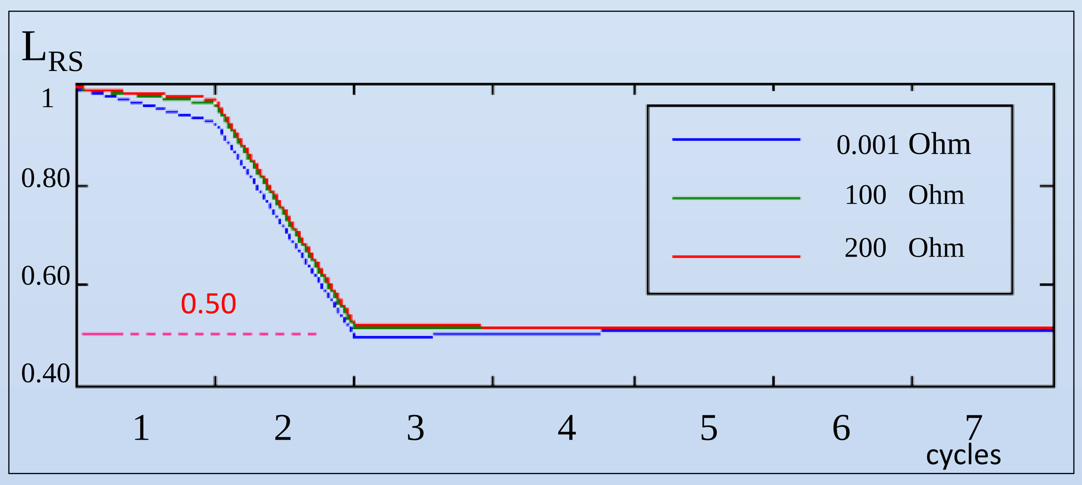
Results Summary

Fault Locator

The locator method is based on monitoring the positive sequence component of the current at both sender and receiver ends. L_{RS} give the fault location estimation :

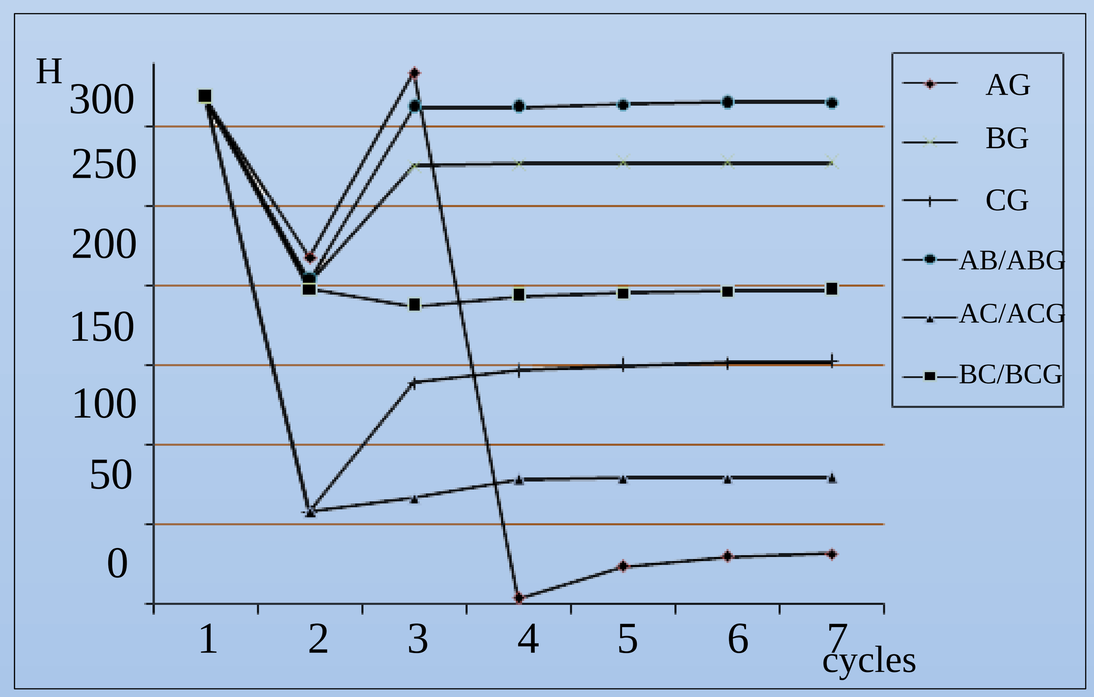
$$L_{RS} = (L_R - L_S) / (L_R + L_S)$$

Where L_R , L_S are the Lightness of receiver and sender end respectively. Fault estimation result example is shown in the figure below, the case is LG(AG) fault at 50% of the line length with three different fault resistance values.



Fault Classifier

From monitoring the negative sequence component of the current, the H values for each fault condition is located in different range, and those ranges stay valid for classification purposes for certain value of the fault resistance.



Concluding Remarks

A new approach for locating and classification of various faults on a double transmission line has been described. The locator is based on chromatically monitoring the positive sequence component of the current at both the sender and the receiver, while the classifier is based on monitoring the negative sequence component of the current at one of the terminals.

Reference: [1] G.R. Jones, A.G. Deakin and J.W. Spencer. (2008). Chromatic monitoring of complex conditions. CRC Press.