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## United States Patent [19]

US005537327A

Patent Number:5,537,327Date of Patent:Jul. 16, 1996

### Snow et al.

### [54] METHOD AND APPARATUS FOR DETECTING HIGH-IMPEDANCE FAULTS IN ELECTRICAL POWER SYSTEMS

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- [21] Appl. No.: 141,308

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- [22] Filed: Oct. 22, 1993
- [51] Int. Cl.<sup>6</sup> ...... G06F 15/22; G01R 31/08

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Primary Examiner—Emanuel T. Voeltz Assistant Examiner—Kamini Shah Attorney, Agent, or Firm—Salzman & Levy

### [57] ABSTRACT

The present invention features a method and apparatus for detecting and enabling the clearance of high impedance faults (HIFs) in an electrical transmission or distribution system. Current in at least one phase in a distribution system is monitored in real time by sensors. Analog current signature information is then digitized for processing by a digital computer. Zero crossings are identified and current maxima and minima located. The first derivatives of the maxima and minima are computed and a modified Fast Fourier Transform (FFT) is then performed to convert time domain to frequency domain information. The transformed data is formatted and normalized and then applied to a trained neural network, which provides an output trigger signal when an HIF condition is probable. The trigger signal is made available to either a network administrator for manual intervention, or directly to switchgear to deactivate an affected portion of the network. The inventive method may be practiced using either conventional computer hardware and software or dedicated custom hardware such as a VLSI chip.

### 32 Claims, 6 Drawing Sheets



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% HIZPROC % Developed by Dr. Peter B. Snow for NYSEG March 9, 1993 % enter a file for processing - for example \ksc\hiz42\_3.dat % now put the file in vector a - for example a = hiz42\_3 % now type in hizproc to activate this processing program % clear the old matrices clear b cl c2: % first get the size of the input vector [jd, ja] = size(a);% now shift the signal to the origin y=0 avg1 = mean(a);a = a - avg1;%now find the element numbers of the zero current crossings k = 1;for i=1:jd-1; if a(i) < 0.0;if a(i+1) > 0.0;b(k) = i;k = k + 1;end: end; end; [jd, ja] = size(b);k = 1;% now find maximum values for each cycle for i = 1: ia - 1; i1 = b(i);j2 = b(i+1);c1(k) = max(a(j1:j2));c2(k) = min(a(j1:j2));k = k + 1end: % now take first derivative of max, min vectors e1 = diff(c1); $e^2 = diff(c^2);$ % now take the FFT and convert to power spectrum g1 = fft(e1, 512);g2 = fft(e2, 512);pg1 = g1 .\* conj(g1) / 512;pg2 = g2 .\* conj(g2) / 512;sumfft1 = sum(pq1);sumfft2 = sum(pg2);sumfft = (sumfft1 + sumfft2) / 2;

Figure 3

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