Faculty of Electrical Engineering

REAL - TIME HARMONIC SIGNAL DETECTION AND SOURCES LOCATION IDENTIFICATION SYSTEM FOR POWER DISTRIBUTION SYSTEM

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REAL – TIME HARMONIC SIGNALS DETECTION AND SOURCES LOCATION IDENTIFICATION SYSTEM FOR POWER DISTRIBUTION SYSTEM

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A thesis submitted
in fulfilment of the requirements for the degree of Master of Science in Electrical Engineering

Faculty of Electrical Engineering

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DECLARATION

I declare that this thesis entitled "Real – Time Harmonic Signal Detection and Sources Location Identification System for Power Distribution System" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : NABILAH BINTI MAT KASSIM

Date : 20 NOVEMBER 2017

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for award of Master of Science in Electrical Engineering.

Signature : .....

Name : DR. AIDA FAZLIANA BINTI ABDUL KADIR

Date : 20 NOVEMBER 2017

DEDICATION

This is special dedicated to

my parents,

Mat Kassim bin Ya'acob & Fatimah Binti Ahmad Kassim,

My beloved husband,

Mohamad Sharif bin Ishak,

and my family for their continuous love and prayers,

also to all my friends for their patient, kindness and cooperation .

I wish to thanks all of you for your support during my studies in UTeM.

May God bless all of them.

ABSTRACT

One of the major issues of power quality is harmonic distortion, which refers to the distortion in the waveforms of the power system. This issue is even more prevalent nowadays, as new electrical power equipment is being constantly developed and introduced into the market, and these systems contribute towards the distortion of the electrical power supply. High levels of harmonic distortion may cause excessive heating of the components in the electrical power equipment as a result of current surge, which leads to equipment failure. This in turn, increases downtime in production facilities, and may lead to severe financial losses. Thus, it is essential to trace and identify harmonic sources in the power system so that precautionary steps can be taken to prevent the detrimental impact of harmonic distortion. Therefore, this research is focused on analysing harmonic signals and identifying the location of harmonic source by utilizing periodogram and spectrogram techniques. The harmonic signals are generated from the rectifier load to the test system using MATLAB/Simulink program. There are two forms of representation used for the harmonic signals generated in this study which are power spectrum, and time-frequency representation. The former and latter representation is obtained from the periodogram and spectrogram technique, respectively. The following signal parameters are also estimated, namely, the root mean square voltage, root mean square current, fundamental root mean square for voltage and current, total harmonic distortion, total non-harmonic distortion, and total waveform distortion for voltage and current. The harmonic signals are detected according to the procedure outlined in the IEEE Standard 519-2014, and the equations for harmonic source identification are formulated based on the characteristics of the harmonic source either at the downstream, upstream or both sides of the point of common coupling in the test system. The performance of the harmonic source identification techniques is verified using four test cases and the radial system network. A real-time monitoring system is developed upon completion of the verification process in order to detect the harmonic signals and identify the location of the harmonic source in an actual power system. A total of 25 signals with different characteristics are generated, tested and evaluated in order to determine the accuracy of the signal parameters of the monitoring system. The average mean absolute percentage error is determined to be 0.711 percentage. Based on the results, it can be concluded that the real-time harmonic signal detection and source identification system developed in this study is reliable and accurate to analyse harmonic signals, and identify the location of harmonic sources in power systems.

ABSTRAK

Salah satu isu utama kualiti kuasa adalah herotan harmonik, yang merujuk kepada penyelewengan dalam bentuk gelombang sistem kuasa. Isu ini adalah lebih berleluasa pada masa kini, peralatan kuasa elektrik yang baru sedang dikembangkan dan diperkenalkan di pasaran, dan sistem ini menyumbang kepada gangguan pada bekalan kuasa elektrik. Tahap herotan harmonik yang tinggi boleh menyebabkan panas berlebihan kepada peranti peralatan kuasa elektrik serta mengakibatkan lonjakan arus elektrik seperti membawa kepada kegagalan peralatan. Seterusnya, meningkatkan lengahan masa kepada peralatan pengeluaran, dan mungkin membawa kepada kerugian kewangan yang teruk. Oleh itu, adalah penting untuk mengesan dan mengenalpasti sumber harmonik dalam sistem kuasa supaya langkah berjaga-jaga yang boleh diambil untuk mengelakkan kesan yang memudaratkan daripada herotan harmonik. Dengan yang demikian, kajian ini tertumpu kepada menganalisis isyarat harmonik dan mengenalpasti lokasi sumber harmonik dengan menggunakan teknik periodogram dan spectrogram. Isyarat harmonik dijana daripada beban arus penerus kepada sistem ujian menggunakan program MATLAB / Simulink. Terdapat dua bentuk perwakilan yang digunakan untuk janaan isyarat harmonik di dalam kajian ini seperti spektrum kuasa dan perwakilan masa frekuensi. Perwakilan pertama dan kedua diperolehi daripada teknik periodogram dan spectrogram. Parameter isyarat berikut juga dianggarkan, iaitu punca min kuasa dua voltan, punca min kuasa dua arus, asas punca min kuasa dua daripada voltan dan arus, asas jumlah herotan harmonik, jumlah herotan bukan harmonik, dan jumlah herotan bentuk gelombang daripada voltan dan arus. Isyarat harmonik dikesan mengikut prosedur yang digariskan dalam IEEE Standard 519-2014, dan persamaan untuk mengenalpasti sumber harmonik yang dirumuskan berdasarkan kepada ciri-ciri sumber harmonik sama ada di hilir, hulu atau kedua-dua belah titik gandingan bersama dalam sistem ujian. Prestasi teknik pengenalanpastian sumber harmonik disahkan menggunakan empat kes ujian dan rangkaian sistem jejarian. Satu sistem pemantauan masa-nyata dibangunkan setelah selesai proses pengesahan untuk mengesan isyarat harmonik dan mengenalpasti lokasi sumber harmonik di dalam sistem kuasa yang sebenar. Sebanyak 25 isyarat dengan ciri-ciri yang berbeza yang dihasilkan, diuji dan dinilai untuk menentukan ketepatan parameter isyarat sistem pemantauan. Purata min mutlak peratusan kesilapan ini telah dikira dengan nilai peratusan 0.711. Berdasarkan hasil kajian, hal ini dapat disimpulkan bahawa sistem masa-nyata pengesanan isyarat dan mengenalpasti sumber lokasi harmonik yang dibangunkan dalam kajian ini adalah boleh diguna pakai dan menganalisis isyarat harmonik yang tepat, dan dapat mengenalpasti lokasi sumber harmonik dalam sistem kuasa.

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PCC	-	Point of Common Coupling
THD	-	Total Harmonic Distortion
FFT	-	Fast Fourier transform
STFT	-	Short Time Fourier Transform
WT	-	Wavelet Transform
ICA	-	Impedance Component Analysis
HSE	-	Harmonic State Estimation
RMS	-	Root Mean Square
THDv	-	Instantaneous Total Harmonic Distortion of Voltage
TiHDv	-	Instantaneous Total Interharmonic Distortion of Voltage
DB	-	Distribution Board
VB	-	Visual Basic
MATLAB	-	MATLAB Software
MAPE	-	Mean Absolute Percentage Error
Z_l	-	Magnitudes of Fundamental Impedance Power Spectrum
Z_h	-	Magnitude of Harmonic Impedances Power Spectrum
GUI	-	Graphical User Interface
IEEE	-	Institute of Electrical and Electronics Engineers
MS	-	Malaysian Standard
IEC	-	International Electrotechnical Commission
ADSP	-	Advance Digital Signal Processing
FS	-	Frequency Spectrogram
PS	-	Phase Spectrogram
CIM	-	Critical Impedance Technique
THDv,ave	-	Average of Instantaneous Total Harmonic Distortion of Voltage
TiHDv,ave	-	Averatge of Instantaneous Total Interharmonic Distortion of Voltage
NI DAQ	-	National Instruments Data Acquisition
AI	-	Analog Input

AO	-	Analog Outputs
DIO	-	Digital Input / Output
OSWS	-	One Sample Window Shift
Z_{150Hz}	-	Impedance Power Spectrum at Frequency 150 Hz
TFR	-	Time – Frequency Representation
Hz	-	Frequency unit, Hertz
USB	-	Universal Serial Bus
UTeM	-	Universiti Teknikal Malaysia Melaka

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