

# Power Quality Recognition in Distribution System with Solar Energy Penetration Using $S$ -Transform and Fuzzy $C$ -Means Clustering

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## Abstract

This paper presents a technique to recognize the power quality (PQ) disturbances associated with solar energy penetration in distribution network. The voltage signal is analysed with the help of Stockwell's transform ( $S$ -transform) then its features are utilized to recognize power quality events with the help of Fuzzy  $C$ -means clustering (FCM). The operations considered for PQ assessment include grid synchronization and outage of solar photovoltaic (PV) system. The PQ events associated with sudden change in solar insolation have also been investigated. The proposed study is carried out using a standard IEEE-13 bus test system modified by incorporating the solar PV system. The effect of increase in solar energy penetration in terms of power quality assessment has also been investigated with solar PV systems of capacities  $100kW$ ,  $500kW$  and  $1MW$  using the proposed power quality index, maximum deviations in frequency and total harmonics distortions of voltage and current. The study has been carried out using MATLAB/Simulink and simulation results are compared with the real time results obtained using real time digital simulator (RTDS) for validating the effectiveness of proposed study.

*Keywords:* Distribution network, Fuzzy  $C$ -means clustering, power quality, solar photovoltaic system, Stockwell transform.

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