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# An algorithm for Estimation of Rainfall over Chennai using Spatial Gradient Method

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**Abstract:** In the present paper, a technique was developed for rainfall estimation utilizing Kalpana-1 satellite data. In the present technique, two indices are used to discriminate rainy/non-rainy pixels based on spatial gradient of cloud top brightness temperature (CTBT). The two indices are made from the Thermal Infrared (TIR) and Water Vapor (WV) measurements of Kalpana-1 data. The first index is TIR-mean, and WV-mean, provides information about the spatial variability of CTBT in 5X5 pixels. A high value of spatial variability indicates a convective-cloud. The second index is CTBT standard deviation (SD) which provides information about the cloud. A large SD indicates the presence of rainy clouds normally convective clouds where as small SD indicates thin non-rainy cirrus clouds. Using a linear empirical relation, rainfall is assigned to every rainy pixel. The obtained rainfall is compared with other global precipitation product such as TRMM Multisatellite Precipitation Analysis (TMPA-3B42 version 7) and Indian Meteorological Department (IMD) gridded rain gauge data. In terms of Root Mean Square Error (RMSE) and Correlation coefficient (CC). The proposed technique performs better estimation of rainfall when compared to TMPA-3B42 V7.

**Keywords:** Spatial gradient, Cloud top brightness temperature, TIR and WV measurements, Correlation Coefficient, RMSE

## 1. Introduction

Rainfall, which is a highly variable atmospheric parameter at high spatial and temporal scale. Conventionally, rainfall can be measured using rain gauges and ground radars. Due to uneven distribution of rain gauges and scarcity of ground radars, satellite data are used for estimations of rainfalls all over the world [1]. Now a days, satellite data is available at free of cost, hence rainfall estimation using satellite remote sensing data becomes a cost effective method. Large number of rainfall estimation techniques are available which use various sensors data, has its own advantages and limitations. The advantage of Geo-stationary satellites are its high temporal resolution (nearly half an hour) which carries visible (VIS), WV and TIR sensors. But the limitation is, these sensors does not have direct relation with rainfall. Polar orbiting satellites, which carries microwave sensors, have direct relation with rainfall but suffers with low temporal resolution (nearly twice a day). Unlike TIR measurements, Microwave (MW) measurements provide physical connection with rain and hydrometeors since they penetrate through clouds but suffers with poorer temporal and spatial resolutions (lower orbiting satellites gives less coverage). Hence there is a need to merge TIR measurements and MW measurements for better estimates of precipitation which gives rise to hybrid algorithms. Over the few decades, hybrid algorithms were developed by combining the microwave observations from polar-orbiting satellites and TIR-brightness temperature (TB) from the geostationary satellite to estimate rainfall [2, 3]. Few algorithms were developed for Indian region to estimate rainfall utilizing hybrid algorithms [4, 5]. The methods based on VIS/TIR images tries to find a relation between the surface rain rate with cloud top brightness temperatures. Among the VIS, WV and TIR data, many algorithms uses TIR data as they provide information about CTBT. The basic principle in using VIS and TIR channels of geostationary satellites is, thick clouds are associated with rainfall and these thick clouds are appeared as bright clouds in visible imagery. In infrared imagery, heavier rainfall is associated with larger, taller clouds having colder cloud tops. The basic methods used to discriminate raining and non-raining pixels is the simple threshold technique which uses a CTBT threshold of 235 K [6]. If the value of CTBT less than 235 K, then it is considered a rainy pixel; otherwise, it is treated as a non-rainy pixel. This technique fails to discriminate thin cirrus clouds which has low CTBT but does not produce rainfall. Hence, a cloud growth factor is used in association with simple threshold technique to separate the cirrus clouds from convective clouds [7]. The surface rainfall rate associated with the CTBT is not consistent and it varies regionally. Hence, for different topologies different threshold values are assigned in different algorithms [8, 9, 10]. Some algorithms uses machine learning techniques to discriminate the rainy and non-rainy pixels. An efficient way of determining an empirical, nonlinear relationship between a number of "inputs" and one or more "outputs" can be done using Artificial Neural Network (ANN). Now a days, an efficient way have been developed for estimation of rainfall using ANN techniques [11].



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VOLUME - 8 | ISSUE - 1 | OCTOBER - 2018

## SINGLE PHASE GRID CONNECTED FUEL CELL SYSTEM BASED ON BOOST INVERTER

reference number from excel:26,27

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### ABSTRACT

The boost-inverter topology is used as a building block for a single-phase grid-connected fuel cell (FC) system offering low cost and compactness. In addition, the proposed system incorporates battery-based energy storage and a dc-dc bidirectional converter to support the slow dynamics of the FC. The single-phase boost inverter is voltage-mode controlled and the dc-dc bidirectional converter is current-mode controlled. The low-frequency current ripple is supplied by the battery which minimizes the effects of such ripple being drawn directly from the FC itself. Design guidelines, simulation, and experimental results taken from a laboratory prototype are presented to confirm the performance of the proposed system.

**KEYWORDS:** compactness, ripple, simulation, topology.

### 1.0 INTRODUCTION

Alternative energy generation systems based on solar photo voltaic and fuel cells (FCs) need to be conditioned for both dc and ac loads. The overall system includes power electronics energy conversion technologies and may include energy storage based on the target application.

A two-stage FC power conditioning system to deliver ac power has been commonly considered and



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**AUTHOR** LAMPAKI OLYMPIA, PAVLIDOU EVA, ANTONIOU PANAGIOTIS, AND KYRIDIS ARGYRIS GREECE



**TITLE** SCHOOL DROPOUTS-A THEORETICAL FRAMEWORK

**AUTHOR** RALUCA UNGUREANU ROMANIA



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