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Simulated Wind Action on Photovoltaic Module by Non-uniform Dynamic Mechanical Load and Mean Extended Wind Load

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Abstract

Taiwan is centrally situated in the main path of typhoons generated in the Northwest Pacific Ocean (19-28° N, 117-125° E). On average in last one hundred years, three or four typhoons approach or make landfall in Taiwan yearly. This typhoon issue has received considerable attention, since the associated strong winds generally damage photovoltaic (PV) modules severely. Previous IEC standards have examined the effect of static (or dynamic) uniform loads for PV module, but did not consider the non-uniform loads due to wind effects on PV modules. In this paper, we develop an analytical model about a mean extended wind load (MEWL) test method, and a non-uniform dynamic mechanical load (NUDML) system, which can simulate the wind action on PV module by uneven mechanical loads. Results of this study revealed that the result of MEWL test strongly rely on the environmental condition of wind velocity, wind direction angle and the inclined angle of the PV module.

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Keywords: Mechanical load; PV modules; non-uniform; wind load

1. Introduction

Typhoons are one of the world's most frequently occurring natural disaster that cause severe damage. The losses caused by typhoons are not only related to the strength and structure of a particular typhoon, but also to the populati-

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on density, home range, and type of economy in the affected area. Taiwan, located between 22-25° N and 120-121° E, is centrally situated in the main path arc of typhoons generated in the Northwest Pacific Ocean. On average, 3-4 typhoons approach or make landfall in Taiwan yearly. The severity of a typhoon is associated with its wind strength and moisture content. Thus, the installations of photovoltaic (PV) modules are of necessity concerned with the wind uplift produced by typhoons. Breakages of the glass covers of PV modules and frames are mainly due to the strong wind uplift and the associated large deflection. Figure 1 shows several PV modules and trackers damaged by the MERANTI typhoon hitting Southern Taiwan in September 2016. The major damages of modules due to wind loads in open-rack mounting configurations generally include broken glass, crack or micro-crack of cell, failures of metal frame, fastener or support system, etc.

In addition, the trend of module technologies includes plastic frame or frameless module, lightweight of metal frame (0.5-0.3 kg/m), thin glass for packaging (3.3-2 mm) and high-power module (60-72 cells), etc. These changes of components will increase the difficulties of PV modules to withstand wind action. Therefore, a good simulation method of the wind resistance by mechanical load is essential for preventing such damage. In this work, the new concepts of test method and test requirement are introduced about the mean extended wind load (MEWL) induced by wind action on PV module, and a non-uniform dynamic mechanical load (NUDML) test system.

Nomenclature

A_{ref}	surface area of solar panel
C_p	dimensionless pressure coefficient
C_{p1}	maximum pressure coefficient acting on the solar panel
C_{p2}	minimum pressure coefficient acting on the solar panel
C_α	the extended coefficient equals to P_B/P_A or F_B/F_A
e	the arm distance of total force F_I for moment M_I, m
F_A	mean design wind load, *N*
F_B	mean extended wind load, *N*
F_I	total force of triangle I, *N*
F_{II}	total force of rectangle II, *N*
F_{III}	total force of rectangle III, *N*
L	length of PV module, m
M_I	moment equals to total force F_I multiplied by arm distance e, *N*m
P	pressure, Pa
P_∞	static pressure, Pa
P_A	mean design pressure, Pa
P_B	mean extended pressure, Pa
SF	safety factor
V	wind velocity, m/s
W_p	dynamic pressure due to wind velocity, Pa
α	inclined angle of PV module, deg
β	wind direction angle, deg
ρ	air density, kg/m^3