Reflection and Absorption Characteristics of Electromagnetic Waves for PV Modules

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ABSTRACT

In this paper, the authors investigated the reflection and absorption characteristics of a general photovoltaic (PV) module. As a result, the electromagnetic waves could be attenuated 6 dB. However, if the PV module is installed in outer wall of buildings, electromagnetic interference is caused by the surroundings. To reduce this electromagnetic interference, the authors suggested a method to absorb electromagnetic wave using multiple PV modules that have deference impedance, and simulation was performed. As a result, it was confirmed that using a typical PV module and the PV module including electronic device, the reflection waves of those PV modules could be attenuated up to 12dB.

1. Introduction

Photovoltaic (PV) modules are being used as an outer wall for reasons of variety of design, durability and maintenance free. However, there is a problem that PV modules reflect electromagnetic waves. Especially, in case of TV wave, reflection waves from outer wall of buildings interfere with a direct wave from TV station, and "Picture ghosting" occurs in a certain area. The cost of countermeasure for this phenomenon is very high. In this paper, the authors propose the method of reducing reflection of electromagnetic waves to solve these problems using PV modules or systems.

2. Absorption characteristics of one PV module

The prevalent PV modules structure consists of glass, Ethylene-Vinyl-acetate (EVA), silicon (solar cell) and back sheet. The back sheet of PV module is generally made of aluminum, besides the other three materials are dielectric. In consequence, it is possible to use the conventional theory*1 for PV module since they are structured by three layer of dielectric. The absorption characteristic of one PV module was analyzed using this theory. The thickness and relative permittivity of each layer is shown in table 1. As a result, the prevalent PV module can absorb only 6dB. It is difficult to absorb more without changing this structure: for example changing the thickness, permittivity or medium.

Table 1 Structure of PV module

	First layer	Second layer	Third layer
Medium	Glass	EVA	Silicon
Relative Permittivity	3.9	3.1	11.7
Thickness	6mm	0.6mm	0.5mm

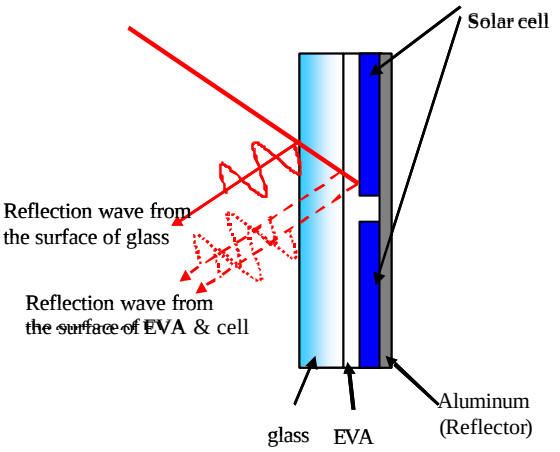

Fig.1 Absorption characteristics of one PV module

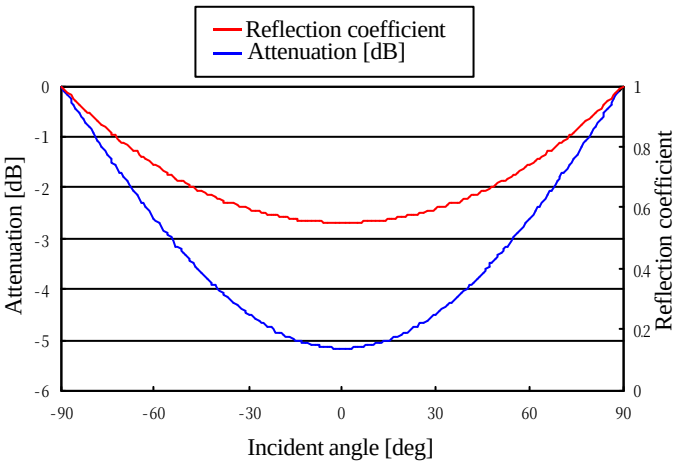

Fig.2 Attenuation and reflection coefficient

3. Absorption method of multi PV modules

Using multiple PV modules that have different impedance, the reflection waves of them can be canceled each other like figure 3. As a method of changing their impedance, the capacitors and electronic devices were connected with inside or outside of PV module and the disposition pattern of solar cells is changed. In fact, when the phase difference of each reflection wave is π[rad] , the interference waves are able to be completely counteracted. The relation of each impedance and reflection coefficient is following as:

$$\Gamma_A = \frac{Z_A - Z_0}{Z_A - Z_0} \qquad (3.1)$$

$$\Gamma_B = \frac{Z_B - Z_0}{Z_B - Z_0} \qquad (3.2)$$

Γ_A, Γ_B: Reflection coefficient
Z_0: characteristic impedance

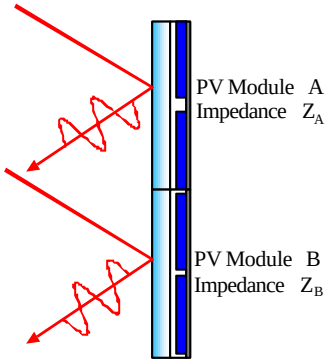

Fig. 3 Method of using multiple PV modules

4. Result

4.1 selection of capacity

In this paper, as changing impedance of PV module, a capacitor was connected with outside of the PV module, and the most suitable value was found by changing capacity. The result is shown in figure 4. It was obtained that the most appropriate capacity is 0.63[pF].

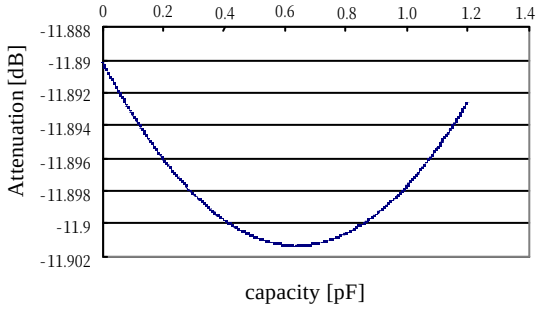

Fig. 4 Selection of Capacity

4.2 Attenuation of using multiple PV modules

Using the capacitor that led 4.1, the simulation was performed for incident angle of electromagnetic waves. This result is shown in figure 5. This method is twice the attenuation of the method using one PV module. However attenuation depends on incident angle in this method. It was conformed that the tilt angle and azimuthal angle of PV modules is important.

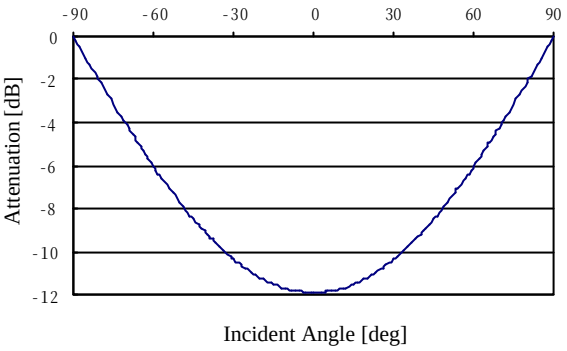

Figure 5 Absorption characteristics

5. Conclusion

In this paper, the authors confirmed the absorption characteristics of one PV module and analyzed the absorption method of using multiple PV modules. The attenuation was 6dB and 12dB in one and multiple PV modules, respectively. The PV module is able to attenuate electromagnetic wave depends on their combination. In the method of using multiple PV modules, there is a problem that someone who is to install PV systems emphasizes power generation or absorption of electromagnetic waves. As our future research, we will investigate most appropriate installation method including these two elements.

Reference

*1:T.Uno, Finite Difference Time Domain Method for Electromagnetic Field and Antennas, Corona Publishing CO. LTD

*2:Blagovest Shishkov et al, Adaptive Beamforming of ESPAR Antenna –Trends of Studying The Institute of Electronics, Information and Communication Engineers 2001, Japan P.107