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**Transparent Patch Antenna on a-Si Thin Film Glass Solar Module**

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Transparent patch antenna on a-Si thin-film glass solar module


An optically transparent microstrip patch mounted on the surface of a commercially available solar module is proposed. The patch comprises a thin sheet of clear polyester with a conductive coating. The amorphous silicon solar cells in the module are used as both a photovoltaic generator and the antenna ground plane. The proposed structure provides a peak gain of 3.96 dBi in the 3.4–3.8 GHz range without significantly compromising the light transmission in the module. A comparison between copper and transparent conductors is made in terms of antenna and solar performance. The proposed technique is considerably simpler than previous integration approaches.

Introduction: There is increased interest in the integration of antenna and photovoltaic technologies for terrestrial applications owing to the smaller footprint and reduced costs, which improve the economic viability of renewable energy. Various integration arrangements have been reported where the solar cell provided a ground plane function for microstrip antenna elements, but this resulted in a reduced efficiency solar cell owing to partial shading by the opaque antenna [1, 2]. Materials that are both transparent and conductive such as AgHT-4, comprising a clear polyester film coated with nano-layers of metal oxides, have been developed [3].

A number of transparent antennas have been studied which show promising characteristics [4]. Recent work reports lower gain for transparent antennas compared to their copper counterparts; a transparent PIFA fabricated on a sheet of resistivity 20 Ω/sq yielded approximately 10 dB lower gain at 2.4 GHz [5], and a planar monopole UWB antenna on AgHT-4 was reported to have 5 dB lower gain owing to the inherent low conductivity of the transparent film [6].

This Letter presents a novel approach to solar antennas by mounting an optically transparent square microstrip patch made of AgHT-4 film on the surface of a glass covered solar module. This post-manufacture technique considerably simplifies the integration process by placing the radiator on the superstrate of commercially available solar modules. The transparent patch is fed using an electromagnetically-coupled microstrip feedline in a two-layer arrangement of glass-Perspex, which provides improved solar efficiency compared to previous integrated patch approaches and improved gain compared to reported transparent antennas. The AgHT-4 film used for the proposed antenna has a minimum visible light transmission (VLT) of 75% and a sheet resistivity of 4.5 Ω/sq. The arrangement employs the solar module glass as a substrate for the microstrip feedline and an additional Perspex layer is used between the feedline and the transparent patch. The transparent antenna gain, impedance properties and radiation characteristics are evaluated and compared with a copper patch counterpart. Numerical results were obtained using CST MWS.

Results and discussion: Fig. 2 shows the measured and simulated $S_{11}$ for copper and transparent antennas.

Fig. 3 shows the simulated and measured gain for copper and transparent antennas.
with a peak value of 3.96 dBi. The values for the copper patch were better than 3.4 dBi across the band (with a peak of 5.81 dBi). Thus the difference in peak gain is 1.85 dB. The measured E- and H-plane radiation patterns for the centre frequency are shown in Fig. 4. The measured cross-polar rejection is better than −15 dB for both planes. The measured radiation efficiencies were 76% and 50% for the copper and transparent cases.

It is worth mentioning that the copper feedline was replaced by a transparent feedline for the transparent antenna and a peak measured gain of −0.8 dBi was obtained. An early attempt to employ the Solarex panel directly as a single-layer substrate (without Perspex and using copper microstrip feed) for the transparent patch resulted in a peak gain of −2.5 dBi; thus the combination of the Perspex and the proximity coupling are key in improving gain.

The output power of the solar antenna panel was measured while illuminated with a light intensity of 1 kW/m² to compare solar efficiencies of the transparent and copper configurations. The reduction in solar efficiency for each step of integration was found to be as follows: copper transmission line 0.56%, clear Perspex 6.2%, copper patch 6.5% and transparent patch 1.7%. Thus the use of the transparent film improves the solar efficiency by 4.8% when compared with the use of a copper patch.

Conclusions: A novel solar antenna with an integrated transparent radiator has been modelled, fabricated and tested for use in the 3.5 GHz band. The two-layer arrangement of an amorphous silicon solar module and Perspex was used for integration with an electromagnetically-coupled transparent patch antenna. The measured gain values are appropriate for wireless communications and sensor networks. The integration enables a reduced footprint structure.

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References