Letters to the Editor

Corrections to "Computer-Aided Design Models for Broadside-Coupled Striplines and Millimeter-Wave Suspended Substrate Microstrip Lines

P PRAMANICK AND P. BHARTIA

The above paper[1] contains three typographical errors. Equation (2b) should read

$$R=\sqrt{\left(k\frac{b}{S}-1\right)\Big/\left(\frac{1}{k}\frac{b}{S}-1\right)}. \tag{2b}$$

Equation (16) should read

$$\epsilon_{ee}^{st}=\epsilon_{ee}^{s}\left(1+2\frac{\epsilon_{eo}^{st}-\epsilon_{eo}^{s}}{\epsilon_{eo}^{s}}\right) \tag{16}$$

and equation (18d) should be

$$C_{f2}=\frac{1}{\pi}\left\{\frac{2}{1-t/(b+\delta)}\ln\left(\frac{1}{1-t/(b+\delta)}+1\right)-\left(\frac{1}{1-t/(b+\delta)}\right)\ln\left(\frac{1}{(1-t/(b+\delta))^2}-1\right)\right\}. \tag{18d}$$

Additional Comments on "p-i-n Diode Attenuator with Small Phase Shift"

J P STARSKI AND B. M. ALBINSSON

The above paper,[2] by Baeten *et al.*, and the subsequent comments by Lo and Vu [1] were both published considerably later than our work [2]. The work described by Lo and Vu is very similar to our project for an absorptive attenuator with optimized phase response, which was done in 1983 and published in 1984.

Our results for a spurious phase shift with attenuation are repeated by Lo and Vu. Contrary to what is stated by Baeten *et al.* in their reply [3] to Lo and Vu's comments, the solution is not particularly sensitive to frequency.

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[1] P. Bhartia and P. Pramanick, *IEEE Trans. Microwave Theory Tech.*, vol. 36, pp. 1476–1481, Nov. 1988
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[2] R J. Baeten, T. Koryu Ishii, and J. S. Hyde, *IEEE Trans. Microwave Theory Tech.*, vol 36, pp 789–791, Apr. 1988.

Reply[3] by T. B. Vu and K. W. Lo[4]

We thank the Editor of this TRANSACTIONS for having drawn our attention to the work of Starski and Albinsson [2] on the subject of small phase variation associated with p-i-n diode attenuators. For us, it was a great surprise, as prior to receiving the Editor's letter we were completely unaware of their work. The main reason is that our work and the work by Starski and Albinsson were carried out independently at about the same time, and by the time they published their work, we had already completed ours. In addition, we subsequently did not have access to the *Proceedings of the 14th European Microwave Conference*.

Having said that, it is important to note that our work was part of a bigger project, which aimed to steer nulls in the radiation pattern of an antenna array by controlling the current amplitudes only. We required an attenuator with a dynamic range of about 30 dB, but the design described by Ekinge and Hedstrom [4] gave too large a phase variation within this attenuation range, and so a new design was required. As we were dealing with a very narrow bandwidth, we aimed to design a digitally controlled attenuator that would give a minimum phase error over a given attenuation range at a spot frequency. We achieved this objective by finding the optimum spacing between the p-i-n diodes. This work commenced in March 1984 in the form of a final-year undergraduate project and, as mentioned above, was completed before the publication of the work by Starski and Albinsson.

In contrast, Starski and Albinsson were concerned with a relatively wide bandwidth, and they tried to optimize the phase response over both the frequency and attenuation ranges. In other words, they used both attenuation and frequency as parameters in their optimization procedure.

To sum up, although the p-i-n diode configurations look similar, the objectives as well as the methods of optimization are different.

Reply[5] by R. J. Baeten, T. Koryu Ishii, and J. S. Hyde[6]

The work by Starski and Albinsson [2] should not be confused with the work reported in our paper. Their work utilized two p-i-n diodes, two hybrid junctions, and two resistive attenuators. Our work uses only one p-i-n diode and no hybrid junction, and there is no resistive attenuator. Therefore there is no meaningful comparison between the two. These are two different types of attenuators. In [2, fig. 7, p. 513], S_{21} (deg) shows a 32° phase shift with 20 dB attenuation at 5.6 GHz. This means that the phase shift is 1.6°/dB attenuation. This is considerably larger

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