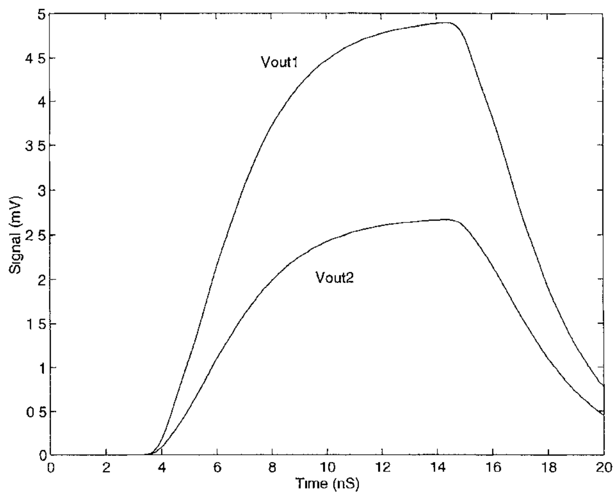

Fig. 3. Vout1 and Vout2 without the 75-Ω input resistors in the cascaded sections.

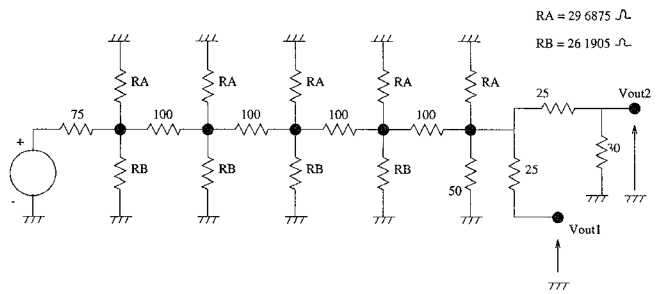

Fig. 4. The dc network including the 75-Ω input resistance

Authors' Reply by S. Lum, M. S. Nakhla, and Q. J. Zhang

Obviously, the steady-state response can be obtained by having all the capacitors open and all the inductors short. The reason that the author of the comment got a different answer from the one presented in our paper is that his calculation did not take into account the 75-Ω input resistance of the cascaded structure As mentioned in our paper, the circuit of Example 1 is obtained by cascading four sections to the circuit of Fig. 3 of our paper. Please note also that we used Fig. 2 to symbolically identify the connection points between the cascaded sections, the output ports, and some of the components which were used later in our paper in the sensitivity analysis comparison. Fig. 2 of our paper was not meant to be used to give the details of the individual cascaded sections. These details are given clearly in Fig. 3 of our paper.

For numerical verification, we repeated our analysis with and without the 75-Ω resistance in the cascaded sections. The following is a summary of the results:

- Fig. 3 (of this reply) shows the output waveforms obtained without the 75-Ω. The peak voltages for V_{out1} and V_{out2} match very well the dc calculations done in our paper.
- Fig. 4 (of this reply) shows the dc network including the 75 Ω. The output voltages calculated using the dc network are $V_{out1} = 0.1159$ mV and $V_{out2} = 0.0632$ mV, which match the peak values of the waveforms reported in our paper.

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Comments on "Measurement of the Microwave Conductivity of a Polymeric Material with Potential Applications in Absorbers and Shielding"

Wen-Pin Liao and Fu-Lai Chu

In Fig. 5, Fig. 7, and Fig. 8 of the above paper,[1] Naishadham and Kadaba have demonstrated the utilization of polyacetylene and PBT conductive polymers as single-layer, double-layer electric Salisbury screen and EMI shield. However, some inconsistencies were found between the calculated results and the assumptions stated in the paper.

As indicated in the paper[1], a comparison between the measured results of dc and microwave conductivities indicates that the microwave conductivity at room temperature is within a small percentage of the dc result and can be used for a wide frequency range. Therefore, the conductivity of the polymers given by $\sigma = 2\pi f_0 \epsilon_0 \epsilon''$ is assumed invariant for all frequencies. Based on this assumption, the shielding effectiveness as a function of frequency for 64-mil-thick free-standing films of polyacetylene and PBT is recalculated and is shown in Fig. 1. Apparent discrepancy is found by comparing it with Fig. 8 of the above paper[1]. It is interesting to find that the shielding effectiveness based on the invariability of ϵ'' for all frequencies determined from the measured results, $\epsilon^* = \epsilon' - j\epsilon'' = 5.1 - j607$ for polyacetylene at 8.895 GHz and $\epsilon^* = 3.0 - j838$ for PBT at 9.89 GHz, shown in Fig. 1, agrees completely with Fig. 8 of the above paper[1]. It is concluded that shielding effectiveness in Fig. 8 of the above paper[1] is under the assumption of frequency invariance of ϵ'' instead of σ.

On the other hand, for the return loss of a single-layer electric Salisbury screen comprising resistive sheets of polyacetylene or PBT, shown in Fig. 5 of the above paper[1], the calculation differences based on the invariability of σ and on the invariability of ϵ'' for all frequencies are insignificant.

For the return loss of a double-layer electric Salisbury screen shown in Fig. 7 of the above paper[1], the recalculation based on the invariability of σ for all frequencies is shown as trace (a) in Fig. 2, which agrees with the comment given by du Toit [1]. The return loss under the assumption of frequency invariant ϵ'' is shown

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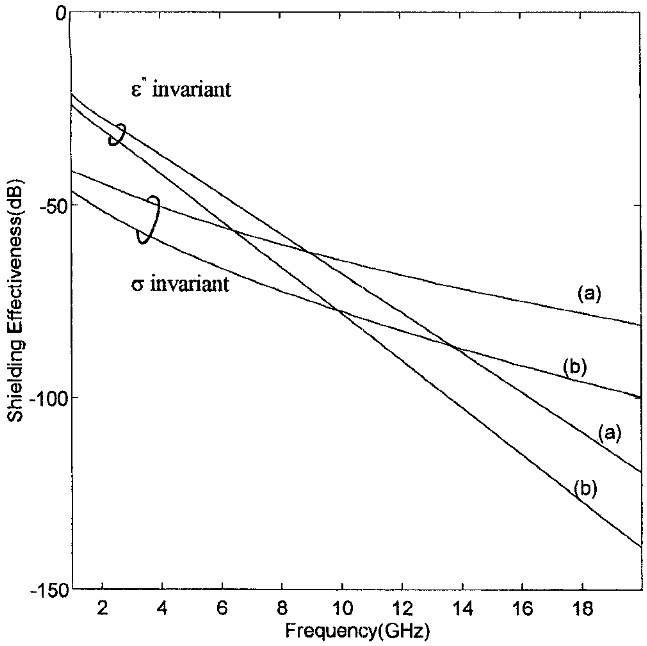

Fig. 1. Shielding effectiveness for a 64-mil-thick free-standing film of (a) polyacetylene and (b) PBT under the assumption that σ and ϵ'' are invariant for all frequencies.

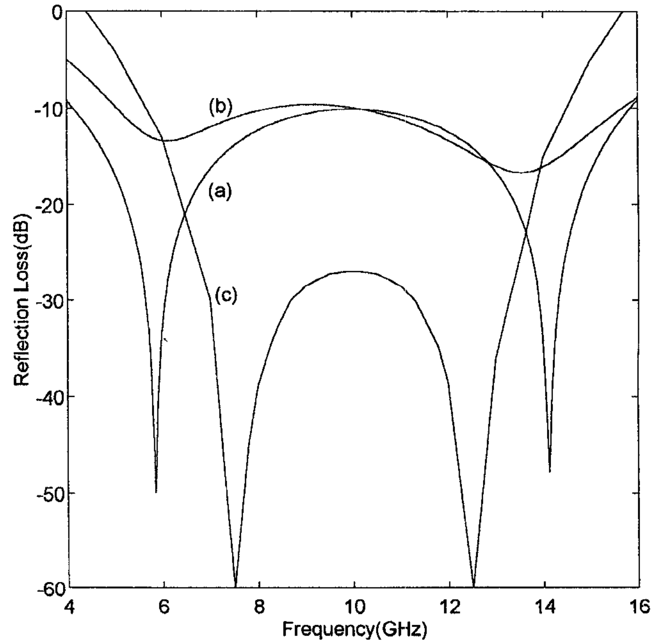

Fig. 2. Return loss of a double-layer electric Salisbury screen with the same conditions given in Fig. 7 of the paper, replotted as trace (c), is neither under the assumption of frequency invariant σ [(trace (a)) nor frequency invariant ϵ'' (trace (b))].

as trace (b) in Fig. 2, while the result of the paper replotted as trace (c) is neither under the σ invariant nor under the ϵ'' invariant assumption.

Authors' Reply by Krishna Naishadham and Prasad K. Kadaba

As correctly pointed out by Liao and Chu, based on the small difference between measured dc and microwave conductivities of PBT and polyacetylene thin (polymer) films, we have assumed in the above paper[1] that the measured conductivity is independent of frequency. Let the microwave conductivity at the measured cavity resonant frequency f_0 be denoted as σ_0. If this conductivity is assumed to be invariant with frequency f, then the imaginary part of the dielectric constant, ϵ'', may be written as

$$\epsilon'' = \frac{\sigma_0}{2\pi f \epsilon_0} \quad (1)$$

where ϵ_0 is the permittivity of free space. On the other hand, if ϵ'' is assumed to be frequency invariant, then the conductivity changes with frequency as

$$\sigma = 2\pi f \epsilon_0 \epsilon''. \quad (2)$$

Our calculation of shielding effectiveness of free-standing polymer films (Fig. 8 in the above paper[1]), and return loss of single- (Figs. 5 and 6 in the above paper[1]) and double-layer (Fig. 7 in the above paper[1]) Jauman absorbers, employed a frequency-invariant ϵ'', contrary to our prior assumption on frequency-invariant conductivity. We appreciate Liao and Chu for bringing this inconsistency to our attention. It seems that absorption calculations based on constant conductivity are more common than those based on constant dielectric loss, in the design of microwave absorbers [1]. We have resimulated the design examples on plane wave shielding and Jauman absorbers from the above paper,[1] under the frequency-invariant conductivity assumption, and obtained results identical to the corresponding graphs above; hence, the reader is referred above for the modified graphs.

We note that our calculations in the above paper[1] for single-layer polymeric absorbers are indistinguishable from the corresponding constant conductivity results. However, there is a significant difference between these two results for a double-layer absorber. In order to be consistent with our frequency-invariant conductivity assumption, Fig. 7 in the above paper[1] should be replaced by the curve (a) in Fig. 2. The two reflection zeros occur at 5.864 GHz and 14.136 GHz, symmetrically around the desired center frequency of 10 GHz, and the maximum reflection loss is about -10 dB. The surface resistivities of conductive sheets are unchanged from the above paper.[1] We have used a Fletcher–Powell optimization routine to synthesize the Jauman absorber in the above paper,[1] based on constant ϵ''. It appears that the curve labeled (c) is an incorrect termination of the optimization algorithm. For the given values of the surface resistivities, we acknowledge that the disposition of curve (b) corresponds to frequency-invariant ϵ''.

It is emphasized that the focus of the above paper[1] is on the microwave characterization of novel conductive polymers, and not on their applications. The paper discusses a new technique to eliminate the uncertainty in estimating the sample depolarization factor in the characterization of thin conductive films by the cavity perturbation method. The application examples have been presented only to illustrate the potential utility of the polymers.

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