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SHORT COMMUNICATION
Functional Adjustment of DLA Networks

P. L. MORAN, N. ABDULLAH BIN N. ISMAIL and P. K. MAJITHIA
Department of Electronic and Electrical Engineering, University of Technology, Loughborough, Leicestershire, U.K.

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Much has been written over the past few years concerning active filters and there are now several ways of designing high performance filters. Many of the theories and techniques are concerned with producing circuits that can be trimmed by resistor adjustment alone and by combining these theories with hybrid technology, miniature high performance modules may be constructed. However, one of the more important applications for active filters is relatively low performance lowpass filters for which the cost must be minimised. When using conventional discrete component circuits and linear amplifiers, it is often found that the capacitors are a significant component cost.

One very neat way to produce low cost filters is to use a distributed-lumped-active (DLA) network[1,2,3] for which the low pass circuit is shown in Figure 1. Assuming a perfect distributed network, the transmission function of this circuit is:[3,4]

$$T(s) = [K/(1-K)]/(K/(1-K) + \cosh(\theta)) \qquad (1)$$

where

$$\theta = \sqrt{sCR} \qquad (2)$$

It is relatively easy to show that the poles of this network P_n are given by:

$$P_n = \frac{\alpha^2 - \pi^2(1+2n)^2}{RC} \pm \frac{i2\pi\alpha(1+2n)}{RC} \quad n = 0,1,2\ldots \qquad (3)$$

$$\text{where } \cosh\alpha = \frac{K}{1-K} \qquad (4)$$

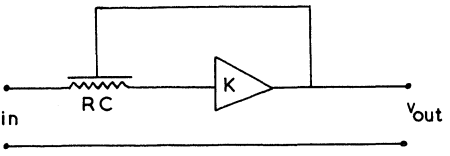

FIGURE 1 D.L.A. lowpass circuit.

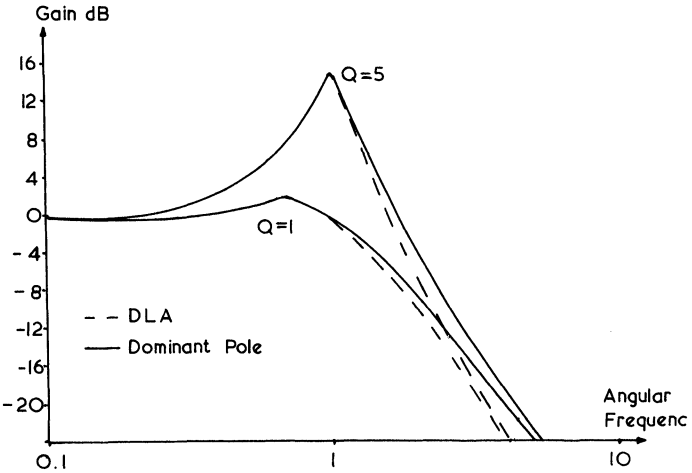

FIGURE 2 Comparison between amplitude of D.L.A. transmission function and the equivalent dominant pole transmission function.

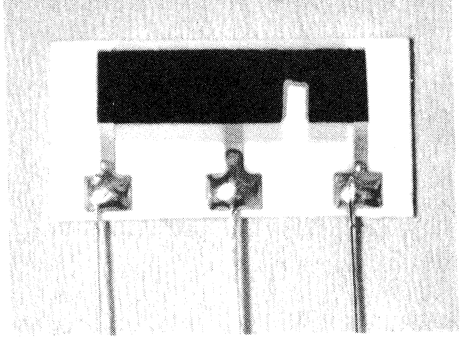

FIGURE 3 Abraded D.L.A. network. (Substrate size 1″ x ½″.)

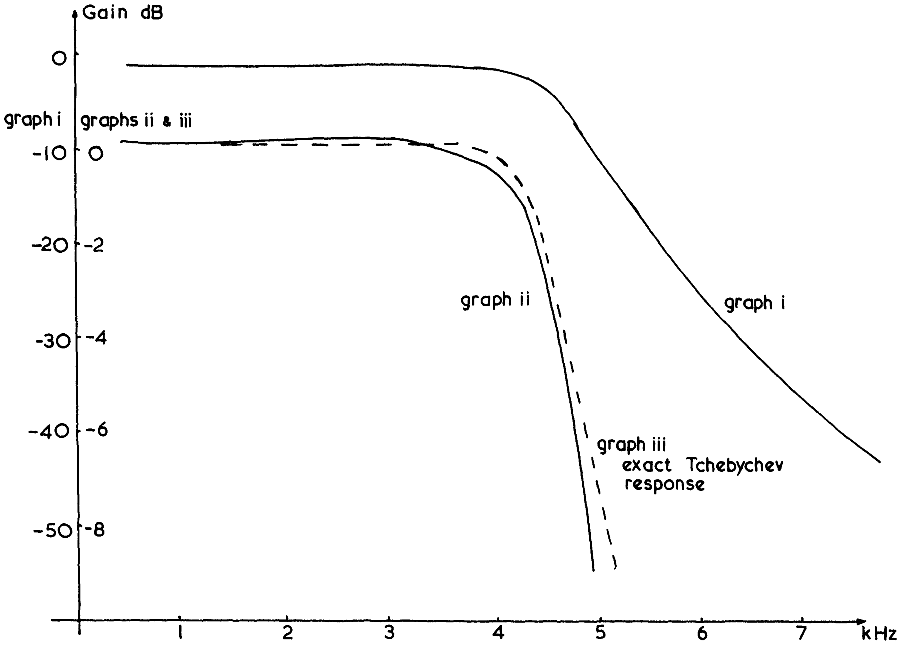

FIGURE 4 Measured response of a cascade of three D.L.A. networks adjusted to approximate to a 0.01 dB 6 pole Tchebychev function.

By letting $n = 0$, a pole pair is obtained whose DLA parameters are given by:

$$\alpha = \pi\sqrt{(2Q-1)/(2Q+1)} \qquad (5)$$

$$K = \cosh(\alpha)/(\cosh(\alpha)+1) \qquad (6)$$

$$RC = (\alpha^2+\pi^2)/\omega_n \qquad (7)$$

$$\text{d.c. gain} = K \qquad (8)$$

In Figure 2 we plot the comparison between the amplitude of the transfer function for the DLA network and that obtained using the equivalent dominant pole with ω_n normalised to unity. It can be seen that up to $\omega \sim \omega_n$ there is little difference between the two networks and that for $\omega \gg \omega_n$ the distributed network cuts off much more sharply (as would be expected from an infinite pole system).

We have investigated therefore the possibility of manufacturing DLA networks using thick film technology. By using gold (ESL 8835–1B) for the ground plane, three layers of dielectric (ESL 4901–H) and a nominal 100 kohm per square resistor paste (ESL 2915)† we have managed to construct RC distributed networks with performance close to the ideal. We found it necessary to fire each layer at a progressively lower temperature, starting with 950°C for the gold and finishing with 825°C for the resistor.

As noted by Wyndrum,[2] the major problem with DLA networks is that of post manufacture adjustment. We have therefore investigated abrading the network and have demonstrated practically and theoretically[5,6] that as far as the dominant pole is concerned functional adjustment is possible.‡ A photograph of an abraded network is shown in Figure 3. To verify that these networks do in fact allow low pass filters to be constructed we have produced a prototype based upon a 0.01 dB ripple 6 pole Tchebychev function for which the response is shown in Figure 4. To compensate for the drop in gain for $\omega > \omega_n$ the stages with a higher ω_n have a slightly higher Q than the design value. Our adjustment technique for each stage is accurate to within ±0.1 dB and the overall filter has an inband ripple of less than ±0.15 dB.

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† The total resistance between the terminals was approx. 1 Mohm.

‡ The value of K required is no longer given by Eq. (6).

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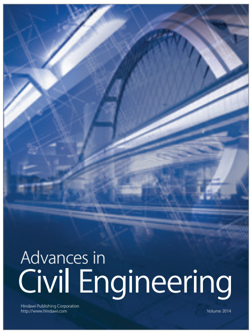
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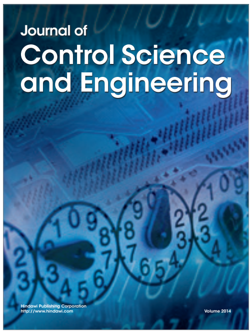
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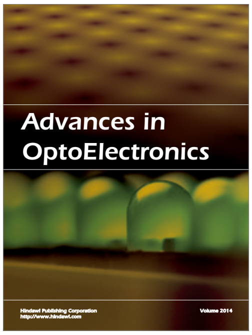
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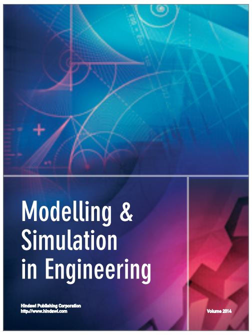
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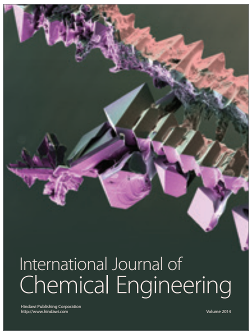
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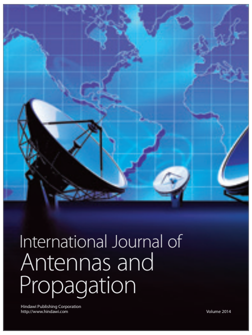
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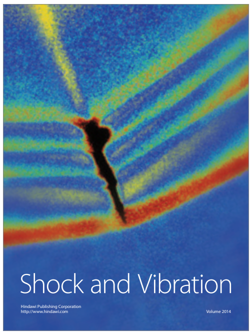
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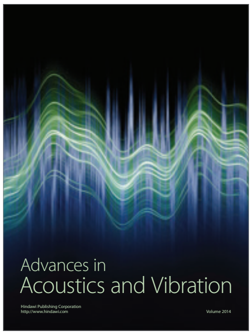
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