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SOME USEFUL DESIGN PARAMETERS OF NON-UNIFORM INTEGRATED BAND-PASS FILTERS

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Important design parameters for a two-port three-terminal band-pass filter configuration of the integrated thin-film exponential distributed parameter R-C-KR microstructure are presented. The circuit exhibits load independent characteristics. The changes in the value of design parameters under varying loading conditions are given. Various plots illustrating the inter-relationship of the different parameters with each other that can serve as guidelines for a system designer to obtain a pre-assigned pattern of the performance characteristics of the microstructure are included.

1. INTRODUCTION

The paper presents a set of performance characteristics suitable for use as design curves for a two-port three terminal subnetwork configuration of the non-uniform distributed parameter (n.u.d.p) R-C-KR microsystem. The study is also extended to show the behaviour of the band-pass characteristics under varying loading conditions. The R-C-KR microstructure, which forms the mathematical model of a thin-film microsystem (Figure 1), consists of two thin-film resistors whose per-unit length (p.u.l) series impedances are $R = R_o \exp(kx)$ and KR respectively, separated from each other by a dielectric film of p.u.l shunt capacitance $C = C_o \exp(-kx)$, where the constants R_o and C_o are resistive and capacitive constant respectively, k is the exponential taper constant and K is the ratio of the resistivity of one layer to that of another layer. Here l is the length of the films (represented by distance variable x).

2. DISCUSSION

The open circuit and loaded voltage ratio transfer functions (T_{vo} and T_{vl}) of Figure 2 obtained from the four-terminal exponential R-C-KR microstructure, are given in terms of their matrix parameter functions (m.p.f's)[1] as:-

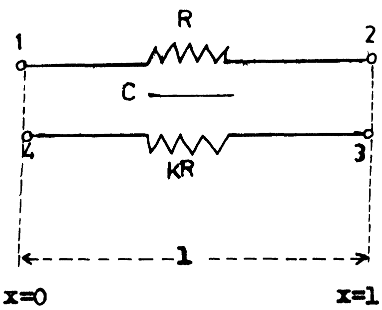

FIGURE 1 Symbolic representation of R–C–KR micro-structure.

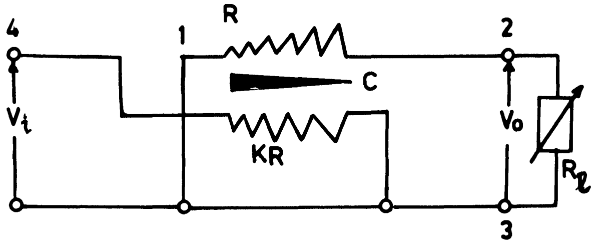

FIGURE 2 Subnetwork under analysis.

$$T_{vo} = \frac{y/W - (1+K)a}{(1+K)g + Ky/W}$$

$$T_{vl} = \frac{y/W - (1+K)a}{(1+K)g + Ky/W + (1+K)y/R_l}$$

where

$$g = m\cosh(ml) + k/2\sinh(ml)$$
$$y = (1+K)R_o\sinh(ml)\exp(kl)$$
$$a = m\exp(0.5\,kl)$$

and

$$R_L = R_o/R_l$$

where R_l is the value of the resistive loading.

Also

$$W = R_t = \int_o^1 R_o\exp(kx) = R_o\frac{e^{kl}-1}{k}$$

and

$$m = [(k/2)^2 + ju(1+K)]^{1/2} \text{ with } u = w R_o C_o$$

The normalised frequency u_t is given by:-

$$u_t = w R_t C_t \text{ where } C_t = \int_o^1 C_o\exp(-kx) = \frac{C_o}{k}(1-e^{-kl})$$

Various design parameters of the above subnetwork have been computed for different combinations of l, k and K under varying loading conditions as shown in the following figures (Figs. 3 - 7).

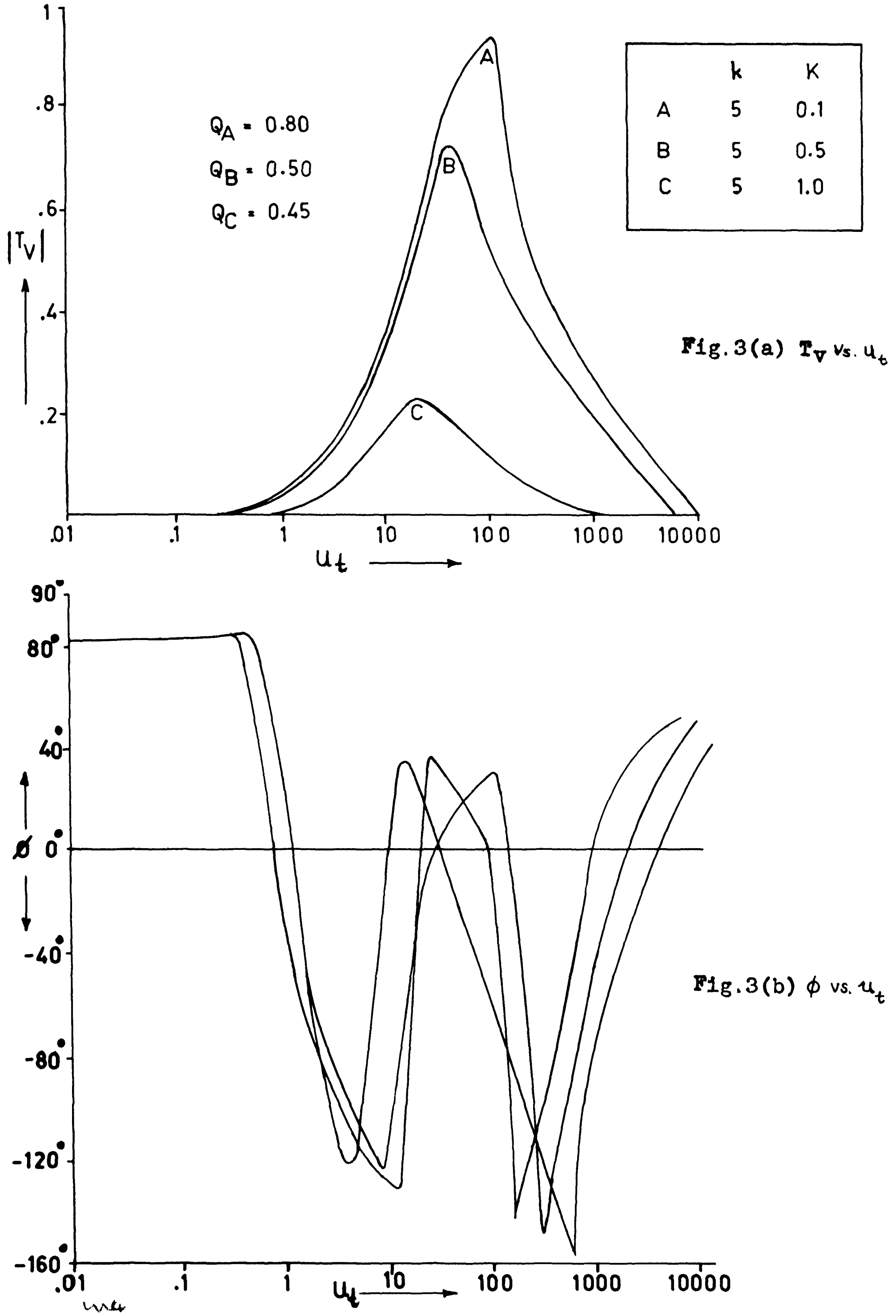

FIGURE 3 Characteristics of the subnetwork without load for various values of k and K.

The results show that the pass-band may be shifted from a higher to a lower frequency region by increasing K. The centre frequency u_{c0} and bandwidth (b.w.) of the pass-band can be controlled according to the system designer's requirement by properly selecting the value of k and K as shown in Figure 3(a). The quality factor, Q, for both the loaded and unloaded configuration has been calculated and shown on the figures (Figures 3(a)

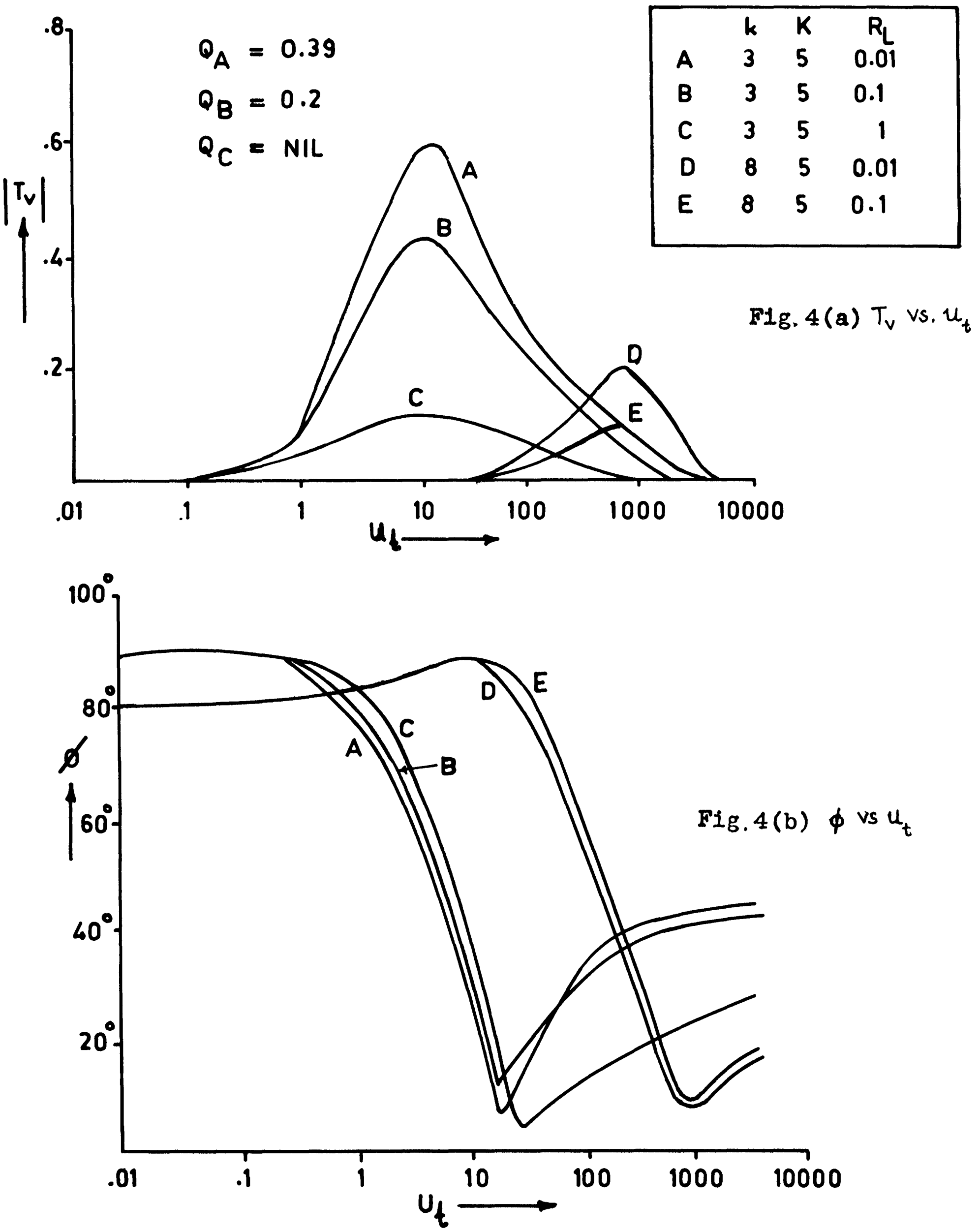

FIGURE 4 Characteristics of the subnetwork with load for various values of k, K and R_L.

and 4(a)). It is evident that the subnetwork without load gives a better Q for k = 5.0 and K = 0.1 as shown in Figure 3(a). Further it can be shown that the subnetwork gives a poor, almost negligible, characteristic for negative values of k. Figure 4 presents the design curves that show the effect of load on such a filter. It is observed that for given values of k and K and with varying load R_l, the pass-band remains the same. This means that the subnetwork is independent of load (which can be seen from Figure 6). The phase angle, ϕ, is minimum (in the vicinity of zero) for the centre frequency u_{c0} of the pass-band in both loaded and unloaded conditions (Figures 3(b) and 4(b).

Figure 5 gives the variations in $|T_{v0}|$ and u_t versus K for k = 8.0 and l = 1.0. It is clear that there is a small increase in T_v as K decreases from 10 to 6, while $|T_v|$ increases rapidly for values of K, less than 2. Similarly the normalised frequency, u_t, increases rapidly from 500 to 1000 for $0.1 \leqslant K \leqslant 1$. The most important observation here is that there is a slow variation in the lower 3 db cut-off frequency, u_{c1}, for $0.1 \leqslant K \leqslant 1$.

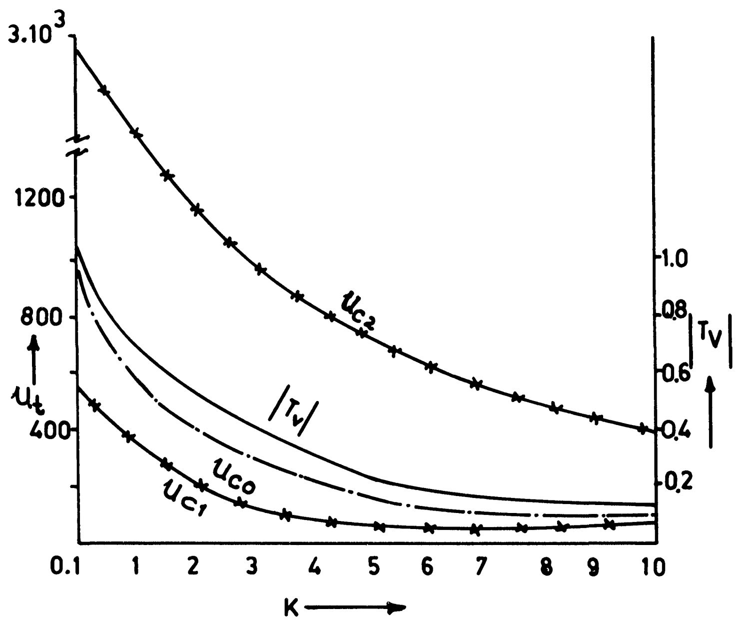

FIGURE 5 Variation of u_t and $|T_v|$ vs. K.

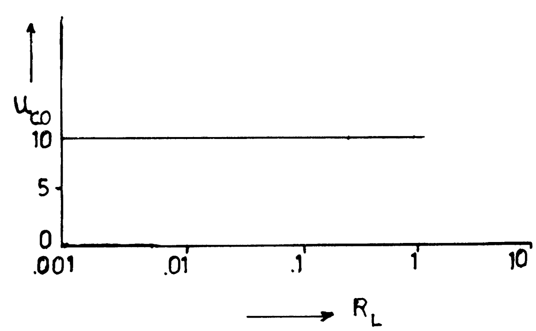

FIGURE 6 Variation of u_{c0} vs. R

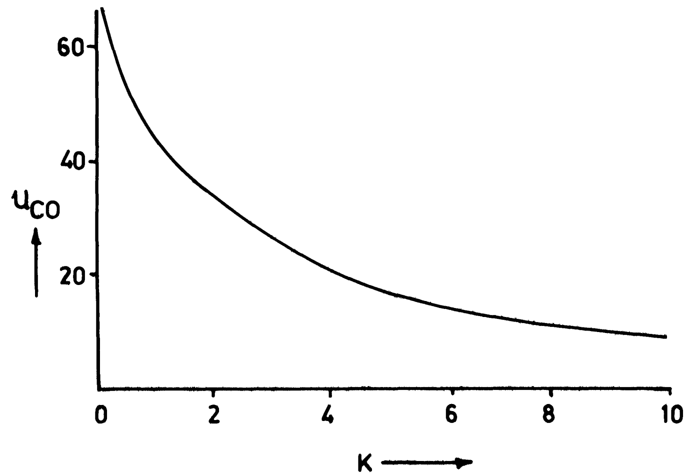

FIGURE 7 Variation of u_{co} vs. K for k = 4.0.

However the upper 3 db cut-off frequency, u_{c2}, moves rapidly towards the higher frequency region for the same change in value of K. Variations of the centre frequency of the pass-band as a function of K for a given value of k are shown in Figure 7. It is found that there is a sharp variation in u_{co} for $0.1 \leqslant K \leqslant 1$, while for higher K, it shows a smooth variation.

These design data are equally applicable to other subnetworks of similar transfer functions in the C-R-KC microsystem.[2] Another subnetwork of similar characteristics has already been reported.[3] Important design parameters of the same subnetwork in a uniform configuration are to be reported shortly.

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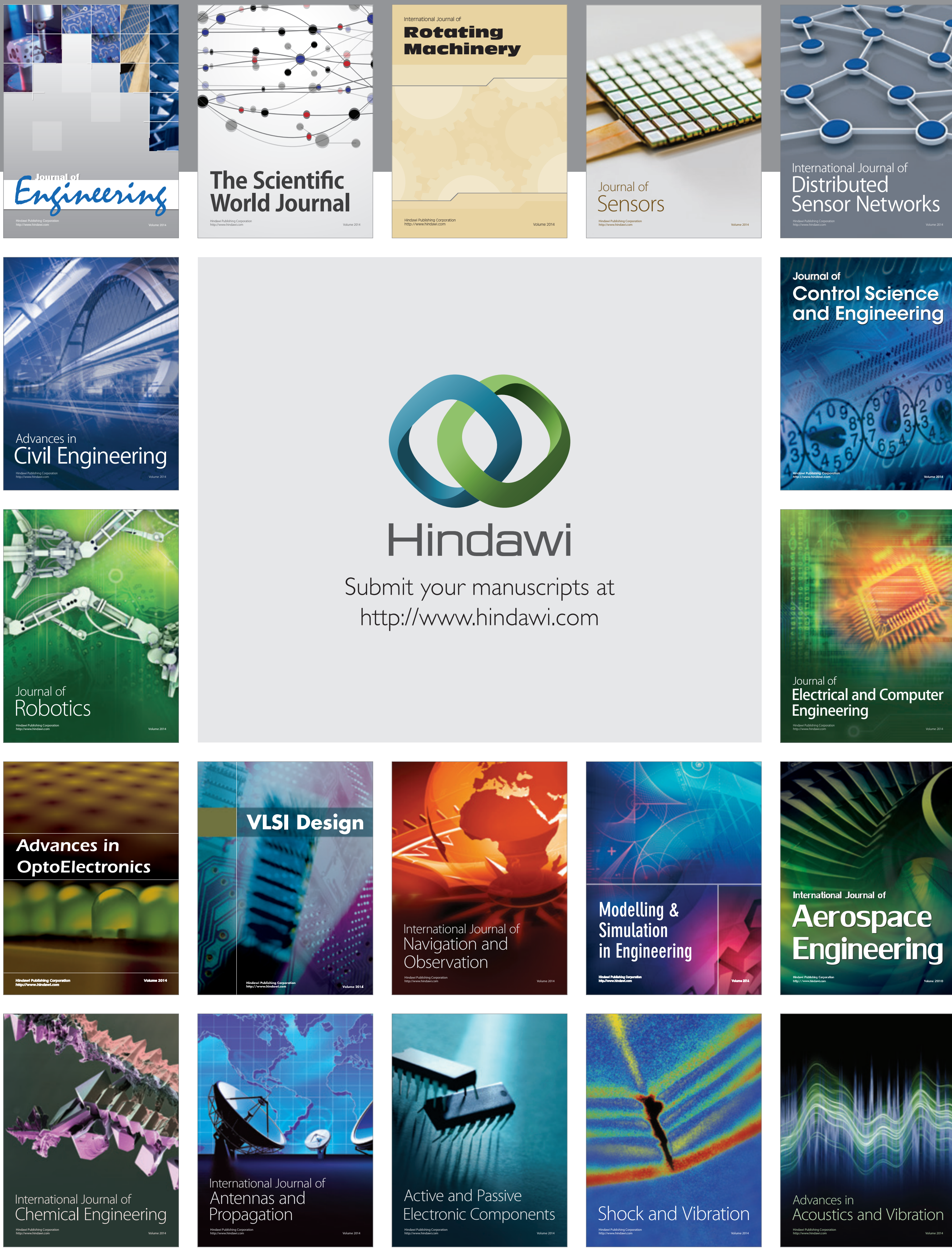

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