Higher-order elliptic filter design

High-speed, current-feedback op-amps such as the *Burr-Brown OP603* make it possible to design active filters working in the megahertz range of frequencies.

Presented here is a quick method of calculating elliptic filters of any order, the example shown being a fifth-order type which is considered as being in two sections, as shown in **Fig. 1**.

Assume the poles $s=\alpha+j\beta$ and zeros Ω are given for a filter having the reflection factor of ρ and modulus α_0.

Design can proceed in three steps. Assume ρ=20% and $\alpha_0=20°$:

$\Omega_2=3.0653$ $s_{1,2}=0.382271\pm j0.67123$
$\Omega_4=4.8753$ $s_3=\gamma=0.49308$
$s_{4,5}=0.13647\pm j1.05129$.

1. If you calculate the constants A_1 and A_2 using the expressions,

$A_1=2\alpha A_2$ and $A_2=1/(\alpha^2+\beta^2)$, then for a third-order filter,

$A_2=1.6759379$ and $A_1=1.2813249$

and for a second-order filter,

$A_2=0.88918$ and $A_1=0.242865$.

2. Calculate normalised capacitances using the expressions in Fig. 1.

3rd-order

$c=1/\Omega_2=0.326232$
$c_1=2.40551$
$c_2=2.02807$
$k=0.134956$

and for a second-order filter,

$c'=1/\Omega_4=0.205116$
$c_1'=2.06648$
$k'=0.087087$.

3. For physical capacitance values, multiply the above c values by a factor of $1/2\pi f_0 R$, where f_0 is the cut-off frequency and R the reference resistance. In the case shown here, f_0 = 1MHz and R = 200Ω.

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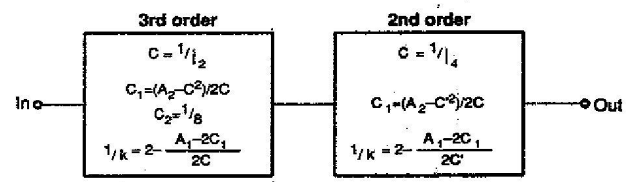

***Fig. 1.** Decomposition into third and second-order sections and formulas.*

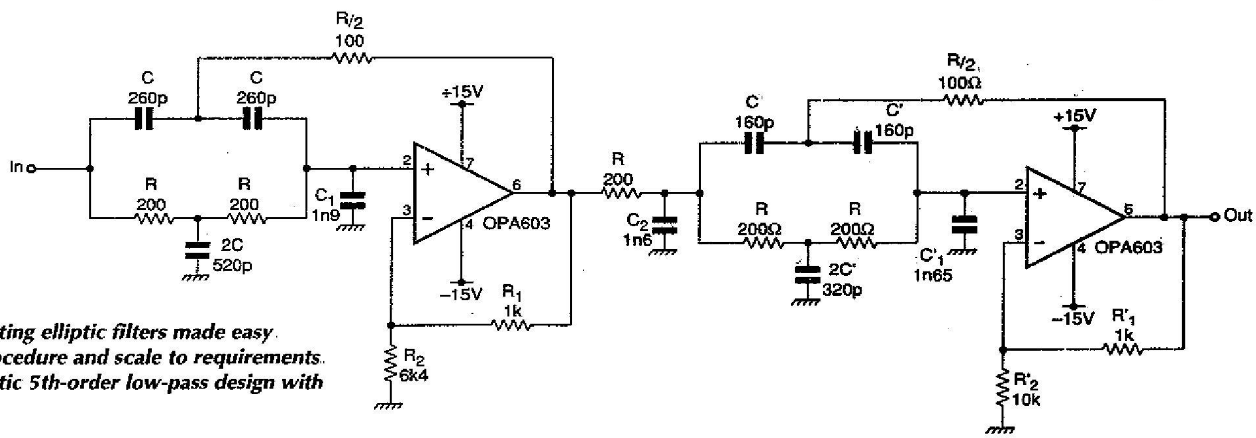

***Fig. 2.** Calculating elliptic filters made easy. Follow the procedure and scale to requirements. This is an elliptic 5th-order low-pass design with 1MHz cut-off.*

Current-dependent rectifier or doubler

This bridge rectifier becomes a voltage doubler at low currents, reverting to normality when current drain increases.

It is essentially a bridge rectifier with the extra capacitors C. When no current is taken, output voltage is twice that at the input and, as current increases, internal impedance causes the output to fall linearly according to $Z_{int}=1/(2Cf)$, assuming ideal components, until the output voltage equals the peak ac, when the circuit becomes an ordinary bridge rectifier.

An application is as a rectifier for lead-acid battery charging, in which a high voltage (25-30V) is needed to drive a small current into a 12V battery that has been discharged for a period and has an isolating layer on the electrodes. As current increases, a lower output from the rectifier reduces dissipation in the charger's output transistor.

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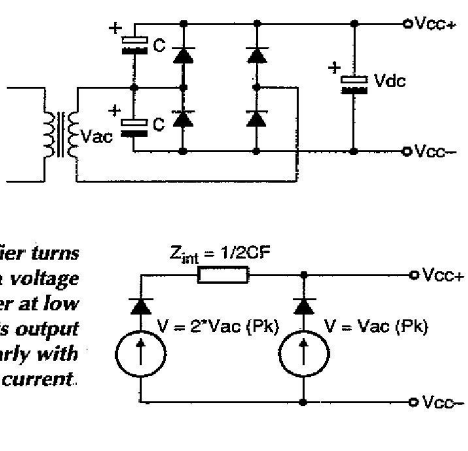

Bridge rectifier turns into a voltage doubler at low currents, its output falling linearly with increasing current.