

# OTA multiplier converts to two-quadrant divider

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An inexpensive two-quadrant divider that is useful in tunable and tracking filters and special-purpose modulators and demodulators may be built using an operational transconductance amplifier (see figure). This circuit is based upon a multiplier circuit by W. G. Jung<sup>1</sup>.

The desired circuit response is achieved by placing the CA3080 multiplier within the feedback loop of the 308 comparator. This method implements the divider function more easily than—and just as accurately as—the logarithmic and antilog converters often employed.

The transfer function of the circuit is given by:

$$V_{out}/V_{in} = -(1+k)/kR_2g_m = -[2(1+k)V_T/kR_2I_B]$$

where  $k$  = the resistance scaling ratio and  $g_m = I_B/2V_T$  for the CA3080.  $V_T$  is the thermal voltage (26 millivolts

at 23°C). The divider gain is thus inversely proportional to the input bias current,  $I_B$ . The plot in the figure shows the divider's nearly ideal response. Gain measurements were made with a selective voltmeter having a bandwidth of 10 hertz (HP 3581C) to eliminate noise effects—the circuit's linearity extends over five decades.

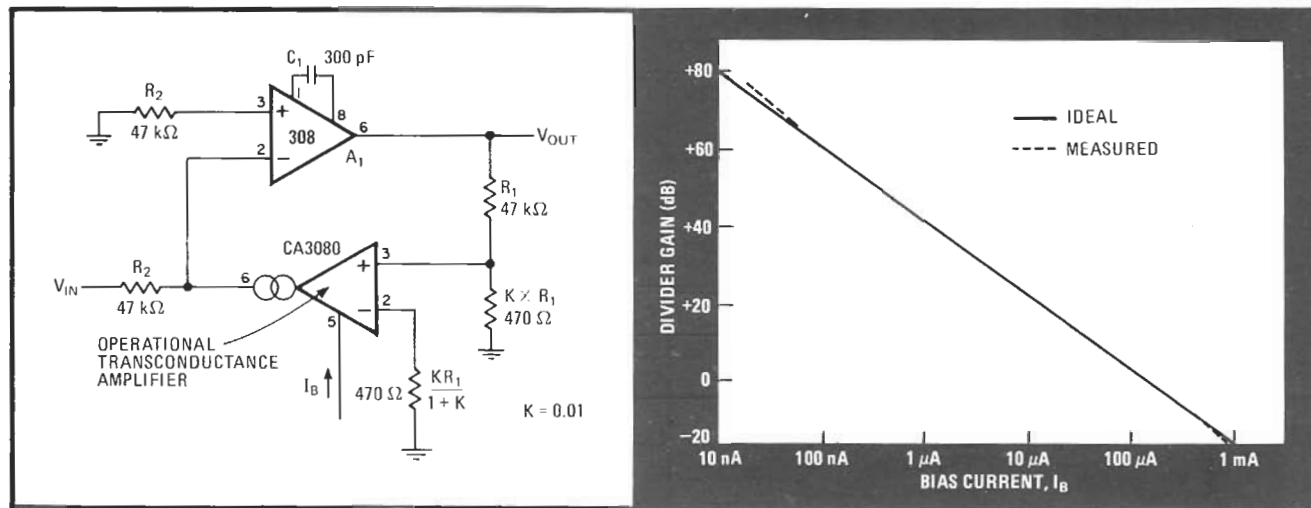
The offset of the 308 is also amplified as the circuit's bias current is reduced. Thus,  $I_B$ 's lower limit should be around 20 nanoamperes. Also, the compensating capacitor must be at least equal to  $A_{max} \times 30$  picofarads, where  $A_{max}$  is the maximum attenuation given by the divider circuit. The circuit uses a 300-pF capacitor because the maximum attenuation is 20 decibels.

The circuit's response to temperature variations is minimal, but in critical applications compensation is necessary for  $V_T$ . A temperature-compensating resistor having a thermal coefficient of 0.33% per °C for the resistor value  $kR_1$  is used in this instance. □

## References

1. W. G. Jung, "Get gain control of 80 to 100 dB," *Electronic Design*, June 21, 1974, pp. 94-99.

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**Inverse.** A basic two-chip multiplier is easily transformed into a two-quadrant divider by the appropriate feedback. This scheme is simpler, no less accurate, and less costly than those using log and antilog converters. Circuit linearity extends to five decades of control current,  $I_B$ . Except for the most critical applications, temperature compensation is not required.