Under this condition, generation cannot keep up with the fast drift process, and the steady-state condition of Eq. 6 no longer holds. This condition results in the space-charge effect. At such a high field, the gain is degraded and it approaches unity again.

Next, consider an intensity-modulated optical signal given by

$$P(\omega) = P_{opt}[1 + m\exp(j\omega t)] \tag{12}$$

where P_{opt} is the average optical-signal power, m the modulation index, and ω the modulation frequency. The average current I_p resulting from the optical signal is given by Eq. 9. For the modulated optical signal, the rms optical power is $mP_{opt}/\sqrt{2}$ and the rms signal current can be written as[4]

$$i_p \approx \left(\frac{q\eta m P_{opt} G_a}{\sqrt{2}h\nu}\right)\frac{1}{\sqrt{1+\omega^2\tau^2}}. \tag{13}$$

At low frequencies, this reduces to Eq. 9. At high frequencies, the response is proportional to $1/f$.

Figure 4 shows an RF equivalent circuit for a photoconductor. The conductance G consists of the contributions from the dark current, the average signal current, and the background current. The thermal noise resulting from the conductance G is given by

$$\langle i_G^2\rangle = 4kTGB \tag{14}$$

where B is the bandwidth. The generation-recombination noise (shot noise) is given by[5]

$$\langle i_{GR}^2\rangle = \frac{4qI_pBG_a}{1+\omega^2\tau^2} \tag{15}$$

where I_p is the steady-state light-induced output current. The signal-to-noise ratio can be obtained from Eqs. 13–15:

$$\left.\frac{S}{N}\right|_{power} = \frac{i_p^2}{\langle i_{GR}^2\rangle + \langle i_G^2\rangle} = \frac{\eta m^2(P_{opt}/h\nu)}{8B}\left[1 + \frac{kT}{qG_a}(1+\omega^2\tau^2)\frac{G}{I_p}\right]^{-1}. \tag{16}$$

One can obtain the NEP (i.e., $mP_{opt}/\sqrt{2}$) from Eq. 16 by setting $S/N = 1$ and $B = 1$. For infrared detectors the most used figure of merit is the detectivity D^* which has been defined by Eq. 4.

The photoconductor is attractive for its simple structure, low cost, and rugged features. Extrinsic photoconductors can extend the long-wavelength limit without using materials of very narrow energy gap, and they are commonly used as infrared photodetectors. For mid-infrared to far-infrared and longer wavelengths, the photoconduc-

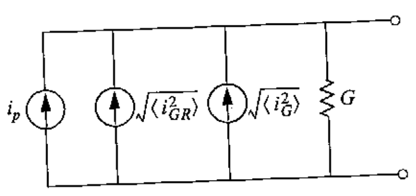

Fig. 4 RF equivalent circuit of photoconductor. (After Ref. 4.)