7.4.1 Noise Bandwidth

Consider that white noise is present at the input to a receiver and a filter with transfer function $H(f)$ centered at f_0, such as is indicated by the solid plot of Fig. 7.9, is being used to restrict the noise power actually passed on to the receiver. Now contemplate a rectangular filter as shown by the dotted plot in Fig. 7.9. This filter is also centered at f_0. Let the rectangular filter bandwidth B_N be adjusted so that the real filter and the rectangular filter transmit the same noise power. Then the bandwidth B_N is called the *noise bandwidth* of the real filter. The noise bandwidth, then, is the bandwidth of an idealized (rectangular) filter which passes the same noise power as does the real filter.

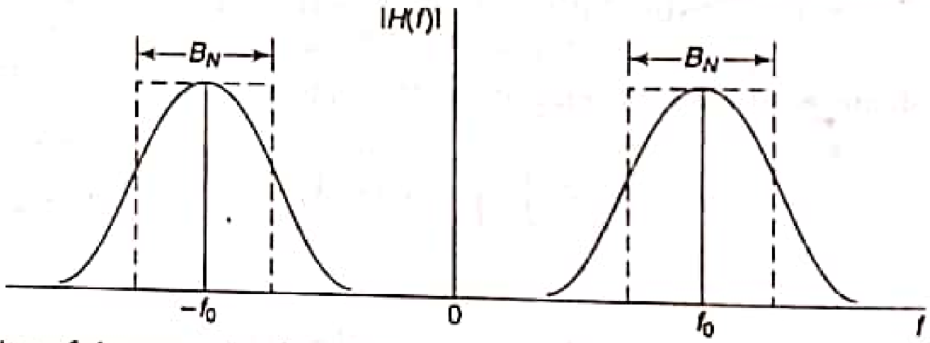

Fig. 7.9 *Illustration of the noise bandwidth of a filter.*

We illustrate the concept of noise bandwidth by considering the case of the low-pass RC filter with transfer function as given by Eq. (7.48). For this filter, $H(f)$ attains its maximum value $H(f) = 1$ at $f = 0$. As given by Eq. (7.52), with white-noise input of power spectral density $\eta/2$, the noise output of the filter is

$$N_o(RC) = \frac{\pi}{2}\eta f_c \tag{7.75}$$

In the presence of such noise, a rectangular low-pass filter with $H(f) = 1$ over its bandpass B_N would yield an output-noise power

$$N_o(\text{rectangular}) = \frac{\eta}{2}\,2B_N = \eta B_N \tag{7.76}$$

Setting $N_o\,(RC) = N_o$ (rectangular), we find the noise bandwidth to be

$$B_N = \frac{\pi}{2} f_c \tag{7.77}$$

Thus, the noise bandwidth of the RC filter is $\pi/2$ (= 1.57) times its 3 dB bandwidth f_c.