second lower threshold v_l to improve the probability of triggering around the vector 45° phase regions. The dual threshold implementation also detects when both x and y components together exceed the second lower threshold by means of a further set of four comparators. This second threshold decision is OR'ed with the higher-level threshold circuit to provide a combined detection function. The choice of second threshold value can be optimized to take advantage of particular signal + noise statistics. If the second threshold $v_l = 0.7v_t$, the noise-free variation in triggering sensitivity drops from 3 to 1.8 dB, with again somewhat less variation observed when realistic noise levels are present. The dual threshold triggering probability under noisy conditions is now calculated from

$$\begin{aligned} p_{DB}(\theta, v_s, v_t, v_l) = {} & p(|v_x| > v_t) + p(|v_y| > v_t) + p(|v_x| > v_l)p(|v_y| > v_l) \\ & - p(|v_x| > v_l)p(|v_y| > v_t) - p(|v_x| > v_t)p(|v_y| > v_l) \end{aligned} \tag{6.21}$$

When there is partial correlation between the noise elements of the vector components, this must be taken into account for better accuracy in modeling of angle dependent vector thresholding. The effect of partial noise correlation is demonstrated in the next section, that describes the greatest-sum, vector modulus approximation algorithm.

6.6.3 Greatest Sum Threshold

The basis of this technique is to generate two partial sums of the orthogonal components, $v_x + k\,v_y$ and $v_y + k\,v_x$, and choosing the largest as the closest vector modulus approximation. With no added noise, and $k = \sqrt{2} - 1$, the approximation varies over the sensitivity range 1:1.08 or 0.7 dB. Let the in-phase and quadrature signal-to-noise voltage ratios be v_s/σ_i and v_s/σ_q, respectively; then the x and y vector components can be written as

$$\begin{aligned} v_x &= v_s \cos(\theta) + \sqrt{(\sigma_i^2 - \sigma_q^2)\cos^2(\theta) + \sigma_q^2} \\ v_y &= v_s \sin(\theta) + \sqrt{(\sigma_i^2 - \sigma_q^2)\sin^2(\theta) + \sigma_q^2} \end{aligned} \tag{6.22}$$

The vector modulus approximation is $v_a = v_x + k\,v_y$ when $v_x > v_y$, or $v_b = v_y + k\,v_x$ when $v_x <= v_y$; the triggering probability as a function of the vector argument is

$$p_{GS}(\theta, v_s, v_t) = p(|v_x| > |v_y|)p(|v_a| > v_t) + [1 - p(|v_x| > |v_y|)]p(|v_b| > v_t) \tag{6.23}$$