This paper investigates the effect of transducer-integrated apodization in row–column-addressed arrays and presents a beamforming approach specific for such arrays. Row–column addressing 2-D arrays greatly reduces the number of active channels needed to acquire a 3-D volume. A disadvantage of row–column-addressed arrays is an apparent ghost effect in the point spread function caused by edge waves. This paper investigates the origin of the edge waves and the effect of introducing an integrated apodization to reduce the ghost echoes. The performance of a λ/2-pitch 5-MHz 128 + 128 row–column-addressed array with different apodizations is simulated. A Hann apodization is shown to decrease imaging performance away from the center axis of the array because of a decrease in main lobe amplitude. Instead, a static roll-off apodization region located at the ends of the line elements is proposed. In simulations, the peak ghost echo intensity of a scatterer at (x, y, z) = (8, 3, 30) mm was decreased by 43 dB by integrating roll-off apodization into the array. The main lobe was unaffected by the apodization. Simulations of a 3-mm-diameter anechoic blood vessel at 30 mm depth showed that applying the transducer-integrated apodization increased the apparent diameter of the vessel from 2.0 mm to 2.4 mm, corresponding to an increase from 67% to 80% of the true vessel diameter. The line element beamforming approach is shown to be essential for achieving correct time-of-flight calculations, and hence avoid geometrical distortions. In Part II of this work, experimental results from a capacitive micromachined ultrasonic transducer with integrated roll-off apodization are given to validate the effect of integrating apodization into the line elements.