Space vector modulation (SVM) control of multilevel inverters (MLIs) is very popular. However, it gets extremely challenging with the increase in the number of output voltage levels due to the emergence of subtriangles in the various sectors of the hexagon, which results in increased computational complexity and storage requirements of switching states and corresponding pulse durations. Currently, this is handled through laborios offline computations in conjunction with the visual inspection of the space vector hexagon and its various sectors. This paper aims to simplify the implementation of the SVM scheme for an n-level MLI by proposing generalized equations that not only facilitate direct online computation of control pulses and obviate the requirement of lookup tables but also result in optimized switching. Yet, the on-time computations of the various MLI switches are still based on simple two-dimensional Cartesian co-ordinate system combined with the basic two-level inverter implementation. The proposed scheme makes use of a unique l-factor approach, which directly identifies the location of the various subtriangles in the space vector hexagon and leads to direct online computations of the control pulses. The proposed scheme is validated by simulations and experimental results for three- and five-level diode clamped MLI.