We present a novel method to solve the Maxwell-Liouville-von Neumann (MLN) equations in an accurate and efficient way without invoking the rotating wave approximation (RWA). The method is a combination of two established concepts, namely the operator splitting method as well as the adjoint representation of the Lie algebra SU( N ) (or pseudospin representation). The former concept ensures the accuracy of the approach, but is computationally expensive. The latter concept provides an efficient representation of the problem and two optimization possibilities. We have implemented and verified both optimization approaches and demonstrate that substantial speedup can be achieved. OCIS codes: (000.3860) Mathematical methods in physics; (000.4430) Numerical approximation and analysis; (020.1670) Coherent optical effects; (190.7110) Ultrafast nonlinear optics.