As the demand for electricity is growing and the penetration of renewable energy resources is increasing, grid synchronization with high accuracy is essential for utility networks. This paper presents a novel fixed-gain filter (FGF) scheme with an optimal fixed feedback gain matrix to estimate the (angle) position and frequency of the grid, which ensures a fast and accurate synchronization under varying grid conditions. Instead of using the conventional phase-locked loop (PLL) scheme that suffers from the difficulty of parameter selection, the concept of the Kalman filter (KF) is synthesized to design the second-order FGF and third-order FGF for synchronization. To overcome the heavy computational processing for the KF, the feedback gain is subject to a single tunable parameter only, which can be calculated offline and refined within a certain small range fulfilling the system stability criterion. Compared with the PLL approach, the new FGF provides a faster and more precise tracking performance, an easier parameter tuning mechanism, a lower program complexity, and a better grid stability, which is verified by simulations and experiments in all cases.