I. INTRODUCTION

The nonvanishing neutrino masses have been confirmed by various neutrino oscillation phenomena and indicate the evidence of new physics beyond the Standard Model. The most attractive idea to naturally explain the tiny neutrino masses is the seesaw mechanism [1], in which the right-handed (RH) neutrinos singlet under the SM gauge group are introduced. The minimal gauged $U(1)_{B-L}$ model based on the gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y \times U(1)_{B-L}$ [2] is an elegant and simple extension of the SM, in which the RH neutrinos of three generations are necessarily introduced because of the gauge and gravitational anomaly cancellations. In addition, the mass of RH neutrinos arises associated with the $U(1)_{B-L}$ gauge symmetry breaking.

Although the scale of the $B-L$ gauge symmetry breaking is basically arbitrary as long as phenomenological constraints are satisfied, one interesting option is to take it to be the TeV scale [3]. It has been recently pointed out [4] that when the classical conformal invariance is imposed on the minimal $U(1)_{B-L}$ model, the symmetry breaking scale appears to be the TeV scale naturally. If this is the case, all new particles, the Z' gauge boson, the $B-L$ Higgs boson H and the RH neutrinos appear at the TeV scale unless the $U(1)_{B-L}$ gauge coupling is extremely small, and they can be discovered at Large Hadron Collider [5–8]. Then we may be able to understand the relation between the gauge symmetry breaking and the origin of neutrino masses.

Although such a TeV scale model is interesting and appealing, one might think that the absence of dark matter (DM) candidate is a shortcoming of this model. A sterile RH neutrino with mass of the order of MeV is one possibility [9]. In this paper, we propose a very simple idea to introduce the DM candidate in the minimal gauged $U(1)_{B-L}$ model. We introduce the Z_2 parity into the model and impose one of three RH neutrinos to be odd, while the others even. In this way, the Z_2-odd RH neutrino becomes stable and the DM candidate. Note that two RH neutrinos are enough to reconcile with the observed neutrino oscillation data, with a prediction of one massless light neutrino. Therefore, without introducing any additional new dynamical degrees of freedom, the DM particle arises in the minimal gauged $U(1)_{B-L}$ model.

The paper is organized as follows. In the next section, we briefly describe our model. In section III, we estimate the thermal relic density of the RH neutrino and identify the model