CHAPTER
7
ANT COLONY OPTIMIZATION FOR PASSIVE FILTER IN DISTRIBUTION NETWORK

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7.1 INTRODUCTION

Electricity is an essential necessity in human life, and it is an indispensable part of modern life. Recently, industries have accelerated their embrace of Industry 4.0 due to the COVID-19 pandemic. They utilize digital technologies to automate manual processes and link devices to exchange data over the internet. These changes require a massive installation of electrical equipment which will increase the electricity demand. The global electricity generation is expected to rise from 26,800 TWh in 2020 to 50,000 TWh in 2050 which is nearly twofold in the next three decades. Therefore, more installation of power generators can be anticipated in future. At the same time, in the transition to a low-carbon world, this electricity will be provided by low-emission energy sources where solar photovoltaic (PV) and wind together account for almost half of the total electricity supply by 2050 (Zhou et al., 2012). Ackermann et al. (2001) shows that Malaysia follows the global trend as well. In Peninsular Malaysia, there will be 3,758 MW of new capacities that need to be developed starting 2020. Among the new capacities, nearly 60% of it will be fulfilled by solar PV in order to reduce the carbon dioxide (CO_2)

emission intensity from 0.082 kilograms of CO_2 per Ringgit Malaysia (kg CO_2/RM) to 0.051 kg CO_2/RM by 2030.

Power generation systems generally can be categorized into centralized and decentralized. A centralized power generation system is where the electricity is generated through central power generators, and it will be transmitted to a huge distribution zone through high voltage transmission lines. While a decentralized power generation system usually located near to the end user and the electricity generated through distributed generators (DG), for instance, solar PV and wind turbines. Central power stations are usually located far away from the end-user and suffer from high-power loss during transmission and distribution (Kuang et al., 2011).

As mentioned in Renewables 2019, distributed solar PV takes centre stage in the future, it will be widely used in homes, commercial buildings, and industry (Alhaddad et al., 2014). The distributed PV capacity will be more than doubled to 530 GW by 2024. However, power electronics and microprocessors used in distributed generators can be a source of harmonics to the power grid (Hung et al., 2014). Harmonic currents injected by converters into the electric power distribution system will interact with existing supply voltage distortion and can significantly affect the harmonic levels. This harmonic distortion will affect power quality, and the massive installation of distribution generators will cause high power loss in the electric power distribution system. Thus, it is necessary to install a passive filter to reduce the harmonic distortion in the network. optimizer tends to go over the limit to reach the optimal generation cost.

7.2 GENERATION SYSTEM AND HARMONIC ISSUES IN DISTRIBUTION NETWORK

The term distributed generation (DG) refers to technologies that generate electricity close to or at the point of usage (Abbas et al., 2021). DG commonly used in residential areas and industrial sectors include solar PV, wind turbines, and diesel generators. Solar PV and wind turbines are the prime renewable energy sources. The advantages of using DG are increase in reliability and security, voltage profile improvement, reduction of power loss in transmission lines and etc.

It is a critical task to integrate DG with the distribution system. When the penetration of DG increases, some problems may exist. For example, solar PV convert solar energy into direct current (DC) and by using power electronic converter to convert it into alternating current (AC) and then transmit to AC distribution system. The power electronic converter is a source of harmonics, it will increase the total harmonic distortion (THD) in the distribution system (Abbas et al, 2021). A study about the impact of large-scale photovoltaic systems on harmonics in distribution systems, their results show that harmonic distortion increases from 4.6% to 13.2% after connecting solar PV to the system. Some suggest finding the optimal location and size of solar PV to reduce the harmonic distortion and power loss in the distribution system (Lakum et al., 2021; Dorigo et al., 1999). However, when penetration of solar PV continues to increase, the harmonic distortion increases and violates the standard limits. According to IEEE 519 standard, the THDv for bus voltage within 1 kV to 69 kV at point of common coupling should be less than 5%. To achieve the standard, by reduce THD by installing a passive harmonic filter and hence the solar PV penetration can be increased (Lakum et al., 2021). Dorigo et al. (1999) tested the effect of solar PV on harmonics in the distribution system using four solar PV units at different locations instead of just a single unit of solar PV. They also conclude that determining the optimal location and size of the filter should also take into consideration the harmonics injected by solar PV.

Another problem that exists is due to the intermittent availability; the solar irradiance varies throughout the day.Thus, the output power of solar PV is difficult to predict, and it will cause difficulties for the central power plant to estimate the power required (Hung et al, 2014). Generally, the solar PV can generate electricity from 7:00 a.m. to 7:00 p.m. In Abbas et al. (2021), the THD in the current waveform was tested at different solar irradiance levels. The results show that the THD