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基于CAN总线的供电系统三相并联逆变器同步控制方法

Three-phase parallel inverter synchronous control method based on CAN bus in power supply system

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中文摘要:

针对三相并联逆变器系统同步控制中CAN（controller area network）总线通信方式存在实时性和准确性随总线负载上升而下降和同步相位调节算法存在谐波频率偏移、波形畸变大等问题，该文提出了一种基于CAN总线通信的基准时间同步方法和基于PWM（pulse width modulation）载波周期的相位同步调整算法，采用动态主从同步控制模式，所有逆变器单元依次作为主控单元，按照时间触发和事件触发相结合的方式实时发出包含频率信息的广播同步信号，所有逆变模块据此确定基准时间并调整输出电压的频率和相位使得同相的逆变器输出电压同频率、同相位，而不同相的逆变器输出电压相位互差120°。仿真分析和试验结果表明，该方法使三相并联逆变器系统输出电压各相之间的相位误差和同相之间相位差均在1°之内，可以在无需增加功率器件耐压值和限流值的前提下提高供电系统供电容量。

英文摘要:

Abstract: Three phase grid-connected inverters are the key parts for the transfer of dispersed power generation, such as photovoltaic, wind generation, and energy storage systems, and so on. The three-phase system could be replaced with three single phase inverters. In this way, it could enlarge the current capacity easily without using high isolated voltage and large current devices, and it will be more cheap and flexible. However, there would be a significant frequency offset.With the help of a CAN (Controller Area Network) bus, all the parallel inverters could be the master in the given rules. The master inverter sends the frequency of itself with a synchronization-triggered frame on its clock period, and then all the other inverters determine the frequency of the interval between the two frames. For the other inverters, the frame is also taken as the reference phase, which can correct the phase error of the sine signal. However, the communication data exchange speed and quality fall as the CAN busloads increase. The phase synchronization method will cause frequency offset and voltage distortion. Therefore, a PWM carrier period based parallel inverter synchronization control method based on a CAN bus was proposed in the paper. The method works in dynamic master/slave mode.In the CAN protocol, the pulse width modulation period is selected as the basic communication period. The period is divided into 3 ranges, according to the zero point of ABC phase voltage. Each range is divided into 3 time periods, exclusive, arbitration, and free. In the exclusive time period, the most important message is delivered. In the design of the CAN application layer, the master dynamic setting was implemented on the ID allocation, in which the address is allocated dynamically, and the master is determined. When the system is powered on, or the new one is connected, all the inverters will get this information, and then send the serial numbers and connected phase name to the bus. They can receive the serial numbers and connected phase name of the others later. The master inverters will be decided on the given rule of the serials number. If the master stops sending synchronization signals, the dynamic setting will be repeated again to make the new one.The simulation and experiment of parallel inverters were finished in the carrier period based phase synchronization method. In simulation, the phase change and frequency change methods were adopted to compare with the proposed methods. The reference voltage was set to 220 volts, 50 Hertz, and zero initial phase angles. In the result, the proposed method reduces the voltage distortion from 26.7% to 8.8%, compared to the phase change method, while reducing the frequency offset from 16.67 Hertz to 0, compared to the frequency change method. It can be proved from the simulation in Matlab that the method can achieve low distortion and little frequency offset, compared to the other methods. Four inverters were engaged in the experiment, and that is enough to show all the possible capacity enlarging cases with no extra expense. The controller of the inverters was developed on the popular digital processor, which is TMS320F28335 from Texas Instrument. The results show the phase synchronization errors keep within 1° between the inverters in the same phase, or different phases.