Implementation of a grid-tied wind power HER-inverter

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Abstract:

The Highly Efficient and Reliable Inverter Concept (HERIC) inverter is a cost-effective topology, which has low leakage currents and a relatively high efficiency. Thus, it is very suitable for wind systems. However, with the reported modulation methods, it is difficult to simultaneously maintain the high efficiency, good power quality, and reactive power injection of the HERIC inverter. In this work, ANN combined pulse width modulation (UP-PWM) scheme is thus proposed to achieve those performances. The hybrid scheme adopts the conventional ANN-PWM in the case of generating the positive power. When generating the negative power, a modulation scheme, which only requires the operation of freewheeling switches, is specifically proposed. Additionally, in the region of the output voltage and current zero-crossing points (ZCP), an ANN-PWM with modified dead time is introduced. In order to validate the effectiveness of the proposed scheme, simulations performed on a MATLAB.
The results demonstrate that the proposed hybrid ANN-PWM method achieves a better performance in terms of reactive power injection than the conventional UP-PWM scheme, and a higher efficiency than the ANN-PWM with dead time. In addition, the proposed UP-PWM scheme also enables a better power quality.

INTRODUCTION

An inverter needs to supply two needs - **Peak**, or surge power, and the typical or usual power.

- **Surge** is the maximum power that the inverter can supply, usually for only a short time - a few seconds up to 15 minutes or so. Some appliances, particularly those with electric motors, need a much higher startup surge than they do when running. Pumps are the most common example - another common one is refrigerators (compressors).
- **Typical** is what the inverter has to supply on a steady basis. This is the **continuous** rating. This is usually much lower than the surge. For example, this would be what a refrigerator pulls after the first few seconds it takes for the motor to start up, or what it takes to run the microwave - or what all loads combined will total up to. (see our note about appliance power and/or name tag ratings at the end of this section).
- **Average** power would usually be much less than typical or surge and is not usually a factor in choosing an inverter. If you run a pump for 20 minutes and a small TV for 20 minutes during a one hour period, the average might be only 300 watts, even though the pump requires 2000. Average power is only useful in estimating battery capacity needed. Inverters must be sized for the maximum peak load, and for the typical continuous load.

Power Ratings of inverters

Inverters come in size ratings all the way from 50 watts up to 50,000 watts, although units larger than 11,000 watts are very seldom used in household or other PV systems. The first thing you have to know about your inverter is what will be the maximum surge, and for how long. (More about 230 volts pumps etc later).

- **Surge**: All inverters have a continuous rating and a surge rating. The surge rating is usually specified at so many watts for so many seconds. This means that the inverter will handle an *overload* of that many watts for a short period of time. This surge capacity will vary considerably between inverters, and different types of inverters, and even within the same brand. It may range from as little as 20% to as much s 300%. Generally, a 3 to 15-second surge rating is enough to cover 99% of all appliances - the motor in a pump may actually surge for only 1/2 second or so.

- **General Rules**: The inverters with the lowest surge ratings are the high-speed electronic switching type (the most common). These are typically from 25% to 50% maximum overload. This includes most inverters made by Stat power, Exeltech, Power to Go, and nearly all the inexpensive inverters in the 50 to 5000-watt range. The highest surge ratings are the transformer based, low-frequency switchers. This includes most Xantrex, Magnum, and Outback Power. Surge ratings on these can range up to 300% for short periods. While high-frequency switching allows a much smaller and lighter unit, due to the much smaller transformers used it also reduces the surge or peak capacity.
- **Pros and Cons**: Although the high-frequency switching type doesn't have the surge capacity of the transformer based, they do have some definite advantages. They are much lighter, usually quite a bit smaller, and (especially in the lower power ranges) they are much cheaper. However, if you are going to run something like a submersible well pump, you will need either very high surge capacity or you will need to oversize the inverter above its typical usage, so that even at maximum surge the inverter will not exceed its surge rating.

RELATED WORK

PayalSomaniet al aimed is to design an efficient solar inverter with higher efficiency and which also controls the power that the inverter injects into the grid.

V. Thiyagarajan et al analysed the performance of HERIC inverter for photovoltaic applications for different Pulse-Width Modulation (PWM) techniques.

Hui Wang proposed an improved modulation method for the AVC-HERIC topology.

David Gámez et al presented a feasible implementation of a single phase inverter prototype via a Highly Efficient and Reliable Inverter Concept (HERIC) topology, which is connected to the grid through a phase and frequency synchronization system by means of a Second Order Generalized Integrator - Frequency Locked Loop (SOGI-FLL).

Chumpol et al introduced the buck-boost-based three-switch three-state Z-source inverter for using with grid-connected PV system, and it can provide dual grounding for suppression problems of PV inverter system and provide boost capability.

Senjun Hu et al proposed an enhanced HERIC based single-phase transformerless inverter with hybrid clamping cell to further eliminate the common-mode leakage current.

Jian Yang et al proposed an improved HERIC inverter. It makes most switching devices operate at zero-current-switching state, by only adding auxiliary inductors on the freewheeling branch.

PiyushaKukade et al presented a cascaded, highly efficient and reliable inverter configuration (HERIC) based multi-level inverter (MLI) to minimise the leakage current in the PV applications.

Gaurav Sharma et al proposed a double-bootstrap gate driving scheme for high-side switches.

AhmetYüksel et al studied a control of a single phase standalone transformerless photovoltaic (PV) inverter by simulation.

EXISTING SYSTEM

Zhongting Tang et al proposed a hybrid unipolar pulse width modulation (UP-PWM) scheme is thus proposed to achieve those performances. The hybrid scheme adopts the conventional UP-PWM in the case of generating the positive power. When generating the negative power, a modulation scheme, which only requires the operation of freewheeling switches, is specifically proposed. Additionally, in the region of the output voltage and current zero-crossing points (ZCP), an UP-PWM with modified dead time is introduced.

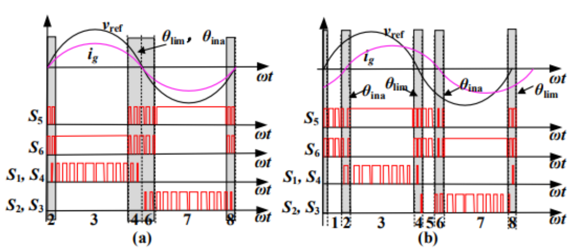


Fig.1 hybrid UP-PWM for the HERIC inverter

To achieve a high efficiency, good power quality, and proper reactive power capability, a hybrid UP-PWM technique for the HERIC inverter is proposed in this section. The operation principles are illustrated in Fig.1. When the inverter is operating at a non-unity power factor, the operation can be partitioned into eight regions as shown in Fig. 1(b). Regions 2, 4, 6 and 8 should be specially considered. As the output voltage or current of the inverter is very small, the operation of power switches is limited and their polarities are difficult to determine. On the contrary, regions 1, 3, 5 and 7 are much easier to cope with. In this regard, the proposed hybrid UP-PWM strategy adopts different modulation schemes according to the operational regions. There are three modulation schemes: (1) Conventional UP-PWM in regions 3 and 7. The conventional UP-PWM strategy can achieve low switching power losses and low ripple currents. (2) UP-PWM with dead time in regions 2, 4, 6 and 8. Due to the polarity uncertainty of the grid current, the UP-PWM with dead time is adopted to ensure a stable operation of the inverter system. In addition, the adverse effect of the minimum pulse width limitation can be improved by modifying the dead time. (3) UP-PWM for negative power generation in regions 1 and 5. To provide reactive power and also reduce the switching power losses, the modulation, only requiring the operation of AC bypass switches like Fig. 3(a), is applied to the HERIC inverter. It should be pointed out that regions 1 and 5 are absent in the case of the unity power factor operation. Thus, only two operation modes (i.e., the conventional UP-PWM and UP-PWM with dead time) are active in the proposed strategy, as shown in Fig. 1(a).

According to the operation principle of the proposed hybrid UP-PWM scheme for the HERIC inverter is elaborated in detail as follows:

Region 1: All the four-leg power switches are in off-state, while the additional two power switches are operating at a high frequency. The grid-connected current ig flows through the diodes D1 and D4 to build up a positive voltage vAB, while flows through S5 and D6 to generate a zero voltage.

Region 2: At the current ZCP, the leg power switches S1, S4 and the additional two power switches S5, S6 operate at a high frequency. In that case, there are two current paths. 1) The current ig continues flowing through D1 and D4 to ensure a positive voltage vAB, and the current ig also flows through S5 and D6 to achieve a zero voltage. 2) The grid-connected current polarity changes, and it flows through S1 and S4, resulting in a positive voltage vAB; while a zero voltage vAB is built up, when the current flows through S6 and D5. The dead time must be inserted between operation mode changes.

Region 3: As S6 is always in on-state, while S1 and S4 are switched at a high frequency in this operational region. The grid-connected current ig then flows through S1 and S4 for a positive voltage vAB, while flows through S6 and D5 for a zero voltage.

Region 4: At the voltage ZCP, there are two transitioning modes.

1) S1 and S4 are in on-state to generate a positive voltage vAB and the current ig flows through S1 and S4. Then, S5 and S6 are switched-on to achieve a zero voltage, and then the current ig flows through S6 and D5.

2) S2 and S3 are in on-state, leading to a negative voltage vAB, and the current ig flows through D2 and D3. Following, S5 and S6 are in on-state for a zero voltage, and the grid-connected current ig flows through S6 and D5. During the mode transitions, the dead time should be applied to avoid short-circuiting the DC side.

Region 5: All the four leg power devices are switched-off, while S5 and S6 operate at a high frequency. The grid-connected current ig then continues flowing through D2 and D3 for a negative voltage vAB, while through S6 and D5 to generate a zero voltage.

Region 6: Near the current ZCP, the switches S2, S3 and additional switches S5, S6 operate at a high frequency. There are two current paths.

1) it show that the current ig flows through D2 and D3, which gives a negative voltage vAB, and then through S6 and D5 for a zero voltage.

2) The grid-connected current ig flows through S2 and S3 to ensure a negative voltage vAB, and then through S5 and D6 for a zero voltage. The dead time must be inserted between mode transitions.

Region 7: As S5 is always in ON, while S2 and S3 are switched at a high frequency. The grid-connected current ig flows through S2 and S3 to generate a negative voltage vAB, while through S5 and D6 to achieve a zero voltage.

Region 8: At the voltage ZCP, there are two modes.

1) As S2 and S3 are in on-state to ensure a negative voltage vAB, and the grid-connected current ig flows through S2 and S3. Then, S5 and S6 are switched to achieve a zero voltage, and the grid-connected current ig flows through S5 and D6.

2) As S1 and S4 are in on-state for a positive voltage vAB, and the grid-connected current ig flows through D1 and D4. Then, S5 and S6 are in on-state to achieve a zero voltage, and the grid-connected current ig flows through S5 and D6. The dead time is required during the operation mode transitions.

PROPOSED SYSTEM

In a wind generation ,a hybrid ANN (artificial neural network) unipolar pulse width modulation (UP-PWM) scheme for HERIC inverter is proposed. The hybrid scheme adopts the conventional UP-PWM in the case of generating the positive power. When generating the negative power, a modulation scheme, which only requires the operation of freewheeling switches, is specifically proposed

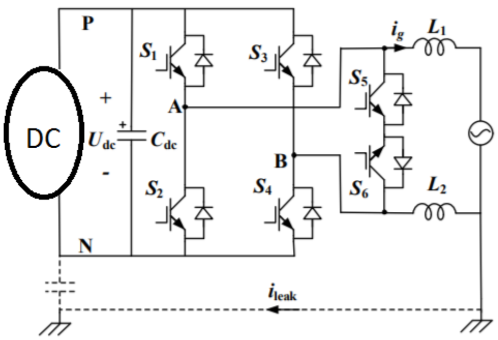


Fig proposed inverter structure

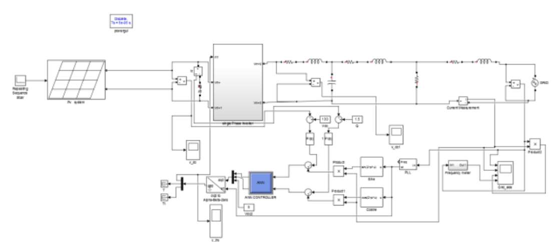
this section, some important concepts related to ANN including the structure of the proposed ANN-based controller as well as details on the training data will be covered.

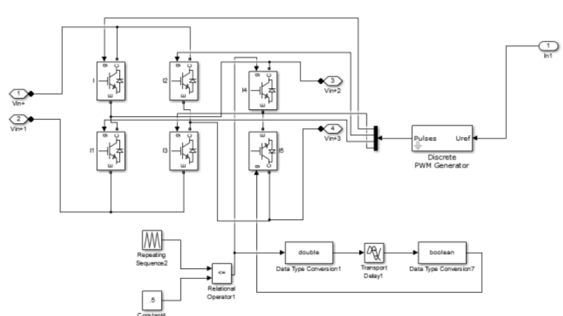
A. Proposed Neural Network Architecture Machine learning, and in particular artificial neural networks, is one key technology in modern control systems. An artificial neural network (ANN) is an extremely flexible computational model that can be optimized to learn input-to-output mappings based on historical data. An ANN is composed of a number of simple computing elements linked by weighted connections. Feed-forward networks do not contain loops, so they are organized in layers and can be used to implement input-to-output mappings that are memoryless, i.e., without dynamics. In its basic form, this model can be expressed as an iterative composition of input-output functions of the form

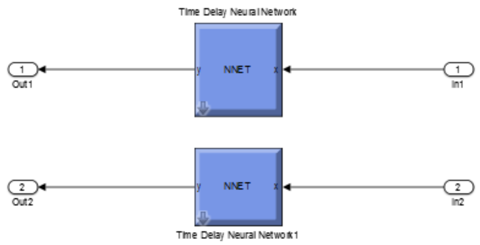
$$f(\vec{x}) = h\left(w_0 + \sum_{i=1}^{M} w_i x_i\right). \quad (1)$$

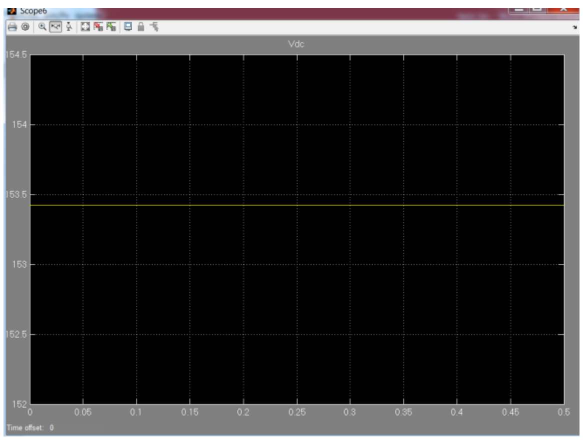
where h(x) is an activation function (usually it is a nonlinear function such as logistic sigmoid or hyperbolic tangent, to ensure the universal approximation property [62]), ~x = {x1, x2, · · · , xM} is the input vector of the ANN with M elements, wi are the weights for each input xi , and w0 is a bias or correction factor. In a feed-forward network, it is possible to distinguish one input layer, one output layer, and hidden layers that connect the input to the output. The objective of the ANN training phase is to optimize some cost function by finding optimal values for the wi and w0. Although recent developments have focused on larger and larger scale problems (deep learning), improved techniques have also been proposed to improve the reliability of networks of smaller size. Toward the same goal, hardware suppliers have started to support reduced-precision floating-point and integer arithmetics, and offer small-scale, dedicated architectures. The result is a sound and scalable technology. In this work, a feed-forward neural network (fully connected multi-layer perceptron) of the "shallow" type, i.e., one hidden layer, was used to implement the control model. A grid search tuning procedure allowed the selection of a configuration with 15 units in the hidden layer, while the number of input and output units is constrained by the number of input and output variables, respectively. Training was done via the Scaled Conjugate Gradient (SCG) method, which exploits the good convergence properties of conjugate gradient optimization and has the computational advantage of not requiring a line search, nor any user-selected parameters.

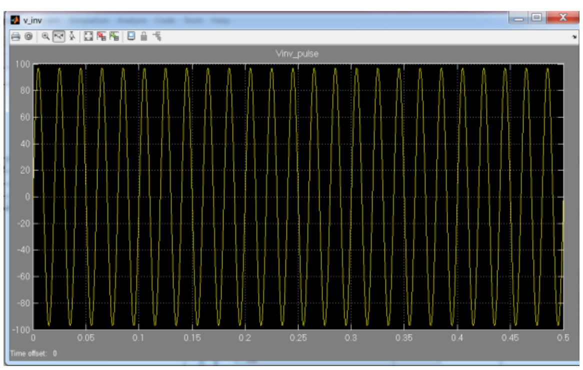
RESULT











CONCLUSION

In this work, a hybrid UP-PWM strategy for the HERIC inverter was proposed. The proposed method takes the advantages of the conventional ANN-PWM, the UP-PWM with dead time and the modulation strategy of reactive power capability. In the operational mode of generating the positive power, the proposed scheme adopts the conventional ANN-PWM. Furthermore, only two additional power switches are operating at a high frequency when the negative power generation is enabled. In that case, the proposed PWM scheme can achieve low switching power losses and small ripple currents. Moreover, the ANN-PWM with dead time is used at the voltage and current ZCPs to ensure a stable operation of the inverter system and also lower distortions. To further improve power quality, the effects of the dead time and minimum pulse width limitation were compensated through the hybrid ANN-PWM scheme. The simulation results have verified the effectiveness of the hybrid ANN-PWM scheme in terms of enhanced power quality, improved efficiency, and more importantly, flexible reactive power controllability.

REFERENCE

[1] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, “A review of single-phasegrid-connected inverters for photovoltaic modules,” IEEE Trans. Ind.Appl., vol. 41, no. 5, pp. 1292-1306, Sep./Oct. 2005.

[2] D. Meneses, F. Blaabjerg, O Garca, and J. A. Cobos, “Review and comparison of step-up transformerless topologies for photovoltaicac-module application,” IEEE Trans. Power Electron., vol. 28, no. 6, pp.2649–2663, Jun. 2013.

[3] F. Blaabjerg, R. Teodorescu, M. Liserre, and A. Timbus, “Overview of control and grid synchronization for distributed power generation systems,” IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1398–1409, Oct.2006.

[4] Z. Guo and F. Kurokawa, “A novel PWM modulation and hybrid control scheme for grid-connected unipolar inverters,” in Proc. IEEE APEC, FortWorth, TX, 2011, pp. 1634–1641.

[5] X. Guo, “A novel CH5 inverter for single-phase transformerless photovoltaic system applications”, IEEE Trans. Circuits Systems II:Express Briefs, vol. 64, no. 10, pp. 1197-1201, Oct. 2017.

[6] H. Xiao and S. Xie, “Leakage current analytical model and application in

[7] single-phase transformerless photovoltaic grid-connected inverter,” IEEETrans. Electromagnetic Compatibility, vol. 52, no. 4, pp. 902-913, 2010.

[8] DIN VDE 0126, “Automatic Disconnection Device Between A Generator

[9] and the Public Low-Voltage Grid,” German Standard, 2010.

[10] M. Victor, K. Greizer, and A. Bremicker, “Method of converting a direct current voltage from a source of direct current voltage, more specifically from a photovoltaic source of direct current voltage, into an alternating current voltage,” U.S. Patent 2005 028 6281 A1, Apr. 23, 1998.

[11] H. Schmidt, C. Siedle, and J. Ketterer, “Wechselrichterzumumwandeln

[12] einerelektrischengleichspannung in einenwechselstromodereinewechselspannung,” EP Patent EP 1 369 985 A2, May 15, 2003.

[13] B. Yang, W. Li, Y. Gu, W. Cui, and X. He, “Improved transformerless

[14] inverter with common-mode leakage current elimination for aphotovoltaic grid-connected power system,” IEEE Trans. Power Electron., vol. 27, no. 2, pp. 752–762, Feb. 2012.