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Power Quality of Pv Inverters, Related To Topology And Control

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SHUNT CONTROLLER

The Shunt Controller allows two circuits to be temporally isolated from an active security system. The unit has two alarm inputs and each one is monitored by a 2K2 resistor. If this input is either open circuit or closed circuit the input is considered to be in alarm. Similarly the set input is also monitored by a 2K2 resistor. The set input controls the isolation of the other two inputs.

Four relays are provided for alarm annunciation and control. In addition a buzzer is provided for local feedback to users. There are two modes of operation of the unit, timed and non timed, which are selected by using the on board switches. In both modes isolation of the two alarm inputs is initiated by applying the 2K2 resistor to the set input. In the non timed mode the isolation will remain until the set condition is removed (by either an open or closed circuit on the set input). In the timed mode the isolation will remain until the selected time matures or, optionally, until the set condition is removed as in the none timed mode.

While the isolation is active the buzzer sounds continuously until the last 15 seconds of the timed period (timed mode only) when the buzzer sounds intermittently. If an attempt is made to remove the isolation manually while either of the two inputs is in alarm then the buzzer will sound intermittently until the fault is removed. The unit will remain in isolation mode until the fault is cleared or, if the timer is on, until the timer matures. If timed mode is selected the unit will come out of isolation mode at the end of the selected period irrespective of the state of the two alarm inputs. In non timed mode the unit will remain isolated until the faults are cleared.

- ✓ Relays 1 and 2 will follow the state of inputs 1 and 2 respectively being operated while the inputs are clear and released while the inputs are in alarm. While the unit is in isolation mode both relays remain operated irrespective of the state of the two inputs.
- ✓ Relay 3 is released under normal operation and operated while the unit is in isolation mode.
- ✓ Relay 4 will be operated while the unit is in isolation mode and will release if an alarm is detected on either of the two inputs. It will remain released until the set input is next activated (i.e. the open or short circuit is removed).

ASPECTS

Converters for PV systems can be divided into two groups, namely: Line commutated inverters and self commutated inverters. Line commutated inverters are commonly used for high power converters, while self-commutated converters are commonly used for small PV-inverters. Only inverters with line currents up to maximum 16 amperes per phase and therefore only self-commutated inverters will be discussed. A further limitation will be the focus on single-phase inverters. Within the mentioned limitations, PV inverters consist in general of different stages and transformer options. To comply with standards, these inverters with their pulse-width modulation (PWM) converter controllers generate a sinusoidal output current. In practice switching frequencies of 20 - 500 kHz are used in different power stages. Several inverter concepts are used in these group of small single-phase inverters, examples are:Single-stage concept of H-bridge pulse-width-modulated (PWM)

DC-DC converter directly coupled to the grid Single-stage concept of H-bridge PWM DC-DC converter coupled to the grid with a low frequency (LF) isolation transformer

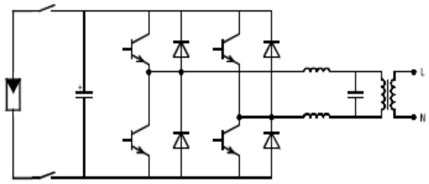


Fig: Single-stage H-Bridge PWM converter and low-frequency transformer Multi-stage concept of PWM DC-DC converter front-end, with 50Hz unfolding bridge directly coupled to the grid

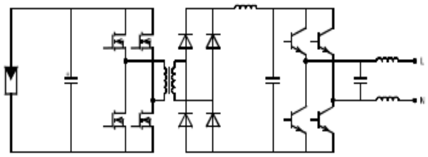


Fig: Multi-stage high-frequency transformer H-Bridge PWM Converter with low-frequency unfolding bridge Multi-stage concept of PWM DC-DC converter front-end with 50Hz unfolding bridge coupled to the grid with a LF-isolation transformer Multi-stage concept of PWM DC-DC converter front-end including a high-frequency (HF) isolation transformer, and a 50Hz unfolding bridge coupled to the grid.Inverters can make use of an extra input buck or boost converter to gain the dynamic range at the input. In these topologies the energy storage capacitor, needed in one-phase inverters, can be placed at the input of the inverter or between the two converter stages. These types cover the majority of small single-phase inverters. For all these inverter types the AC output current will mainly be characterized by the current-feedback control loop.

these features and their indirectly related computer based enhancements are key issues to an efficient terminal operation, we must not forget the foundation upon which we are building. Power quality is the mortar which bonds the foundation blocks. Power quality also affects terminal operating economics, crane reliability, our environment, and initial investment in power distribution systems to support The majority of these inverters are capable of self-generating a 50Hz sinusoidal output current based on internal processor tables and synchronization with the supply voltage. This synchronization is often done by means of a Phase-locked Loop (PLL).Some inverters combine the reference source and the synchronization in the grid voltage, by using the shape of the grid voltage as a reference source. However if the grid voltage is polluted, the reference source will also be polluted and the current control loop of the inverter pollutes his output current accordingly. Filtering out the pollution using such a controller is difficult to do, while obtaining a good (unity) power factor. If it is desired to design an inverter with an unpolluted sinusoidal output current shape, even if the grid voltage is polluted with harmonics, using a good reference source is the first demand. Further the inverters output impedance, as function of the frequency has to be high as well. In practice the output impedance has to be high up to the 40th harmonic, to avoid harmonic current pollution as an interaction on harmonic voltage pollution. High output impedance can be achieved actively by means of the current control loop performance, but also in a passive way. The passive way can be achieved by inductance in the inverters output circuit, i.e. the leakage inductance of the LF transformer. In practice this is only useful for the higher harmonics. Active compensation remains necessary for a good overall result. For modern high frequency switching inverters, adding inductance for reducing the lower harmonics is very bulky and costly. To improve the current source character,

POWER QUALITY: The contemporary container crane industry, like many other industry segments, is often enamored by the bells and whistles, colorful diagnostic displays, high speed performance, and levels of automation that can be achieved. Although new crane installations. To quote the utility company newsletter which accompanied the last monthly issue of my home utility billing: ‘Using electricity wisely is a good environmental and business practice which saves you money, reduces emissions from generating plants, and conserves our natural resources.’ As we are all aware, container crane performance requirements continue to increase at an astounding rate. Next generation container cranes, already in the bidding process, will require average power demands of 1500 to 2000 kW – almost double the total average demand three years ago. The rapid increase in power demand levels, an increase in container crane population, SCR converter crane drive retrofits and the large AC and DC drives needed to power and control these cranes will increase awareness of the power quality issue in the very near future.

POWER QUALITY PROBLEMS**:** For the purpose of this article, we shall define power quality problems as any power problem that results in failure or misoperation of customer equipment, Manifests itself as an economic burden to the user, or produces negative impacts on the environment.'When applied to the container crane industry, the power issues which degrade power quality include:The AC anDC variable speed drives utilized on board container cranes are significant contributors to total harmonic current and voltage distortion. Whereas SCR phase control creates the desirable average power factor, DC SCR drives operate at less than this. In addition, line notching occurs when SCR's commutate, creating transient peak recovery voltages that can be 3 to 4 times the nominal line voltage depending upon the system impedance and the size of the drives. The frequency and severity of these power system disturbances varies with the speed of the drive. Harmonic current injection by AC and DC drives will be highest when the drives are operating at slow speeds. Power factor will be lowest when DC drives are operating at slow speeds or during initial acceleration and deceleration periods, increasing to its maximum value when the SCR's are phased on to produce rated or base speed. Above base speed, the power factor essentially remains constant. Unfortunately, container cranes can spend considerable time at low speeds as the operator attempts to spot and land containers. Poor power factor places a greater kVA demand burden on the utility or engine-alternator power source. Low power factor loads can also affect the voltage stability which can ultimately result in detrimental effects on the Life of sensitive electronic equipment or even intermittent malfunction. Voltage transients created by DC drive SCR line notching, AC drive voltage chopping, and high frequency harmonic voltages and currents are all significant sources of noise and disturbance to sensitive electronic equipment

THE BENEFITS OF POWER QUALITY Power quality in the container terminal environment impacts the economics of the terminal operation, affects reliability of the terminal equipment, and affects other consumers served by the same utility service. Each of these concerns is explored in the following paragraphs.1. Economic Impact The economic impact of power quality is the foremost incentive to container terminal operators. Economic impact can be significant and manifest itself in several ways: a. Power Factor Penalties Many utility companies invoke penalties for low power factor on monthly billings. There is no industry standard followed by utility companies. Methods of metering and calculating power factor penalties vary from one utility company to the next. Some utility companies actually meter kVAR usage and establish a fixed rate times the number of kVAR-hours consumed. Other utility companies monitor kVAR demands and calculate power factor. If the power factor falls below a fixed limit value over a demand period, a penalty is billed in the form of an adjustment to the peak demand charges. A number of utility companies servicing container terminal equipment do not yet invoke power factor penalties. However, their service contract with the Port may still require that a minimum power factor over a defined demand period be met. The utility company may not continuously monitor power factor or kVAR usage and reflect them in the monthly utility billings; however, they do reserve the right to monitor the Port service at any

2. Equipment Reliability

Poor power quality can affect machine or equipment reliability and reduce the life of components. Harmonics, voltage transients, and voltage system sags and swells are all power quality problems and are all interdependent. Harmonics affect power factor, voltage transients can induce harmonics, the same phenomena which create harmonic current injection in DC SCRvariable speed drives are responsible for poor power factor, and dynamically varying power factor of the same drives can create voltage sags and swells. The effects of harmonic distortion, harmonic currents, and line notch ringing can be mitigated using specially designed filters.

3. Power System Adequacy

When considering the installation of additional cranes to an existing power distribution system, a power system analysis should be completed to determine the adequacy of the system to support additional crane loads. Power quality corrective actions may be dictated due to inadequacy of existing power distribution systems to which new or relocated cranes are to be connected. In other words, addition of power quality equipment may render a workable scenario on an existing power distribution system, which would otherwise be inadequate to support additional cranes without high risk of problems.

4. Environment

No issue might be as important as the effect of power quality on our environment. Reduction in system losses and lower demands equate to a reduction in the consumption of our natural nm resources and reduction in power plant emissions. It is our responsibility as occupants of this planet to encourage conservation of our natural resources and support measures which improve our air quality

$$\delta \cong \frac{XP_A}{V_A V_B}$$

$$V_A - V_B \cong \frac{XQ_A}{V_A}$$

VOLTAGE AND FREQUENCY SUPPORT

The power transfer between two sections of the line connecting a DPGS converter to the grid can be studied using a short line model and complex phasors, as shown in Figure.

Fig. (a) Power flow through a line. (b) Phasor diagram.When the DPGS is connected to the grid through a mainly inductive line $X \gg R$, R may be neglected. If the power angle δ is also small, then $\sin\delta \cong \delta$ and $\cos\delta \cong 1$, and where VA, PA, and QA denote, respectively, the voltage, active power, and reactive power in section A, and VB is the voltage in section B, as indicated in Fig. For X >> R, a small power angle δ, and a small difference VA − VB, equations show that the power angle predominantly depends on the active power, whereas the voltage difference VA − VB predominantly depends on the reactive power. In other words, the angle δ can be controlled by regulating the active power, whereas the inverter voltage VA is controlled through the reactive power. Thus, by independently adjusting the active and reactive powers, the frequency and amplitude of the grid voltage are determined. These conclusions are the basis of the frequency and voltage droop control through active and reactive powers, respectively [7]. In this paper, the relation has been adopted to optimize the power extraction from PV panels (MPPT).

SHUNT CONTROLLERS FOR VOLTAGE DIP MITIGATION

Shunt devices are usually adopted to compensate small voltage variations that can be controlled by reactive power injection. The ability to control the fundamental voltage at a certain point depends on the grid impedance and the power factor of the load. The compensation of a voltage dip by current injection is difficult to achieve because the grid impedance is usually low and the injected current has to be very high to increase the load voltage. The shunt controller can be current or voltage controlled. When the converter is current controlled, it can be represented as a grid-feeding component [Fig (a)] that supports the grid voltage by adjusting its reactive output power according to the grid voltage variations. When the converter is voltage controlled, it can be represented as a grid-supporting component [Fig (b)] that controls its output voltage Fig. Use of a shunt controller for voltage dips compensation. (a) Simplified power circuit of the current-controlled shunt controller. (b) Simplified power circuit of the voltage-controlled shunt controller.However, also in this second case, the control action results in injecting the reactive power in order to stabilize the voltage. The vector diagrams of a shunt controller designed to provide only reactive power are reported in Fig. When the grid voltage is 1 pu, the converter supplies the reactive power absorbed by the load, and the vector diagram of the current- or voltage-controlled converter is the same, then, in the first case, it is controlled by the compensating current IC, and in the second one, it is controlled by the load voltage, as underlined in Fig (a) and (b Fig. Vector diagram of the shunt controller providing only reactive power. (a) Current-controlled converter in normal conditions. (b) Voltage-controlled converter in normal condition. (c) Vector diagram for compensation of a voltage dip of 0.15 pu.When a voltage sag occurs, the converter provides reactive power in order to support the load voltage, and the grid current Ig has a dominant reactive component, i.e.,

$$\overline{I}_g + \overline{I}_C = \overline{I}_{\text{load}}.$$

The amplitude of the grid current depends on the value of the grid impedance since

$$\overline{I}_g = \frac{\overline{V}_{L_g}}{j\omega L_g}$$

where V Lg is the inductance voltage drop shown in Fig. (c). If the shunt controller supplies the load with all the requested active and reactive powers, in normal conditions, it provides a compensating current Ic = Iload; hence, the system operates as in island mode, and Ig = 0.In case of a voltage dip, the converter has to provide the active power required by the load, and it has to inject the reactive power needed to stabilize the load voltage, as shown in Fig. (b). Fig. Vector diagram of the shunt controller providing both active and reactive powers. (a) Normal conditions. (b) Vector diagram for compensation of a voltage dip of 0.15 pu.

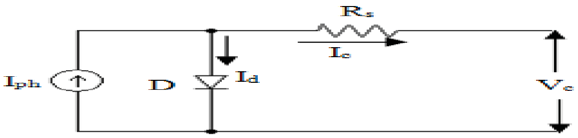
The grid current in this case is reactive. It can be seen that

$$\overline{V}_{\text{load}} = \overline{E} + \overline{V}_{L_g}.$$

is inversely proportional to ωLg. This means that a large inductance will help in mitigating voltage sags, although it is not desirable during normal operation

PV SYSTEM WITH SHUNT-CONNECTED MULTIFUNCTIONAL CONVERTER

Modeling of PV Array: Fig. 2 shows the model of a PV cell. It consists of a current source I_{ph} in parallel with a diode D. The resistance in series R_S represents the intrinsic resistance of the cell.



The power produced by a PV array depends on the temperature and irradiation of the sun [12], [13]. As suggested in [12], a benchmark PV array model is developed with a known temperature and a known solar irradiation level. Later, the model is modified to handle changes in the temperature and irradiation levels of the sun. With changes in the ambient temperature (Ta), the PV cell output voltage and the photo current changes. Similarly, changes in the solar irradiation of the sun (Sc) affects the PV cell operating temperature and the photovoltaic current [12]. The effects resulting due to these changes are represented with the help of coefficients Ctv, Cti, Csv and Csi given using (2) – (5).

$$C_{tv} = 1 + \alpha_t (T_a - T_n)$$

$$C_{ti} = 1 + \frac{\beta_t}{S_c} (T_n - T_a)$$

$$C_{sv} = 1 + \alpha_t \gamma_s (S_n - S_c)$$

$$C_{si} = 1 + \frac{1}{S_c} (S_n - S_c)$$

REFERENCES

1 F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. 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.

2 F. Blaabjerg, R. Teodorescu, Z. Chen, and M. Liserre, "Power converters and control of renewable energy systems," in Proc. ICPE, Pusan, Korea, Oct. 2004.

3 T.-F. Wu, H. S. Nien, H.-M. Hsieh and C.-L. Shen, "PV power injection and active power filtering with amplitude-clamping and amplitude scaling algorithms," IEEE Trans. Ind. Appl., vol. 43, no. 3, pp. 731–741, May/Jun. 2007.

4 M. Ciobotaru, R. Teodorescu, and F. Blaabjerg, "On-line grid impedance estimation based on harmonic injection for grid-connected PV inverter," in Proc. IEEE Int. Symp. Ind. Electron., Jun. 4–7, 2007, pp. 2437–2442.

5 IEEE Standards for Interconnecting Distributed Resources with Electric Power Systems, IEEE Std. 1547-2003, 2003.

6 IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected With Electric Power Systems, IEEE Std. 1547.3-2007, 2007.

7 J. M. Guerrero, J. Matas, L. García de Vicuña, M. Castilla, and J. Miret, “Wireless-control strategy for parallel operation of distributed-generation inverters,” IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1461–1470, Oct. 2006.

8 J. M. Guerrero, J. Matas, L. García de Vicuña, M. Castilla, and J. Miret, “Decentralized control for parallel operation of distributed generation inverters using resistive output impedance,” IEEE Trans. Ind. Electron., vol. 54, no. 2, pp. 994–1004, Apr. 2007.

9 K. De Brabandere, B. Bolsens, J. Van den Keybus, A. Woyte, J. Driesen, and R. Belmans, “A voltage and frequency droop control method for parallel inverters,” IEEE Trans. Power Electron., vol. 22, no. 4, pp. 1107– 1115, Jul. 2007.

10 M. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions. Piscataway, NJ: IEEE Press, 1999.

11 M. H. J. Bollen and I. Gu, Signal Processing of Power Quality Disturbances. New York: Wiley, 2006.

12 H. Kömürgügil and Ö. Kükrer, “A new control strategy for single-phase shunt active power filters using a Lyapunov function,” IEEE Trans. Ind. Electron., vol. 53, no. 1, pp. 305–312, Feb. 2006.

13 M. E. Ortúzar, R. E. Carmi, J. W. Dixon, and L. Morán, “Voltage source active power filter based on multilevel converter and ultra capacitor DC link,” IEEE Trans. Ind. Electron., vol. 53, no. 2, pp. 477–485, Apr. 2006.

14 B.-R. Lin and C.-H. Huang, “Implementation of a three-phase capacitor clamped active power filter under unbalanced condition,” IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1621–1630, Oct. 2006.

15 I. Exteberria-Otadui, A. López de Heredia, H. Gaztañaga, S. Bacha, and M. R. Reyero, “A single synchronous frame hybrid (SSFH) multifrequency controller for power active filters,” IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1640–1648, Oct. 2006.

16 G. Escobar, P. Mattavelli, A. M. Stakovis, A. A. Valdez, and J. Leyva-Ramos, “An adaptive control for UPS to compensate unbalance and harmonic distortion using a combined capacitor/load current sensing,” IEEE Trans. Ind. Electron., vol. 54, no. 2, pp. 839–847, Apr. 2007.

17 D. O. Abdeslam, P. Wira, J. Mercklé, D. Flieller, and Y.-A. Chapuis, “A unified artificial neural network architecture for active power filters,” IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 61–76, Feb. 2007.

18 M. Routimo, M. Salo, and H. Tuusa, “Current sensor less control of a voltage-source active power filter,” in Proc. 20th IEEE Annu. APEC, Mar. 6–10, 2005, vol. 3, pp. 1696–1702.

19 P. Wang, N. Jenkins, and M. H. J. Bollen, “Experimental investigation of voltage sag mitigation by an advanced static VAr compensator,” IEEE Trans. Power Del., vol. 13, no. 4, pp. 1461–1467, Oct. 1998.

20 P. Mattavelli and F. Pinhabel Marafao, “Repetitive-based control for selective harmonic compensation in active power filter,” IEEE Trans. Ind. Electron., vol. 51, no. 5, pp. 1018–1024, Oct. 2004.

21 F. Botterón and H. Pinehiro, “A three-phase UPS that complies with the standard IEC 62040-3,” IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 2120–2136, Aug. 2007.

22 G. Escobar, A. A. Valdez, J. Leyva-Ramos, and P. Mattavelli, “Repetitivebased controller for a UPS inverter to compensate unbalance and harmonic distortion,” IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 504–510, Feb. 2007.

33 H. Hinz and P. Mutschler, “Voltage source inverters for grid connected photovoltaic systems,” in Proc. 2nd World Conf. Exhib. Photovolt. Solar Energy Convers. Wien, Austria, Jul. 1998, pp. 2045–2048.

34 T. Esram and P. L. Chapman, “Comparison of photovoltaic array maximum
Power point tracking techniques,” IEEE Trans. Energy Convers., vol. 22, no. 2, pp. 439–449, Jun. 2007.

35 F. Liu, S. Duan, F. Liu, B. Liu, and Y. Kang, “A variable step size INC MPPT method for PV systems,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2622–2628, Jul. 2008.