

Application Note

Compatibility of Transformerless Inverters

Much has been written recently about superstrate-based thin film modules and the effect of negative voltage biases in PV systems designed with transformerless inverters. On some module and system combinations, this negative voltage bias can result in what is known as transparent conductive oxide (TCO) corrosion. This effect has been well understood since the original National Renewable Energy Laboratory (NREL) testing and subsequent published papers of 2001 and 2002. First Solar was involved in the early testing with NREL and has continued an in-house testing program over the last five years. As the NREL testing revealed, the presence of negative bias is only one of the conditions required to induce TCO corrosion. In addition to a high voltage negative bias, the presence of moisture, heat, current leakage paths, and a conductive surface in contact with the front glass (such as an aluminum frame) are also required. While thin film PV modules are routinely generalized by their technology, it is important to consider several differentiating factors for each module. Testing shows that module packaging design, manufacturing processes, and use of a proper system design are all critical factors in determining the module reliability.

With the release of the FS Series 2 PV Module in late 2005, First Solar was able to offer a module designed and tested to be robust against the conditions necessary for TCO corrosion. New Highly Accelerated Life Tests were developed and executed at -1000 voltage bias levels, providing up to a 4x safety factor above typical field bias levels. However, even with the promising accelerated testing results achieved with the FS Series product design, not all module and inverter combinations should be assumed compatible. During the first four years of commercial sales to Europe, First Solar restricted the use of its products with transformerless inverters pending full field trials with several inverter designs.

The field testing and analysis is based on the classification of inverter architectures published by Dr. Schmidt at Fraunhofer ISE¹ and includes systems based on Class A, B and C architectures. While testing is continuing on some of the architectures, First Solar is now satisfied that with proper review of the inverter topology and control of the system design, high performance, reliable systems can be realized with select transformerless inverters. Through its System Design and Application (SDA) review process and with the cooperation of our project developer partners, First Solar is completing a systematic review of all proposed designs containing transformerless inverters to ensure compatibility. As these reviews are completed, approved SDA's and supporting application notes will be released.



¹ „Requires a thin film module a specific inverter?“ by H. Schmidt: „Benötigen Dünnschichtmodule spezielle Wechselrichter?“ 4th Userforum "DÜNNSCHICHT-PHOTOVOLTAIK". Module - Systeme - Anwendungen. 2008

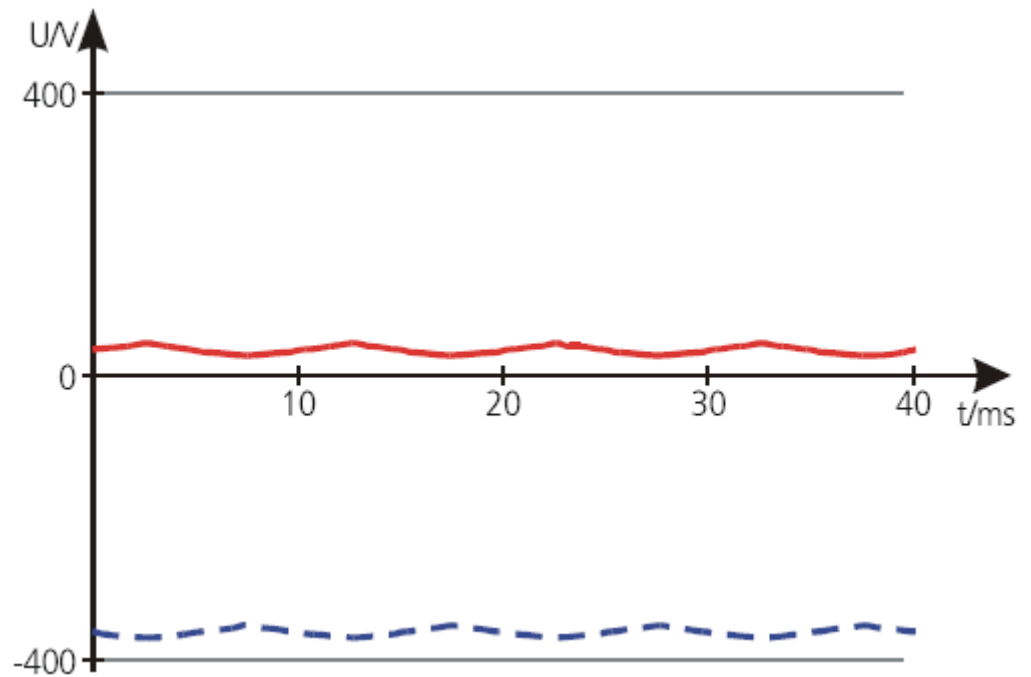
Appendix A

Classification and Grouping of differed Inverter architecture

(Fraunhofer –Institut für solar Energiesysteme ISE Author; Heribert Schmidt, Bruno Burger, Klaus Kiefer)

Group A:

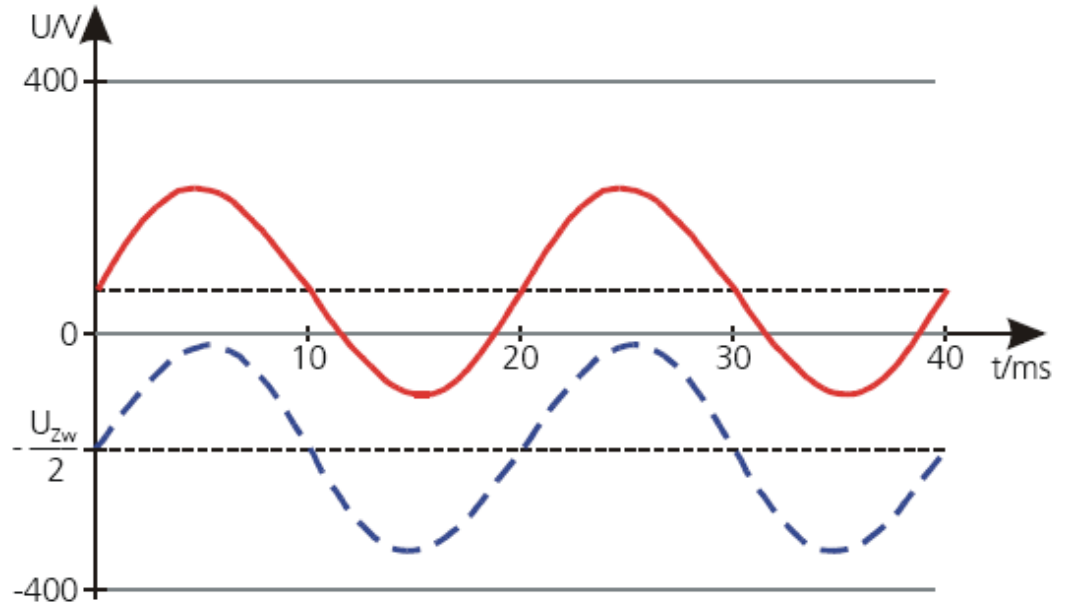
- Inverter with and without transformer
- Floating voltage
- Symmetrical or unsymmetrical voltage to ground
- 100Hz voltage ripple (single phase inverter about 3...5% of USG)



Group B:

Transformerless inverter with a sinusoidal AC-Voltage as DC-Voltage overlaid

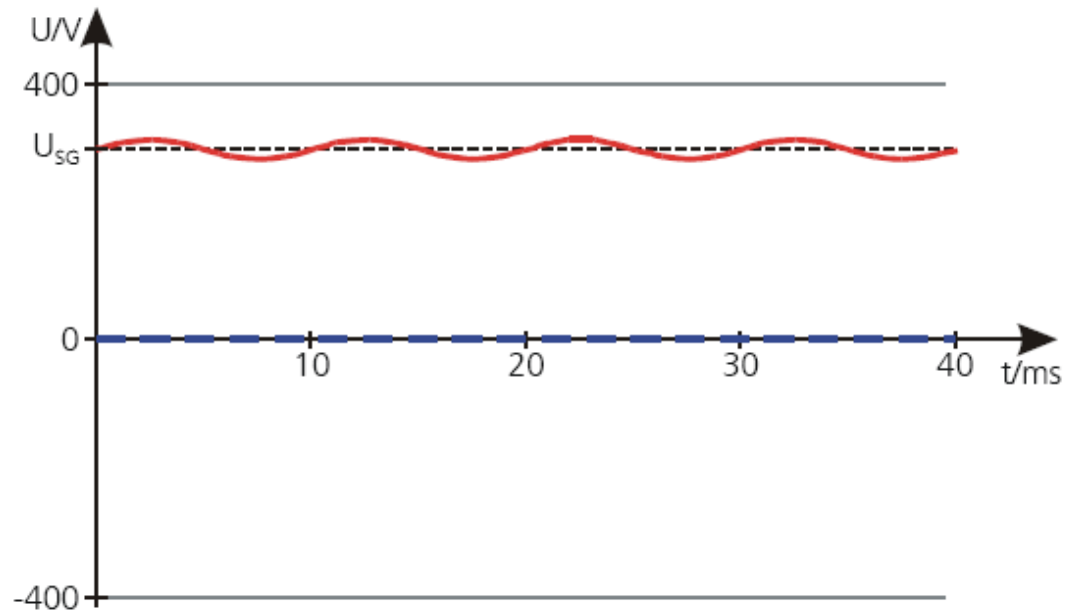
- Fixed voltage
- Symmetrical voltage
- Half grid voltage (115V /50 Hz overlay)



Group C:

Transformerless Inverter with one pole connected to ground

- Fixed voltage
- Unsymmetrical voltage



Symbol Caption

- U_{SG} PV generator voltage (plus to minus)
- U_{ZW} chopper circuit voltage (link voltage)

Appendix B – List of Compatible TL Inverters

The following inverters have been tested by First Solar to ensure functional compatibility and reliable performance of First Solar FS Series 2 PV modules over the life of the modules. Due to the electrical similarity of the FS Series 3 Modules, First Solar also supports the compatibility of these inverters for FS Series 3 Modules. Each inverter has varying specifications and performance characteristics that need to be considered for each individual application. Except as noted below, absence from the list does not indicate that there is an incompatibility with an inverter; only that First Solar or its partners have not completed performance verification of the component.

Compatible TL Inverters for First Solar Series 2 modules:

- Conergy - Vision IPG 2000, 3000, 4000, 5000
- Power One PVI 3.0-OUTD, 3.0-OUTD-S, 3.6-OUTD, 3.6-OUTD-S, 4.2-OUTD, 4.2-OUTD-S, 5000-OUTD, 5000-OUTD-S, 6000-OUTD, 6000-OUTD-S
- PVI Central SB 50-TL, 100-TL, 150-TL, 200-TL, 250-TL, 300-TLSMA
2100TL, 3000TL, 4000TL, 5000TL,
3300TL HC, 4200TL HC, 5000TL HC
SMC 6000TL, 7000TL, 8000TL, 9000TL, 10000TL, 11000TL
- Sputnik Engineering SolarMax 2000C, 3000C, 4000C, 4200C, 6000C
- Sunways NT 8000, 10000