Freescale Semiconductor
Application Note

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Freescale DSCs in PV Solar Inverter Applications

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1 Introduction

This application note introduces key topologies for solar panel inverters and suggests Freescale Digital Signal Controllers (DSC) to their control.

The photovoltaic (PV) solar panels are one of the important energy harvesting devices from the Sun. The conversion of the solar photo energy to the electrical energy is based on the modified P-N barrier. One PV cell produces the DC voltage in range of 0.5–0.6 V. The solar cells in the serial connection are mounted to the solar panels. The output voltage of the solar panels reaches up to 50 V or more. The solar inverter is the device, which converts this low DC voltage to the power line level AC voltage. The simple block schematic is shown in Figure 1.

Contents

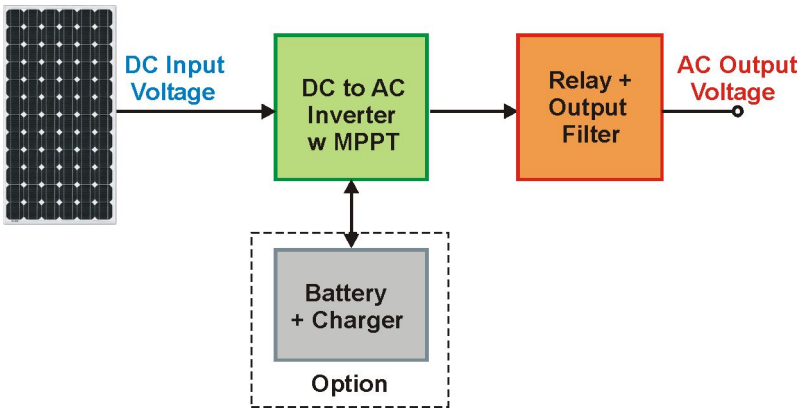

Figure 1. Block schematic

The power range of the solar inverters can be split into several groups:

- Small inverters – roughly up to 1 kW output power
  - Low voltage – Microinverter for each solar panel
  - High voltage – one inverter for the serial string of the solar panels (with/without isolation).
- Medium inverters – from 1 to roughly 5 kW output power
  - Non-isolated – not connected to the AC power grid (OFF-GRID)
  - Isolated – connected to the AC power grid (ON-GRID)
- Large inverters – more than 5 kW output power (isolated)
  - One-phase configuration
  - Three-phase configuration

The solar inverters not connected to the AC power grid usually use the battery for the energy accumulation. Then the application comprises the battery charger.

2 Freescale solution

Freescale provides powerful DSCs of the MC56F84xx and MC56F82xx families for the control of PV solar power inverters.

2.1 MC56F84xxx family

This family provides excellent set of the internal peripheral modules, including:

- 100 MHz/100 MIPS 32-bit DSP core
- Large RAM and FLASH memory with DMA
- Single-cycle math computation, fractional arithmetic support
- Two 12-bit high speed ADCs with 3.3 Msps
- One 16-bit ADC with 1 Msps
- High-resolution PWMs with 312 ps resolution
- Up to 24 PWM channels including two PWM modules
- Four analog comparators with integrated 6-bit DACs
- Four DMA channels
- Intermodule crossbar connection
- Various communication peripherals

2.2 MC56F82xx family

This family provides powerful set of the internal peripheral modules, including:

- 60 MHz/60 MIPS 32-bit DSP core
- On-chip RAM and FLASH memory
- Single-cycle math computation, fractional arithmetic support
- Two 12-bit 8-channel ADCs with dynamic x2, x4 programmable amplifier
- Up to 9 eFlexPWM channels including six channels with high-resolution Nano-Edge placement
- Two 16-bit quad timers
- Three analog comparators with integrated 5-bit DACs
- Intermodule crossbar connection
- Various communication peripherals

These DSCs with the high computation power are excellent choice for the power conversion applications.

3 Inverter topologies

The main topologies of the PV solar panel inverters are explained briefly in the following subsections.

3.1 Microinverter topology

In case one solar PV panel is shaded in the panel string (that is, one panel doesn't have solar energy), the output power of the whole PV string is lowered. This issue can be solved by using a microinverter. It converts the DC output voltage of the each individual solar PV panel to the power line level AC voltage or to the high-voltage DC-Bus. The outputs of the each microinverter are connected in parallel to provide higher output power. In case a high-voltage DC-Bus is used, the DC to AC power conversion provides one central power inverter. The microinverter topology is shown in Figure 2.

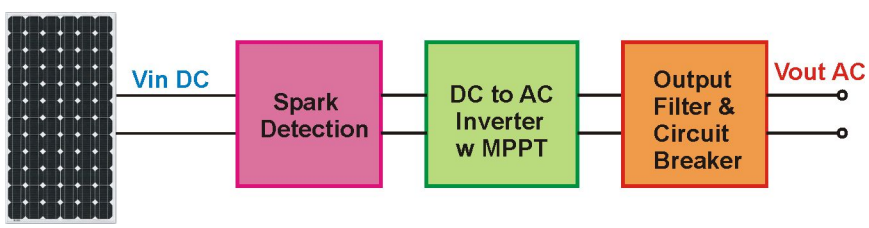

Figure 2. Microinverter topology

The microinverter includes the following units.

- Spark Detection unit: The spark detection circuit provides the protection against spark generated by the failed solar panel. If the spark arises, the spark detection circuit disconnects the panel from the microinverter.
- DC to AC Inverter: It can be built in various topologies. The maximum power point tracking (MPPT) feature is implemented in the control software. The inverter has implemented the phase synchronization feature to the grid voltage too. It generates pure sine shape current to deliver power to the connected grid.
- Output Filter and Circuit Breaker: The output filter lowers the high-frequency emissions generated by the switching stage of the inverter. The circuit breaker disconnects the load when the microinverter is overloaded.

The microinverter is usually equipped with the communication unit to provide the status information or receive the control commands to/from the central controller.

The powerful DSCs of the Freescale MC56F82xx or MC56F84xxx MCU family can be used as the control unit. The accurate selection depends on the selected topology of the microinverter.

3.2 Medium inverter with battery charger option

This kind of the PV inverter occupies the power range up to 5 kW of the output power. It can be used in various configurations:

- Isolated or grid connected
- With or without the battery charger
- For one or two PV panels, or for the larger strings

All these options determine the final topology and configuration of the PV inverter. They typically use one-phase topology. The basic block schematic of a medium inverter is depicted in Figure 3.

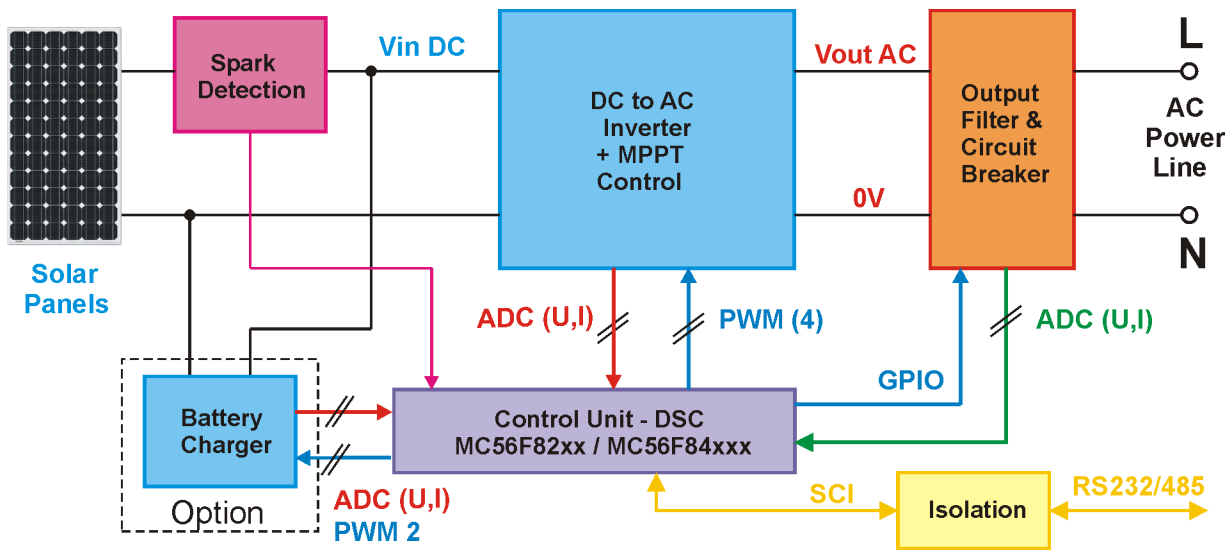

Figure 3. Medium inverter

This kind of the inverter has units similar to the microinverter. The inverter has a Spark Detection circuit, Communication circuit, and the Output Filter with the Circuit Breaker (For information on the functions of these units, see Microinverter topology). The final topology of the inverter depends on the input DC voltage level (number of PV panels connected serially) and the input-output isolation requirements.

The battery charger circuit provides the energy storage feature for the independently used PV inverter without grid connection. The Digital Signal Controller contains the software to control the selected inverter topology, MPPT, and the battery charger.

The inverter can be controlled by the DSC of MC56F84xxx family. In case of isolated topology, the two DSCs of the MC56F82xx family can be used. Both DSCs are connected by the isolated SPI or SCI internal serial link. In this case, the first DSC controls the battery charger and maintains the MPPT feature. The second DSC controls the inverter and maintains the external link communication.

3.3 Large inverters for the PV panels

These PV inverters are intended for the large PV fields. The PV panels are serially connected in several sections. The block schematic of a large inverter is shown in Figure 4.

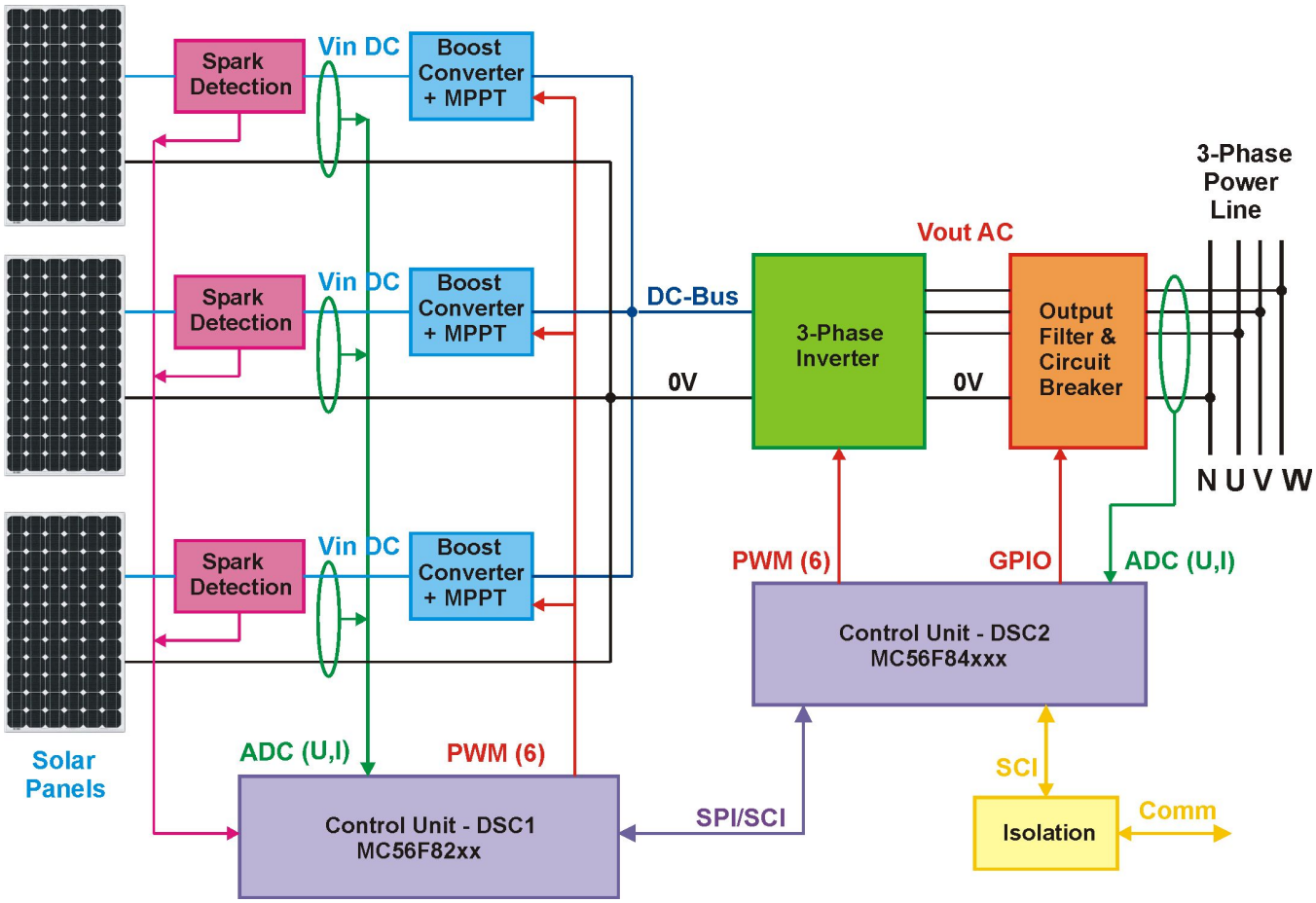

Figure 4. Large three-phase inverter

Figure 4 shows the three PV panel string as an example. The number of the strings depends on the final solution. Each string is equipped with the Spark Detection circuit and Boost Converter with MPPT feature. All boost converters are independently controlled by the first DSC (DSC1), MC56F82xx. The MPPT feature is implemented in the control software for the each PV panel string. All PV panels deliver the power to the high-voltage DC-Bus. Then, this DC voltage is inverted to the three-phase output voltage synchronized to the grid power line. This high-power inverter is controlled by the second DSC (DSC2), MC56F84xxx. The inverter delivers the three-phase true sine shape current to the power line.

4 Conclusion

All the challenging requirements for these power conversion applications will be fulfilled with the new families of DSCs provided by Freescale. The excellent properties of the DSCs are strengthened by the rich set of the highly optimized and proved software libraries available on **freescale.com**.

5 References

The following pages and tools are available on **freescale.com**

Html pages:

- MC56F84xx: Digital Signal Controllers
- TWR-56F8400: MC56F84789 Motor and Power Control MCU Tower System Module

References

- 56F824X_825X: Digital Signal Controller
- TWR-56F8257: Motor Control Tower System Module
- Digital Power Conversion

Featured software and tools:

- CodeWarrior Development Studio for 56800/E Digital Signal Controllers (Classic IDE)
- FreeMASTER Run-Time Debugging Tool
- Embedded Software and Motor Control Libraries

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