How A New Power Stack Communication System Improves IGBT Reliability and Shortens Development Time

Albert Charpentier, CTO, AgileSwitch, LLC

Overview

While inverter manufacturers have traditionally designed and produced their own proprietary Power Stacks for renewable energy and high efficiency motor drive applications, there is a growing trend toward using third party Stacks to reduce development times, improve lifetime reliability of their inverters, and better manage supply chains (Yole Developpement).

To meet the demands for improved reliability, and shorter development cycles, inverter producers have increasingly requested Stacks with deeper monitoring and control capability, and easier customization of integrated best in class components. These requirements, however, have created a burden on the traditional serial interface structure found on most third party Stacks.

A new class of Power Stacks is emerging that provides for advanced fault and monitoring capability while enabling continuous monitoring of the performance and health of the switching system. Data from this monitoring, augmented by predictive analytics, helps pre-empt system failure and adjusts overall system performance accordingly. Coupled with a hybrid capacitor bank that balances the benefits of electrolytic storage capability with the filtering of high frequency ripple currents of film based capacitors, these new third party Stacks increase system lifetime by at least twice that of conventional systems.

Further, these programmable and hardware configurable Stacks shorten development times and lower supply chain risks and costs through multi-sourcing of IGBTs.

Traditional IGBT Gate Drive and Interface boards are currently driven by a main CPU/DSP control unit which is usually a standalone embedded control board. The main CPU control unit communicates to the Power Stack via a ribbon cable. The signals on the ribbon cable allow signal line control for the triggers, errors, current, temperature and voltage monitors.

This parallel ribbon cable interface is a communication bottleneck that limits the information flow to the CPU to adequately monitor all aspects of the Power Stack. Improved communication protocols allow better monitoring of the IGBTs for improved performance and reliability. A new serial communication protocol is less expensive and more reliable than the current ribbon interconnect system. Figures 1& 2 depict a typical solution.

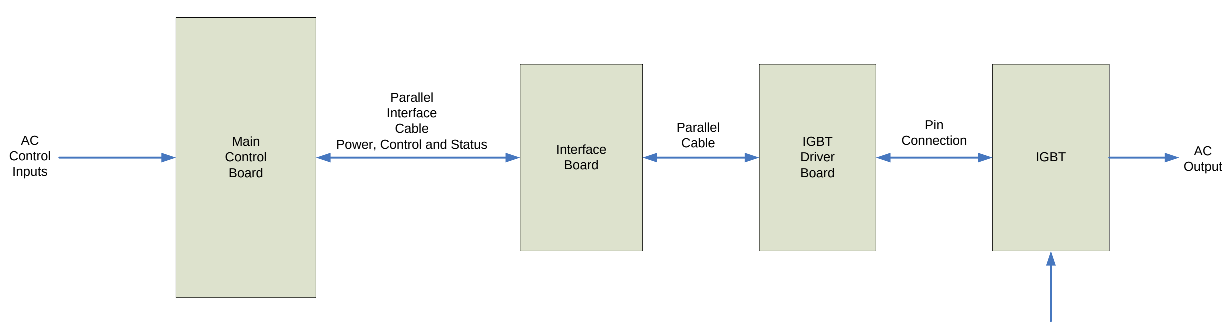


Figure 1. Typical Communication Paths utilized in Power Stack systems.

Pin No	Signal	Pin No	Signal
1	GND	2	BOT-HB1-IN
3	ERROR-HBI-OUT	4	TOP-HB1-IN
5	BOT-HB2-IN	6	ERROR-HB2-OUT
7	TOP-HB2-IN	8	BOT-HB3-IN
9	ERROR-HB3-OUT	10	TOP-HB3-IN
11	OVERTEMP-OUT	12	NC
13	VDC-LINK MONITOR	14	VCC - Supply Voltage
15	VCC - Supply Voltage	16	+15V
17	+15V	18	GND
19	GND	20	TEMP-SENSE-OUT
21	GND	22	I-SENSE1-OUT
23	GND	24	I-SENSE2-OUT
25	GND	26	I-SENSE3-OUT

Figure 2. Pin out of a typical 3 phase Power Stack Parallel Ribbon Cable.

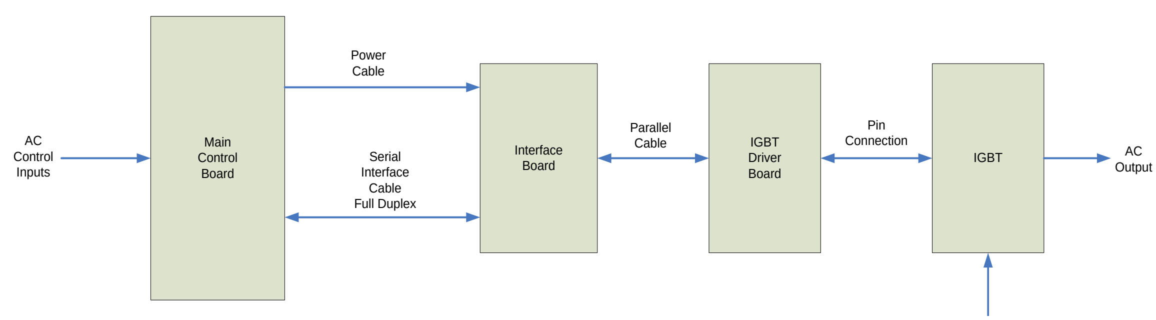
It is clear that the parallel ribbon cable system limits the communication from host CPU to Power Stack. The number of monitors is limited. For example, it would be useful to monitor the temperature of each IGBT module separately. There are only three error signals HB Error 1, 2, and 3. That does not allow a detailed view of what exactly caused the error. Having such a limited communication limits the expansion of new information for future designs.

In summary the current parallel ribbon cable system has the following limitations:

1. The power and grounds supplied on a ribbon cable do not adequately support the power and grounding requirements of the interface board.
2. Supplying power over the same cable as the signal lines can cause additional noise on the control signals and make EMI shielding more difficult.
3. This signals cannot be made differential leading to improved noise immunity
4. The parallel interface is not an industry standard which complicates the customer interface to digital logic components on the interface board.
5. Due to the limited number of pins on the parallel interface it is not possible to provide adequate status/error information back to the main control unit.

Benefits of a Serial Interface

Figure 3 shows an overview of a serial communication interface. In this drawing the Parallel interface cable is replaced by a Power cable and a Full Duplex Serial Interface cable.



The serial interface implementation will be offered in varying levels of complexity depending on customer requirements. This will require offering a number of Serial Interface options:

Option 1:

1. A 20 pin ribbon cable will send the control triggers to the power stack as is done in the current ribbon system.
2. Serial communication signals are delivered through this interface cable as Differential SPI used to transfer control and status/error information to/from the Interface board.

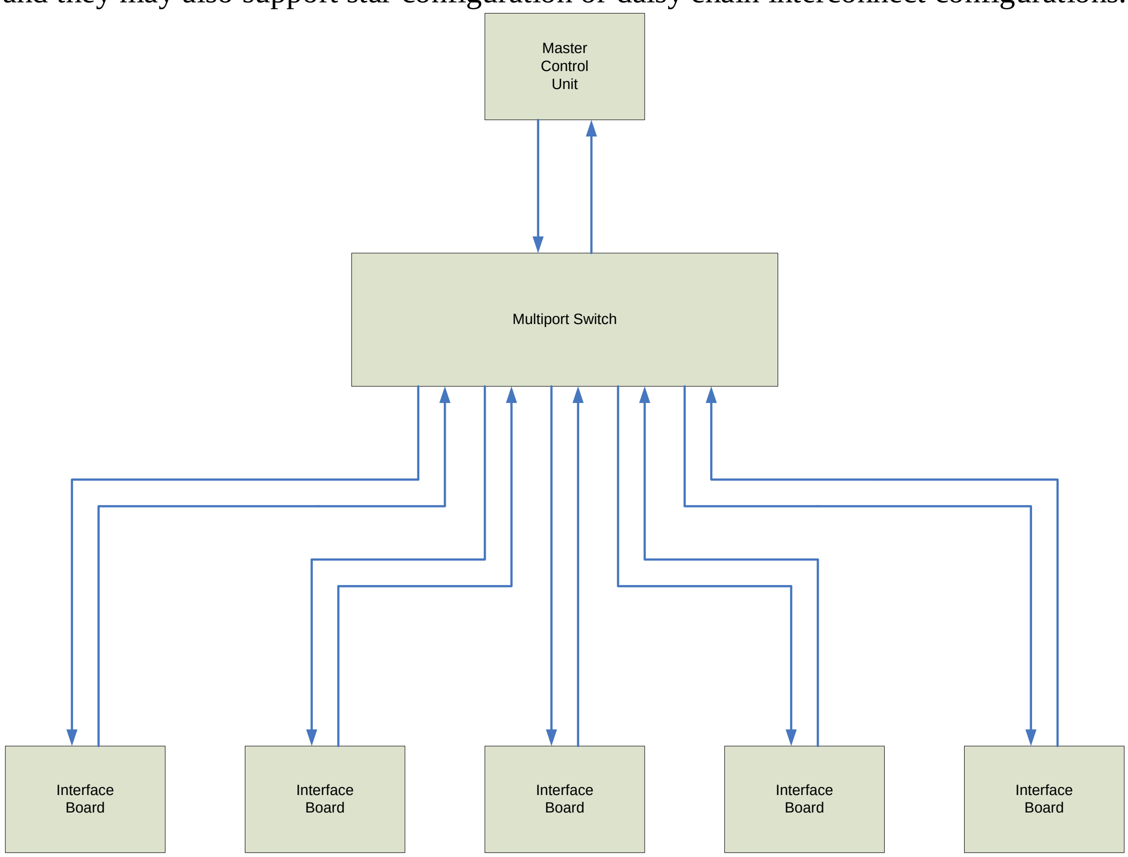
Option 2:

1. Only the Triggers are delivered through a Ribbon Cable and/or Fiber.
2. The serial communication is delivered via differential SPI or RS422/RS485 Full Duplex Interface via isolated wire or fiber for system errors and monitors.

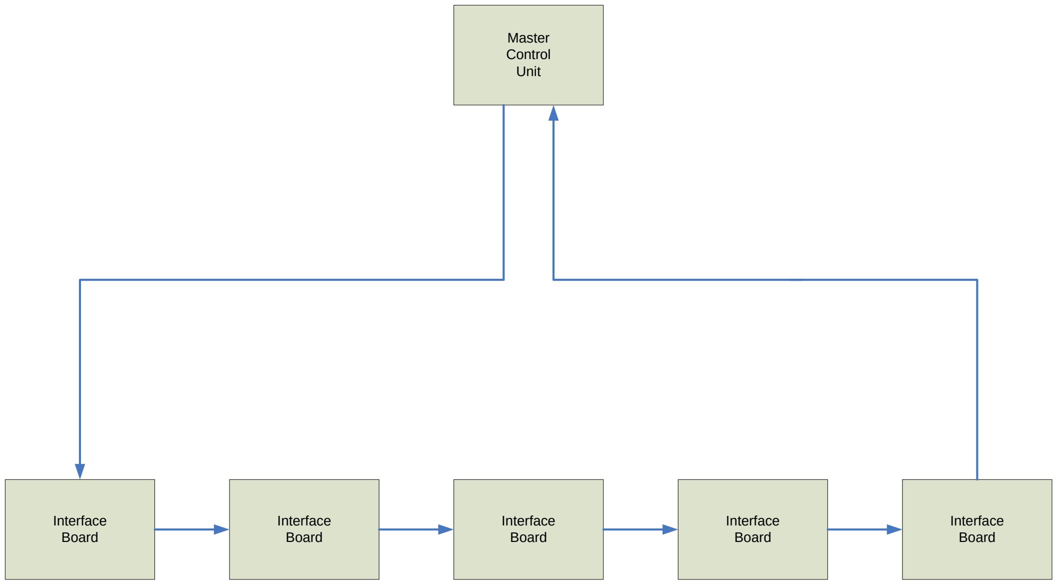
Option 3:

1. Only the Triggers are delivered through a Ribbon Cable and/or Fiber.
2. Ethernet Full Duplex Interface for system errors and system monitors.

Either serial interface option will be able to support single or multiple power stack applications and they may also support star configuration or daisy chain interconnect configurations.



Serial Interface Control – Star Configuration



Serial Interface Control – Daisy Chain Configuration

The Future of Stack Control Systems.

The communication systems thus far presented are an evolutionary step to a complete serial control system for power stacks. We anticipate that future Power Stacks will support a master to local clock synchronization structure between the master control unit (master clock) and the interface boards (local clock).

This high frequency clock synchronization system will allow the implementation of a new frame timing control. This protocol will allow the host CPU to construct "frames" that controls the trigger timing for each IGBT for a frame time. The frame time can be set by the host and the timing accuracy of the trigger is +/- 10ns.

A Power Stack demonstrating these capabilities will be described at the presentation.

Albert Charpentier, CTO, AgileSwitch, LLC

Albert Charpentier has been involved with cutting edge technology throughout his career. He is an entrepreneur interested in new applications of emerging technology in the electronic field. He holds ten patents in the fields of semiconductor processing, chip design, hearing aids, and near field radar.

Albert started his career at MOS technology, which was purchased by Commodore Business Machines in 1976. There he designed calculators, microprocessors, ROMs, DRAM, SRAM, and video chips. Albert was Vice President of Engineering at Commodore, where he led the development team responsible for the Commodore 64 Computer.

He left Commodore in 1982 to start his first company. He was the founder and President of Ensoniq, a leading manufacturer of high-end electronic musical instruments, audio chips and add-in cards for PCs. Ensoniq was purchased in 1998 by Creative Technologies, a Singaporean company known for its SoundBlaster audio brand. In 1999, Albert led a group of investors in the purchase of ActivE Inc, a small IT company.

He was Chairman and interim CEO and hired a new CEO and management team. The company was sold to Neoware in 2002. Neoware was later purchased by HP. In 2000, Albert started Intellifit. Intellifit licensed near field radar technology from Battelle Memorial and developed a new type of body scanner that takes measurements directly through clothing. The measurements can be used for health care reports, fashion reports, sizing recommendations and custom clothing applications. Intellifit was merged with Unique Solutions, a Canadian company, in 2009.

Mr. Charpentier earned a Bachelor of Science in Electrical Engineering from the University of Pennsylvania.

About AgileSwitch

AgileSwitch is developing transformative technology that dramatically improves the performance and efficiency of drivers for IGBT switches. IGBTs are used in a variety of power converters including solar inverters, wind turbines, motor drives, UPS, industrial machines, HEV, traction and power distribution.

Power converters have been incrementally improved over recent decades and have reached the point where a large effort is needed to achieve a small gain in performance or efficiency. The Company's technologies can help cut power use by up to half in some applications and provide substantial performance benefits in powering most electronic equipment.

The Company's technologies are specifically targeted toward converters for systems focused on renewable energy (e.g. solar, wind, smart grid, HEV) as well as other mission critical applications (e.g. traction, UPS).