SPD Smart Glass Electronics Overview

Research Frontiers Inc. Annual Meeting

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SPD Control Systems Corporation
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1. Introduction

My name is John Petraglia. I am the CEO of SPD Control Systems Corporation. In the audience are Jay Moskowitz, our Founder and Chairman of the Board, and Peter Solaski, our Chief Technology Officer. Our company is licensed by Research Frontiers to design and manufacturer SPD electronic control systems.

I would like to thank Bob Saxe, Joe Harary, and the Board of Directors for inviting me to talk about SPD electronics and the importance of electronics in the emerging Smart Glass industry.

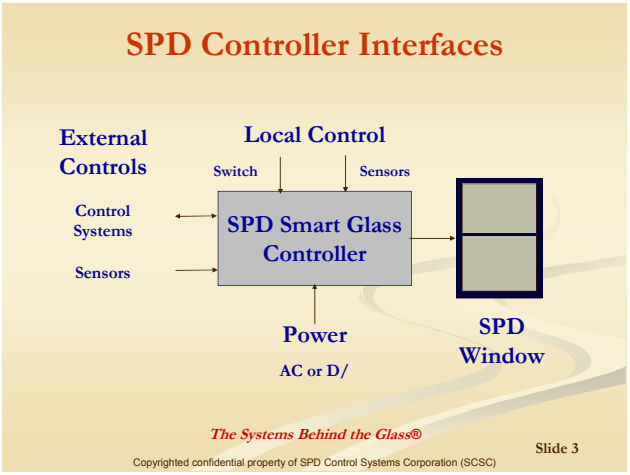
It has been an exciting 12 months since the last RFI Annual Meeting. There have been product announcements by RFI licensees' Inspectech, Isoclima, and Innovative Glass. Hitachi Chemical Company Ltd. announced production of SPD film in February. We have been working closely with Hitachi Chemical Company, Dainippon Ink and Chemical, and Isoclima, as they are actively working to introduce their own SPD film. We want to ensure that our controllers work well with all the suppliers of SPD film.

We have had interest from 5 major automotive companies. At least two of those companies are seriously planning on using SPD Smart Glass in the near term. We have introduced SPD Smart Glass and our controllers to two world class architects and they are considering pilot projects. We are also working on a LEED certified office building here on Long Island. And, we are bidding on an aerospace project with an RFI licensee.

There are many opportunities for integrating SPD Smart Glass into the existing products manufactured by the automotive, aerospace, marine and architectural industries. This talk focuses on the unique requirements and needs for sophisticated controllers in these markets.

2. Driving SPD Film

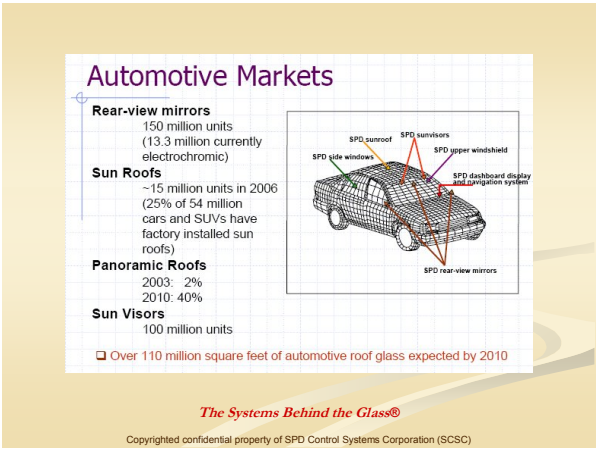
SPD Smart Glass requires alternating current to set tint levels. The SPD controller itself is powered by alternating or direct current. The power may be from a standard electrical system, a photovoltaic array or a battery. The controls may be a slide switch, push button or any other switch to cause the SPD Smart Glass to vary the tint level. There may be sensors, such as a photocell light sensor, to cause the tint to change under dynamic environmental conditions. Tint level commands may be sent over a network to the SPD controllers from another system or subsystem, such as a vehicle central computer or a master building control system.



Controllers to power SPD glass can be simple or sophisticated. To efficiently operate Smart Glass in a wide range of applications, the controller must be capable of driving the film to achieve optimum optical and energy saving characteristics. The parameters that affect the performance are the waveform, frequency, and duty cycle. The SPD controller can detect a broken window, interface to digital communication busses, and accept input from various types of sensors. Sensors include photocell, temperature and motion detectors.

3. Vehicles

SPD Smart Glass and plastic products will be used in vehicles for sunroofs, side windows, rear window, top of the front windshield, side mirrors, rear view mirrors, sun visors and panoramic roofs. The issues in integrating SPD Smart Glass controllers into a vehicle include determining an appropriate physical location near each SPD window, satisfying power constraints, vehicle communication interface selection, diagnostics, quality assurance testing, compact size, extreme temperatures, and just-in-time delivery of controllers to the vehicle assembly line.



Besides the obvious aesthetic value of SPD windows there is a substantial energy efficiency gain by blocking solar energy. This allows for a less powerful air conditioning unit and reduced air conditioning operation resulting in up to a 10% increase in miles per gallon according to government estimates.

The dynamic tinting of the windows can be manual and automatic. Manual tinting allows passengers and the driver to directly control the tint using devices such as push buttons and solid state sliding switches. Automatic tinting can be accomplished for many conditions including the vehicle turned on and off, glare, internal temperature, changing state boundaries, emergency conditions, security conditions, time-of-day, personal settings, door lock state, and more. For example, when a car is unlocked the windows clear to allow you to look into the car before entering and when the car is started the window tint is automatically changed to the level before the car was turned off.

The vehicle's SPD controllers need to be informed about the conditions that may cause the tinting level to change. The communication to the SPD controllers may be over the vehicles digital bus, status control lines, or directly from sensors. The primary communication interfaces and protocols are the LIN and CAN busses. These standard communication paths provide a digital information link between the different vehicle subsystem controllers and the SPD controllers.

The automakers we are dealing with require each SPD window to have a controller since a controller must be close to the window it is driving. SPD controllers must be DC powered from the vehicle battery and produce AC to control window tinting. Each window has an individual switch, just like the switch for each power window allows the passenger to control his or her individual window. And, a switch is provided to the driver to control the tinting of all of the windows.

Vehicle manufacturers prefer to stock minimum inventory. Controllers have to be delivered just-in-time for installation on the assembly line. Our company solves this requirement for European vehicle companies, for example, by using a U.S. based electronics' assembler with a factory in Romania and a warehouse near the vehicle assembly plant.

4. Airplanes

The aerospace SPD application is primarily for cabin windows, but there is also a potentially significant market in cockpit doors and interior partitions that divide various classes within an aircraft. The many problems and limitations with traditional pull-down window shades on an aircraft include not being able to easily control all the shades when needed, not being able to control glare, and not being able to control heat buildup in the cabin due to sun light. SPD window shades solve these problems. In addition, there is also an aesthetic value, the ability to increase interior space and comfort, and provide passengers and flight crews with more control over the cabin environment.

The efficiency gains are due to reduced maintenance as well as the weight savings resulting in fuel savings that can occur when you replace standard shade assemblies with SPD polycarbonate shade assemblies. The relative weight savings from using SPD shades can be even more dramatic when compared to the fact that our competitor's electrochromic window shades add weight because they require use of glass and containment systems to prevent glass shards from harming passengers. Electrochromic systems also add weight from the additional wiring, control switches and power supplies that have to have their power output precisely conditioned because electrochromic glass can fail due to even small voltage spikes.

The control of the aircraft's tinting is relatively straightforward. The changing of tint is affected by individual passenger, pilot, and flight attendant switches. Automatic tinting of some or all the windows could be due to glare, solar heat buildup, and emergency conditions. The communication bus is typically the CAN bus, similar to the CAN bus used in a vehicle. The FAA testing requirements are even more rigorous than the intensive testing requirements for vehicles. For example, the recent FAA approval of the Raytheon's King Air SPD window shades reportedly required that the windows are to withstand the equivalent of hundreds of lightning strikes on the same window!

5. Architecture

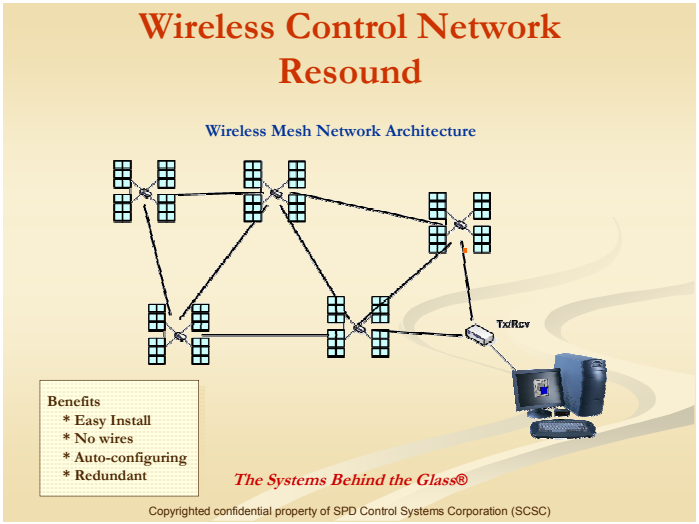
Controlling SPD windows in a residential or small commercial project is relatively straightforward. The most challenging application for SPD electronics is controlling hundreds of windows in a large building. For example, a large building may require that we build integrated SPD systems to control the tinting of individual windows, all the windows in a room, all the windows for a specific tenant, and the windows of a building façade.

The advantages of SPD Smart Glass for windows, skylights, sun tunnels, atriums, penthouses and other uses are aesthetics, no need for window treatments, glare control, and up to a 20% energy savings. In addition, there are the benefits of more efficient use of daylighting, safety and

security, and protection of interiors from heat and UV damage. We believe the overall savings will be much higher if SPD windows are integrated with the building's heating, air conditioning and lighting control systems.

Thought and planning must be given to how to wire a building for SPD windows. Each SPD controller requires power for its own operation and for powering the SPD windows. In more elaborate and sophisticated buildings, SPD controllers also require wiring for communicating control information from a central SPD building control system and for wall panels that control one or more windows. We must address the fact that the windows for most buildings are not wired for electricity or network communication.

The solution is to place the SPD controllers close to the windows they are driving and to have a communication network using these same SPD controllers where the controllers communicate wirelessly with each other to form a network grid to a Central SPD Window Control System. Wireless handheld control units are used to change tint manually for individual and groups of windows. The only wiring required is for powering the SPD controllers and the SPD windows. All communication to the Central SPD Control System is wireless through the wireless control network formed by the SPD controller nodes dispersed throughout the building.



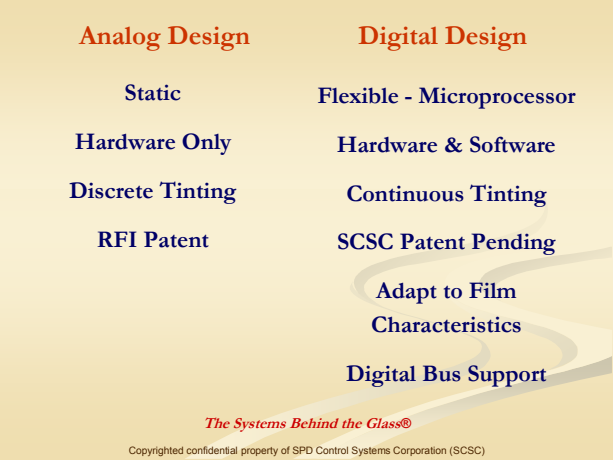
Our personnel have extensive experience designing complex systems including many wireless systems. We are utilizing this experience to develop a wireless network for connecting SPD controllers to a central windows control system.

An interesting example of a completely wireless SPD implementation is an office building on Long Island where we are installing electronics for a large SPD skylight. There are no wires because all communication for the controllers and handheld control units is wireless. And, the controllers and windows are powered by a photovoltaic array mounted next to the skylight. The photovoltaic array will even power our central SPD building control system. The building is targeted for LEED silver certification.

6. Under the Controller Hood

As you can see from the above discussion, SPD controllers are used in diverse applications with their own unique operating requirements. One design approach is to use a microprocessor driven controller. The controller can then be easily modified for different requirements such as communication busses, sensors, control units, and wireless networks. Using a microprocessor also allows for the incorporation of algorithms for controlling the SPD optical and energy conservation characteristics. SPD Control Systems has a patent pending for this approach using an intelligent microprocessor controller.

An alternative non-microprocessor solution is similar to a lighting rheostat. This controller design is adequate for many simple applications. However, the controller cannot be used with a digital communication bus needed to communicate with digital vehicle and aerospace subsystems, and cannot operate in a wireless network. Non-microprocessor controllers can be controlled from a central system but this configuration is not as flexible as a microprocessor solution. The way to understand the difference between a microprocessor based SPD system and a non-microprocessor system is to consider the difference between hardware only and a flexible software based system.



7. Summary

I hope that this discussion of SPD Smart Glass electronics has given you a better understanding of how we are working with major customers in the various markets for SPD Smart Glass, and the role that simple and sophisticated control systems play in each these markets. SPD control systems require flexibility in driving SPD Smart Glass, reacting to a wide range of environmental conditions, and in the case of large architectural projects, the complexities of coordinating the façade of a building with hundreds of windows.

In the past year, we have expanded our resources, accelerated our efforts, and are very excited about recent developments in the SPD industry and the active work that we are doing with various licensees and the world's largest automakers.

For additional information about our SPD Smart Glass controllers for various industries, please visit our website at www.spdControlSystems.com.

Thank you for your attention.

