System Integration

As theatre has come to rely more heavily on technology, the problem of controlling the various systems has arisen. Complicated sequences incorporating lighting, sound, video, motion systems, pyrotechnics, and other technologies demand perfect synchronization, both for aesthetics and for safety.

For decades, the manufacturing industries have used industrial automation equipment to control motion systems, audible warnings, and other devices. The AV market has developed links between various pieces of equipment in order to simplify tasks such as duplicating tapes or playing back specific video segments on demand. Musicians use data interfaces to connect their instruments, producing multiple sounds from a single key press.

The synthesis and adaptation of these technologies has allowed them to be incorporated in Theatre under the unified term Show Control.

Show control, in general, refers to the interconnection of traditionally unrelated systems under a master controller. However, in order to understand a full system, one must be able to identify and work with its component parts.

GPI

The simplest of interconnection protocols, GPI, or General Purpose Interface, allows a simple switch closure to trigger a function in a system. For example, the “go” button of a light board or the “take” button of a video mixer could, through GPI, be wired to an external switch.

However, as demonstrated in the pneumatics lab, that external switch does not have to take the form of a pushbutton. A pressure switch in the floor, motion detector, infrared threshold detector, RF controlled relay, computer controlled relay, or any other number of switch closure devices could be used.

Many of these types of sensors have switch closure functions built in. That is to say, when activated, they connect an input to an output, thus completing the circuit.

Others, when triggered, provide a 5, 12, 120, or some other voltage output on a single pin.

?? How could we interface a GPI device to a voltage output??

Serial

Just as on your computer, many devices today are equipped with serial ports. Video matrix switchers, hard-drive based video or audio playback devices, stage machinery controllers, relay banks are examples of devices that could be controlled with serial commands.

RS-232 is the most common serial control protocol. (Different protocols use different speeds, pinouts, word lengths, error checking, etc.) Essentially, any device which is equipped with an RS-232 interface can be controlled, usually by computer.

Serial interfaces allow you to compose simple commands to be sent to the device. For example, an RS-232 equipped DVD player could accept the command “Cue to chapter 4, frame 1350 and play.” These commands nearly always take the form of a Hex value, but a lookup table is usually available either online or with the provided literature.

Most computers come with a terminal application which allows you to place data on the computers various output ports. The general process involves opening a connection to the port, inputting a data string, and writing that string to the port.

Most show control packages, such as Showmagic, allow you to create cues or easy-access buttons which contain the appropriate data. A simple press of the spacebar or click of a button on-screen sends the data over the serial port, instead of having to work within a terminal application.

MIDI

MIDI stands for Musical Instrument Digital Interface, and was originally developed to allow musicians to control numerous synthesizers at once. For example, a keyboardist striking a C chord could trigger a second synthesizer, set to emulate a guitar, to strum the same chord.

Standard MIDI commands include "note on," "note off," "program change," and other musically-oriented commands. This command set is referred to collectively as "general MIDI." Many devices, light boards in particular, allow a specific note to be mapped to a channel, macro, cue, or other event.

Difficulty arises when working with general MIDI, as it is often difficult to decipher how "C Sharp #2" corresponds to "Cue 15 Go." For this reason, an extension to the MIDI command set was created by the entertainment industry.

MSC, or Midi Show Control, contains commands such as "cue go," "load cue," or "blackout." Devices which speak MSC are generally easy to integrate with each other. For example, we often link the Hog and the Obsession with a MIDI cable. The Obsession is set to fire MSC commands, and the Hog is set to receive them. Every time a cue is fired in the Obsession, a command "Cue ## Go" is sent to the Hog. Note that, by specifying the cue number, synchronicity between the boards is maintained. A simple "go" command could allow one board to get ahead of the other, especially if the boards contained different numbers of cues.

Most MIDI devices have a 'debug' mode which allows you to view the actual data sent across the link. This allows for easy troubleshooting.

Note that MIDI incorporates a Device ID in the command string. Multiple devices can be daisy chained, and set to respond only to commands containing their ID. It is therefore important to set the master device to send the same ID as the receiving device is set to listen to. Setting a receiving device to device ID 0 (zero) instructs it to respond to ALL commands.

Timecode

Timecode was originally developed in the video industry to ensure that tapes in multiple playback machines remained synchronized. Timecode consists of a constant stream of numbers in the format dd:hh:mm:ss:ff, updated with each frame of video.

Timecode has been incorporated into many other devices, such as audio playback devices and show control systems. Computerized systems which are timecode enabled often allow an event to be fired once a certain timecode is reached. 4D theatres often use this to fire pyrotechnic or other effects at a specific instant during the film.

DMX

As previously discussed, DMX is the standard control protocol for the lighting industry. However, numerous other devices can be set to follow DMX commands. Banks of relays can be set to a specific starting channel, just like a dimmer rack. The relay then "listens" (with the help of a microcontroller) for its data byte, reads it, and closes if the byte value is above a certain threshold. For example, setting DMX address 1 to 100% (Dim 1 @ full) could close a relay which in turn actuates a pneumatic cylinder.

Other devices use map channels and channel values to specific functions. We've already discussed that automated lights can use multiple channels. So to do other DMX controlled devices. For example, DMX interfaces exist that allow channel values to be mapped to infrared pulses. This allows you to simulate a standard remote control in order to control a consumer DVD player. High End makes a system called Catalyst, which incorporates real-time video effects. From the light board, video can be played, stopped, colorized, rotated, or any other number of video effects.

Putting it All Together

Show control systems are technologically challenging, but often less complicated than they would seem. Studying the documentation of the devices found in theatres can often lead to discoveries about novel ways of interconnecting them.

Adding a third piece – such as a serial or DMX controlled relay board – can often allow the connection of devices which would otherwise be incompatible. For example, a video mixer with a GPI interface can not be directly controlled via DMX. However, a DMX relay board could be used, and patched such that bringing a channel to full would close the relay. Alternately (in a tight situation), a relay could be connected to a dimmer. When the dimmer was powered, the relay would close, firing the GPI device.

The creation of show control systems has greatly simplified the process of connecting unrelated systems. A computer equipped with a serial port, a MIDI port, and a DMX port can link virtually any system we use.

Possibilities for control systems are endless. Once you have a basic understanding of device interconnection, it becomes possible to create complex systems without too much effort.

Reference:

Control Systems For Live Entertainment, 2nd Ed.. John Huntington, Focal Press.