

GilderAppNote

Application Hints from Gilderfluke & Co.

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Motion Base Controls using GilderGear

Safety

Motion Bases normally need a mix of analog outputs (for controlling the hydraulic, pneumatic or electric actuators that move the Motion Base), digital (on/off) outputs (typically for controlling solenoid valves and relays), and DMX-512 (for controlling lights and '4-D' effects).

Although there are variants to this, most Motion Bases use either three or six actuators for moving the Motion Base platform. This gives the base either three or six 'Directions of Freedom' (DOF). This is why most Motion Bases are commonly referred to as a 3-DOF or 6-DOF.

A typical 3-DOF Motion Base can move in:

- Pitch (nose up and down)
- Roll (left and right side of the vehicle up and down)
- Heave (entire vehicle up and down)

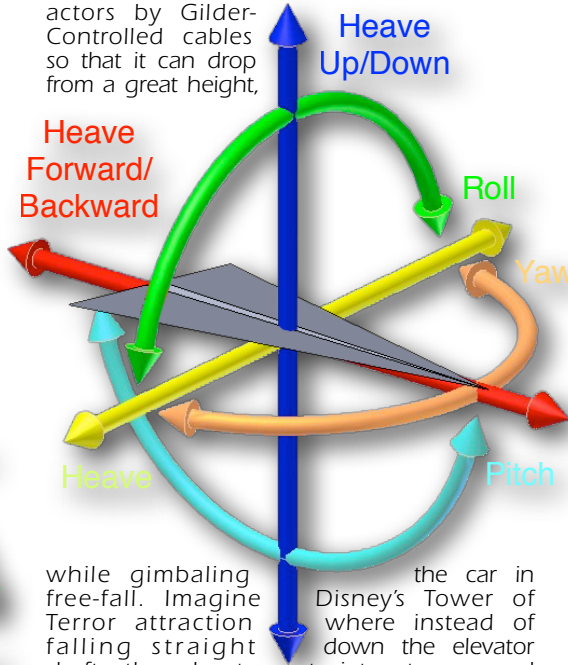
3-DOF Motion Bases use three actuators. Typically one is at the front center, and the remaining two at the two back corners. This puts more load bearing capacity at the rear of the Motion Base (where the riders are typically situated), instead of at the front (where there is typically less weight to move).

A typical 6-DOF Motion Base adds three more axis of movement that allow the vehicle to move in all possible directions:

- Yaw (nose left and right)
- Heave Left & Right (entire vehicle moves left and right)
- Heave Forwards & Backwards (entire vehicle moves forward and backwards)

Of course there are variants on these basic 3-DOF and 6-DOF themes. Some 'moving seat' Motion Bases only use one or two axis of control. We have controlled 3-DOF and 6-DOF Motion Bases mounted on moving vehicles, on turntables, or both. There are some 3-DOF Motion Bases that have been built so that the

geometry imparts a little bit of yaw or other movement into them as they move. A 'Motion Base' used to film *Fast and Furious 7* suspends an automobile full of actors by Gilder-Controlled cables so that it can drop from a great height,



while gimbaling the car in free-fall. Imagine Disney's Tower of Terror attraction where instead of falling straight down the elevator shaft, the elevator twists, turns and gimbals on the way down!

The Gilderfluke & Co. [USB-MbJoystick](#) allows movement in all six directions of freedom for programming 6-DOF Motion Bases. When it is configured for three directions of freedom Motion Bases, rods restrict is movements to those of a typical 3-DOF Motion Base. If neither of these scenarios fit your Motion Base's geometry, you can use the [USB-AtoD](#) to build your own joystick or 'Waldo', with the exact geometry of your Motion Base.

Gilderfluke & Co. has controllers that feature a mix of outputs ([Br-MiniBrick8](#), [Sd-50/8](#), [Sd-50/40](#), etc.), and other controllers that have only one type of outputs ([PB-DMX/xx](#), [SER-DMX](#), [Br-MiniBrick4](#), [Z-Brick](#), etc.). A typical Motion Base control system is made up of one of more of these different controllers, networked together using DMX-512 (see sidebar for an explanation of DMX-512 networking).

All of our controllers will allow you to program and download up to 255 different 'shows'. These can be set to be played when triggered by a switch, a serial command (from a touch screen, PLC or iPad/iPhone), whenever the controller is powered up, or using the 365

At a minimum, a Motion Base will need several E-Stop switches inside and around the Motion Base. These are wired in series so that hitting any of them will trigger an E-Stop.

An E-Stop needs to immediately turn on the cabin lights, lower the Motion Base to the load/unload position (in a controlled fashion), and open the doors to allow the passengers to evacuate, all with or without power.

A power failure or signal from the fire alarm must also trigger an E-Stop.

Hydraulic Motion Bases typically have a 'blocking valve' that allows the base to move only when it is energized. When it is not energized, hydraulic oil from the accumulators is routed through small fixed orifices to bring the base back to the 'home' position at a controlled rate.

In a simple E-Stop loop, the blocking valve and an input to the DMX-512 'master' are wired into the loop. Hitting an E-Stop button drops power to the blocking valve to park the base and the master turns on the lights and starts the 'run for your lives' announcement video.

Gilderfluke & Co. makes an Electronic 'Blocking Valve' ([BLK-VALVE](#)) for Motion Bases that don't have an actual blocking valve.

For electric Motion Bases, the 'homing' functions are normally programmed into the VFDs that control the actuators. Electric bases should have enough energy storage to return to the 'home' position, even in a complete power failure.

If more than a simple

Safety (continued)

E-Stop loop is needed for a Motion Base, you can use a [KP-300-DMX](#) and Br-Brain4 to add an operator panel and additional safety inputs to the control system.

The [KP-300-DMX](#) adds fifteen safety inputs, E-Stop loop, controls for a Hydraulic Power Unit (HPU), blocking valve and show cycle counters. The eight 'show start' buttons can be used to access specific shows, or each button can access a list of shows.

Any of the safety inputs can be configured to either 'pause' the show (for lower priority errors like a rider opening a seatbelt), or E-Stop the show (for higher priority errors like a capsule door opening when it shouldn't).

The input that triggers an error are indicated on the [KP-300-DMX](#). Momentary errors like a differential pressure sensor that indicates a hydraulic filter is dirty (the error signal goes away when the ride stops) or if the rider who quickly refastens his seatbelt when the ride stops will leave flashing red LED on the [KP-300-DMX](#) as a telltale sign.

If additional inputs are required for an installation, then a [Kp-300-EXP](#) Expansion can be used to add even more inputs and outputs to a [KP-300-DMX](#).

Control Panel

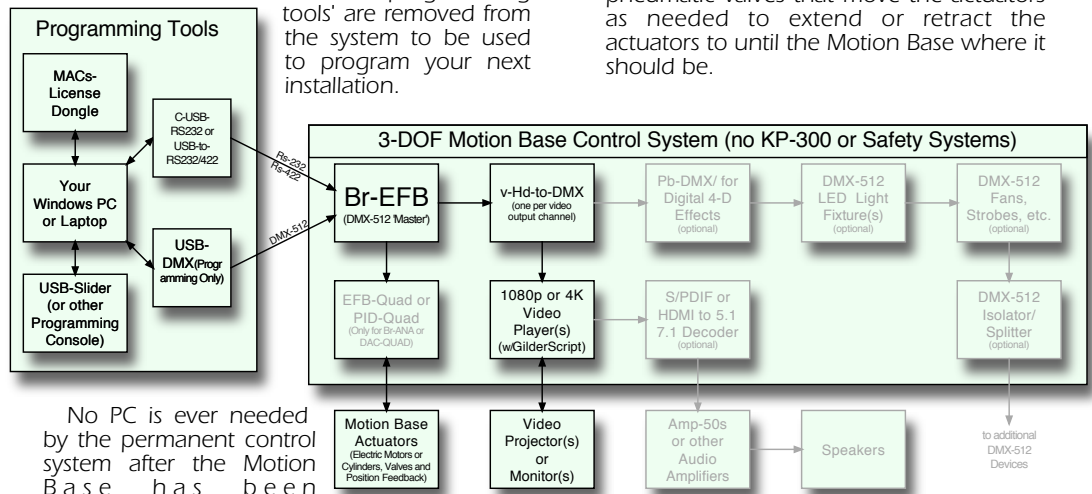
Any motion base needs a way to select and start your shows.

If you are using a Kp-300 as your safety system, it is also the operator panel for the system. Any of the eight KP-300's 'show start' buttons can be used to start a single specific show, or a selection from among as many as 250 different shows.

day scheduler and clock available on several of our controllers ([Sd-50/8](#), [Sd-50/40](#), [Br-Brain4](#)).

The length of the shows that a controller will hold is only limited by the size of the flash memory available on the controller. In most of our controllers, this is a standard Sd/SdHC flash card, which gives the controller a virtually unlimited show length capacity.

The [Pc-Macs](#) software and the 'programming tools' shown in the following block diagrams are used only during the initial programming and setup of the Motion Base. Once the Motion Base shows are programmed, the shows are stored on the 'Master' (usually in an Sd or SdHC flash card), and the 'programming tools' are removed from the system to be used to program your next installation.



No PC is ever needed by the permanent control system after the Motion Base has been programmed. We don't consider PCs as reliable enough for use in permanent installations.

In each of the following block diagrams, more controllers are shown than you will ever need in a typical Motion Base installation. Once you determine the number and types of outputs your installation will need, you can redraw these block diagrams with the appropriate numbers and types of controllers.

The controller that you have chosen to use as the 'Master' is moved to the 'first' position in the diagram, as it will be what the programming system will be attaching to, and will be sending its commands to the rest of the system.

The typical controller used for a Motion Base platform is the [Br-EFB](#), [Br-ANA](#) or [DAC-QUAD](#).

The [Br-EFB](#) are used in a Motion Base control system to close four hydraulic, pneumatic or electric motion base actuators' servo loops to control their speed and positions. The [Br-EFB](#) is shown as the DMX-512 'master' in the most of following illustrations.

The [Br-ANA](#) or [DAC-QUAD](#) are used in a Motion Base control system to provide 0-10 volt signals that typically control:

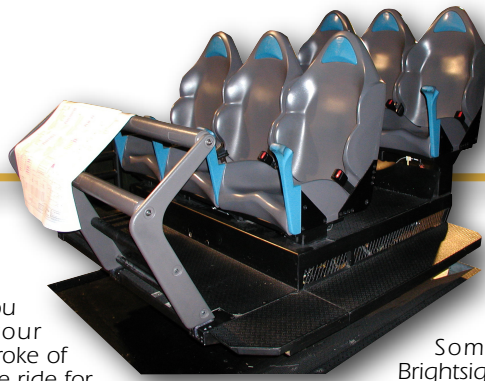
- Variable Frequency Drives (VFDs) to control the speed and direction of electric motors (for electrically driven Motion Bases), or
- Electronic FeedBack (EFB) cards ([EFB-QUAD](#) or [PID-QUAD](#)) that measure the current position of the actuators, compares this with the command signals, and opens and closes the hydraulic or pneumatic valves that move the actuators as needed to extend or retract the actuators to until the Motion Base where it should be.

The [Br-ANA](#) has sixteen 0-10 volt analog outputs. The [DAC-QUAD](#) has four 0-10 volt analog outputs.

You can use a single [DAC-QUAD](#) for up to a 4-DOF Motion Base. You will need to use two [DAC-QUADs](#) for a 6-DOF Motion Base, with two extra analog outputs free for other uses.

The [Br-ANA](#), with sixteen analog outputs, can run a single 6-DOF base, with ten extra analog outputs free for other uses.

The [DAC-QUADs](#) and [Br-ANAs](#) 0-10 volt outputs can be adjusted electronically, which means that you can adjust the two endpoints of the actuators (fully retracted and fully extended) without climbing in and out of the control room with a little screwdriver thousands of times. If you need more analog control signals than either of these provide, then you just use more of them. They both use an Sd flash card (micro Sd for the [DAC-QUAD](#)) for storing shows when they are used as a DMX-512 'Master', so they have unlimited show length capacity. Both of these controllers can control one full DMX-512 universe (512 analog dimmers, or 4096 on/off functions).



In some applications you may need to have your Motion Base reduce the stroke of the actuators to 'gentle' the ride for some passengers. A switch is typically attached to the [DAC-QUAD](#) or [Br-ANA](#) trigger inputs directly. When the switch is thrown, the [Br-ANA](#) or [DAC-QUAD](#) can be configured to scale its analog outputs to reduce the fully extended position of the actuators.

Some low speed, short stroke Motion Bases use air bags for the actuators. These are often controlled using solenoid valves, which use digital (on/off) control signals. Solenoid valves can be controlled using a [Br-MiniBrick8](#), Br-ZBR, [PB-DMX/xx](#).

If your Motion Base doesn't need any 0-10 vdc control signals, the [Br-ANA](#) or [DAC-QUAD](#) can be omitted from the control system design.

Virtually all Motion Bases need at least one video playback device, and often several. You can use any 1080p or 4K resolution BrightSign player, so

cut in half.

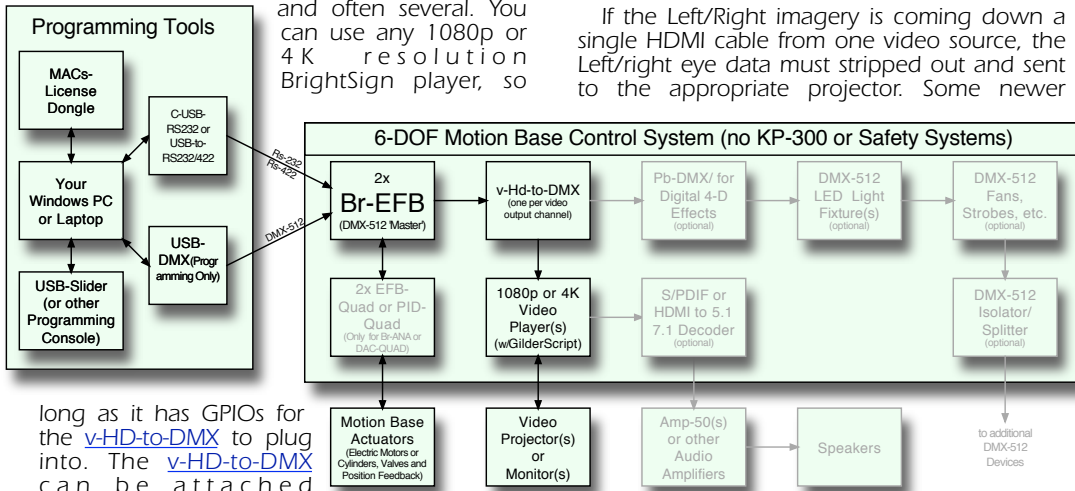
Some of the higher-end Brightsign players can do what is called 'frame-packing.' This allows a single player to send full high resolution video from a single player without any loss. It sends alternate left eye/right eye images out through a single HDMI port.

The new v-4K players can 'frame-pack.' This allows one player to send full 1080p or UHD 4K video containing both left eye/right eye through one HDMI 1.4a or 2.0 cable.

Any single projector 3D display currently requires 'active shutter' glasses. These need regular recharging, and are far more expensive and delicate than simple polarized 3-D glasses.

To use polarized 3-D glasses, you need to use two projectors. Each is fitted with a polarizing filter on their lenses (one horizontal and one vertical).

If the Left/Right imagery is coming down a single HDMI cable from one video source, the Left/right eye data must be stripped out and sent to the appropriate projector. Some newer



long as it has GPIOs for the [v-HD-to-DMX](#) to plug into. The [v-HD-to-DMX](#) can be attached anywhere on the DMX-512 network. Each video player can hold hundreds of videos. Its capacity is only limited only by the size of the Sd/SdHC/SdXC card used to store the video on them. If more than a single video output is needed, then multiple video players can be used.

Often these are separate screens that show the guests waiting in line their 'safety briefing' or advertisements for this or other attractions. Using the GilderScript, you can easily set up a 'background video loop' that plays until a cue in the main show is sent through the DMX-512 to kick off the triggered announcements.

3-D projection is often used in Motion Base attractions. You have several ways of generating 3-D imagery.

The simplest way is to use a single BrightSign player, and encode the video using any 'split screen' format (either side-by-side or top-over-bottom). The disadvantage to this solution, is that the resolution of the imagery is

projectors can do this themselves. You simply set one for 'right eye' and the other for 'left eye' (Example: Optoma HD25-LV). Only a HDMI Splitter is needed to share the HDMI cable to both projectors.

Other projectors which don't understand 3-D imagery will need you to use an upstream processor to strip off the Left/Right eye data from a single HDMI cable.

The next controller shown in these drawings are the [PB-DMX/xx](#). These are relay output controllers that can directly control larger sized solenoid valves. They are available with 8, 16, 24 or 32 relays each. The relays are rated for 3.5 amps of continuous current, and are fused for five amps each. When you order these, you can choose whether the solid state relays are rated for AC (12 to 240 volts), DC (up to 60 volts), or a mix of AC and DC relays. In Motion Bases, these relays are typically used to control 4D effects like fans, ticklers, water spitters, air

Control Panel (continued)

If you aren't using a KP-300, your user interface can be as simple as a single momentary button, or as complex as a PLC; HMI interface:

Buttons: you can use a button to select a specific show. If you have more than just one show, more buttons can be used, or you can use a single button to select an play all your shows round-Robbin or using a randomizer. Different Gilderfluke & Co. controllers have different numbers of optically isolated trigger inputs.

[GilderTrigger](#): You can run the GilderTrigger app on an iPhone, iPad or Android device. These use a WiFi network to talk through a [Modem-Internet](#) to control the system. Once you point them at the IP address for the control system, they can self-configure all the buttons for all of your shows, including special hidden buttons for maintenance-only shows.

Kp-400 or Kp-500: 7.0" or 10.2" widescreen, water-resistant touch panels that run a hardwired version of the GilderTrigger app.. No WiFi needed.

Crestron, AMX, or other control systems. These can easily control any Gilderfluke & Co. system through their serial ports.

Stand-alone Human-Machine Interface (HMI): Touch panels are available from companies like Beijer and Maple Systems that can be programmed to control Gilderfluke & Co. systems.

PLCs: If you have a Programmable Logic Controller (PLC) running the ramps or other safety features of your motion base, you can also use its Human-Machine Interface (HMI) touch panel to select and play shows as well. -G

DMX-512

DMX-512 is the standard connection used to control all theatrical lighting equipment, as well as to network all Gilderfluke & Co. systems together.

By networking, you can easily snap together a control system of any size with any mix of outputs.

Almost all Gilderfluke & Co. controllers have DMX-512 inputs and/or outputs.

The DMX-512 network allows you to easily attach any DMX-512-compatible equipment (light dimmers, smog machines, lasers, strobes, fans, etc.) to your Motion Base. These are typically used for what are called '4-D effects'.

In a DMX-512 network, there is one 'Master', sending data to all the 'Slaves'.

Each DMX-512 'slave' is individually addressed, and can be attached anywhere on the DMX-512 network. The maximum wire length for a DMX-512 network is nearly a mile (1.5 Km).

It is recommended to isolate the DMX-512 line anywhere it leaves the control box. This protects the control system from lightning hits or other catastrophes.

jets, etc..

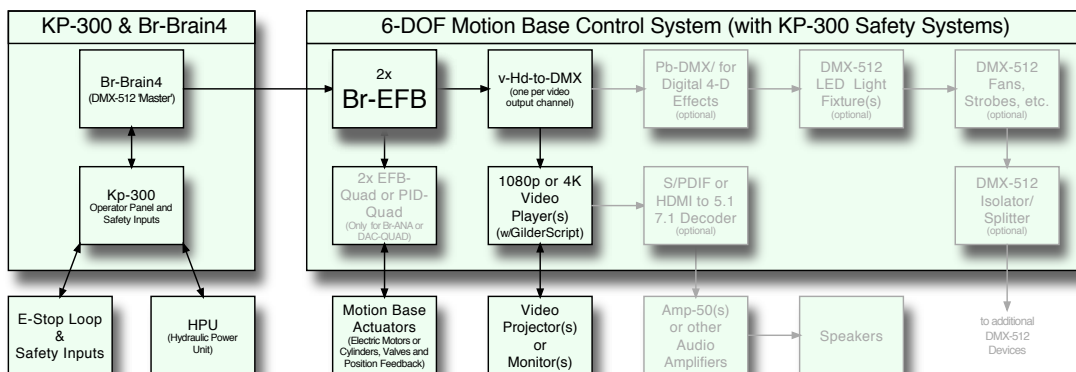
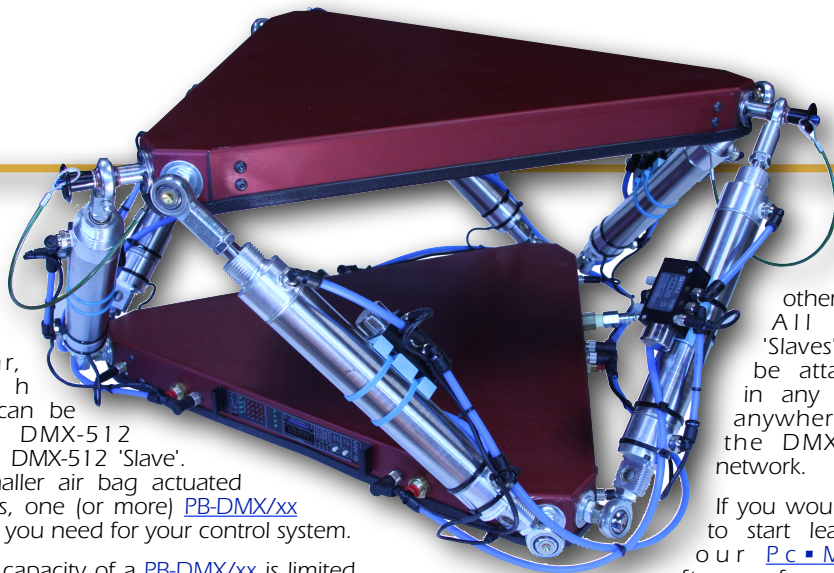
Like all GilderGear, each [PB-DMX/xx](#) can be used as a DMX-512 'Master' or a DMX-512 'Slave'. In many smaller air bag actuated Motion Bases, one (or more) [PB-DMX/xx](#) is typically all you need for your control system.

The show capacity of a [PB-DMX/xx](#) is limited only by the size of the µSd flash card used. The number of PB-DMXs that are needed (and the number of relays on each [PB-DMX/xx](#)) for a given project is determined by the number of solenoid valves (and other devices) that need to be turned on and off.

One of the great features about GilderGear is that it doesn't all need to be located in one big control room. If you need to have a safety

other end. All the 'Slaves' can be attached in any order anywhere on the DMX-512 network.

If you would like to start learning our [Pc•Macs](#) software for show programming, you can download the current release of [Pc•Macs](#) for free from our web page. The web page makes it look like you are buying something when all you need to do is a download. Just set the 'shipping' to 'download' when you are checking out, and the web page should send it to you gratis.



video playing in the lobby of the facility, you can put the video player on the back of the monitor and connect it to the control system through a simple DMX-512 cable.

In the diagrams above, the 'DMX-512 Controlled Light Fixtures' represent any additional DMX-512 controlled gear that your show needs. These can be LED lights, dimmers, strobes, smog machine, fans or any other type of lighting gear that may be located in the Motion Base. The number and types of GilderGear you need is determined by the requirements of your Motion Base.

The order that the DMX-512 controlled 'Slaves' are attached to the DMX-512 network is completely arbitrary. The 'Master' just needs to be at one end of the DMX-512 network, and a terminator resistor (120Ω, ¼ watt) at the

The [MACs-License](#) and [USB-DMX512 Adapter](#) are only necessary if your show is larger than the equivalent of sixteen analog and/or 128 digital on/off functions. Most Motion Bases use fewer channels than this. If this is the case, you can use [Pc•Macs](#) gratis. You will use just a serial port for connecting your PC to the Control System during programming. You can also use this link to download the latest Beta version of [Pc•Macs](#). The Beta [Pc•Macs](#) is shown our videos: [Software Downloads](#)

Please download and run the [Pc•Macs](#) Beta installer. Once complete, you should be all set.

We have training videos on GilderYouTube demonstrating [Motion Base Programming](#) and [our small Motion Base](#), and videos which walk you through programming your first show. [Sample Shows](#) for use with a [KP-300-DMX](#) are available for download, and the [Kp-300 Manual](#) describes exactly how they are put together and used.

The plans and parts list to [Build our Small 6-DOF Motion Base](#) are here.

Once you can program a small show on a [Br-MiniBrick8](#), you can program a show of any size using GilderGear. The only difference is the number of channels you need to wrangle. -G

| Pair | Wire # | Color | Function | XLR-3 or XLR-5 |
|--------|--------|----------------|---------------|-------------------|
| Pair 2 | 1 | White / Orange | Data I+ | XLR-3/XLR-5 Pin 3 |
| | 2 | Orange | Data I- | XLR-3/XLR-5 Pin 2 |
| Pair 3 | 3 | White / Green | no connection | no connection |
| | 6 | Green | | |
| Pair 1 | 4 | Blue | Signal Common | XLR-3/XLR-5 Pin 1 |
| | 5 | White / Blue | | |
| Pair 4 | 7 | White / Brown | Signal Common | XLR-3/XLR-5 Pin 1 |
| | 8 | Brown | | |
| Shield | | Drain | | |

DMX-512 is normally run through a shielded twisted pair cable. There are specific cables that are made for DMX-512, or you can use standard CAT-5 (or better) cables. The USITT wire assignments are shown above. -G

Capsule Entry and Exit Ramps and Doors:

Because they can move in every direction, 6-DOF motion bases typically need to have a ramp (or two) which moves into place to allow the passengers to embark and disembark. When the motion base is in motion, the ramp must retract to a position that is completely out of the envelope where the motion base will operate.

Because 3-DOF motion bases don't normally have a Left/Right 'Heave', they typically don't need a movable load/unload ramp. When the load/unload position is with the Motion Base fully 'down', all that is typically needed is a small gap between the motion base and the edge of the ramp, similar to the gap between a subway train and the station platform. In a very few cases, some larger 3-DOF bases have a flap that folds up to fill the gap between the motion base and the platform during load/unload.

Both 3-DOF and 6-DOF Motion base capsules will often have a door or two that need to be opened to allow the passengers to enter and exit.

If the capsule doors are manually opened and closed by the operator, then the only thing you need to do is have a switch on the door that will E-Stop (or pause) the show if the door comes open in the middle of a flight.

If the capsule doors are operated by a powered actuator (electric, hydraulic or pneumatic), then they will need to be controlled and monitored so that they operate safely.

The following schematic shows the wiring for a 6-DOF hydraulic motion base with a single hydraulically powered ramp and capsule entry door. If you have a base with two ramps and doors, just duplicate those parts of the schematic that control the one door and ramp to add a second set.

This schematic is derived from a set of drawings we did for a client who was retrofitting several motion bases with GilderGear. We provided Kp-300 operator panels for handling most of the safety aspects of the attractions. The ladder logic for the ramps and doors can be built in a small Programmable Logic Controller, a Kp-300 Expansion or using discrete relays and components. Solid state relays should be used whenever possible. The main requirements of the design are:

- 1) The ramp will only operate if the base is fully down, the capsule door is closed, and the operator is pressing the Ramp/Door enable pushbutton (or during an E-Stop).
- 2) The capsule door will only operate if the base is fully down, the ramp is down, and the operator is pressing the Ramp/Door enable pushbutton (or during an E-Stop).

Switches on each of the six cylinders sense if the base is in the fully 'down' position before it will allow the door or ramp to move. The BaseDownOverride KeySwitch can be used to override the base down sensors and evacuate the capsule in an emergency.

The commands to open and close the door and raise and lower the ramp are programmed into the motion base shows. In this application, the door and ramp will normally only move if the ride operator is holding down the 'Ramp/Door Enable' button after starting a show and again at the end of the show. This is for safety reasons, so that the operator has to see that the passengers' arms and legs are clear of the door and nothing is obstructing the ramp before they are allowed to move. The only

exception to this is during an E-Stop. "E-Stop Not" from the show control system is programmed ACTIVE in every show EXCEPT the E-Stop Shows. This holds opens the NC contacts of K11 unless an E-Stop show is running. This means that during an E-Stop, the HPU will be stopped and the blocking valve opened to return the base to the home position using power stored in the accumulators. Optionally, an E-Stop message can also be shown in the capsule and other monitors in the facility. When the six home sensors are ALL tripped (the Motion Base is parked), the ramp will move down. When the ramp is fully down, the capsule door will open. When the capsule door is opened, the entry/exit doors to the room will both open.

The control system should be powered from a small UPS to provide power for the E-Stop sequence to complete during a power failure. This only takes a few seconds of backup time.

The valves used to control the doors and ramps should have two solenoids so that they can be stopped mid-stroke. They should also have mechanical overrides to manually open and close the valves to handle 'worst case' failures.

The connections to/from the KP-300 are the DB-25 connectors shown at the left of the schematic. The inputs can be set for either a dry contact (as shown by the simple switches on the schematic) or for externally powered inputs. If the switch provides a voltage to the KP-300, jumper that input for 'External' power. Inputs expect 24 VDC nominally.

Unused inputs to KP-300 should be bridged and configured for 'internal' power. These are shown as 'Spare Switch 1' through 'Spare Switch 6'.

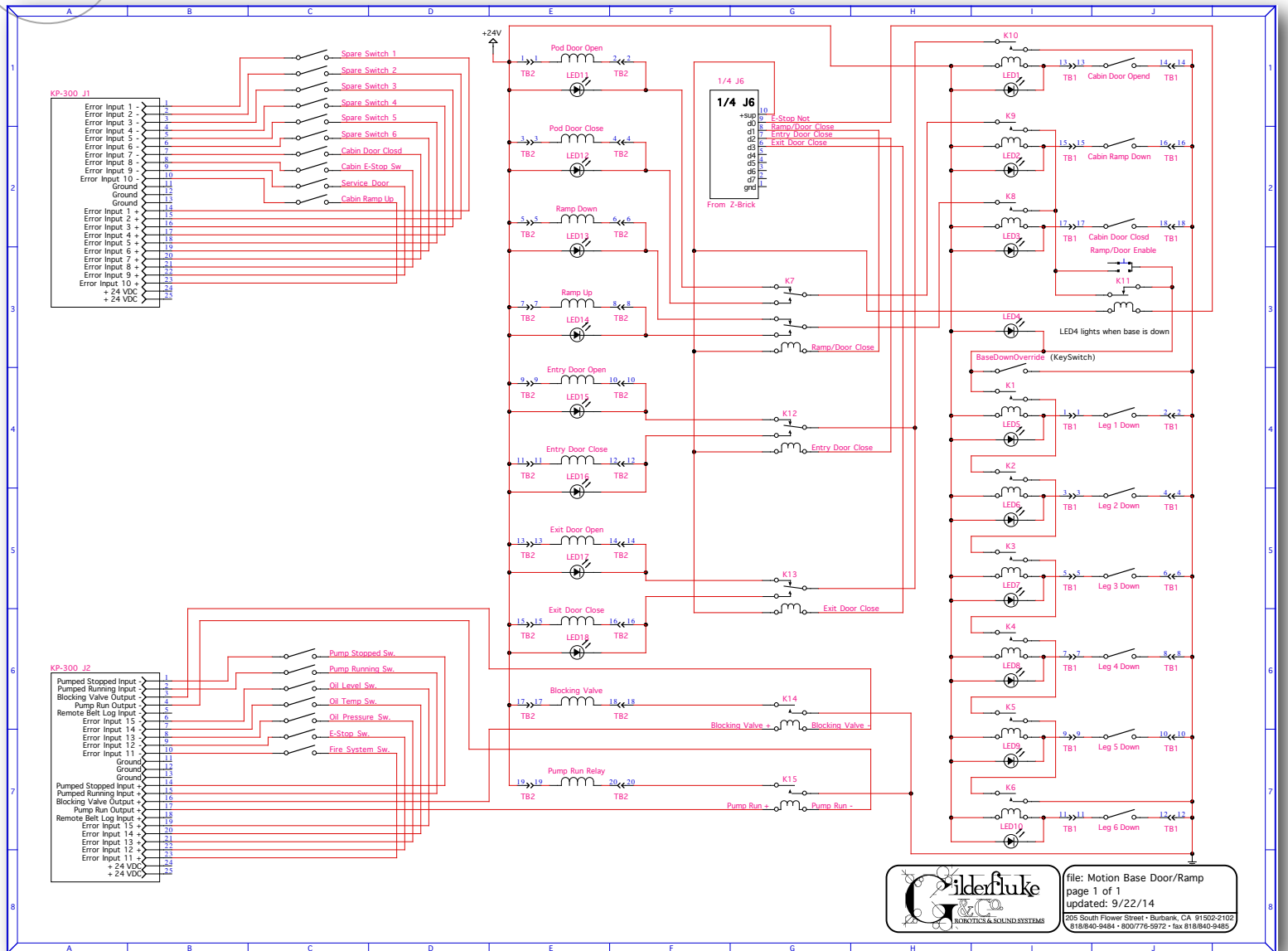
Relays K7, K12, K13, K14, and K15 should be sized to run from a Z-Brick, and include fly back diode protection. Solid state relays are always preferred.

The four outputs that come from the show control system are shown on a ¼ J6. This could be coming from a Br-miniBrick8, Z-Brick or Pb-DMX/xx or other Gilderfluke & Co. digital output card. These outputs are programmed as part of your shows as follows:

1. E-Stop Not: Programmed active in all shows EXCEPT the actual E-Stop Shows, where it is left off.
2. Ramp/Door Close This output is programmed 'on' in your shows when you want the capsule door to close and the ramp to raise.
3. Entry Door Close: This output controls the electrically activated door that allows passengers to enter the room. Program this output 'off' to open the door during your 'load' show.
4. Exit Door Close: This output controls the electrically activated door that allows passengers to exit the room after their ride. Program this output 'off' to open the door during your 'unload' show.

The HPU is controlled through the 'Pump Run' output. This goes to a solid state relay, which controls the contactor that actually turns on the HPU. The output of the Kp-300 is latched. It should not be latched by the contactor. So that the Kp-300 knows that the HPU is running or stopped, separate 'Pump Running' and 'Pump Stopped' switches should come from the HPU. The 'Pump Running' should only go active when the HPU is actually running, and not just parrot the status of the KP-300's 'Pump Run' output.

The 'Remote Belt Log' is used to temporarily disable seat belt sensors on empty seats. There is also a button on the KP-300 for this. Since there were no seat belt sensors in this application, the 'Remote Belt Log' input was not used.



The other Safety inputs are wired to the KP-300's Error Inputs:

- Error Inputs 1-6 are unused, but could be used for monitoring seat belts, float switches (to catch oil leaks), cabin smoke detectors or other purposes.
- Error Input 7: 'Cabin Door Closed' This triggers an E-Stop if the cabin door opens during a flight.
- Error Input 8: 'Cabin E-Stop' button located in the cabin.
- Error Input 9: 'Service Door' This E-Stops the ride if someone enters the 'pit' area under the Motion Base.
- Error Input 10: 'Cabin Ramp Up' Monitors that the ramp is in the proper position for flight. E-Stops the ride if it isn't.
- Error Input 11: 'Fire System' The building's fire alarm system provided a normally closed output. This contact opens when the fire alarm is going off, which E-Stops the ride.
- Error Input 12: 'E-Stop' Button located near the room exit.
- Error Input 13: 'Oil Pressure' E-Stops the ride if the oil pressure from the HPU falls too low.
- Error Input 14: 'Oil Temperature' E-Stops the ride if the oil gets overheated.

- Error Input 15: 'Oil Level' Grab a mop! E-Stops the ride if the reservoir runs low on hydraulic fluid.

The switches shown at the right side of the schematic are the interlocks that keep things from moving when they shouldn't:

- Relays K1-K6, and the 'Leg Down' switches sense when the Motion Base is in the 'Parked' position. The Doors/Ramps can't move unless all six of these switches are closed (or the 'BaseDownOverride' KeySwitch is closed). Proximity or magnetic switches work well for these.
- K8 and the 'Cabin Door Closed' Switch prevent the ramp from moving unless the cabin door is closed.
- K9 and the 'Cabin Ramp Down' Switch prevent the cabin door from moving unless the ramp is all the way down.
- K10 and the 'Cabin Door Opened' Switch prevent the room entry and exit doors from moving unless the cabin door is open. - G

