VALVE DRIVERS

Valve Drivers are power amplifiers that take a low power analog control signal, and produce a high power Pulse Width Modulated (PWM) signal. HED Valve Drivers are used drive valves, motors, pumps, or anything that uses PWM signals.

A PWM signal switches between 0 Volts and the supply voltage (i.e. 12 Volts) with a cycle time ranging from 27Hz to 600Hz (as set by the **Freq.** pot). The percentage of the cycle time spent at the supply voltage changes according to the input analog signal. For example, the signal can stay at 0V (corresponding to full off), the signal can stay at the supply voltage (corresponding to full on), or the signal could be anywhere in between (which corresponds to partially on).

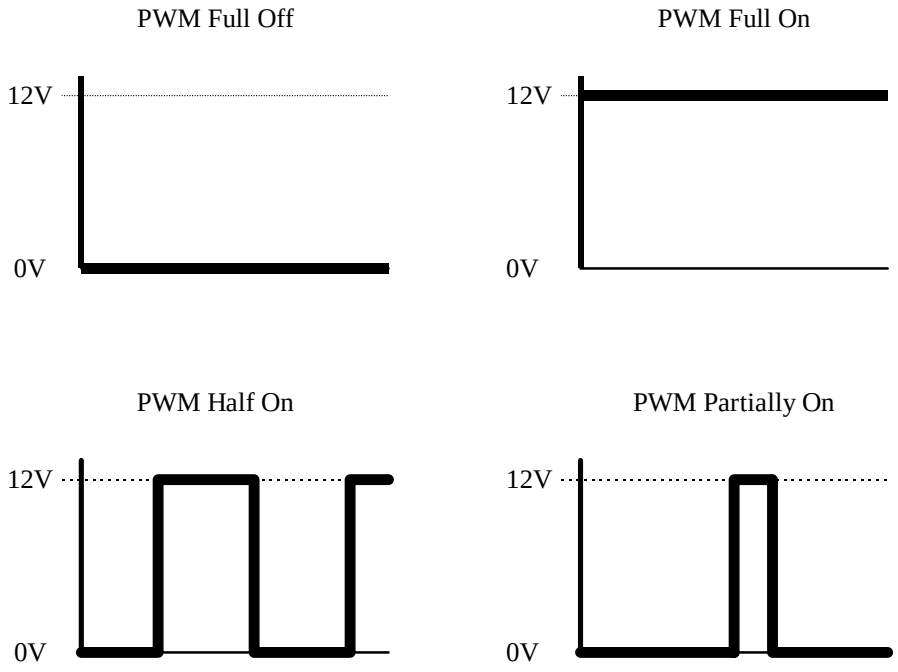

Figure 4: PWM Waveforms

The reason PWM outputs are used, is that they are far more efficient at providing power that an analog driver. When a FET (solid state switch) of a PWM driver is closed, it has a resistance of about 0.3Ω. For a 2.5A output, there is a maximum power lost in the FET (valve driver) of 1.9W. Conversely for an analog driver, the maximum power lost is $V_{battery}$/2.5 watts. For a 12V system, an analog driver would have to dissipate 4.8W. For a 24V system, an analog driver would have to dissipate 9.6W (that's hot stuff).

HED Valve Drivers have a small window around the center voltage for which the outputs are off. This is called a deadband, or a window. This keeps the valve from reacting to noise when the lever (or other input device) is in the off or neutral position. The input lever needs to be moved a little bit from

center before anything happens. HED Valve Drivers also have a large window, or Over Voltage Range, which the input can not exceed. If it does, the input is assumed to be shorted to the supply line or ground. The input is therefore considered invalid.

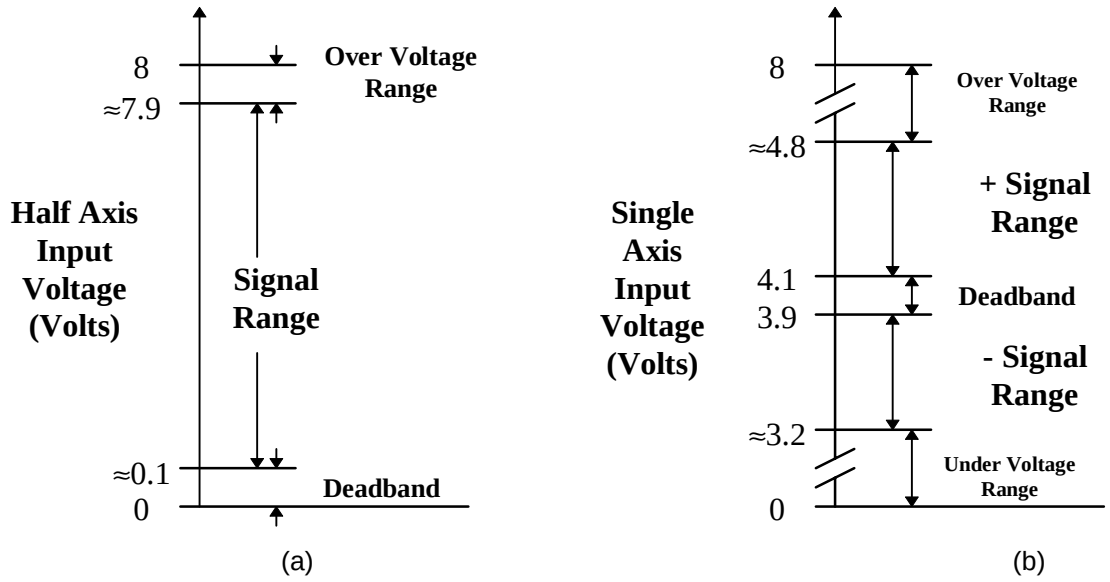

Figure 5: Input Voltage Windows for HED Valve Drivers. (a) Half Axis Valve Drivers used for unidirectional functions, and (b) Single Axis Valve Drivers used for bi-directional functions.

There are four settings on the Valve Drivers **Frequency, Threshold, Max** and **Ramp**. They are adjusted by four potentiometers on the Valve Driver.

Frequency sets the frequency of the PWM. This tunes the PWM signal to the desired frequency for the valve.

Threshold sets the PWM duty cycle for the point when the valve driver just turns on. This is usually the slightly below minimum signal to get the function (controlled by the valve) to move.

Max sets the valve driver duty-cycle for when the input is full on. This is particularly useful for limiting the maximum flow.

Ramp sets a rate of change of the signal output. This creates an exponential decay of the output from level to level. Ramp can be in both directions, or in just one direction. The greater the Ramp, the less jerky the machine response will be. For example a large ladder truck may want a Ramp for Ladder Extend so that there is no jerky motion towards a burning building. However, it may be advantageous to have no Ramp on Ladder Retract so it can be retracted as quickly as possible, if needed.

Unidirectional Valve Drivers

Half Axis Controllers (HAC):
The HACs are Valve Drivers that have one PWM output, designed to control unidirectional functions. For example, an HED HAC board can be used to control flow for a system that has single directional flow. The speed of a generator is one application for an HED HAC Valve Driver.

Bi-directional Valve Drivers

Bi-directional Valve Drivers are designed to control not only the amount of flow, but also the direction of flow. For example, these Valve Drivers can be used to control crane functions like Raise/Lower, Swing Left/Right, and Extend/Retract.

Single Axis Controllers (SAC):
The SACs are Valve Drivers that have two PWM outputs in order to control bi-directional flow. The SAC boards are actually two HAC boards in one, which work in a complimentary fashion. One HAC works in the positive direction, and the other one works in the negative direction. The purpose of the HED SAC is to drive a valve with two coils. One coil pushes the valve in one direction, and the other coil pushes the valve in the opposite direction.

Solid State Propel (SSP):
The Solid State Propel (SSP) Valve Driver has two outputs. The first output is a PWM signal that is similar to adding together the two outputs of a SAC card. This PWM signal is proportional to the absolute value of the input signal (centered at 4V). The second signal is an on/off signal, used to control the direction of flow. This can be done with a directional solenoid.

Servo Board (SVC):
The Servo Board (SVC) is similar to the Solid State Propel Board, except there is no need for external direction control. There are two outputs, one for each of the coil wires. One output will be ground and the other will be the PWM signal. As the input passes through center (4V), the Valve Driver internally switches the outputs polarity, therefore changing the direction of current flow.

Valve Driver Options

The following is a description of the various options offered by HED's valve drivers. The intent here is to help provide the customer with the best valve driver for their particular situation.

Current Feedback: Both the "004 series" and the "006 series" valve drivers offer current feedback. Current feedback measures the average current supplied by the valve driver. This value is compared to the input signal. If the current is too low, the PWM duty cycle is increased. If the current is too high, the PWM duty cycle is decreased. Current feedback helps minimize the effects of changes in coil resistance and supply voltage. Current feedback adds consistency to the function.

When to use Current Feedback: If the operator has tight control of the valve driver's function (i.e. remote control), current feedback is not needed. If the function is moving too slow or too fast, the operator can adjust the command. On the other hand, if the operator does not have direct control of the function, or does not want to spend their time controlling the function, current feedback can be beneficial. These would normally be automated, or background functions (i.e. Ground Speed, or Drum Rotation).

Feedback: Some HED valve drivers can be set up to use feedback signals, in a closed loop control system. A closed loop system has the normal command signal (i.e. lever), and also has an input from a sensor on a machine function being effected by the valve driver. The sensor could be measuring rotation, position, or whatever. The valve driver can then adjust its output to minimize the function error. Closed loop systems are far more powerful than open loop systems. They can provide much better, and more accurate operation.

Overload Protection: An overload is when the output is almost shorted, but not enough to trip the short circuit protection circuitry. This situation can cause the output driver to overheat. The "005

series" valve drivers use PROFETs as output drivers. These devices are thermally protected, and will turn off if they get too hot.

Pilot Output: The "006 series" valve drivers have an optional, additional output. This output is for activating Pilot Valves. In some hydraulic systems, a pilot valve needs to be turned on, in order to allow any proportional valves to operate. Therefore the Pilot output turns on (+Battery) as soon as the PWM output turns on. Actually, the HAC-006's pilot turns on just before threshold.

Relay/Dual Decode Input: In some applications, it is desirable to have the valve driver's output shut off according to an input. Perhaps an external switch is to be used, but power does not want to be routed through it. This could be because the switch is far from the valve driver. It would be inefficient to use long, high power cables to switch power directly. Another use for this input is if an inductive lever is used with the valve driver. The lever's Dual Decode signal should be used to turn off the outputs.

If this option is desired, it is important to indicate what type of input is used. Dual Decodes and some other switches are grounded when the outputs are shut off (Switch-To-Ground). Normally a Switch-To-Ground will be assumed.

Short Circuit Protection: Some HED valve drivers are protected against having their outputs shorted to ground. The outputs will shut themselves off when shorted. After a delay, they will try to turn back on. If the short is still there, they will turn off again.

Sourcing vs. Sinking Outputs: The SAC-006 offers either sourcing or sinking outputs. For diagnostic purposes, sourcing outputs are usually preferred. The reason for this is that the "non-switched" coil wire, on a sinking circuit, is hot (+battery). If there is a problem, and a technician measures the voltage on that wire, they may assume that since there is power everything must be fine.

Two Wire Connections: The "004 series" valve drivers, and the Sinking SAC-006, need to have both coil wires attached to the valve driver. The other valve drivers* only need one wire per coil. The two wire circuit can add wiring to the machine, and therefore cost.

* Servo valve drivers (SVC-001) also require two wires per coil, but since there is only one coil, there is only a total of two wires. This is no more than a normal SAC.

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