# PWM Technical File

Updated 5/2017

## PWM Control Basics and Terminology

**PWM (Pulse Width Modulated)** control systems are being used widely in modern liquid applications. The use of this technology is driven by the need in agriculture for precision application of fertilizers and chemicals. The goal is to apply what is needed at the correct time while minimizing input cost, preventing runoff which may contaminate water supplies, and eliminate drift.

The PWM signal is an efficient technique to control current to a proportional electrical hydraulic valve. The PWM signal switches on and off to achieve the required control current (see Figure 1). The duty cycle "D" refers to the "on" portion of the cycle. The duty cycle can be anywhere from 0 (signal always off) to 1 (signal always on).

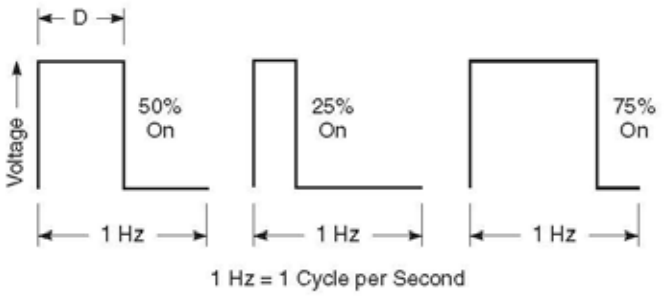


Figure 1

**Dither** is a rapid, small variation in the control signal designed to keep the valve spool in motion. This movement is intended to avoid **stiction** and average out **hysteresis**.

**Stiction** keeps the valve spool from moving when control signal changes are small. When the valve spool finally moves it can overshoot the correct position.

**Hysteresis** is the tendency for the spool movement to be different if the signal is increasing or decreasing. This can happen even with the identical control signal.

## Valve Settings & Performance

**I-Min or Minimum PWM** is the minimum control current induced into the control valve. This is typically set to the point where the control signal creates a response from the valve spool. For Ace Pumps, this is typically set to the point when our pump starts to turn or where a minimum application pressure is achieved. This eliminates the **Deadband** which is typical for all control valves (see Figure 2).

**I-Max or Maximum PWM** is the maximum control current supplied to the control valve. This is typically set to the point where the control signal results in maximum performance. For Ace Pumps, set this to achieve the maximum shut-off pressure recommended for the pump model.

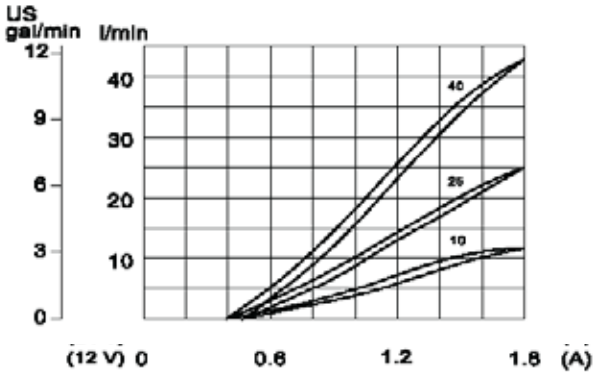


Figure 2
Typical Valve Performance Graph

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## Ace PWM Products

Gemini™ Dual Pump Kit


**Valve Specifications:**
Type.....Proportional flow control
Normally closed
Solenoid.....10 Volt
Socket.....Deutsch DT04-2P
Override.....Manual

### 150 SERIES
### HIGH PERFORMANCE

**FMCSC-150F-HYD-304-PWM**
**FMCSC-155FS-HYD-304-PWM**

### 205 SERIES
### HIGH FLOW

**FMCSC-205F-HYD-304-PWM**
**FMCSC-205FS-HYD-304-PWM**

**Valve Specifications:**
Type.....Proportional flow control
Normally closed
Solenoid.....12 Volt
Socket.....Deutsch DT04-2P
Override.....Manual

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## Generic PWM Setup Instructions

All PWM controllers are slightly different in the terminology used and setup procedures. Please consult your controller documentation or their technical service department for additional assistance with your specific application and implement in use.

See page 4 for specific starting controller settings for units that have been tested in our lab. The following general settings are suggested as a starting point for non-listed controllers. Every system may behave slightly different due to mounting location, hose length, application rates, etc. The setup generally requires further adjustment to fine tune operation.

| Setting | Suggested Starting Value |
|---|---|
| Valve Type | Select "PWM" - If agitation is desired when application is stopped.<br>Note: For power beyond applications an additional switch is needed to turn the pump off.<br>Select "PWM Close" - All oil flow is stopped when the master switch is off. |
| Valve Calibration Number | 43 or 0043 for some systems that require a 4 digit calibration number<br>1st digit - This is how aggressively the valve moves to make adjustments. The range is 1-9 with lower numbers being more aggressive.<br>2nd digit - This is the range around the set point where the valve will not change. The 3 indicates that the controller will not make adjustments if the rate is within +/- 3% of the desired setting. |
| PWM Frequency | 122 Hz |
| Minimum PWM | Start at the lowest PWM setting and increase until the pump reaches the desired minimum application pressure.<br>Set this point as the minimum PWM. |
| Maximum PWM | Increase the PWM setting until the maximum Shut-Off pressure per chart below is reached. Set this point as the maximum PWM |

### SHUT-OFF PRESSURE

Shut-off pressure is the liquid pressure at the pump discharge with all flow turned off. This means closing the boom, agitation, and any by-pass valves. It is the highest pressure a centrifugal pump will achieve for a given RPM and relates directly to the flow of hydraulic oil. A pressure gauge must be located between the pump discharge and the shut off valves.

Maximum Shutoff Pressure:

| | | | |
|---|---|---|---|
| FMC-75-HYD | 100 PSI | FMCSC-155FS-HYD | 120 PSI |
| FMC-HYD | 100 PSI | FMCSC-150SP-HYD | 120 PSI |
| FMC-150-HYD | 120 PSI | FMCSC-205F-HYD | 120 PSI |
| FMC-150F-HYD | 120 PSI | FMCSC-205FS-HYD | 120 PSI |
| FMC-150FS-HYD | 120 PSI | | |

**Important:**

The manual override on the valve must be disabled for proper operation:

Gemini - See Gemini Operating Instructions for details.

All HYD-304-PWM Models - Turn knob under valve cap counterclockwise until it stops.

## Recommended PWM Starting Settings

| PWM Controller | Valve Type | Valve Cal | PWM Freq. | Notes/Other |
|---|---|---|---|---|
| Raven SCS Consoles<br>SCS 440, 450, 460, 660, 660M | PWM | 43 | 122 Hz | |
| Raven CAN & ISO Systems | PWM | 43 | 122 Hz | Activate PWM Smart Control<br>PWM Standby standard<br>Optional Pressure Standby requires transducer |
| Raven Hawkeye - Viper 4 | PWM | Default | 122 Hz | Pressure Min, Max, and Target<br>Valve Cal = Response Rate Number |

* This section will be update with additional controllers as the compatibility is determined.

**General Notes:**

Some controllers have an automatic calibration procedure which simplifies system setup. See your controller documentation for the suggested setup procedure.

Some controllers allow an intermediate PWM setting which is closer to the normal operating point rather than minimum PWM. This allows the controller to reach the application rate more quickly.

Some controllers have a smart or learning feature that automatically adjusts settings based on valve and system performance. This features should be activated if available.

A signal boosting device may be needed for some applications. This may be needed due to low voltage, long wires, or controller specifications.

**Troubleshooting:**

**Symptom:** Unstable water flow
**Solution:** Switch the controller to manual mode which sends a constant PWM signal to the valve.
If the surging stops, the issue is related to the controller, controller settings, or PWM control valve.
If the surging continues, review the proper hydraulic setup steps and plumbing to see if there is some other system issue.