



PWM Technical File

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).

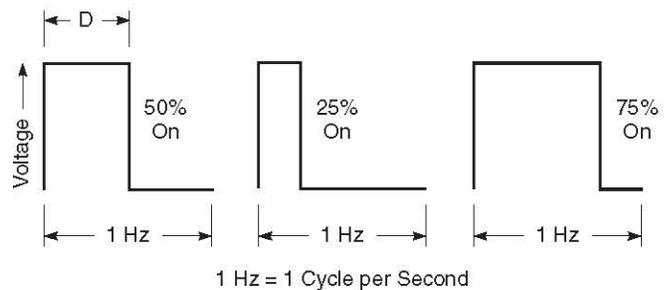


Figure 1

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. (see p. 3)

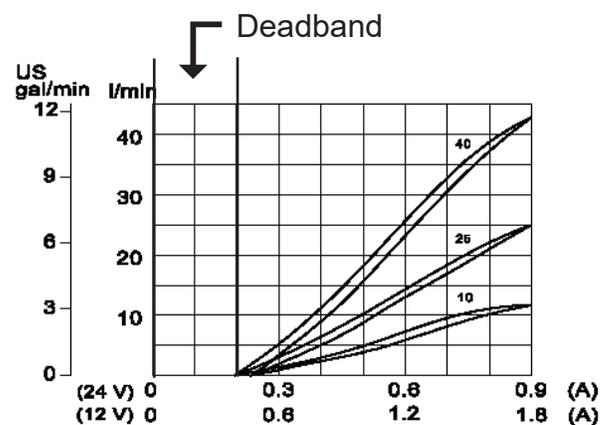


Figure 2

Typical Valve Performance Graph

Ace Products with Integrated PWM Valve

Implement a PWM Control System on your Equipment today!

Benefits of a PWM control system:

- Quick rate changes for constant or variable rate applications
- The pump only runs as fast as needed for the application rate
 - Minimizing power required to run
 - Reducing heat in the hydraulic and liquid systems
 - Extending pump life
 - Preventing foaming in tank due to high bypass flows



Benefits of Ace's Integrated PWM solutions:

- A pump for every application - four motors available on thirteen standard pump models
- Valves tested and selected to give the best control with each pump and hydraulic motor combination
- Integrated valves eliminate the need for add on valves, manifolds, and additional hoses
- Two valve design on 206 and 304 models prevents overspeeding
- For use on Closed Center hydraulic systems - consult Ace iHSG for tractor/pump compatibility
- All models have a manual override for troubleshooting or emergency operation



Pump Models and Features



Valve Specifications:

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

Pump Model	Material	Seal Type	Max. Flow	Max. Shut-Off Pressure
FMCS-C-HYD-206-PWM	Cast Iron	Severe Duty Silicon Carbide	92 gpm 350 lpm	120 psi 6.9 bar
FMCWS-HYD-206-PWM	Cast Iron		92 gpm 350 lpm	120 psi 6.9 bar
FMCS-C-150F-HYD-206-PWM	Cast Iron	Severe Duty Silicon Carbide	145 gpm 549 lpm	120 psi 6.9 bar
FMCS-C-150FS-HYD-206-PWM	316 SS	Severe Duty Silicon Carbide	145 gpm 549 lpm	120 psi 6.9 bar
FMCS-C-150F-HYD-304-PWM	Cast Iron	Severe Duty Silicon Carbide	155 gpm 587 lpm	130 psi 9 bar
FMCS-C-155FS-HYD-304-PWM	316 SS	Severe Duty Silicon Carbide	155 gpm 587 lpm	130 psi 9 bar
FMCS-C-205F-HYD-304-PWM	Cast Iron	Severe Duty Silicon Carbide	240 gpm 908 lpm	120 psi 6.9 bar
FMCS-C-205FS-HYD-304-PWM	316 SS	Severe Duty Silicon Carbide	240 gpm 908 lpm	120 psi 6.9 bar
FMC-650F-HYD-PWM	Cast Iron	Standard Carbon - Ceramic	170 gpm 644 lpm	160 psi 11 bar
FMC-650FS-HYD-PWM	316 SS	Standard Carbon - Ceramic	170 gpm 644 lpm	160 psi 11 bar
FMCWS-650F-HYD-PWM	Cast Iron		170 gpm 644 lpm	160 psi 11 bar
FMCWS-650FS-HYD-PWM	316 SS		170 gpm 644 lpm	160 psi 11 bar
FMC-750F-HYD-M22-PWM	Cast Iron		290 gpm 1097 lpm	150 psi 10.3 bar
FMC-755FS-HYD-M22-PWM	316 SS		290 gpm 1097 lpm	150 psi 10.3 bar

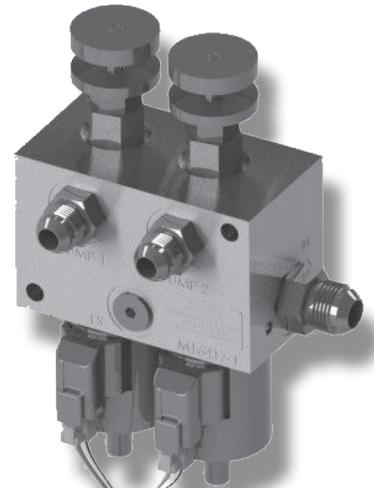
Add on PWM Product

Gemini™ Dual Pump Kit



Includes:

- Switch Box Assembly (15')
- Implement Wire Harness (12')
- Valve Manifold
- Hydraulic return tee & adapter for Load Sense (LS) port



Features:

- Operate two pumps independently
- Supply oil from one tractor remote or power beyond circuit
- Use on tractors with Load Sensing (LS) or Pressure Compensated (PC) hydraulic systems
- Two modes of operation:
 - Manual mode - independent on/off operation from the cab with independent manual flow adjustment at the hydraulic manifold
 - PWM mode - independent pump regulation with PWM signal from controller (not included)

Operates any combination of Ace Pumps equipped with the 204 or 206 motor

Pump Models	FMC-75-HYD-204 FMC-75-HYD-206	FMC-HYD-204 FMC-HYD-206	FMC-150-HYD-206	FMC-150F-HYD-206 FMC-150FS-HYD-206
Choose any two depending on application requirements!				
Material	Polypropylene	Cast Iron	Cast Iron	Cast Iron or Stainless Steel
Max. Flow	25 gpm	85 gpm	135 gpm	145 gpm
Max. Pressure	100 psi	100 psi	120 psi	120 psi

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 6 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. Note: For power beyond applications an additional switch is needed to turn the pump off. 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 1st digit - This is how aggressively the valve moves to make adjustments. The range is 1-9 with lower numbers being more aggressive. 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. Set this point as the minimum PWM.
Maximum PWM	Increase the PWM setting until the maximum Shut-Off pressure is reached.(see note below) Set this point as the maximum PWM

Manual Override Instructions

All Ace PWM products have a manual override function built into the valve. The override is proportional on all models except the Gemini which is on/off. This feature is useful for troubleshooting by determining if problems are due to hydraulic or electrical issues. The feature may also be used to operate the pump at a constant rate in the case of a controller failure.

Important: The manual override on the valve must be disabled for normal PWM operation:

- Gemini - Push red knob in, turn 180 degrees counterclockwise and release
- All 206-PWM Models - Remove cap and rotate knob counterclockwise to engage
- All 304-PWM Models - Remove cap and rotate knob counterclockwise to engage
- All M16-PWM (650 Series) Models - Rotate knob counterclockwise to engage
- All M22-PWM Models
 - 1) Remove cap nut from valve (1/2" hex)
 - 2) Loosen lock nut
 - 3) Adjust with 5/32" allen wrench clockwise to increase flow

Regulating Hydraulic Flow to the Pump

WARNING: NOT SUITABLE FOR PUMPING FLAMMABLE LIQUIDS.

WARNING: FAILURE TO REGULATE OIL FLOW WILL CAUSE MOTOR FAILURE.

There are three general types of hydraulic systems: 1) Load Sensing (LS), also known as Pressure-Flow Compensating Closed Center, 2) Pressure Compensating Closed Center (PC), and 3) Open Center (OPEN). The flow of hydraulic oil is regulated in a different manner for each type of hydraulic system. Consult the Tractor Hydraulic System Pump Selection Guide(HSG), Internet Hydraulic Selection Guide (IHSG) at www.AcePumps.com, or your tractor dealer to determine the type hydraulic system on your tractor and the method of regulation.

LOAD SENSING AND PRESSURE COMPENSATING CLOSED CENTER SYSTEMS

Regulate oil flow with tractor's **FLOW CONTROL**.

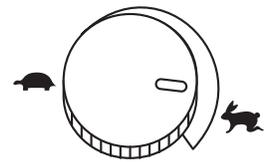
Do not use a Flow Limiter or Restrictor Orifice with Ace PWM pumps.

Setup Instructions:

1. Prime pump by filling the system with water and venting any trapped air.
2. Adjust tractor flow control to minimum flow setting (turtle). The control is located in the cab or on the remote outlet.
3. Manually set the PWM signal in rate controller to 100%.
4. Move hydraulic lever to "Lower/Retract" position to start pump.

Note: Always turn the pump off in the "Float" position (fully forward).
Turning the pump off in "Neutral" will cause damaging pressure spikes.

5. Shut off sprayer boom, agitation, and bypass valves.
6. Adjust tractor flow control until sprayer shut-off pressure is below maximum shown in table on page 3.
7. Open the sprayer agitation valve to get desired spraying pressure.



Flow Control

OPEN CENTER SYSTEM

Ace Pumps with integrated PWM valves are not intended for use with open center hydraulic systems.

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 - See table on Page 3

Recommended Starting PWM Settings

PWM Controller	Valve Type	Valve Cal	PWM Freq.	Notes/Other
Ag Leader Direct Command	PWM 12 volt		122 Hz	PWP Gain = 3000, PWM Standby = 50, Zero Flow Offset = 10
Micro-Trak XRS Orchard & Vineyard	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Micro-Trak Dual ISOmod Dual channel	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Micro-Trak SprayMate Plus 3 section applications	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Micro-Trak RateKing Plus 3, 5, or 7 section	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Micro-Trak Rate King Dual Plus 3, 5, or 7 section Dual channel	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Micro-Trak Roadmaster Anti-icing and Dust control	PWM	-1	200 Hz	Valve Cal range 3 to -12 (default = -1) Frequency range 50 - 500 Hz (default = 200)
Raven SCS Consoles SCS 440, 450, 460, 660, 660M	PWM	43	122 Hz	
Raven CAN & ISO Systems	PWM	43	122 Hz	Activate PWM Smart Control PWM Standby standard Optional Pressure Standby requires transducer
Raven Hawkeye - Viper 4	PWM	Default	122 Hz	Pressure Min, Max, and Target Valve Cal = Response Rate Number
Raven Hawkeye - RCM	PWM	Default	122 Hz	Pressure Min, Max, and Target Valve Cal = Response Rate Number
TeeJet 845	PWM	9.5	133 Hz	Access OEM menu for PWM settings Verify frequency on valve coil See manual for additional setup instructions

* 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.

A connector with pig tails is supplied for your convenience. The valve connection is not polarity sensitive. You may contact the controller manufacturer to purchase a waterproof adapter cable.

Trouble Shooting

Symptom	Possible Cause	Solution
PWM signal does not adjust pump speed	Manual override is engaged	Disengage the manual override (see p. 5)
Pump runs when master switch is off	Manual override is engaged	Disengage the manual override (see p. 5)
	PWM valve type is selected in the rate controller	If agitation is not desired when the master switch is turned off select PWM Close valve type in the rate controller
Pump does not reach maximum rated shut-off pressure	Low oil flow	Increase oil flow to the remote or use tractor with higher flow capability
	Maximum PWM is set too low in controller	Increase maximum PWM value in controller
	Hydraulic hose diameter is undersized	Install properly sized hydraulic hose - see recommended hose size in your pump's operating manual
	Rate controller indicates over current warning	A signal booster or boost box may be needed for your system
	Pump is installed on a low flow remote or power beyond without adequate oil flow	Move pump to a priority remote
	Pressure compensating valve on the motor is set too low	Adjust valve setting (see p. 9)
Pump flow is surging or cycling	Valve calibration setting is too aggressive	Change valve cal to a less aggressive setting
	Oil flow too high causing relief valve to open	Reduce the oil flow to the pump
Slow response time or rate adjustment	PWM range too wide	Trim dead band by setting minimum PWM closer to application setting (see p. 5)
	Check controller settings	Contact controller manufacturer for support
	Incorrect valve calibration setting	Change valve cal to a more aggressive setting
Pump does not run when master switch is on	Tractor remote is off	Turn on the tractor remote
	Pressure and return lines are reversed	Swap the lines on the tractor
	Valve is bent or damaged	Replace valve
	Valve does not have power	Check coil with a screwdriver for magnetism
Pump does not run when master switch is on and coil is magnetized	Valve coil is not receiving adequate voltage	Check voltage with a multimeter (12 VDC required for proper operation)

Adjusting Pressure Compensating Valve

This procedure is only for pump assemblies using the 206-PWM and 304-PWM hydraulic motors.

The typical indicator for this adjustment is being unable to achieve the pump's maximum shut-off pressure of 120 psi. This is typically due to some variation in the tractor's hydraulic system.

Additionally, a BAC-75-HYD-304-PWM replacement motor will come factory set for use on a 205F Series pump. The valve must be adjusted for use on the 150F and 155FS pumps or damage may occur. On new production pumps, this is done at the factory during the assembly and testing process.

WARNING - AVOID HIGH PRESSURE FLUIDS

Escaping fluid under pressure may penetrate the skin causing serious injury. Tighten all connections before applying pressure and inspect hoses regularly for wear or damage. If an accident occurs, seek medical attention immediately. Any fluid injected into the skin must be surgically removed immediately or gangrene may result.

Avoid the hazard by relieving pressure before disconnecting hydraulic lines. Refer to tractor owners manual for the correct method to relieve hydraulic pressure from the tractor supply.

Procedure:

1. Turn off oil flow to the remote and relieve pressure trapped in the circuit.
2. Remove the cap with 5/16" Allen wrench



3. Adjust valve with 3/16" Allen wrench. Turn CW to increase pressure and CCW to decrease pressure (1 turn = approximately 7 psi)



4. Replace cap and test **WARNING! DO NOT OPERATE WITHOUT CAP.**
5. Repeat from step 1 as needed until pressure is achieved.

Caution: Do not exceed the maximum shut-off pressure for the pump. (see p. 3)



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Ace Form # PWM TECH FILE
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