SharpShooter™

Owner's Manual

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COMPONENT SELECTION

Identifying the Required Components - The SharpShooter system is comprised of a number of components. The first step is to identify what components are required for a specific installation. Capstan offers several shortcuts in this process. A generic SharpShooter configuration drawing is included here showing how the various components hook together to become a system. In addition, installation guides are available for specific sprayers. Contact Capstan for a list of installation guides.

Available Installation Guides
2005 JD 4720 with 90' x 5-Section Boom
2005 Apache with 100' x 5-Section Boom
2005 Case SPX3185 with 90' x 6-Section Boom
2001 RoGator 854 with 90' x 5-Section Boom

Generally, every installation will require one Pulse Generator, one Power Hub, one Pressure Sensor, several Valve Drivers and many Nozzle Valves. Extension harnesses provide additional cable length to reach the various parts of the sprayer.

It is important to adhere to the following rules:
1. Never plug more than 14 nozzles into a single Valve Driver.
2. Skip two nozzle pigtails for additional length in boom hinges.
3. Install Nozzle Alternators on Valve Drivers to flip-flop even/odd pulses where adjacent valves are pulsing together.
4. Always use 110 degree spray angle tips and maintain boom height at 2 feet or greater. If 80 degree spray angle tips are used, maintain boom height at 3 feet or greater.
5. Never use Air Induction (AI) spray tips.
6. Avoid combining fast speeds, high pressures, low rates, large droplets and low booms to prevent nozzle skipping.

Example Component Selection

Example Sprayer: Self-Propelled Sprayer with 60' boom and 20" Nozzle Spacing

All sprayers require a Pulse Generator, Power Hub, Circuit Breaker Kit and Pressure Sensor. Use the configuration drawing to select part numbers:

Parts List for Example Sprayer

Qty.	Part Number	Description
1	118500-002	Pulse Generator PWM/PSI
1	118600-001	Power Hub, 40'
1	116301-001	Pressure Sensor Assembly, 100psi
1	118604-001	Circuit Breaker Kit, 50amp

The example sprayer has boom shutoff valves and a pressure gauge mounted in the center of the boom and the 40' long Power Hub power wire is plenty long to reach the battery. Locating the Power Hub in the center of the boom uses fewer extension wires. Since the Pulse Generator is located in the cab, an extension harness is needed that is long enough to reach the cab. Choose a shutoff valve adapter to match the connectors on the shutoff valves.

Parts List for Example Sprayer

Qty.	Part Number	Description
1	118600-040	Extension 6 x 40' (Pulse Generator)
1	118602-003	Shutoff Adapter, Apache

The 60' boom has 36 TeeJet nozzles. The boom has three sections with 12 nozzles on each section. Therefore, Valve Drivers need to be ordered. For the center section, order boom wires as if there were 16 valves so two pigtails can be skipped to provide the wire length to safely route around the pinch points of each boom hinge. The two outside sections will use a 4x20" boom wire and a 8x20" boom wire plugged together to make 12 nozzles. The center section will use two 8x20" boom wires plugged together to make 16 nozzles.

Parts List for Example Sprayer

Qty.	Part Number	Description
36	116190-111	Valve Assembly, TeeJet
3	118400-002	Valve Driver
2	117501-006	Nozzle Harness, 4x20"
4	117501-005	Nozzle Harness, 8x20"

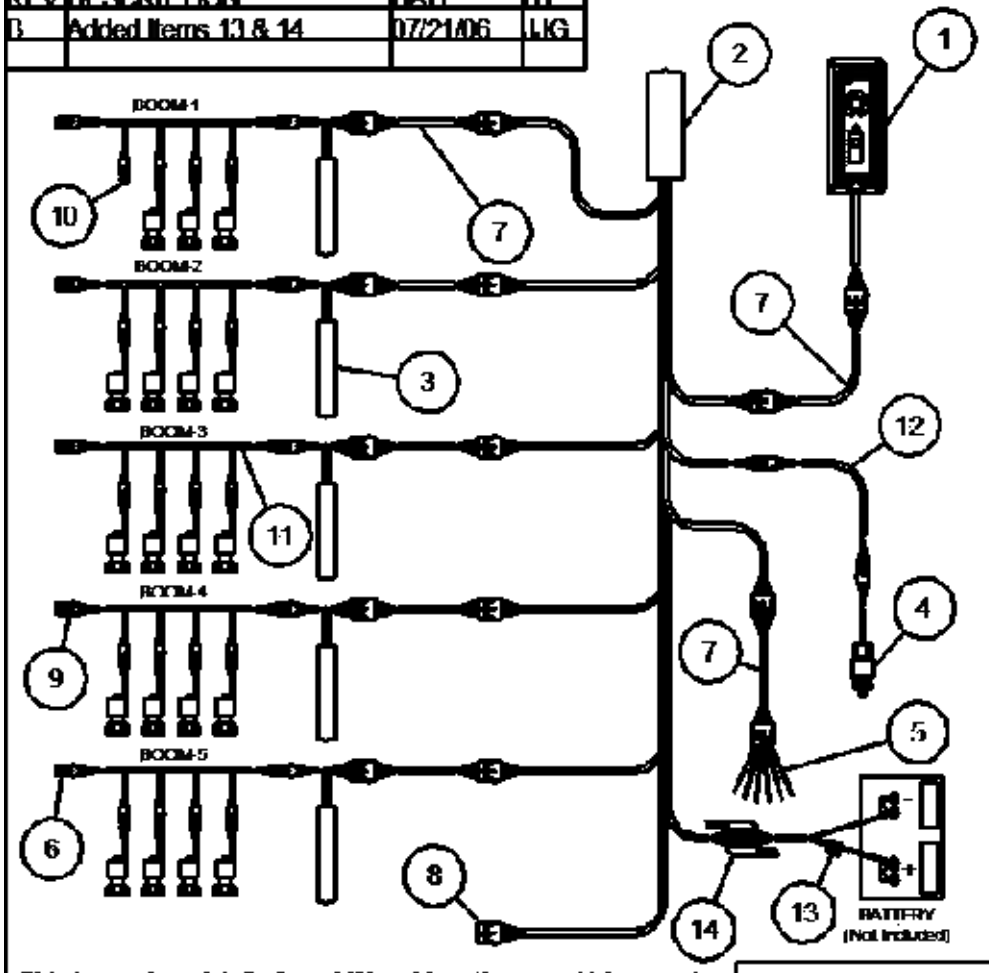
Run extension wires from the Power Hub to the Valve Drivers. In this example, all three wires will be 20'. Generally, the Valve Driver is installed towards the center of the boom, with the nozzle harnesses extending away from the boom. The center section will cross the center of the sprayer, so two sections will have to start at the same place. Therefore, a nozzle alternator is needed to reverse the even/odd pulse sequence in the boom wire that runs the opposite way. Also, plug any unused connectors to keep mud and bugs out.

Parts List for Example Sprayer

Qty.	Part Number	Description
3	118600-020	Extension, 6x20'
1	116200-013	Nozzle Alternator
4	116200-045	Tower Plug, 2-Pin
6	116200-046	Tower Plug, 3-Pin
3	116200-059	Tower Plug, 6-Pin

There are a few more items required that are available at a local hardware store. Use nylon cable ties to fasten all wires to the boom, as a snagged or pinched wire can cause problems. Also, the Pressure Sensor will generally require a pipe tee and nipple depending on the design of the sprayer.

REV	DESCRIPTION	DATE	BY
B	Added Items 13 & 14	07/21/06	LJG



ID	PART NUMBER	DESCRIPTION	QTY
1	118500-002	Pulse Generator, PWM/PSI	1
2	118600-001	Power Hub, 40ft	1
3	118400-002	Valve Driver	1-6
4	116301-001	Pressure Sensor	0-1
4	118601-001	Pressure Sense Pigtail	0-1
5	118602-001	Boom Shutoff Pigtail	1-1
5	118602-002	Shutoff Adapter, RoGator	0-1
5	118602-003	Shutoff Adapter, Apache	0-1
5	118602-004	Shutoff Adapter, John Deere	0-1
5	118602-005	Shutoff Adapter, Case	0-1
6	116190-111	Nozzle Valve Assy, TeeJet	0-84
6	116290-111	Nozzle Valve Assy, Arag	0-84
6	116390-111	Nozzle Valve Assy, Wilger	0-84
6	116290-211	Nozzle Valve Assy, HF Arag	0-84
7	118600-010	Extension, 6 x 10ft	A/R
7	118600-020	Extension, 6 x 20ft	A/R
7	118600-030	Extension, 6 x 30ft	A/R
7	118600-040	Extension, 6 x 40ft	A/R
7	118600-050	Extension, 6 x 50ft	A/R
7	118600-060	Extension, 6 x 60ft	A/R
8	116200-059	Plug, 6-Pin Tower	0-6
9	116200-046	Plug, 3-Pin Tower	0-6
10	116200-045	Plug, 2-Pin Tower	A/R
11	117501-005	8 x 20" Nozzle Harness	A/R
11	117501-006	4 x 20" Nozzle Harness	A/R
11	116200-040	1 x 20" Nozzle Harness	A/R
11	116200-013	Nozzle Alternator Adapt Asy	A/R
11	116200-032	Y Adaptor	A/R
12	116200-010	Extension, 3 x 10ft	0-1
13	118604-001	Circuit Breaker Kit, 50A	0-1
14	118605-001	Power Disconnect Kit	1-1

Skip two valve pigtails for additional length around hinges, etc.
Plug Nozzle Harnesses (11) end-to-end, Do Not Exceed 14 valves. Use Alternator (11) to reverse even/odd alternation.
Use Sensor Pigtail (4) with Existing Sensor.

CAPSTAN AG SYSTEMS, INC.
101 N. KANSAS AVE., TOPEKA, KS 66603

ShapShooter w Hub

DATE	BY	SCALE	PAGE	SIZE
01/06/06	LJG	None	1 of 1	A

CONFIG.

OPERATOR CONTROLS

The SharpShooter Cab Control Box has two switches: Rocker and Rotary. The Rocker Switch has three positions and an indicator light. The three Rocker Switch positions are: PWM, Off and PSI. The Rotary Switch has twelve detent positions: Close, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 and Open.

PWM Mode - With the Rocker Switch in PWM Mode, SharpShooter will pulse the nozzle valves at the duty cycle percent selected by the Rotary Switch. The rate controller will function normally, raising and lowering the pressure to control the proper application rate. Changing the pulse duty cycle percent will cause the rate controller to operate in higher or lower pressure ranges.

SharpShooter's pulse duty cycle percent closely approximates actual flow reduction through the nozzle. Manual flow control is possible using speed and pressure calibration techniques. When calculating actual nozzle flow, it is recommended to account for the pressure drop across the nozzle valve orifice, especially on large size tips (08's, 10's, 15's) where nozzle valve pressure drop is significant. The SharpShooter tip selection guide is a good reference to determine nozzle valve pressure drop for various tip sizes. A physical flow calibration is always recommended before applying any product to the crop or field.

SharpShooter's Low Pressure Shutoff feature is disabled in PWM Mode. This is done intentionally to simplify system operation during periods of troubleshooting and maintenance.

PSI Mode - With the Rocker Switch in PSI Mode, SharpShooter will pulse the nozzle valves at a duty cycle percent that will result in the boom pressure indicated by the Rotary Switch. The color graphic surrounding the Rotary Switch indicates Preferred (Green), Caution (Yellow) and Warning (Red) ranges of operation. The SharpShooter tip selection guide is a good reference to determine suitable spray pressure ranges for various speeds and tip sizes.

Open/Close Valves - In either PWM Mode or PSI Mode, the Rotary Switch "Open" and "Close" positions will fully open or fully close the nozzle valves. This feature might be handy in situations where the operator wishes to disable the pulsing of the valves. Pulsing may not be desired for row banding, drop nozzles, special applications, maintenance, troubleshooting or in the event of a system failure.

Indicator Light - The indicator light located in the Rocker Switch will be lit when power is supplied to the SharpShooter system.

In PWM Mode, the light will flash quickly, two times per second (2hz), indicating that the nozzle valves are pulsing at a fixed duty cycle percentage as selected on the Rotary Switch.

In PSI Mode, the light will be constant indicating that the nozzle valves are pulsing at a variable duty cycle percentage to achieve the pressure selected on the Rotary Switch. The light will flash slowly, one time per second (1hz), when automatic pressure control is suspended. There are five conditions when SharpShooter control is suspended and the light will flash slowly:

1. Minimum Duty Cycle Limit
2. Maximum Duty Cycle Limit
3. Low Pressure Shutoff
4. Start-Up Delay
5. Run/Hold Delay

12-Position Rotary Detent Switch

Close Valves	60
10	70
20	80
30	90
40	100
50	Open Valves

Indicator Light

Solid = Power On and Controlling
Fast Flash = PWM % Mode
Slow Flash = 1. Minimum Duty Cycle Limit
2. Maximum Duty Cycle Limit
3. Low Pressure Shutoff
4. Start-Up Delay
5. Run/Hold Delay

3-Position Rocker Switch

Down = PWM % Mode
Center = Off
Up = PSI Mode

OPERATION

SharpShooter is especially useful in solving three fundamental spraying problems:

1. Inconsistent application over wide speed ranges.
2. Excessive spray drift at high rates and/or speeds.
3. Limited variable rate application ranges.

Solving Problem 1: Inconsistent Application over Wide Speed Ranges

To achieve a consistent application over a wide speed range, select the appropriate spray tip size, style and pressure for the application rate and coverage at the fastest speed desired. Move the SharpShooter's Rocker Switch to PSI Mode and adjust SharpShooter's knob to the desired spray pressure. When slowing down, SharpShooter will adjust the nozzle pulsing to keep the spray pressure up where needed to obtain good coverage. SharpShooter will maintain the desired spray pressure over a wide speed range, up to 8:1.

Solving Problem 2: Excessive Spray Drift at High Rates and/or Speeds

To control spray drift over a wide rate or speed range, select the appropriate spray tip size, style and pressure for the application rate and drift control at the fastest speed desired. Move the SharpShooter's Rocker Switch to PSI Mode and adjust SharpShooter's knob to the desired spray pressure. When speeding up, SharpShooter will adjust the nozzle pulsing to keep the spray pressure down where needed for drift control. SharpShooter will maintain the desired spray pressure over a wide speed range, up to 8:1.

Solving Problem 3: Limited Variable Rate Application Ranges

To achieve a wide application rate range for variable rate applications, select the appropriate spray tip size, style and pressure for the coverage desired at the highest application rate and fastest speed. Move the SharpShooter's Rocker Switch to PSI Mode and adjust SharpShooter's knob to the desired spray pressure. When changing rates, SharpShooter will adjust the nozzle pulsing to allow for a wide range of flow changes while keeping the spray pressure constant. SharpShooter will maintain the desired spray pressure over a wide application rate range, up to 8:1.

When things go wrong

SharpShooter has been designed with several features that allow the operator to continue spraying in the event of a component failure.

Turn SharpShooter Off

With the SharpShooter Pulse Generator (Cab Control Box) turned to "Off" or removed, the Valve Drivers will continue to open or close the nozzle valves with the boom section on/off switches. The spray rate controller will continue to function normally. This feature will allow the operator to repair/replace the SharpShooter Pulse Generator in the event of a failure.

Turn SharpShooter on in PWM mode

In PWM mode, the nozzle valves will pulse at the selected duty cyle. The duty cycle percentage very closely approximates the actual flow through the nozzle. For instance, using a #8 sized tip and a 50% duty cycle will result in similar flow as a #4 size tip. Using a nozzle chart, the operator can spray according to traditional speed and pressure techniques. This feature will allow the operator to spray with a failed flowmeter or rate controller.

In the event of a pressure sensor failure, SharpShooter's PWM mode will allow the operator to adjust the pressure range that the rate controller operates within. This pressure range can be changed on-the-go for varying spray conditions.

Open/Close Valves

On the SharpShooter's Pulse Generator selection knob, an "open valve" and "close valve" position is available. Whether in PSI or PWM Mode, the open/close valve position will open/close the nozzle valves regardless of pressure or flow settings. This feature will allow the operator to control the valves regardless of the flow or pressure settings. This intuitive control method could be useful in emergency situations where an untrained person might need to stop the spray or empty the tank.

Interchangeable Components

SharpShooter uses multiple Valve Drivers, Nozzle Valves, and Extension Harnesses. In the event that one of these components fails, another identical component can often be swapped into its place to assist in troubleshooting. It is recommended that the operator carry a spare Valve Driver and several spare nozzle valves in down-time critical situations.

CONTROL FEATURES

Start-Up – In PSI Mode, SharpShooter will begin pulsing at 50% duty cycle and remain constant until the start-up delay time has elapsed. This allows the flow control system to establish itself before the SharpShooter begins controlling pressure. To alert the operator that the initialization delay has been activated, the Rocker Switch indicator light will flash slowly. Start-Up delay time is equal to Run/Hold delay time.

Low Pressure Shutoff – In PSI Mode, SharpShooter will turn off the nozzle valves when the pressure falls below 8 psi. This feature is intended to duplicate the effect of nozzle drip checks found on sprayers. To alert the operator that the low pressure shutoff feature has been activated, the Rocker Switch indicator light will flash slowly. When pressure rises above 10 psi again, SharpShooter will pulse at 50% duty cycle for the start-up delay period before resuming pressure control.

The low pressure shutoff feature can be disabled on the cab control circuit board by turning S4#3 to ON. When disabled, the SharpShooter will maintain a minimum duty cycle percent, equal to the pulse frequency, regardless of low or zero pressure.

The shutoff and turn on pressure values can be changed with the use of a computer and terminal emulator program via the DB9 serial port.

Run/Hold - In PSI Mode, SharpShooter will stop controlling pressure when the boom is turned off and the run/hold signal is removed. When the boom is turned back on again and the run/hold signal is returned, SharpShooter will resume pulsing at the duty cycle present when the boom was shutoff. This duty cycle will remain constant for a delay period of five seconds, allowing the flow control system to resume control. Once the delay period has elapsed, the SharpShooter will resume pressure control. To alert the operator that the run/hold delay has been activated, the Rocker Switch indicator light will flash slowly.

The run/hold feature can be disabled on the cab control circuit board by turning S1#2 to ON. When disabled, the SharpShooter will attempt to control pressure, regardless of its ability to do so, and will modulate to minimum or maximum duty cycle. This modulation to minimum or maximum duty cycle will cause SharpShooter, when the boom is turned back on, to spike/dip the pressure and cause control instability until the system catches up and pressure control is resumed.

The run/hold delay value can be adjusted from 0 to 20 seconds on the cab control circuit board by turning R51, 10-turn rotary potentiometer (see picture in circuit board setup section). Or, with the use of a computer and terminal emulator program via the DB9 serial port.

Pulse Frequency and Minimum Duty Cycle – Recommended pulse frequency for spray applications is 10 pulses per second or 10hz. SharpShooter automatically establishes a minimum pulse duty cycle equal to the frequency. So when pulse frequency is set at 10hz,

the SharpShooter will modulate from 10% to 100%, resulting in a pressure control range of 100:1 at a constant flow or a flow control range of 10:1 at a constant pressure.

Nozzle Pulse Frequency and Minimum Duty Cycle
(Actual values may vary with physical limitations of equipment.)

Freq. Hz	Duty Cycle%	GPM Range	PSI Range	Freq. Hz	Duty Cycle%	GPM Range	PSI Range
1	1-100	100	10,000	11	11-100	9.1	83
2	2-100	50	2,500	12	12-100	8.3	69
3	3-100	33.3	1,111	13	13-100	7.7	59
4	4-100	25	625	14	14-100	7.1	51
5	5-100	20	400	15	15-100	6.7	44
6	6-100	16.7	278	16	16-100	6.3	39
7	7-100	14.3	204	17	17-100	5.9	35
8	8-100	12.5	156	18	18-100	5.6	31
9	9-100	11.1	123	19	19-100	5.3	28
10	10-100	10	100	20	20-100	5	25

SharpShooter pulse frequency can be changed on the cab control circuit board by setting SW1 (10 position rotary detent switch) to the desired position, 1,2,…9,0, where the "0" position is 10 hz. Add 10 to the Rotary Switch setting by turning S4#1 to ON.

Invert - SharpShooter may require the cab control pulse duty cycle output to be inverted when driving some valve signal amplifiers. Invert the duty cycle output by turning switch S4#2 to ON.

Pull-Up Resistors – SharpShooter may require the use of pull-up resistors when driving some valve signal amplifiers. SharpShooter has two pull-up resistors, one for the even pulse signal and one for the odd pulse signal. The even pull-up resistor is enabled by turning S1#4 to ON and the odd pull-up resistor is enabled by turning S1#3 to ON.

Invert and Pull-Up Resistor Settings

Nozzle Valve Amplifier	Invert S4#2	Pull-Up Odd S1#3	Pull-Up Even S1#4
Capstan Direct Drive	ON	OFF	OFF
Capstan Valve Driver	OFF	ON	ON
Capstan Slave Module	OFF	ON	ON
Capstan Commander Module	OFF	ON	ON

Control Parameters – SharpShooter uses three control parameters to stabilize the pressure control algorithm in the control software: Proportional Gain, Integral Gain and Derivative Gain. In general terms, the proportional gain determines the speed that SharpShooter drives the duty cycle toward the target value. The integral gain determines the acceleration and the derivative gain determines the accuracy.

Proportional gain can be adjusted from -20 to +20 on the cab control circuit board by turning R49, 10-turn rotary potentiometer (see picture in circuit board setup section). Integral gain can be adjusted from -20 to +20 on the cab control circuit board by turning R50, 10-turn rotary potentiometer (see picture in circuit board setup section).

Proportional, integral and derivative gains can be set with the use of a computer and terminal emulator program via the DB9 serial port.

Factory setting for proportional gain is "8", for integral gain is "2" and for derivative gain is "1".

Boost – SharpShooter has a unique ability to turn on a second boom when the capacity of the pulsing nozzles have been exceeded. Turning S4#4 to ON enables the boost feature. A boost output pigtail must be added to the SharpShooter cab control box by a trained technician. Contact Capstan or your local dealer for more information.

The boost feature works by turning on a second boom when 100% pulse duty cycle is achieved. When the boost is turned on, the pulse duty cycle immediately modulates downwards to a value calculated based on tip size. In addition, a transition time may be entered to account for the speed at which the boost boom turns on. Conversely, when the boost boom is turned off, SharpShooter modulates upwards to a value calculated on tip size. The tip sizes of the two booms dictate the amount of "thermostat", preventing the boost boom from turning on and off too much. It is recommended that the boost boom tip size should be half of the pulsing boom tip size, resulting in a capacity increase of 50%.

Boost settings can be set with the use of a computer and terminal emulator program via the DB9 serial port. Boost settings include PWM tip size, PWM valve size, boost tip size and boost transition time.

Flow Meter Simulator – SharpShooter has an internal flow meter that mathematically calculates what the actual flow through the pulsing nozzles should be. This calculated flow is handy for estimating nozzle wear and for troubleshooting system problems. When a healthy SharpShooter system is operating, the calculated flow should match the actual flow recorded by the rate controller. As the pulsing nozzles wear, they become more restrictive and the actual flow will be lower than the calculated flow.

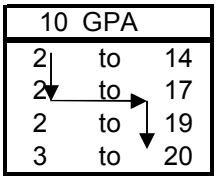
The SharpShooter flow meter output and setup parameters are available with the use of a computer and terminal emulator program via the DB9 serial port. Flow meter settings include pulsing valve size, tip size, valve count, boost tip size and specific gravity.

Hour Meter – SharpShooter has an internal hour meter that records the total time that the SharpShooter pulsing nozzles have been operating. The SharpShooter hour meter is available with the use of a computer and terminal emulator program via the DB9 serial port.

TIP SELECTION AND CAPACITIES

The following tip selection chart describes the speed ranges that can be expected when operating with a rate controller at various rates and pressures. To use the chart, select the application rate and move down the column to the desired speed range. Select a tip that provides the boom pressure you wish to spray.

SharpShooter will allow faster and slower travel than the range shown in the chart, however, the pulse duty cycle range will reach a limit, the indicator light will flash slowly and the pressure will rise or fall away from the target pressure.



Sprayer Applications: 20" Spacing, 10hz, Water													
Tip Size	PSI	Speed Range, mph											
Application Rate, gpa >		5 GPA			10 GPA			15 GPA			20 GPA		
11004	30	2	to	20	1	to	10	1	to	7	1	to	5
	40	3	to	23	1	to	12	1	to	8	1	to	6
	50	3	to	26	2	to	13	1	to	9	1	to	6
	60	4	to	28	2	to	14	1	to	9	1	to	7
11005	30	3	to	24	2	to	12	1	to	8	1	to	6
	40	4	to	28	2	to	14	1	to	9	1	to	7
	50	4	to	32	2	to	16	1	to	11	1	to	8
	60	4	to	35	2	to	17	1	to	12	1	to	9
11006	30	4	to	29	2	to	14	1	to	10	1	to	7
	40	4	to	33	2	to	17	1	to	11	1	to	8
	50	5	to	37	2	to	19	2	to	12	1	to	9
	60	5	to	41	3	to	20	2	to	14	1	to	10
11008	30	5	to	37	2	to	18	2	to	12	1	to	9
	40	5	to	42	3	to	21	2	to	14	1	to	11
	50	6	to	47	3	to	24	2	to	16	1	to	12
	60	6	to	52	3	to	26	2	to	17	2	to	13
11010	30	5	to	43	3	to	22	2	to	14	1	to	11
	40	6	to	50	3	to	25	2	to	17	2	to	12
	50	7	to	56	3	to	28	2	to	19	2	to	14
	60	8	to	61	4	to	31	3	to	20	2	to	15
11012.5	30	6	to	50	3	to	25	2	to	17	2	to	13
	40	7	to	58	4	to	29	2	to	19	2	to	14
	50	8	to	65	4	to	32	3	to	22	2	to	16
	60	9	to	71	4	to	35	3	to	24	2	to	18
11015	30	7	to	55	3	to	28	2	to	18	2	to	14
	40	8	to	64	4	to	32	3	to	21	2	to	16
	50	9	to	72	4	to	36	3	to	24	2	to	18
	60	10	to	78	5	to	39	3	to	26	2	to	20
No Tip	10	6	to	46	3	to	23	2	to	15	1	to	12
	20	8	to	65	4	to	33	3	to	22	2	to	16
	30	10	to	80	5	to	40	3	to	27	2	to	20
	40	12	to	92	6	to	46	4	to	31	3	to	23
	50	13	to	103	6	to	51	4	to	34	3	to	26
	60	14	to	113	7	to	56	5	to	38	4	to	28

To select a droplet size, the pressure drop across the SharpShooter nozzle valve must be taken into account. The chart below shows the actual tip pressure for various boom pressures. When using reference droplet size data provided by the tip manufacturers, use the actual tip pressure or reference pressure shown below.

Sprayer Droplet Size Reference Pressure: Water										
Tip Size	Boom Pressure, PSI									
	10	20	30	40	50	60	70	80	90	100
11004	9	19	28	38	47	56	66	75	84	94
11005	9	18	27	36	45	54	63	72	82	91
11006	9	17	26	35	43	52	61	70	78	87
11007	8	17	25	33	42	50	58	66	75	83
11008	8	16	24	32	39	47	55	63	71	79
11010	7	14	21	28	35	42	49	56	64	71
11012.5	6	12	18	24	30	36	42	48	55	61
11015	5	10	15	21	26	31	36	41	46	52

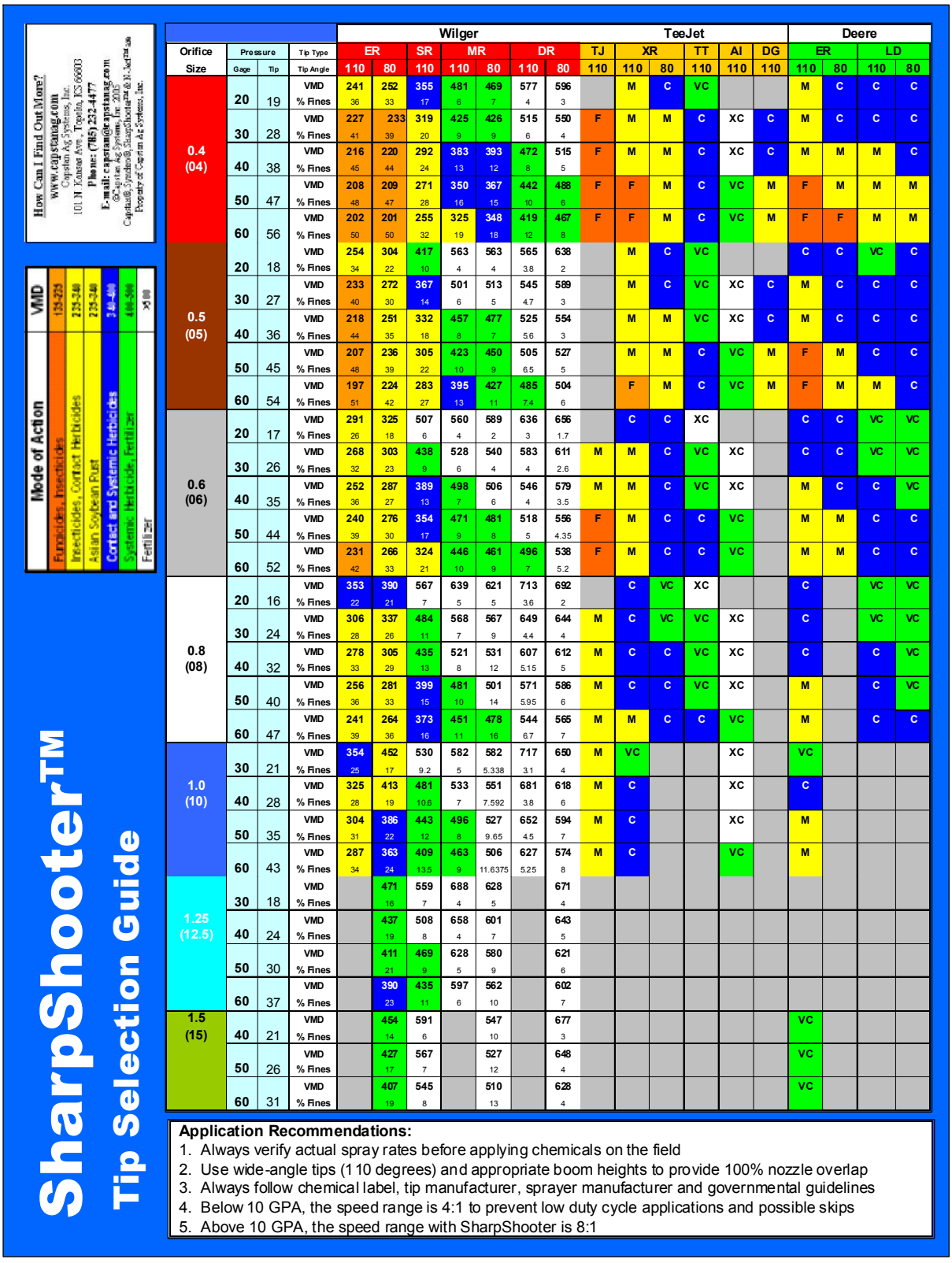
SharpShooter may be used with Capstan's N-Ject and N-Ject LF nitrogen application systems. The following charts describe the application rates available at various speeds. SharpShooter will maintain a constant manifold pressure over the rate range shown. At higher rates, the manifold pressure will rise above the target pressure.

N-Ject LF Applications: 30" Spacing, 3Hz, 28%UAN												
Valve Size	PSI	Application Range, GPA										
	Speed >	4 MPH			6 MPH			8 MPH			10 MPH	
5/32" LF	10	3	to	50	2	to	34	1	to	25	1	to 20
	20	4	to	71	2	to	48	2	to	36	1	to 29
	30	4	to	87	3	to	58	2	to	44	2	to 35
	40	5	to	101	3	to	67	3	to	50	2	to 40
	50	6	to	113	4	to	75	3	to	56	2	to 45
	60	6	to	124	4	to	82	3	to	62	2	to 49

N-Ject: 30" Spacing, 3Hz, NH3												
Valve Size	PSI	Application Range, #N/Acre										
	Speed >	4 MPH			6 MPH			8 MPH			10 MPH	
3/32" N-Ject	10	4	to	84	3	to	56	2	to	42	2	to 34
	20	6	to	117	4	to	78	3	to	59	2	to 47
	30	7	to	143	5	to	95	4	to	72	3	to 57
	40	8	to	164	5	to	109	4	to	82	3	to 66
	50	9	to	182	6	to	121	5	to	91	4	to 73
	60	10	to	198	7	to	132	5	to	99	4	to 79
	70	11	to	213	7	to	142	5	to	107	4	to 85
	80	11	to	226	8	to	151	6	to	113	5	to 90
	90	12	to	239	8	to	159	6	to	120	5	to 96
	100	13	to	251	8	to	167	6	to	126	5	to 100
5/32" N-Ject	10	7	to	139	5	to	93	3	to	70	3	to 56
	20	10	to	195	7	to	130	5	to	98	4	to 78
	30	12	to	237	8	to	158	6	to	119	5	to 95
	40	14	to	272	9	to	181	7	to	136	5	to 109
	50	15	to	302	10	to	201	8	to	151	6	to 121
	60	16	to	329	11	to	219	8	to	165	7	to 132
	70	18	to	353	12	to	235	9	to	177	7	to 141
	80	19	to	376	13	to	251	9	to	188	8	to 150
	90	20	to	396	13	to	264	10	to	198	8	to 158
	100	21	to	416	14	to	277	10	to	208	8	to 166

SharpShooter™ Tip Selection Guide

Orifice Size	Pressure		Speed Range, mph					
	Gage	Tip	5 GPA	8 GPA	10 GPA	12 GPA	15 GPA	20 GPA
0.4 (04)	20	19	4.1 to 16.4	2.6 to 10.2	1.0 to 8.2	0.9 to 6.8	0.7 to 5.5	0.5 to 4.1
	30	28	5.0 to 19.9	3.1 to 12.4	1.2 to 9.9	1.0 to 8.3	0.8 to 6.6	0.6 to 5.0
	40	38	5.9 to 23.8	3.7 to 14.9	1.5 to 11.9	1.2 to 9.9	1.0 to 7.9	0.7 to 5.9
	50	47	6.4 to 25.8	4.0 to 16.1	1.6 to 12.9	1.3 to 10.7	1.1 to 8.6	0.8 to 6.4
	60	56	7.0 to 28.1	4.4 to 17.6	1.8 to 14.1	1.5 to 11.7	1.2 to 9.4	0.9 to 7.0
0.5 (05)	20	18	5.0 to 19.9	3.1 to 12.5	1.2 to 10.0	1.0 to 8.3	0.8 to 6.6	0.6 to 5.0
	30	27	6.1 to 24.4	3.8 to 15.3	1.5 to 12.2	1.3 to 10.2	1.0 to 8.1	0.8 to 6.1
	40	36	7.4 to 29.7	4.6 to 18.6	1.9 to 14.9	1.5 to 12.4	1.2 to 9.9	0.9 to 7.4
	50	45	7.9 to 31.5	4.9 to 19.7	2.0 to 15.8	1.6 to 13.1	1.3 to 10.5	1.0 to 7.9
	60	54	8.6 to 34.5	5.4 to 21.6	2.2 to 17.3	1.8 to 14.4	1.4 to 11.5	1.1 to 8.6
0.6 (06)	20	17	5.8 to 23.2	3.6 to 14.5	1.5 to 11.6	1.2 to 9.7	1.0 to 7.7	0.7 to 5.8
	30	26	7.2 to 28.7	4.5 to 18.0	1.8 to 14.4	1.5 to 12.0	1.2 to 9.6	0.9 to 7.2
	40	35	8.9 to 35.6	5.6 to 22.3	2.2 to 17.8	1.9 to 14.9	1.5 to 11.9	1.1 to 8.9
	50	44	9.3 to 37.2	5.8 to 23.2	2.3 to 18.6	1.9 to 15.5	1.5 to 12.4	1.2 to 9.3
	60	52	10.2 to 40.6	6.3 to 25.4	2.5 to 20.3	2.1 to 16.9	1.7 to 13.5	1.3 to 10.2
0.8 (08)	20	16	7.5 to 30.1	4.7 to 18.8	1.9 to 15.0	1.6 to 12.5	1.3 to 10.0	0.9 to 7.5
	30	24	9.2 to 36.8	5.8 to 23.0	2.3 to 18.4	1.9 to 15.3	1.5 to 12.3	1.2 to 9.2
	40	32	11.9 to 47.5	7.4 to 29.7	3.0 to 23.8	2.5 to 19.8	2.0 to 15.8	1.5 to 11.9
	50	40	11.8 to 47.2	7.4 to 29.5	3.0 to 23.6	2.5 to 19.7	2.0 to 15.7	1.5 to 11.8
	60	47	12.9 to 51.5	8.0 to 32.2	3.2 to 25.8	2.7 to 21.5	2.1 to 17.2	1.6 to 12.9
1.0 (10)	30	21	10.8 to 43.0	6.7 to 26.9	2.7 to 21.5	2.2 to 17.9	1.8 to 14.3	1.3 to 10.8
	40	28	14.9 to 59.4	9.3 to 37.1	3.7 to 29.7	3.1 to 24.8	2.5 to 19.8	1.9 to 14.9
	50	35	13.9 to 55.6	8.7 to 34.7	3.5 to 27.8	2.9 to 23.2	2.3 to 18.5	1.7 to 13.9
	60	43	15.3 to 61.2	9.6 to 38.3	3.8 to 30.6	3.2 to 25.5	2.6 to 20.4	1.9 to 15.3
1.25 (12.5)	30	18	12.5 to 49.8	7.8 to 31.1	3.1 to 24.9	2.6 to 20.8	2.1 to 16.6	1.6 to 12.5
	40	24	18.6 to 74.3	11.6 to 46.4	4.6 to 37.1	3.9 to 30.9	3.1 to 24.8	2.3 to 18.6
	50	30	16.1 to 64.3	10.0 to 40.2	4.0 to 32.2	3.3 to 26.8	2.7 to 21.4	2.0 to 16.1
	60	37	17.7 to 70.9	11.1 to 44.3	4.4 to 35.5	3.7 to 29.6	3.0 to 23.6	2.2 to 17.7
1.5 (15)	40	21	22.3 to 89.1	13.9 to 55.7	5.6 to 44.6	4.6 to 37.1	3.7 to 29.7	2.8 to 22.3
	50	26	18.0 to 71.8	11.2 to 44.9	4.5 to 35.9	3.7 to 29.9	3.0 to 23.9	2.2 to 18.0
	60	31	19.6 to 78.4	12.3 to 49.0	4.9 to 39.2	4.1 to 32.7	3.3 to 26.1	2.5 to 19.6



Orifice Size	Pressure Gage	Pressure Tip	Tip Type	Wilger ER 110	Wilger ER 80	Wilger SR 110	Wilger MR 110	Wilger MR 80	Wilger DR 110	Wilger DR 80	TeeJet TJ 110	TeeJet XR 110	TeeJet XR 80	TeeJet TT 110	TeeJet AI 110	TeeJet DG 110	Deere ER 110	Deere ER 80	Deere LD 110	Deere LD 80
			Tip Angle	110	80	110	110	80	110	80	110	110	80	110	110	110	110	80	110	80
0.4 (04)	20	19	VMD	241	252	355	481	469	577	596		M	C	VC			M	C	C	C
			% Fines	36	33	17	6	7	4	3										
	30	28	VMD	227	233	319	425	426	515	550	F	M	M	C	XC	C	M	C	C	C
			% Fines	41	39	20	9	9	6	4										
	40	38	VMD	216	220	292	383	393	472	515	F	M	M	C	XC	C	M	M	M	C
			% Fines	45	44	24	13	12	8	5										
	50	47	VMD	208	209	271	350	367	442	488	F	F	M	C	VC	M	F	M	M	M
			% Fines	48	47	28	16	15	10	6										
	60	56	VMD	202	201	255	325	348	419	467	F	F	M	C	VC	M	F	F	M	M
			% Fines	50	50	32	19	18	12	8										
0.5 (05)	20	18	VMD	254	304	417	563	563	565	638		M	C	VC			C	C	VC	C
			% Fines	44	22	10	4	4	3.8	2										
	30	27	VMD	233	272	367	501	513	545	589		M	C	VC	XC	C	M	C	C	C
			% Fines	40	30	14	6	5	4.7	3										
	40	36	VMD	218	251	332	457	477	525	554		M	M	VC	XC	C	M	C	C	C
			% Fines	44	35	18	8	7	5.6	3										
	50	45	VMD	207	236	305	423	450	505	527		M	M	C	VC	M	F	M	C	C
			% Fines	48	39	22	10	9	6.5	5										
	60	54	VMD	197	224	283	395	427	485	504		F	M	C	VC	M	F	M	M	C
			% Fines	51	42	27	13	11	7.4	6										
0.6 (06)	20	17	VMD	291	325	507	560	589	636	656		C	C	XC			C	C	VC	VC
			% Fines	26	18	6	4	2	3	1.7										
	30	26	VMD	268	303	438	528	540	583	611	M	M	C	VC	XC		C	C	VC	VC
			% Fines	32	23	9	6	4	4	2.6										
	40	35	VMD	252	287	389	498	506	546	579	M	M	C	VC	XC		M	C	C	VC
			% Fines	36	27	13	7	6	4	3.5										
	50	44	VMD	240	276	354	471	481	518	556	F	M	C	C	VC		M	M	C	C
			% Fines	39	30	17	9	8	5	4.35										
	60	52	VMD	231	266	324	446	461	496	538	F	M	C	C	VC		M	M	C	C
			% Fines	42	33	21	10	9	7	5.2										
0.8 (08)	20	16	VMD	353	390	567	639	621	713	692		C	VC	XC			C		VC	VC
			% Fines	22	21	7	5	5	3.6	2										
	30	24	VMD	306	337	484	568	567	649	644	M	C	VC	VC	XC		C		VC	VC
			% Fines	28	26	11	7	9	4.4	4										
	40	32	VMD	278	305	435	521	531	607	612	M	C	C	VC	XC		C		C	VC
			% Fines	33	29	13	8	12	5.15	5										
	50	40	VMD	256	281	399	481	501	571	586	M	C	C	VC	XC		M		C	VC
			% Fines	36	33	15	10	14	5.95	6										
	60	47	VMD	241	264	373	451	478	544	565	M	M	C	C	VC		M		C	C
			% Fines	39	36	16	11	16	6.7	7										
1.0 (10)	30	21	VMD	354	452	530	582	582	717	650	M	VC			XC		VC			
			% Fines	25	17	9.2	5	5.338	3.1	4										
	40	28	VMD	325	413	481	533	551	681	618	M	C			XC		C			
			% Fines	28	19	10.6	7	7.592	3.8	6										
	50	35	VMD	304	386	443	496	527	652	594	M	C			XC		M			
			% Fines	31	22	12	8	9.65	4.5	7										
	60	43	VMD	287	363	409	463	506	627	574	M	C			VC		M			
			% Fines	34	24	13.5	9	11.6375	5.25	8										
1.25 (12.5)	30	18	VMD		471	559	688	628		671										
			% Fines		16	7	4	5		4										
	40	24	VMD		437	508	658	601		643										
			% Fines		19	8	4	7		5										
	50	30	VMD		411	469	628	580		621										
			% Fines		21	9	5	9		6										
	60	37	VMD		390	435	597	562		602										
			% Fines		23	11	6	10		7										
1.5 (15)	40	21	VMD		454	591		547		677							VC			
			% Fines		14	6		10		3										
	50	26	VMD		427	567		527		648							VC			
			% Fines		17	7		12		4										
	60	31	VMD		407	545		510		628							VC			
			% Fines		19	8		13		4										

Application Recommendations:

1. Always verify actual spray rates before applying chemicals on the field
2. Use wide-angle tips (110 degrees) and appropriate boom heights to provide 100% nozzle overlap
3. Always follow chemical label, tip manufacturer, sprayer manufacturer and governmental guidelines
4. Below 10 GPA, the speed range is 4:1 to prevent low duty cycle applications and possible skips
5. Above 10 GPA, the speed range with SharpShooter is 8:1

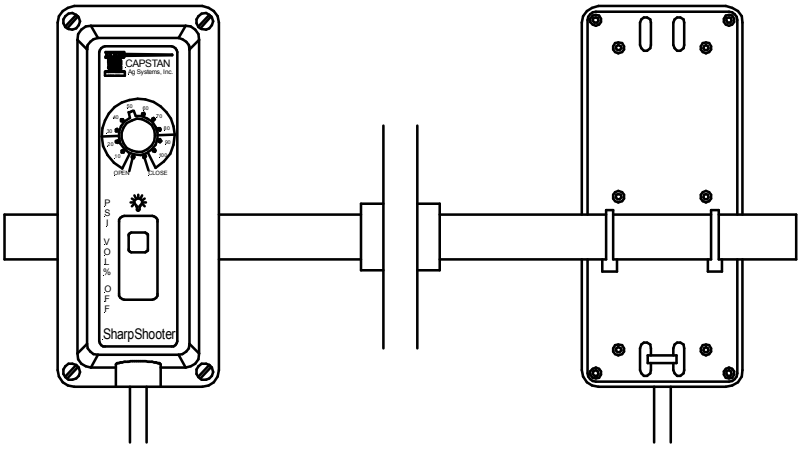
INSTALLATION

Installing the Pulse Generator –

Identify a mounting location in the cab within reach and view of the operator. The Pulse Generator is not weatherproof, so choose a location that is protected from the elements.

The SharpShooter Pulse Generator has several slots in the aluminum back plate. These slots are designed to allow a nylon cable tie, or hose clamp, to be passed through the slots and around a mounting rail. If no mounting rail is provided, the Pulse Generator can be fastened to a bracket using bolts or screws.

Use caution when mounting the Pulse Generator so that the circuit board does not get broken, grounded or pinched. It is recommended that the Pulse Generator be mounted so the plastic box can be removed without unfastening the aluminum back plate. This way the serial port can be accessed easily for setup and/or troubleshooting.



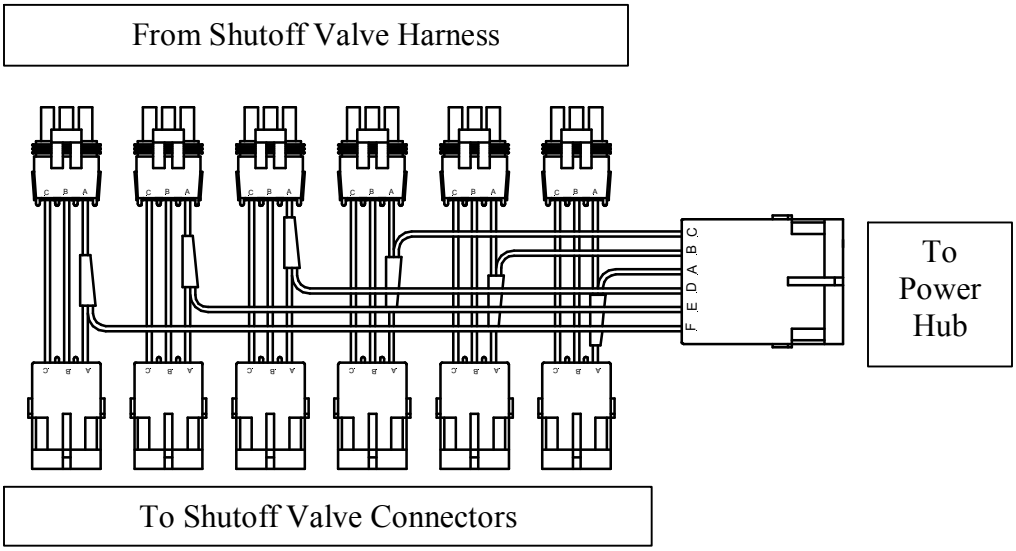
An extension wire is generally required to reach the Power Hub. Route the extension wire into the cab. Generally, cab manufacturers provide a way for wires to enter the cab. For instance, John Deere cabs have a rubber grommet that closes in the rear window molding.

It is also important to note that the Pulse Generator has a 10 amp fuse in the power lead. Locate this fuse so that it is available for service.

Installing the boom shutoff adapter –

The boom shutoff adapter intercepts the signals that open and close the boom section shutoff valves. SharpShooter uses this signal to turn on and off the nozzle valves. When the signal wire is powered up, 12vdc, the nozzle valves open and when the signal wire has no power, the nozzle valves close.

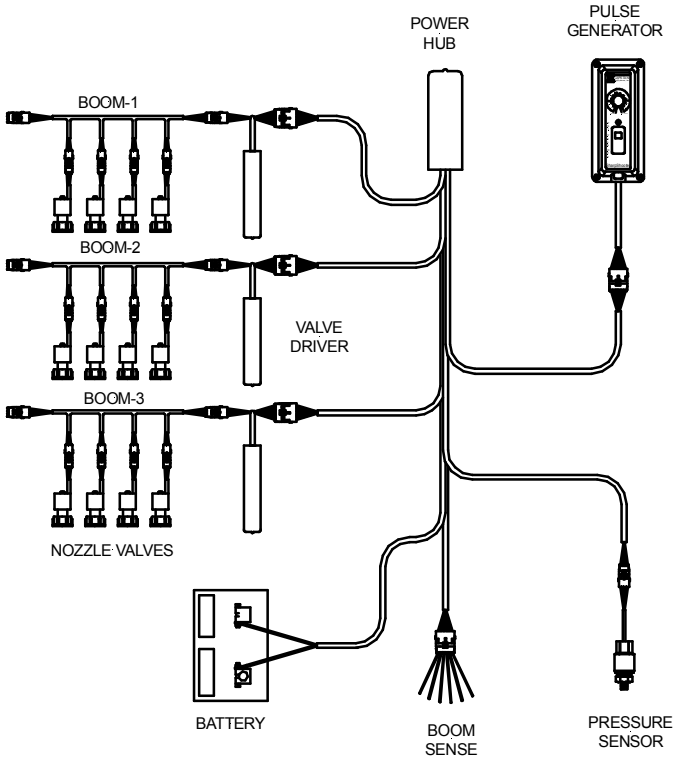
Capstan offers several boom shutoff adapters for various sprayer models. Each model is different, but generally, the boom shutoff adapter is located near the sprayer's boom shutoff valves. Disconnect each boom shutoff valve connector and plug the boom shutoff adapter between the valve and shutoff harness. An extension harness may be required to reach the Power Hub connection.



If no shutoff adapter is available to match the sprayer, the boom shutoff pigtail (PN: 118602-001) can be used to hand wire the shutoff signals. Connect the boom-1 shutoff signal to pin-A, boom-2 to pin-B, etc. Consult the SharpShooter wiring schematic for additional information.

Installing the Power Hub –

Thoughtfully choosing the mounting location of the Power Hub can save time, trouble and parts. As the Power Hub has a 40' power wire, locate the Power Hub within 40' of the battery. The Power Hub is also where the pressure sensor and boom sections connect. Locating the Power Hub near the pressure sensor will eliminate the use of an extension wire. The Power Hub may also be mounted so that two boom sections can be directly connected without the use of an extension wire.

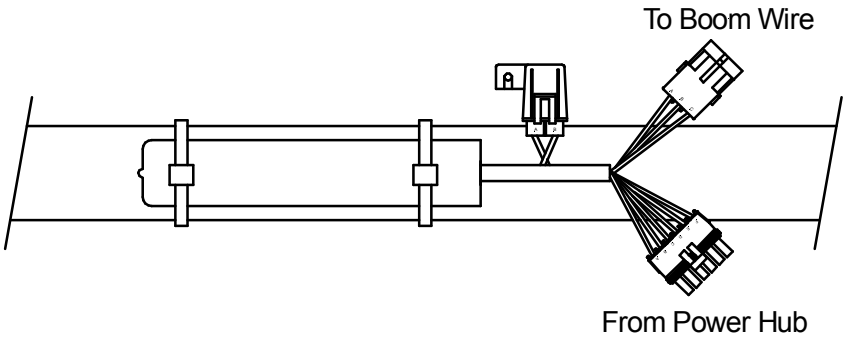


Shorten the power wire to the appropriate length and terminate the wire with the battery ring terminals provided. If a battery fuse kit is provided, crimp it onto the red power lead in lieu of the ring terminal. It is recommended to use battery terminal corrosion inhibitor to prevent salt buildup and extend the life of the battery terminals.

The Power Hub can be mounted with nylon cable ties.

Installing the Valve Drivers –

The Valve Drivers connect between the Power Hub and boom wire and can be mounted to the boom structure or boom hoses using nylon cable ties. The Valve Driver is generally located adjacent to the first nozzle on the associated boom section and an extension wire is used to connect to the Pulse Generator. The Valve Driver has a 10 amp capacity and therefore, also has a 10 amp fuse in its power lead. Therefore, the Valve Driver is limited to driving 14 sprayer nozzle valves (8 N-Ject or N-Ject LF valves). It is recommended that the Valve Driver be located so that the fuse is available for service.

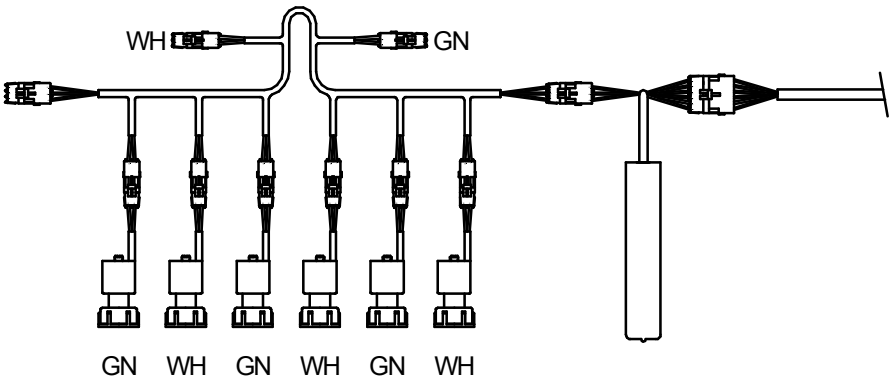


Boom Wires, Nozzle Alternators and Dust Caps –

Route the boom wires along the boom so that a nozzle pigtail is available at each nozzle. The 8-nozzle and 4-nozzle boom wires can be plugged together to create 12-nozzle strings, 16-nozzle strings, etc.

The pigtail wires are color coded so that there is a white wire or green wire indicating the nozzle's alternation, odd or even. It is important to alternate adjacent nozzles to create pulse blending and decrease the chances of leaving skips in the field.

For example, when additional boom wire length is required to go around a hinge, skip two nozzle pigtails so that the nozzle alternation is preserved.



Since two boom sections are generally started at the center of the boom and boom wires extended to the left and to the right, there will be two "even" pulse valves adjacent to each other. A nozzle alternator can be placed between the Valve Driver and boom wire to "flip" the odd/even pulse alternation (the colors, of course, will not flip, so it is important to remember that the nozzle alternation has been flipped).

If the boom section has an unused nozzle pigtail, simply shift the boom wire over one nozzle to preserve the nozzle alternation and eliminate the use of the nozzle alternator.

Another trick for experienced Packard connector users is to simply switch the green and white wire in the 3-pin connector at the beginning of the nozzle string (this requires a tool). This will also flip the odd/even pulse alternation and eliminate the use of a nozzle alternator.

Be sure to walk down the boom and count off nozzles as even, odd, even, etc. Boom sections with an odd number of nozzles will generally cause some kind of alternation problem.

Once the boom wires and alternation is in place, fasten the boom wires to the boom with nylon cable ties. Do not be afraid to use too many cable ties. Loose boom wires can get snagged by tree limbs, etc.

Install dust caps in any unused connectors to keep dirt, bugs, corrosion, etc. from building up, thus preventing the use of the connector in the future.

Nozzle Valves -

Capstan makes several types of nozzle valves to accommodate the various types of nozzle bodies used on sprayers. It is important to have the correct nozzle valve for the nozzle body being used. Incorrect nozzle valves may screw onto the body, but will leak or pop off under pressure.

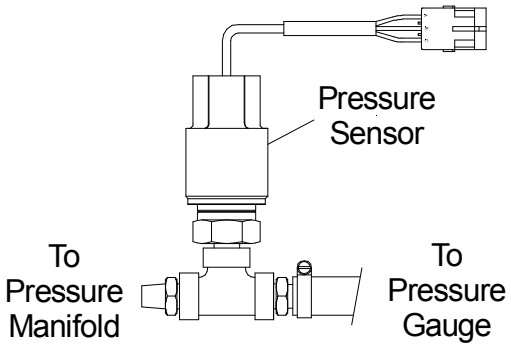
Install the nozzle valve by removing the diaphragm drip check and replacing it with the nozzle valve. An o-ring is used as a seal between the nozzle valve and nozzle body. This o-ring is commonly shipped on the nozzle pigtail. Remove the o-ring from the pigtail and insert it inside the flynut. The nozzle valves only need to be snug to prevent leakage. Over tightening nozzle valves may result in the flynut jumping off of the threads.

Plug the nozzle valve into the boom wire and secure the wire with a nylon cable tie.

Pressure Sensor –

The Pressure Sensor must be installed in the plumbing in a location that will have an accurate reading when all or only one boom section is turned on. A good location for the Pressure Sensor is near wherever the pressure gauge port is located. This is commonly located at the center of the boom near the boom section manifold.

SharpShooter's Pressure Sensor has a male ¼" pipe thread boss. Sometimes an unused boss is available on the sprayer, but more commonly it is necessary to remove the pressure gauge and install a tee. The SharpShooter Pressure Sensor will then screw into one leg of the tee and the pressure gauge in to the other leg. A short nipple may be required to install the tee and a reducer bushing may be required to facilitate ¼" pipe threads. Use thread sealant to prevent leakage and be cautious not to over tighten the metal sensor when installing it into plastic bosses. Metal sensors often crack plastic bosses when over tightened.



Whenever possible, Capstan recommends that the Pressure Sensor be installed vertically and with the sensor pointed upwards. This helps to keep debris from settling in the sensor.

If a Pressure Sensor is already present on the sprayer, it is possible to intercept the pressure signal to use with SharpShooter. SharpShooter uses a 0.5 to 5vdc sensor output. Connect the

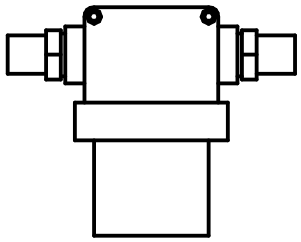
sensor signal circuit to pin-A in the Pressure Sensor connector. Consult the SharpShooter wiring schematic for additional information.

Wire Routing and Securing –

Once the SharpShooter system is installed, check the wire routing to be sure the boom folds up without pulling or pinching any wires. Secure any loose wires with nylon cable ties.

Strainers –

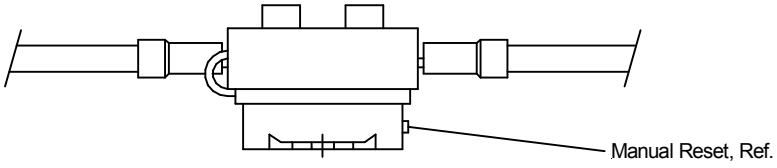
Most sprayers are built with strainers to filter debris from the spray. An 80-mesh screen is recommended to prevent nozzles from plugging. Check the mesh size of the strainers and replace the screens if they are too coarse.



Use 80-mesh, or finer, strainer screens.

Circuit Breaker Kit –

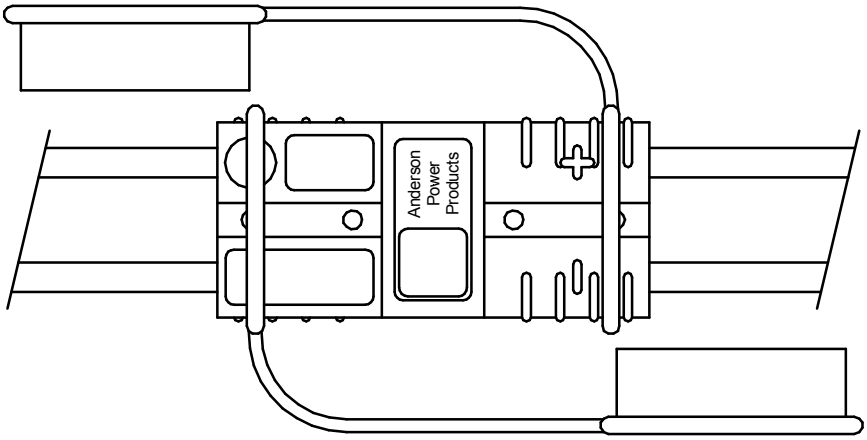
A circuit breaker kit is available for SharpShooter installations where circuit protection is desired in the power cables that provide battery power. To install the circuit breaker kit, select a location in the positive power wire (red) where the circuit breaker is accessible for service. With the power wire disconnected from the battery, cut the wire and strip the insulation from both of the cuts. Crimp the ring terminal provided to each wire end. Install the rubber boot on the circuit breaker and secure the ring terminals to the circuit breaker terminals. The rubber boot may have to be trimmed for wire clearance. Reconnect the battery wire. Note the reset button on the circuit breaker for future reference.



Power Disconnect Kit –

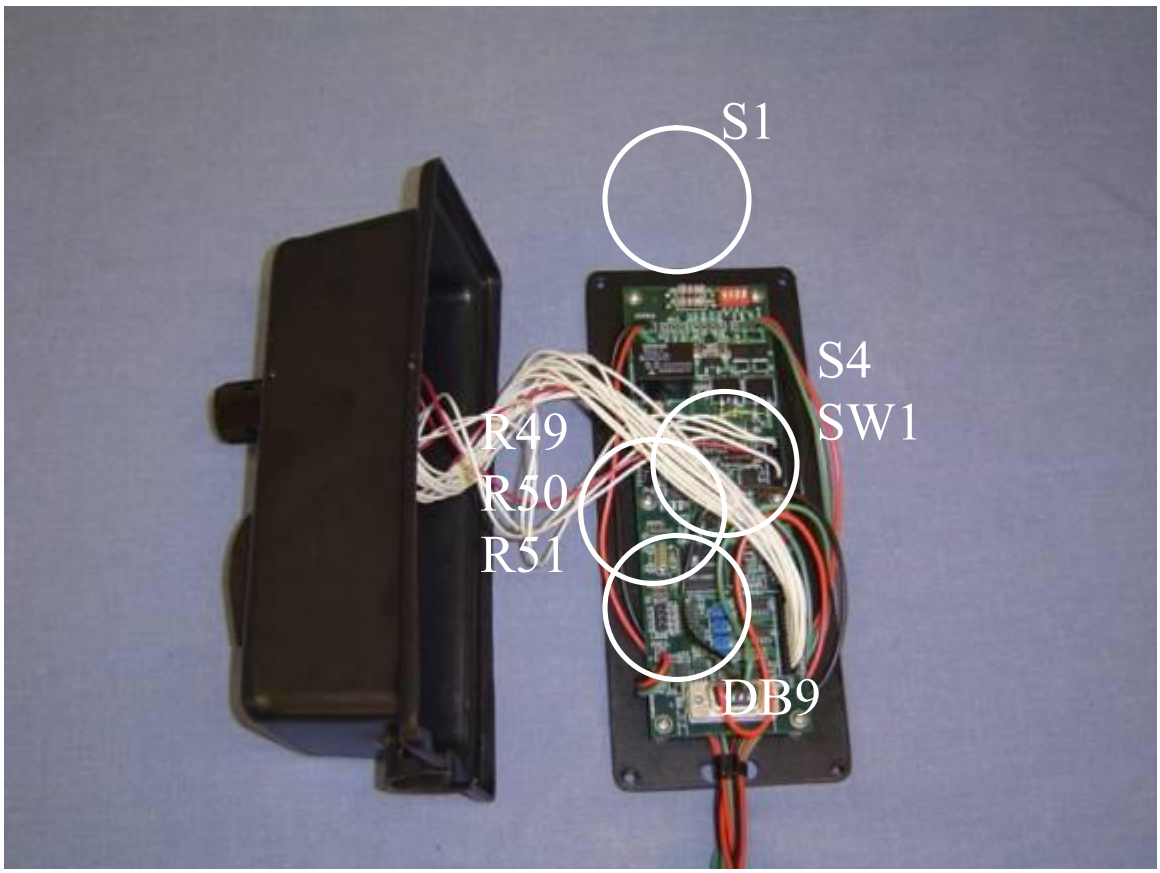
A power disconnect kit is available for trailer sprayer applications where unhooking the battery power wires is desirable. With the battery power wires disconnected, cut and strip the wires at the desired disconnect location. Crimp the spacer bushing and terminal onto each wire. Insert the terminals into the housing, making sure the positive and negative wires are in the correct housing location. The housing locations are marked with a “+” and “-“.

Install the rubber dust boots for use when the wires are disconnected. Reconnect the battery wires.



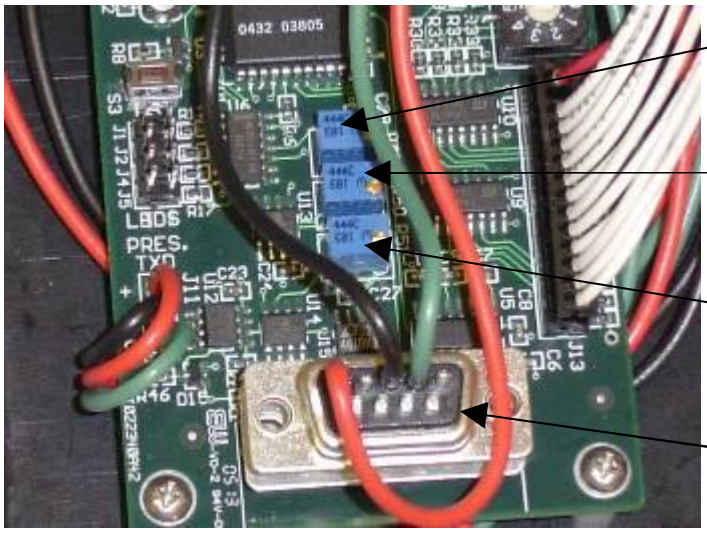
CIRCUIT BOARD SETUP

To access the circuit board setups, remove the four corner screws from the Pulse Generator and lift the lid away from the back plate.



Factory Defaults:

Identifier	Description	Function	Default Setting
R49	Potentiometer, 10-turn	Proportional Gain	"3.61K Ohms" = 8
R50	Potentiometer, 10-turn	Integral Gain	"3.30K Ohms" = 2
R51	Potentiometer, 10-turn	Run/Hold Delay	"1.13K Ohms" = 3sec
S1 #1	DIP Switch, Position #1	DB9 Power	"Off" = Disabled
S1 #2	DIP Switch, Position #2	Run/Hold	"Off" = Enabled
S1 #3	DIP Switch, Position #3	Odd Pull-up Resistor	"On" = Enabled
S1 #4	DIP Switch, Position #4	Even Pull-up Resistor	"On" = Enabled
S4 #1	DIP Switch, Position #1	Frequency Multiplier	"Off" = SW1 X 10
S4 #2	DIP Switch, Position #2	Pulse Invert	"Off" = Standard
S4 #3	DIP Switch, Position #3	PSI Shutoff	"Off" = Enable
S4 #4	DIP Switch, Position #4	Boost Boom	"On" = Disable
SW1	Rotary Potentiometer	Pulse Frequency	"0" = 10hz

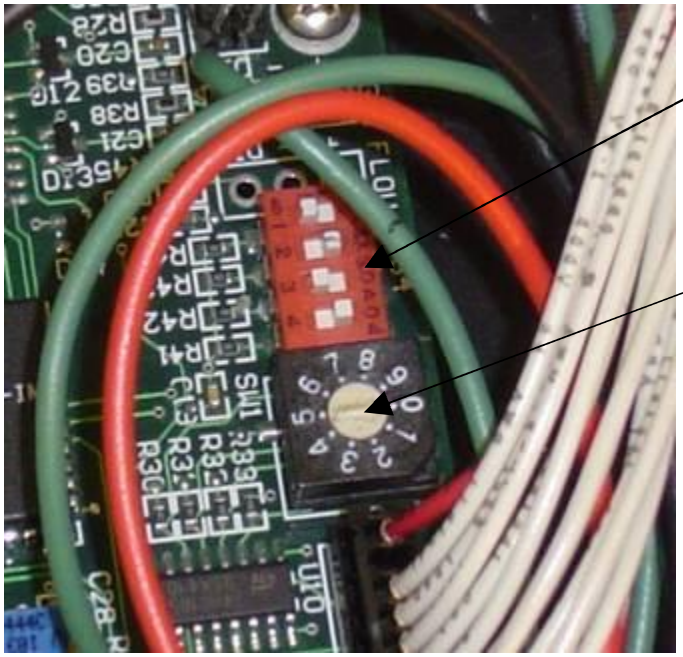


R49 = Proportional Gain
10-Turn Potentiometer
-20 to +20

R50 = Integral Gain
10-Turn Potentiometer
-20 to +20

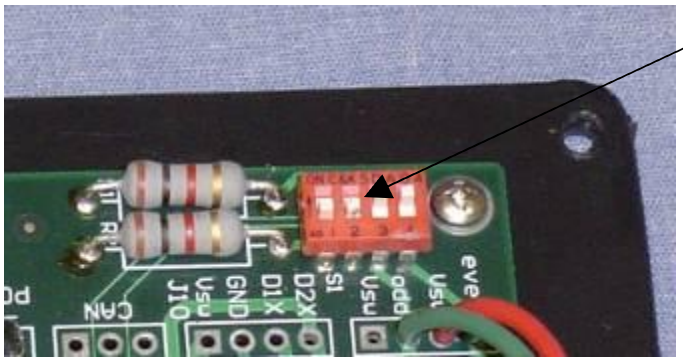
R51 = Run/Hold Delay
10-Turn Potentiometer
0 to 20 Seconds

DB9 = Serial Port



S4 DIP Switch
#1: ON = Freq. x 10
#2: ON = Invert
#3: ON = Disable PSI Shutoff
#4: ON = Disable Boost

SW1 Rotary Detent Switch
#1 = 1 Hz
#2 = 2 Hz
#9 = 9 Hz
#0 = 10 Hz
Etc.



S1 DIP Switch
#1: ON = DB9 Power Enabled
#2: ON = Run/Hold Disabled
#3: ON = Odd Resistor Enabled
#4: ON = Even Resistor Enabled

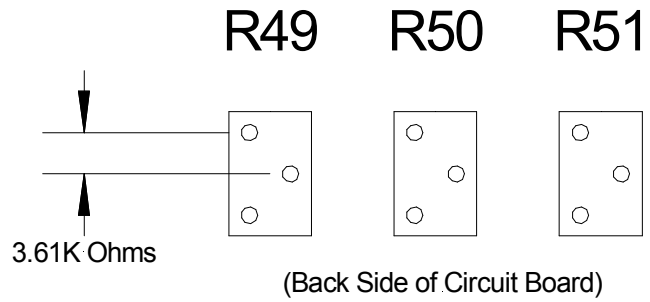
Manually Setting R49, R50 and R51 Potentiometers –

R49, R50 and R51 potentiometers are for setting proportional gain, integral gain and delay timeout. These potentiometers must be enabled using the serial setup and diagnostic procedure. It is far easier to set these parameters using the serial setup and diagnostic procedure. However, in cases where a computer is not available, the potentiometers can be set using an ohmmeter.

Disconnect the Pulse Generator from the Power Hub extension. Remove the circuit board from the Pulse Generator by first removing the plastic cover (4 screws) and then the circuit board (6 screws).

On the back side of the circuit board, find where the potentiometer pins protrude through the circuit board.

Clip an ohmmeter across the top two pins as shown below:



Turn the potentiometer screw clockwise to reduce resistance and counterclockwise to increase resistance. Set the potentiometers as follows:

Pot. ID:	R49	R50	R51
Resistance:	3.61K Ohms	3.30K Ohms	1.13K Ohms
Function:	Proportional Gain	Integral Gain	Delay Timeout
Cal. Value:	8	2	3 Seconds
Raw Value:	676	555	150
% Value:	68%	56%	15%

R49, R50 and R51 are 10-turn, 10K Ohm potentiometers with no end stops. Therefore, you can not turn the pots fully ccw and count the appropriate number of turns to result in the proper gain value.

Tuning Proportional Gain Potentiometer, R49 –

The proportional gain establishes the velocity at which the pulse duty cycle will change when a pressure error is detected. Higher gain values result in faster response velocities. The factory default setting is "8". If the proportional gain is too high, oscillating in the pressure control may result. To stabilize control, reduce the proportional gain value by turning R49 clockwise. Each full 360 degree turn of R49 will result in a proportional gain value change

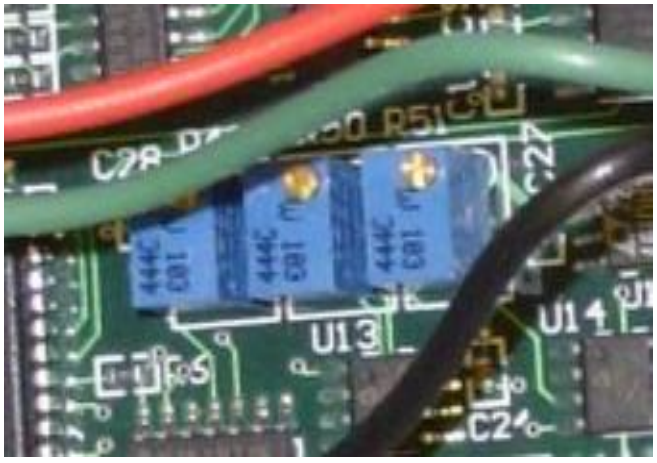
of 4. If the pressure control response is too slow, increase the proportional gain value by turning R49 counterclockwise.

Generally, it works well to adjust both R49 and R50 equally when tuning gain values.

Tuning Integral Gain Potentiometer, R50 –

The integral gain establishes the acceleration at which the pulse duty cycle will change when a pressure error is detected. Higher gain values result in faster response accelerations. The factory default setting is "2". If the integral gain is too high, oscillating in the pressure control may result. To stabilize control, reduce the integral gain value by turning R50 clockwise. Each full 360 degree turn of R50 will result in an integral gain value change of 4. If the pressure control response is too slow, increase the integral gain value by turning R50 counterclockwise.

Generally, it works well to adjust both R49 and R50 equally when tuning gain values.



Tuning Delay Timeout, R51 –

The delay timeout establishes the time that SharpShooter waits in order for the flow control system to stabilize when starting and stopping the pressure control system. The factory default delay time is 3 seconds. If the delay time is too short, the pressure control system may become unstable. To stabilize control, increase the delay time by by turning R51 counterclockwise. Each full 360 degree turn of R51 will result in a delay time change of 1.5 seconds. If the pressure control response is too slow, decrease the delay time by turning R51 clockwise.

SERIAL SETUP AND DIAGNOSTICS

HyperTerminal – Accessing information from the SharpShooter DB9 serial port is easily done using a computer with a terminal emulator program, like Microsoft HyperTerminal. HyperTerminal is commonly supplied with Microsoft computers and is accessed by selecting: Start → Accessories → Communications → HyperTerminal. Connect the computer to the SharpShooter cab control box circuit board using a male to female DB9 cable. These cables are commonly found in computer supply stores and come in various lengths. Set up the emulator and communication information as follows:

HyperTerminal Setup Information

Emulator Information		Communication Information	
Emulation:	ANSIW	Bits per Second:	19,200
Telnet Terminal ID:	VT100	Parity:	None
Backscroll Buffer Lines:	500	Stop Bits:	1
		Flow Control:	None

Program Information - When HyperTerminal is running and SharpShooter is powered up, a header file is the first thing to be displayed. The header starts by displaying a message that the EEPROM information is valid.

```
==  TermTestEEprom ()  ==
-    Valid Data in EEPROM
```

Next, the header file describes the program version data and hour meter value.

```
Module Type……..:      SharpShooter
Software Rev……..:     - Rev  1.04  -
Compiler Version……...:  612
Compile Date…….……..:  Jul 20 2006
Compile Time…….……:    15:51:35

Current Run Time……..:  120:25
```

Next, the header file confirms the hardware switch positions on the SharpShooter circuit board.

```
S1.x……:    switches 1, 3, and 4 are not monitored
S1.1……:    NA – DB-9.9 Power (default = OFF)
S1.2……:    OFF – Run/Hold ENABLED
S1.3……:    NA – PWM Odd Pullup (default = ON)
S1.4……:    NA – PWM Even Pullup (default = ON)
SW1……...:  0
S4.1……:    OFF – Tmr2 Freq = 10.00 Hz
S4.2……:    OFF – Output is NOT inverted
S4.3……:    OFF – Low Pressure Shutoff: ENABLED
S4.4……:    ON – Boost: DISABLED
```

Next, the header file confirms the software calibration values present on the EEPROM.

```
== Pressure Control Mode ==
 == PID Parameters ==
 P_GAIN……:   7.23
 I_GAIN……:   1.90
 D_GAIN……...:  0.00
 K_GAIN……...:  -0.10
 == Pressure Txd Parameters ==
  Txd MIN Pres……...:  0.0
  Txd MAX Press……:  100.0
  Txd MIN Output……...:  0.5
  Txd MAX Output……:  5.0
  Calc Slope……:  22.2
 == Other Parameters ==
  Print Limit……:  2
  Controller Rate [mS]……:  100
  Hold Timeout [mS]……: 3040
  Pressure Shut Off [psi]……..:  8.0
  Pressure Turn On [psi]……..:  10.0
```

Accessing Real-Time Information - In PWM Mode, a new line of data appears whenever the Rotary Switch is turned to a new position. In PSI Mode, data scrolls in columns, with column labels every 50 lines. Pushing the "M" key will display a menu of setup information.

Scrolling Data In PWM Mode - In PWM Mode, SharpShooter prints a line of data each time the set-point knob is turned to a new position, as shown below.

```
PwmMode: New Pos:  4 EVEN: 39.84 ODD: 39.84
PwmMode: New Pos:  5 EVEN: 49.61 ODD: 49.61
PwmMode: New Pos:  6 EVEN: 59.77 ODD: 59.77
PwmMode: New Pos:  5 EVEN: 49.61 ODD: 49.61
PwmMode: New Pos:  4 EVEN: 39.84 ODD: 39.84
PwmMode: New Pos:  3 EVEN: 29.69 ODD: 29.69
PwmMode: New Pos:  4 EVEN: 39.84 ODD: 39.84
```

"PwmMode:" indicates that the SharpShooter is running in PWM mode.
"New Pos: 4" indicates that the knob is turned to position number 4.
"EVEN: 39.84" indicates the pulse duty cycle of the even nozzles.
"ODD: 39.84" indicates the pulse duty cycle of the odd nozzles.
Scrolling Data In PSI Mode - In PSI mode, SharpShooter scrolls data in ten columns, as shown below. Titles scoll intermittently with the data to help identify each column.

```
Act,   SP,   DC,   Freq,  R/H, RunTime,Tmo,   Gp,   Gi,   Flow,
41.5,  40.0,  46.3,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.7,
41.0,  40.0,  46.3,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.7,
39.6,  40.0,  45.9,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.5,
42.7,  40.0,  46.7,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.8,
44.1,  40.0,  47.1,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.9,
42.2,  40.0,  46.7,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.8,
41.1,  40.0,  46.7,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.7,
39.6,  40.0,  46.3,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.6,
39.6,  40.0,  46.3,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.6,
39.6,  40.0,  46.3,  10.0,  RUN,  0:01,  1.0,  8.0,  2.0,  4.6,
```

- "Act" is the actual pressure, in psi, that SharpShooter is reading on the Pressure Sensor.
- "SP" is the pressure set point, in psi, that SharpShooter is controlling.
- "DC" is the pulse duty cycle (percent) of the SharpShooter pulsing nozzle.
- "Freq" is the frequency of the nozzle pulses in Hz.
- "R/H" is the state code of the software.
- "Run Time" is the hour meter, showing hours and minutes of pulse operation.
- "Tmo" is the run/hold delay time used in the control algorithm.
- "Gp" is the proportional gain value used in the control algorithm.
- "Gi" is the integral gain value used in the control algorithm.
- "Flow" is the calculated flow used to compare with the flowmeter.

Main Menu - Pressing the "M" key brings up the main menu as follows.

```
Menu:
 1. PID Parameters
 2. Pressure Txd Parameters
 a. read potentiometers
 c. Clock
 $. Clock Reset
 f. Flow Setup
 g. Gains & Tmo on Pots
 h. Run-Hold Timeout
 m. pwm test
 o. Toggle Digital output
 p. Pressure Shutoff Limit
 q. QUIT
```

Whenever SharpShooter is in menu mode, pressure control is suspended. To re-establish control, exit the menu mode by pressing "q" for quit and data will begin scrolling as described previously.

PID Parameters Menu - Pressing "1" in the main menu brings up the first line of the PID Parameters menu. Pressing "enter" will bring up the next line. Default values are shown in parenthesis. To change a value, type the new value and press "Enter". The complete menu is shown below.

```
Setup PID Parameters
-PID Proportional Gain.(8.0)…..:   8.000    New:
-PID Integral Gain.(2.0).....:     2.000    New:
-PID Derivative Gain.(0.)....:     0.000    New:
-PID System Gain.(-0.1).....:     -0.100    New:
-Print Limit.(2).....:             2        New:
-Controller Rate[mS].(100).....:   100      New:
-Pots Enabled (YES).....:          YES      New (Y/N):
        Pots = Disabled

 Press a key to exit
```

- "PID Proportional Gain" establishes the speed in which SharpShooter changes the pressure. A higher number results in faster control.
- "PID Integral Gain"establishes the acceleration in which SharpShooter changes the pressure. A higher number results in faster control.
- "PID Derivative Gain" establishes the accuracy in which SharpShooter changes the pressure. A higher number results in faster control.
- "PID System Gain" establishes the sensitivity of the control algorithm.
- "Print Limit" establishes the rate in which SharpShooter scrolls data.
- "Controller Rate" establishes the rate in which SharpShooter runs the control algorithm.

- "Pots Enabled" allows the PID Proportional Gain, PID Integral Gain and Run-Hold Timeout to be controlled by adjusting the potentiometers located on the SharpShooter circuit board.

Pressure Txd Parameters - Pressing "2" in the main menu brings up the first line of the Pressure Transducer Parameters menu.

```
Setup Pressure Transducer
-Txd MIN Press(PSI)(0.0)..:  0.0  New:
-Txd MAX Press(PSI)(100): 100.0  New:
-Txd MIN Output(V)(0.5)...:  0.5  New:
-Txd MAX Output(V)(5.0).:  5.0  New:
-Calc Slope(PSI/V)......: 22.2

 Press a key to exit
```

- "Txd MIN Press(PSI)" is the minimum pressure read by the Pressure Sensor.
- "Txd MAX Press(PSI)" is the maximum pressure read by the Pressure Sensor.
- "Txd MIN Output(V)" is the Pressure Sensor signal voltage when at minimum pressure.
- "Txd MAX Output(V)" is the Pressure Sensor signal voltage when at maximum pressure.
- "Calc Slope(PSI/V)" is automatically calculated by SharpShooter.

Read Potentiometers - Pressing "a" on the main menu brings up the "Read Potentiometers" menu as follows. Three potentiometers are located on the SharpShooter cab control circuit board. They are labeled R49, R50 and R51 and are 10-turn potentiometers. Since each potentiometer is a 10-turn screw, it is difficult to know where it is set by looking at it. The "Read Potentiometers" menu shows the actual bit value and bit percentage of each potentiometer making setting them easy and accurate.

```
R49  R49(%)      R50  R50(%)      R51  R51(%)
 674, +65.9       554, +54.2       52,  +5.1
 675, +66.0       553, +54.1       53,  +5.2
 676, +66.1       553, +54.1       51,  +5.0
 676, +66.1       551, +53.9       51,  +5.0
 676, +66.1       554, +54.2       51,  +5.0
 675, +66.0       553, +54.1       52,  +5.1
 674, +65.9       551, +53.9       51,  +5.0
 674, +65.9       554, +54.2       54,  +5.3
 676, +66.1       553, +54.1       51,  +5.0
```

Clock - Pressing "c" on the main menu displays the clock time in hours:minutes. The clock, or hour meter, counts time while the SharpShooter nozzles are pulsing. The clock accumulates time continuously while nozzles are pulsing and saves the value to permanent memory every five minutes.

```
231:19
```

Clock Reset - Pressing "$" on the main menu initiates the clock reset function. A password is required to reset the clock.

```
Clock Reset
 Enter Password: _____________
 !! Clock is Reset !!

 New Time:     0:00
```

Flow Setup - Pressing "f" on the main menu brings up the flow setup menu. The flow setup parameters are required for boost and flowmeter calculations.

```
Setup Flow Calculation Parameters
-PWM Valve Size (15.5).....:  15.50          New:
-Tip Size (8).....:  8.000          New:
-Number of Valves (54).....:  54          New:
-Specific Gravity (1.0).....:  1.000          New:
-Boost Tip Size (4).....:  4.000          New:
-Boost Timeout (3000).....:  3000.000          New:

 Press a key to exit
```

- "PWM Valve Size" refers to the size, or flow parameter, of the pulsing valve. Capstan offers several PWM valve sizes depending on the product to be applied. The following valve sizes are available from Capstan:

Arag, TeeJet, Wilger Sprayer Valves	1/8" Orifice	Valve Size = 15.5
N-Ject LF Liquid Fertilizer Valves	5/32" Orifice	Valve Size = 22.3
N-Ject Anhydrous Ammonia Valves	3/32" Orifice	Valve Size = 6.0
N-Ject Anhydrous Ammonia Valves	1/8" Orifice	Vavle Size = 8.4
N-Ject Anhydrous Ammonia Valves	5/32" Orifice	Valve Size = 10.0

Valve size is calculated in the same manner as flat fan spray tips. Valve size can be measured by flowing water through the valves, with no downstream tip or orifice, at 40psi. The flow rate in gallons per minute at 100% duty cycle multiplied by ten is the valve size.

- "Tip Size" refers to the size, or flow parameter, of the spray tip downstream of the pulsing valve. Capstan uses the flat fan tip size based on the flow at 40psi. This size is generally printed on the tip. If the tip shows "11008", then the tip size is 8. Flood tips are sized at 10psi and therefore, the printed tip size must be doubled. European tips may be sized on metric values and should be converted mathematically, or flow tested, to get an accurate value.
- "Number of Valves" refers to the number of SharpShooter pulsing nozzles on the boom. For instance, on a 90' boom with 20" nozzle spacing, there are usually 54 nozzles, or valves.

- "Specific Gravity" is the density of the material being applied expressed as a ratio to water. Therefore, the specific gravity of water is: 1.0. Liquid fertilizer can vary significantly, but is generally around: 1.2. Anhydrous Ammonia varies with temperature/pressure, but is generally around: 0.60.
- "Boost Tip Size" is the tip size used on the boost boom (See Tip Size above). SharpShooter assumes that the boost boom is a conventional boom without pulsing nozzles. If the boost feature is enabled, SharpShooter assumes that there are the same number of boost nozzles as SharpShooter pulsing nozzles. If fewer boost nozzles are in use, then the boost tip size can be "faked" for an equivalent flow.
- "Boost Timeout" refers to the time required to turn on the boost boom and is expressed in milliseconds. If a 1-Second ball valve is used, then the boost timeout would be (1) second or 1000 milliseconds. If solenoid valves are used, the boost timeout might be (¼) second or 250 milliseconds.

Gains & Tmo on Pots - Pressing "g" on the main menu scrolls the gain and timeout values associated with the potentiometers on SharpShooters cab control circuit board. Since each potentiometers is a 10-turn screw, it is difficult to know where it is set by looking at it. Potentiometers must be enabled in "PID Parameters Menu".

```
Gp(R49)Gi(R50) Tmo(R51)
+7.96,   +2.00,   +1.0,
+7.96,   +1.90,   +1.0,
+8.01,   +2.00,   +1.0,
+8.01,   +2.05,   +1.1,
+7.96,   +1.90,   +1.1,
+8.01,   +2.15,   +1.0,
+7.91,   +1.95,   +1.0,
+7.96,   +2.05,   +1.0,
+7.96,   +2.00,   +1.0,
```

Gp, or proportional gain, is set using potentiometer R49. Gi, or integral gain, is set using potentiometer R50. Tmo, or Run/Hold Timeout, is set using potentiometer R51. The "Gains & Tmo on Pots" menu shows the actual gain or timeout value used by the SharpShooter pressure control algorithm. See also "Read Potentiometers", "PID Parameters Menu" and "Run-Hold Timeout".

Run-Hold Timeout - Pressing "h" on the main menu brings up the Hold Timeout menu. Hold Timeout is the time required for the flow controller to establish rate control and is expressed in milliseconds. If the rate controller takes five seconds to establish rate control, then the hold timeout should be set at 5000.

```
Setup Hold Timeout
-Hold Timeout[mS](3000)….: 3000    New:

 Press a key to exit
```

The Hold Timeout value is used by SharpShooter whenever pressure control is suspended. Pressure control is commonly suspended for power-up, run/hold, open/close valves, low pressure shutoff, etc.

The run/hold feature must be enabled on the SharpShooter cab control circuit board by flipping DIP switch S1#2 to OFF.

PWM Test - Pressing "M" on the main menu enables the PWM test feature.

```
Set PWM:
```

Pressing a number key on the keyboard will cause SharpShooter to pulse at the duty cycle associated with the equivalent dial position.

Toggle Digital Output - Pressing "o" on the main menu initiates the toggle digital output menu. This feature allows the boost boom to be toggled on and off from the keyboard.

```
Toggle Digital Out: OFF -> ON
Toggle Digital Out: ON -> OFF
```

Pressure Shutoff Limit - Pressing "p" on the main menu initiates the pressure shutoff limit menu. The pressure shutoff limit is the pressure value below which SharpShooter will shut off the pulsing nozzles. This allows SharpShooter to work very much like diaphragm drip checks. The pressure turn on value is different than the shutoff limit. In many cases, when the boom turns off, a pressure spike is seen. The turn on pressure value should be set higher than the spike value to prevent inadvertent boom turn on.

```
Setup Pressure Shut Off
-Pressure Shut Off[lbs](8.0)…..:   8.0    New:
-Pressure Turn On[lbs](10.0)....:   10.0    New:


 Press a key to exit
```

The low pressure shutoff feature must be enabled on the SharpShooter cab control circuit board by flipping DIP switch S4#3 to OFF.

Erasing Stored Data - Pressing a capital "X" on the main menu deletes any saved setup parameters and returns SharpShooter to default values. SharpShooter will doublecheck that EEPROM data is to be erased by asking the operator Yes or No. After deleting stored data, SharpShooter must be turned off and on again to establish default values.

```
== Erasing EEprom ==
Are you SURE you want to erase the memory?
  Press capital Y for yes, n to exit:  Y

Deleting:        250……..
 == Complete ========
```

TECHNICAL BULLETIN
CAPSTAN® AG SYSTEMS, INC.

Spray Skips from Poor Pulse Blending

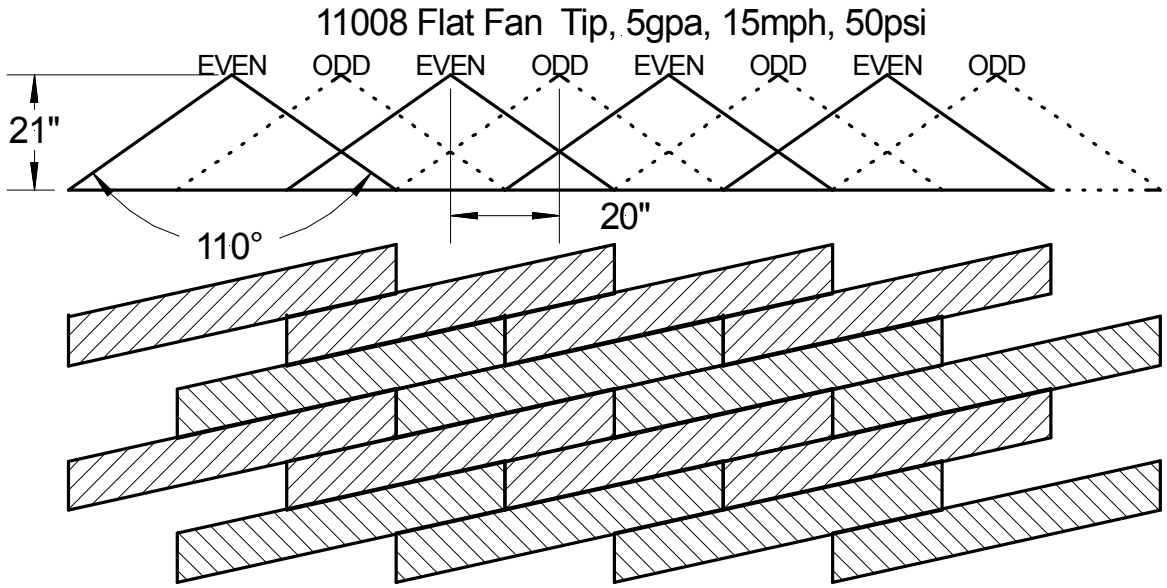
For: Synchro®, SharpShooter™ and Case AIM Command™ Blended Pulse Spray Systems

July 11, 2001 (Revised April 12, 2006)

Over the years, Capstan's field engineers have received many questions about blended pulse spraying and its potential for causing skips in the field. In rare instances, skipping has been documented in the field. This technical bulletin is intended to explain pulse blending and the techniques used to provide optimum spray coverage and prevent skipping.

What is Blended Pulse Spraying? Each nozzle in a blended pulse spray system emits 10 spray pulses per second with adjacent nozzles having alternating timing. The alternating pulses, combined with overlapping spray patterns and the natural dispersion of droplets traveling in air, blend together to provide consistent coverage on the target.

What Makes The Pulses Blend? Below is an illustration of what a blended pulse spray pattern might look like if sprayed on a flat surface. This spray pattern would be similar to a #8 size flat fan spray tip with a 110 degree fan angle spraying 5gpa at 15mph and 50psi boom pressure. Nozzles are 20" apart. Each tip is rotated 12.5 degrees to prevent pattern interference between adjacent nozzles. Boom height is 21" above the spray target.



In this example, each nozzle is spraying 1/3 of the time, but adjacent nozzles alternate and overlap to fill in the areas between nozzles. As the sprayer increases speed, rate or boom

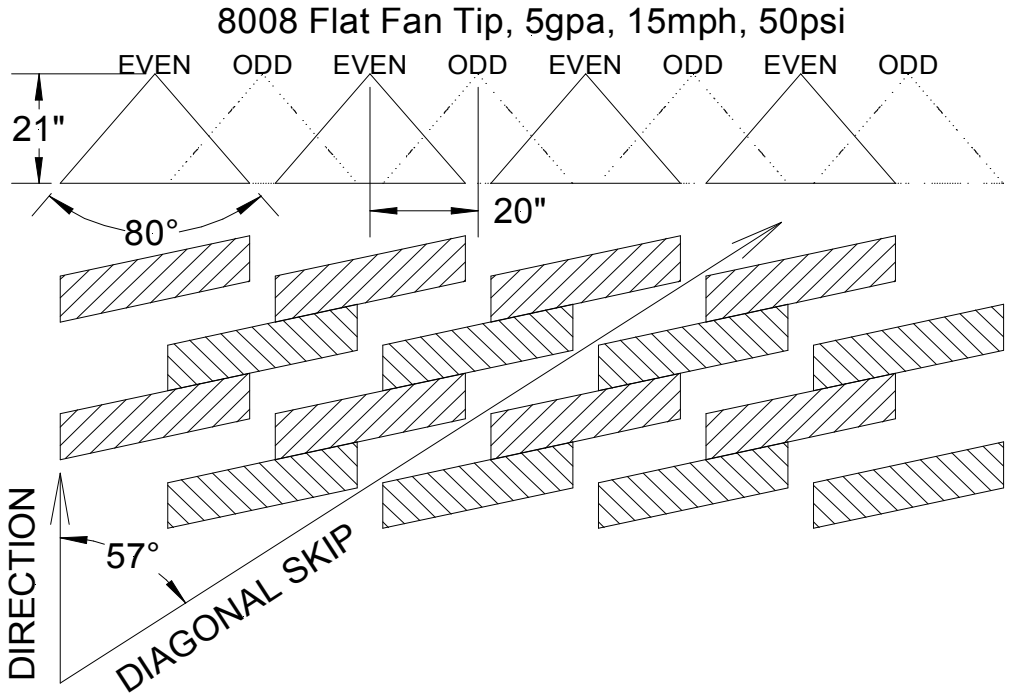
height, the pulses become wider, providing additional overlap, better pulse blending and increased spray coverage.

As the sprayer decreases speed or rate, skips will begin to appear. For this reason, a smaller tip size would be recommended for this example if slower speeds are desired.

Not shown in the diagram is pattern width and natural droplet dispersion. These factors help to smooth out the pulses and fill in skips. The amount of droplet dispersion depends on the style of tip being used. For instance, low-drift tips typically emit large droplets and provide minimal droplet dispersion.

What Causes Skipping? Below is a same illustration except that 80 degree fan angle tips are used instead of the 110 degree tips used above. In this case, the 21" boom height is not enough to provide adequate nozzle overlap and skips are seen. Tips emitting small droplets with plenty of droplet dispersion will fill in large skips, but large droplet tips may not and the skips will result in poor coverage. It is interesting to see that the skips appear as diagonal lines in the direction of travel. The angle of the diagonal depends on the speed of the sprayer.

To



Prevent Skipping:

1. Use wide-angle spray tips and appropriate boom heights to provide 150% nozzle overlap.
    - For 80 Degree Tips use 36" or greater boom height
    - For 110 Degree Tips use 21" or greater boom height
    - Use pressures which fully develop the intended fan angle.

2. Avoid pulse duty cycles below 33%.
    - Use spray tips appropriately sized for the desired speed, rate and pressure ranges.
    - Avoid speeds in the lower 1/3 of the speed range
    - Avoid rates in the lower 1/3 of the rate range

3. Use additional caution when using drift control tips or drift control additives that increase droplet size and reduce droplet dispersion. Carefully observe boom height, duty cycle and tip selection recommendations to insure adequate spray coverage.

4. **Always read and follow chemical label instructions!** Agronomic and environmental factors significantly affect efficacy of chemicals and will magnify the adverse effects of poor coverage. Carefully observe boom height, duty cycle and tip selection recommendations under hot and dry field conditions, large/mature weed pressures, etc.

5. **Always apply blended pulse broadcast sprays using a 10hz or greater pulse frequency!** Capstan's "Commander" module and SharpShooter Pulse Generator allow the pulse frequency to be reduced for non-sprayer applications where uniform coverage is not required.

For additional information contact your Synchro, SharpShooter, or Case AIM Command dealer.

TROUBLESHOOTING: PULSE GENERATOR FUNCTION CHECK

With the Pulse Generator connected to the extension harness, turn the Rotary Switch knob to 50 and turn on SharpShooter in PWM Mode by flipping the Rocker Switch downward, toward the bottom of the Pulse Generator.

Observe the Rocker Switch light flashing two times per second. This confirms that the Pulse Generator fuse is functioning, that power is being received by the circuit board and that the Rocker Switch is functioning.

Turn the boom on and observe the nozzles pulsing at 50% duty cycle. Turn the Rotary Switch knob down to 20 and observe a decrease in flow and increase in pressure. Turn the Rotary Switch knob up to 80 and observe an increase in flow and decrease in pressure. This confirms that the Pulse Generator is functioning in PWM Mode.

Turn the Rotary Switch knob to 40 and turn on SharpShooter in PSI Mode by flipping the switch upward toward the Rotary Switch knob. Observe SharpShooter adjust the pulse duty cycle to achieve 40psi. The spray rate controller may need to be adjusted to put SharpShooter in a practical control range.

Using the spray rate controller in manual mode, decrease the flow until SharpShooter reaches minimum pulse duty cycle and begins to flash the Rocker Switch light one time per second. Using the spray rate controller, increase the flow until SharpShooter reaches maximum duty cycle (100% or open flow) and begins to flash the Rocker Switch light one time per second. This confirms that the Pulse Generator is operating in PSI Mode.

If SharpShooter system is not working properly:

- Check circuit breaker near battery and fuse near Pulse Generator
- Check circuit board setups
- Check serial setups
- Use serial diagnostics to check Rocker and Rotary Witch function
- Use serial diagnostics to check Pressure Sensor function
- Perform system voltmeter checks

TROUBLESHOOTING: SWAPPING COMPONENTS

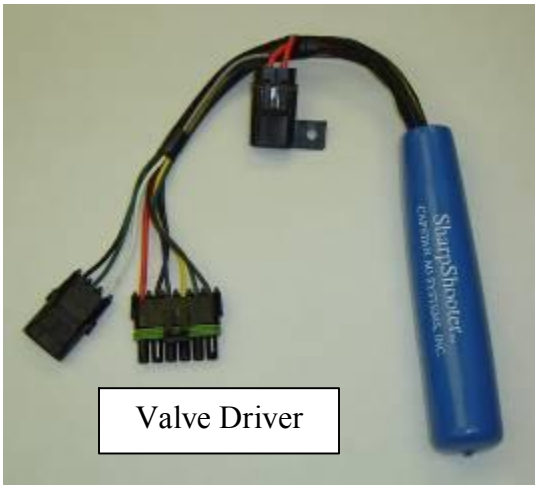
SharpShooter systems are comprised of a number of components. Some of these components are used in multiples. Components with multiple usage are:

- Nozzle Valves
- Valve Drivers
- Extension Harnesses

When troubleshooting failed components, it can be helpful to swap the failed part with a working part from another location. If the problem follows the failed part to the new location, repair or replace the failed part.

If the problem does not follow the failed part, then the problem is likely elsewhere in the system and other troubleshooting means may be followed.

Use caution when swapping failed components as in rare cases the failed component may cause other components to fail at the new location.



TROUBLESHOOTING: FUSES

Fuses are located in three places within SharpShooter system:

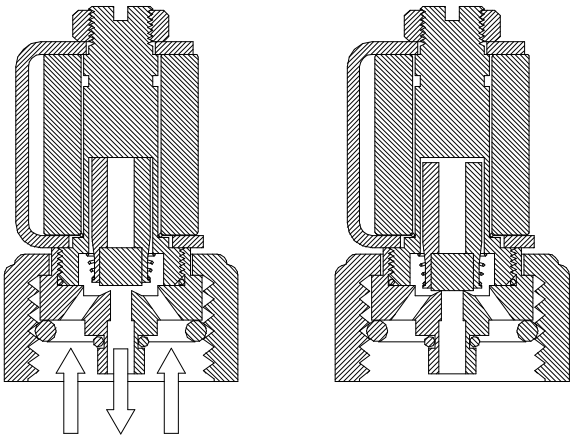
Location	Rating	Type	Color
Pulse Generator	10amp	ATO/ATC	Red
Valve Driver	10amp	ATO/ATC	Red
Battery (Optional)	50amp	Breaker w Manual Reset	N/A

Blown fuses are indicators of a short or overload condition. Therefore, never replace a fuse with a larger fuse. Larger fuses may result in costly component failures.
Note: Only 14 nozzle valves may be installed with a single Valve Driver. In addition, seven valves must be on the even circuit and seven must be on the odd circuit. Additional valves will result in blown Valve Driver fuses.

TROUBLESHOOTING: PLUGGED NOZZLE VALVES

Plugged nozzle valves can be classified in two categories:

- Plunger Blockage
- Plunger Stuck



Plunger blockage results when larger debris catches between the orifice and plunger seal. This is the smallest flow passage within the nozzle valve.

Stuck plungers result when smaller debris collects around the barrel of the plunger and binds the plunger in place.

Symptoms of plugged nozzle valves are:

- Constant Spray
- Dripping when shut off

To remove the debris:

1. Remove the plunger by unscrewing the coil from the valve body.
2. Look for debris and remove it by washing with water.
3. Use caution not to drop and lose the o-ring, plunger, flynut or coil.
4. Inspect all boom filter screens for plugged or torn screens.

Operating a plugged valve for extended periods of time may result in nozzle valve coil failure. For this reason, Capstan recommends cleaning any plugged nozzle valves immediately.

TROUBLESHOOTING: NOZZLE VALVES

Coil Failure

Disconnect the Nozzle Valve from the boom wire pigtail by unplugging the 2-pin Packard connector located on the spray boom.

Use a voltmeter to measure 19 to 22 ohms of resistance across pins A and B on the nozzle valve connector.

If proper resistance is not found:

- Clean connector terminals
- Replace coil

Coil failures often are the result of two factors:

1. Extended valve use with a plugged plunger.
2. Extended use in liquid fertilizer overspray environments.

For this reason, Capstan recommends cleaning any plugged nozzle valves immediately. In addition, Capstan recommends rinsing the inside of the boom with clean water and washing the outside of the coils with clean water as often as practical.

Worn Plunger Seals

After extended use, the soft plunger seal will wear a groove where the seal impacts the hard orifice seat.

As this groove deepens, the pressure capacity of the valve will decrease, until it interferes with the operating pressure of the sprayer.

The result is erratic pulsing, often described as “flickering”. SharpShooter will operate normally at lower pressures until replacement parts can be acquired. High operating pressures and abrasive spray solutions will accelerate the wear of the plunger seal material.

TROUBLESHOOTING: VOLTAGE CHECK

Checking the Battery Voltage

Disconnect the Pulse Generator from the extension harness by unplugging the 6-pin Packard connector generally located in the cab.

Using a voltmeter, observe 13.5 vdc between pins A and B with the engine running or 12.0 vdc without the engine running.

Be sure the polarity is accurate by observing positive voltage when the red (positive) probe is connected to pin A and the black (negative) probe is connected to pin B.

If no voltage is present:

- Check the 50 amp circuit breaker located at the battery.
- Check the Power Hub battery connections.
- Check the condition of the battery.
- Check the condition of the alternator.

Checking System Load Capacity

Disconnect the Nozzle Valve, located farthest from the battery, from the boom wire pigtail by unplugging the 2-pin Packard connector generally located at the end of the spray boom.

Turn the Sharpshooter Pulse Generator off and turn all boom sections on.

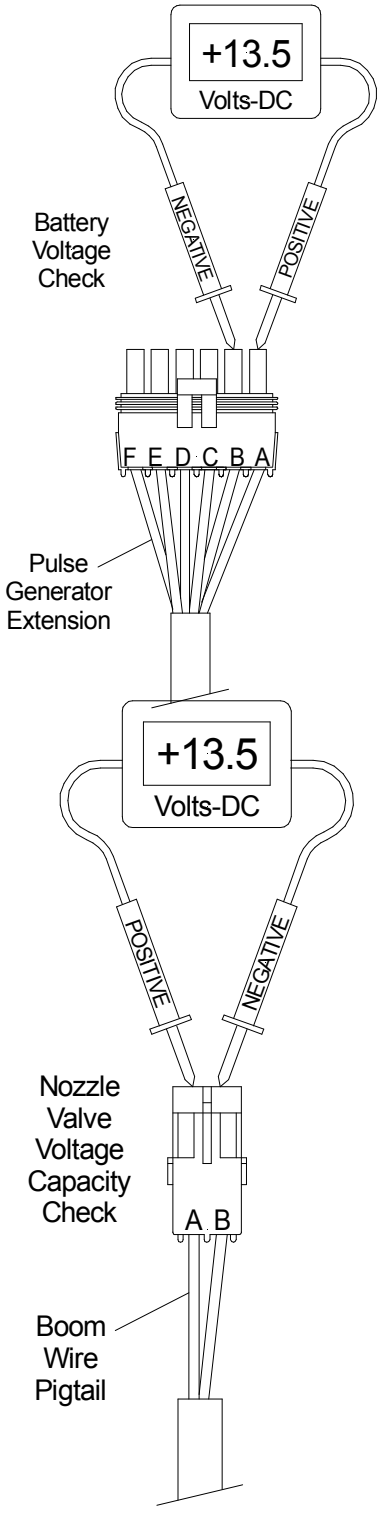
Start the engine and turn on all electrical loads including air conditioning, foam markers, monitors, etc.

Using a voltmeter, observe the system voltage between pins A and B.

SharpShooter nozzle valves operate best at 12vdc or higher. Less than 12vdc will result in reduced pressure capacity, often resulting in erratic nozzle pulsing, described by some as "flickering". (Check also for worn plunger seals.)

If low voltage is observed:

- Check and clean the battery terminals
- Check the battery condition
- Check the alternator condition
- Check condition of extension connections



Valve Driver Voltage Check

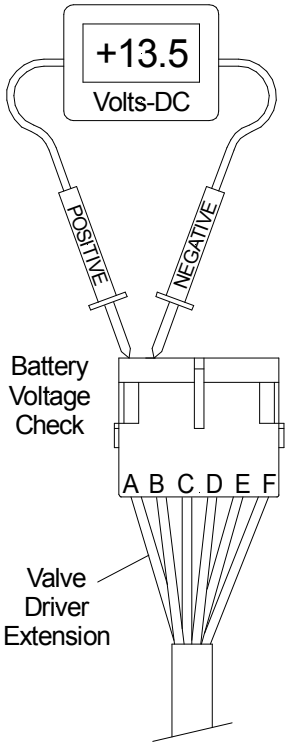
Disconnect the Valve Driver from the extension harness by unplugging the 6-pin Packard connector generally located at each boom section.

Using a voltmeter, observe 13.5 vdc between pins A and B with the engine running or 12.0 vdc without the engine running.

Be sure the polarity is accurate by observing positive voltage when the red (positive) probe is connected to pin A and the black (negative) probe is connected to pin B.

If no voltage is present:

- Check the 50 amp circuit breaker located at the battery.
- Check the Power Hub battery connections.
- Check the Power Hub Valve Driver extension connection.
- Check the condition of the battery.
- Check the condition of the alternator.



TROUBLESHOOTING: PRESSURE SENSOR

Check the Pressure Sensor Signal as follows:

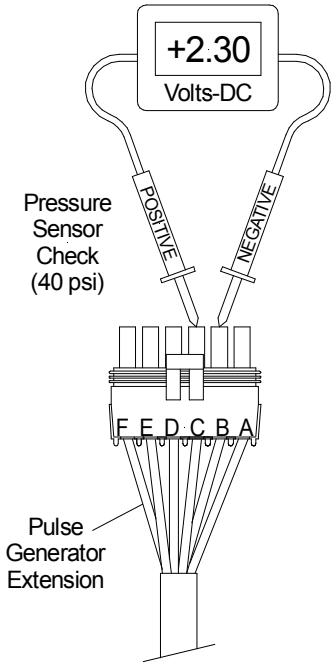
Disconnect the Pulse Generator from the extension harness by unplugging the 6-pin Packard connector generally located in the cab.

With the engine running and pump turned on, use the spray rate controller to establish 40psi on the pressure gauge.

Using a voltmeter, observe 2.3 vdc between B and C of the Pulse Generator extension harness connector.

Using the spray rate controller, adjust the pressure to 100psi and observe 5.0vdc on the voltmeter.

Using the spray rate controller, adjust the pressure to 0psi (or turn the pump off) and observe 0.5vdc on the voltmeter.



If accurate voltage is not present:

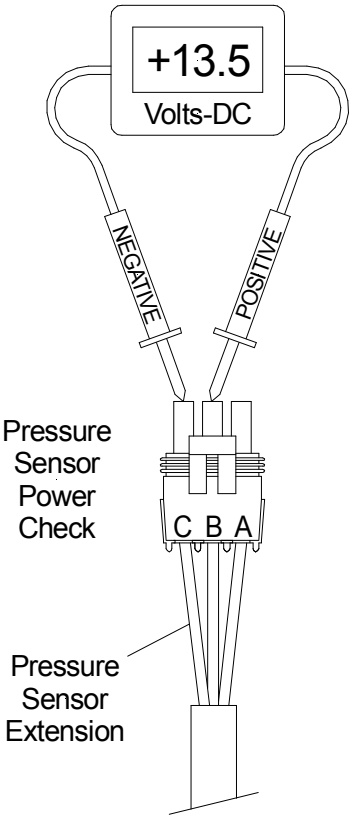
- Verify the accuracy of the sprayer's pressure gauge.
- Check for power to the Pressure Sensor (Below).
- Check Pressure Sensor calibration using the serial diagnostics.
- Replace the Pressure Sensor.

Check for power to the Pressure Sensor as follows:

Disconnect the Pressure Sensor from the extension harness by unplugging the 3-pin Packard connector generally located near the center of the boom.

Using a voltmeter, observe 13.5 vdc between pins B and C with the engine running or 12.0 vdc without the engine running.

Be sure the polarity is accurate by observing positive voltage when the red (positive) probe is connected to pin A and the black (negative) probe is connected to pin B.



If no voltage is present:

- Check the 50 amp circuit breaker at the battery.
- Check the Power Hub battery connections.
- Check the condition of the battery.
- Check the condition of the alternator.

TROUBLESHOOTING: PULSE CIRCUIT CHECK

Pulse Generator Output Check

Disconnect the Valve Driver from the extension harness by unplugging the 6-pin Packard connector generally located at each boom section.

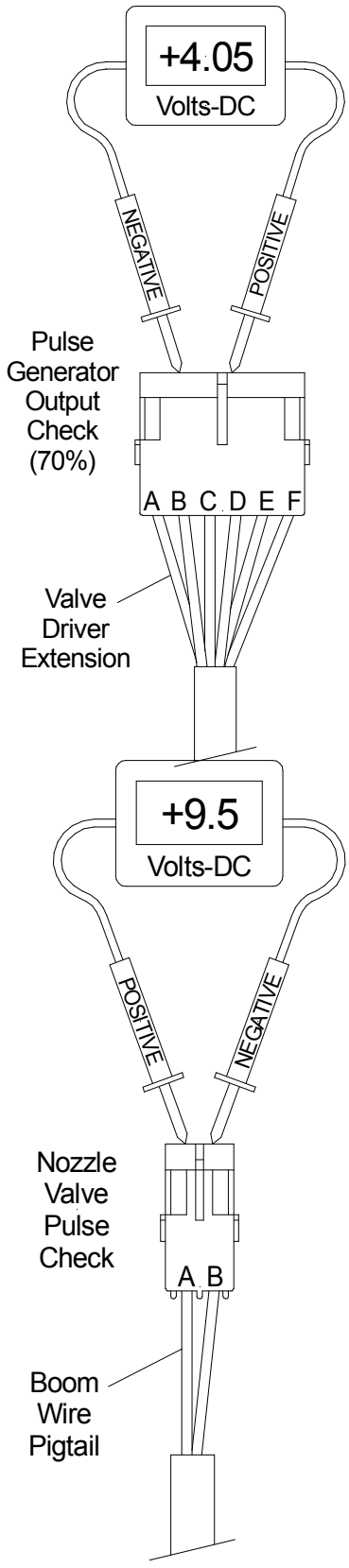
Turn the SharpShooter Pulse Generator on in PWM Mode and select 70 on the rotary knob. The Rocker Switch light should flash two times per second.

Using a voltmeter, observe 4.05vdc between pins B and D. This measurement is complicated by the fact that the signal is a 12vdc 10hz square wave which most voltmeters measure as low voltage. In addition, the signal is inverted, so the 70% duty cycle selected on the knob will actually be a 30% duty signal at the Valve Driver. Measurements may vary depending on the voltmeter used. This tests the even pulse.

Make the same measurement between pins B and E. This tests the odd pulse.

If accurate voltage is not found:

- Check the Valve Driver extension connections.
- Check the Pulse Generator extension connections.
- Check the Pulse Generator serial diagnostics.



Valve Driver Output Check

Disconnect the Nozzle Valve from the boom wire pigtail by unplugging the 2-pin Packard connector located on the spray boom.

Turn the SharpShooter Pulse Generator on in PWM Mode and select 70 on the rotary knob. The Rocker Switch light should flash two times per second. Turn the boom section on corresponding to the nozzle being tested.

Using a voltmeter, observe 9.5vdc between pins A and B. This measurement is complicated by the fact that the signal is a 12vdc 10hz square wave which most voltmeters measure as low voltage. Measurements may vary depending on the voltmeter used. (Note the color of the wire in position B as either white or green.)

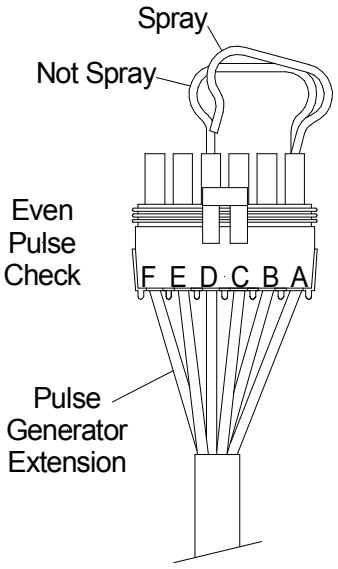
Make the same measurement on an adjacent nozzle valve. The wire color in position B should change from white to green or green to white.

If accurate voltage is not found:

- Check the boom wire extension connections.
- Check the Valve Driver extension connections.
- Check the Pulse Generator extension connections.
- Check the Pulse Generator serial diagnostics.

Valve Driver Input Check

Disconnect the Pulse Generator from the extension harness by unplugging the 6-pin Packard connector generally located in the cab.



With the engine running, pump turned on and boom turned on, use the spray rate controller to establish 40psi on the pressure gauge. The boom should be spraying.

Tap a jumper wire between pins A and D on the extension harness connector, tapping several times per second. Observe every other, even, nozzle valve turn off as the jumper connects and turn on as the jumper disconnects.

Tap a jumper wire between pins A and E on the extension harness connector, tapping several times per second. Observe every other, odd, nozzle valve turn off as the jumper connects and turn off as the jumper disconnects.

Be careful to observe nozzle pulsing on each boom section.

If the boom sprays, but does not pulse when the jumper wire is tapped:

- Check the Power Hub Pulse Generator extension connection
- Check the Valve Driver extension connections

TROUBLESHOOTING: BOOM SHUTOFF AND RUN/HOLD SIGNAL CHECK

Run/Hold Signal

Disconnect the Pulse Generator from the extension harness by unplugging the 6-pin Packard connector generally located in the cab.

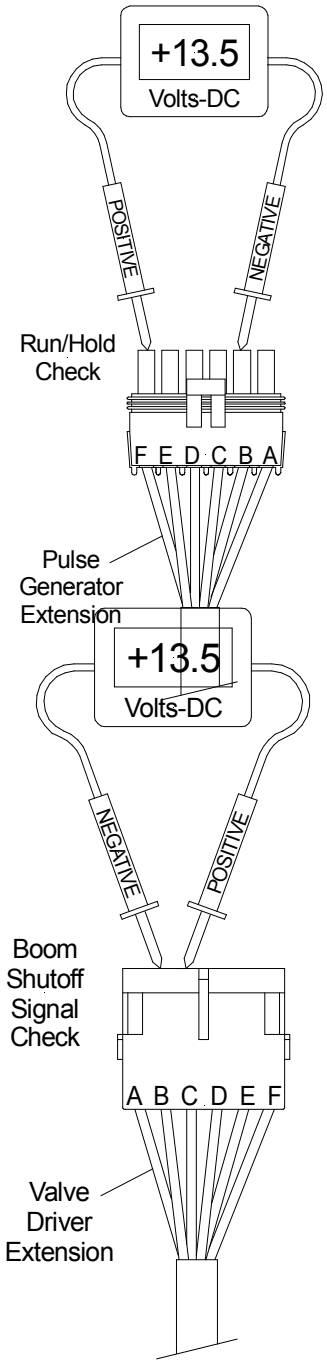
With the engine running, pump turned on and boom turned off, use the spray rate controller to establish 40psi on the pressure gauge. The boom should not be spraying.

Turn on boom section number one and observe the nozzle valves on boom section number one turn on and spray fully open. Using a voltmeter, observe 13.5vdc between pins B and F with the engine running or 12.0vdc without the engine running.

Turn off boom section number one and observe the spray and voltage disappear. Repeat the test for boom sections two thru six.

If no spray or voltage is observed:

- Check the boom shutoff adapter connections.
- Check the boom shutoff extension connections.
- Check the Valve Driver extension connections.



Valve Driver Shutoff Signal

Disconnect the Valve Driver from the extension harness by unplugging the 6-pin Packard connector generally located at each boom section.

Turn the boom shutoff switch on corresponding to the Valve Driver extension being tested.

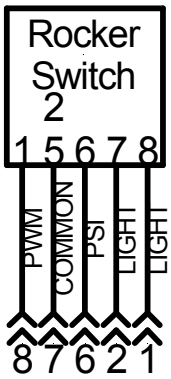
Using a voltmeter, observe 13.5vdc between pins A and C with the engine running or 12.0vdc without the engine running.

Turn the boom shutoff switch off and observe the voltage disappear.

If no voltage is present:

- Check the boom shutoff adapter connections.
- Check the boom shutoff extension connections.
- Check the Power Hub Valve Driver extension connection.
- Check the boom shutoff switches.

TROUBLESHOOTING: ROCKER SWITCH



Remove the Pulse Generator cover by removing the four corner screws. Disconnect the Rocker Switch from the circuit board by unplugging the 8-pin connector.

Flip the Rocker Switch to the OFF position. Using a voltmeter, verify that there is no continuity between connector pins 7 and 8 (switch terminals 1 and 5) and connector pins 6 and 7 (switch terminals 5 and 6). Verify that there is approximately 19 ohms resistance between connector pins 1 and 2 (switch terminals 7 and 8).

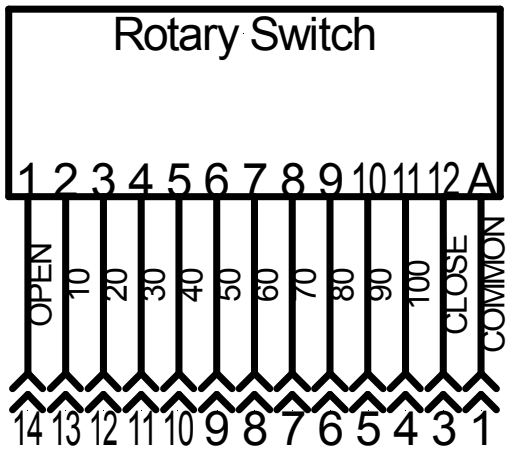
Flip the Rocker Switch to the PWM position. Using voltmeter, verify that there is continuity between connector pins 7 and 8 (switch terminals 1 and 5).

Flip the Rocker Switch to the PSI position. Using a voltmeter, verify that there is continuity between connector pins 6 and 7 (switch terminals 5 and 6).

If the switch does not function properly:

- Replace the Rocker Switch and Connector Assembly.

TROUBLESHOOTING: ROTARY SWITCH



Remove the Pulse Generator cover by removing the four corner screws. Disconnect the Rotary Switch from the circuit board by unplugging the 14-pin connector.

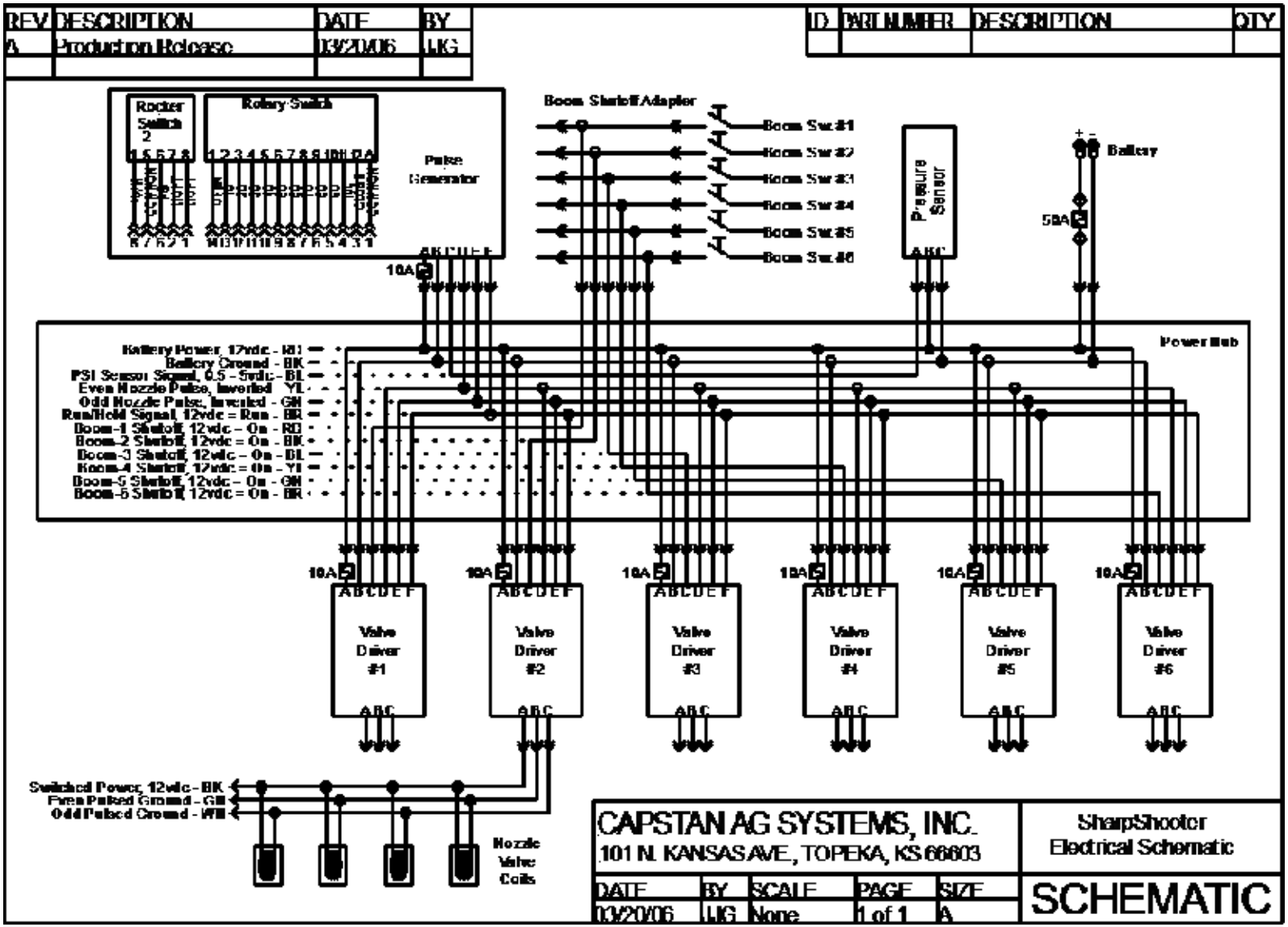
Rotate the Rotary Switch to the "OPEN" position. Using a voltmeter, verify that there is continuity between connector pins 1 and 14 (switch terminals A and 1).

Rotate the Rotary Switch to the 10 position. Using a voltmeter, verify that there is continuity between connector pins 1 and 13 (switch terminals A and 2).

Check each position of the 12-position Rotary Switch, as shown in the diagram above.

If the switch does not function properly:

- Replace the Rotary Switch and Connector Assembly.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Rotary Switch
Pulse Generator
Boom Shutoff Adapter
Boom Sw #1
Boom Sw #2
Boom Sw #3
Boom Sw #4
Boom Sw #5
Boom Sw #6
Pressure Sensor
Battery
5A
10A
Power Hub
Battery Power, 12vdc - RD
Battery Ground - BK
PSI Sensor Signal, 0.5 - 5vdc - BL
Even Nozzle Pulse, Inverted - YL
Odd Nozzle Pulse, Inverted - GN
Run/Hold Signal, 12vdc = Run - BR
Boom-1 Shutoff, 12vdc = On - RD
Boom-2 Shutoff, 12vdc = On - BK
Boom-3 Shutoff, 12vdc = On - BL
Boom-4 Shutoff, 12vdc = On - YL
Boom-5 Shutoff, 12vdc = On - GN
Boom-6 Shutoff, 12vdc = On - BR
Valve Driver #1
Valve Driver #2
Valve Driver #3
Valve Driver #4
Valve Driver #5
Valve Driver #6
Switched Power, 12vdc - BK
Even Pulsed Ground - GN
Odd Pulsed Ground - YL
Nozzle Valve Coils
CAPSTAN AG SYSTEMS, INC.
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WARRANTY POLICY

Capstan Ag Systems, Inc., the Seller, warrants to the original Purchaser/User, its products to be free from defects in material and workmanship in normal use and service for a period of one year from date of purchase.

Purchaser, by acceptance of Seller's product, assumes all risk and liability of the consequences of any use or misuse by Purchaser, its employees or others.

The Seller's obligation under this warranty shall be limited to the repairing or replacing at the Seller's option, the product or part thereof which the Seller's inspection discloses to be defective, free of charge, FOB point of manufacture, provided the Buyer; (i) Notify Seller of defect within thirty (30) days of failure; (ii) Returns the defective product to Seller, transportation prepaid; and (iii) Establishes that the product has been properly installed, maintained and operated in accordance with Seller's instructions or instructions contained in its operations or maintenance manuals and within the limits of normal usage.

All replacement products, or parts thereof, furnished under this warranty, will be invoiced in the usual manner and adjustments will be made after the product, or part thereof, claimed to be defective has been returned to and inspected at Seller's factory.

Replacement products, or parts thereof, furnished under this warranty shall be FOB Buyer's location, and Seller shall not be responsible for installation costs (For all international transactions, replacement products shall be furnished FOB Seller's factory and Buyer shall be responsible for all customs and brokerage fees.) Buyer shall be liable for all freight, inspection and handling costs if such product or such parts do not prove to be defective. In no event will any claim for labor or incidental or consequential damages be allowed for removing or replacing a defective product. No warranty is made as to any product or part which has been subject to misuse, abuse, accidents, or alterations, or to improper or negligent use, maintenance, storage or transportation and handling.

The liability of the Seller under this warranty, or for any loss or damage to the products whether the claim is based on contract or negligence, shall not in any case exceed the purchase price of the products and upon the expiration of the warranty period all such liability shall terminate. The foregoing shall constitute the exclusivity remedy of the Buyer and the exclusive liability of the Seller.

The terms of this warranty do not in any way extend to any product which was not manufactured by the Seller or an affiliate of Seller.

This warranty shall be void, and Seller shall not be liable for nay breach of warranty, if the product or parts shall have been repaired or altered by persons other than the Seller, unless expressly authorized by Seller in writing.

The foregoing warranty is exclusive and is in lieu of all other warranties expressed or implied. All implied warranties of merchantability and fitness for a particular purpose are hereby disclaimed by Seller and are excluded from this agreement. Seller shall not be liable for any incidental or consequential damages resulting from any breach of warranty.

Limitation of Liability – Buyers exclusive remedy for breach of warranty shall be repair or replacement of defective products: Provided, if the products are incapable of being repaired or replaced, Buyer's exclusive remedy shall be money damages, but such damages shall not exceed the purchase price of the products.

Any claim for breach of Seller's warranty must be in writing addressed to Seller and must set forth the alleged defect in sufficient detail to permit its easy identification by Seller. All breach of warranty claims must be made within thirty (30) days after expiration of the warranty period which is applicable to the defective product. The applicable time periods are set forth in the above warranty term. Any breach of warranty claim not timely made will not be honored by the Seller and will be of no force and effect.

On any claim of any kind, including negligence, Seller's liability for any loss or damage arising out of, or from the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation of use of any products shall in no case (except as provided in the terms of the Patent Indemnity) exceed the purchase price allocable to the products.

In no event, whether as a result of breach of contract or warranty or alleged negligence, shall Seller be liable for incidental or consequential damages, including, but not limited to: personal injury, loss of profits or revenue, loss of use of equipment or any associated equipment, cost of capital, cost of substitute equipment, facilities or services, downtime costs, environmental damage, crop losses, or claims of customers of Buyers for such damages.

Patent Indemnity. Seller retains for itself any and all property rights in and to all designs, inventions and improvements pertaining to any products and to all patents, trademarks, copyrights and related industrial property rights arising out of work done in connection therewith. Buyer expressly agrees that it will not assert any rights to property rights retained herein by Seller.

WARRANTY AND REPAIR EVALUATIONS

Any part or module that needs to be repaired or evaluated for warranty has to be authorized before return. Contact the factory (785-232-4477) to get a Return Goods Authorization (RGA #). This helps to track the part coming into the factory for repair or replacement.

If warranty is requested on a nozzle valve, the entire valve must be returned to the factory. Warranty will not be offered on individual valve parts.

Before returning any component to the factory, clean the part as well as possible to remove any dirt or chemical residue. Parts received at the factory that are not clean will be returned and warranty refused.

After receiving the RGA#, package the part, include your name, address and phone number, customer's name and description of problems or failure. Then ship to:

Capstan Ag Systems, Inc.
Attn: Warranty & Repair
101 N. Kansas Ave.
Topeka, KS 66603

Phone: (785) 232-4477
Fax: (785) 232-7799

Upon receipt of the part in question, the part will be evaluated for warranty or repaired and returned.

SPARE PARTS RECOMMENDATION

Use the following chart as a reference when considering spare parts inventories.

SharpShooter Spare Parts Inventory Recommendation

Part Number	Description	Operator	Local Dealer	Regional Distributor
118500-002	SharpShooter II Pulse Generator, PWM/PSI			1
118400-002	Valve Driver, 6-Pin SharpShooter		1	4
116301-001	Pressure Sensor, 100psi, Packard		1	4
116390-111	Nozzle Valve, Wilger, 150psi, Grip Body, OM Coil	2	10	20
116290-111	Nozzle Valve, Arag, 150psi, Grip Body, OM Coil	2	10	20
116190-111	Nozzle Valve, TeeJet, 150psi, Grip Body, OM Coil	2	10	20
716009-111	Plunger Assy., PFE		100	300
715022-206	O-Ring, Wilger, -116, Viton (Between Body and Nozzle)		10	50
715022-205	O-Ring, Arag, -115, Viton (Between Body and Nozzle)		10	50
715022-202	O-Ring, TeeJet, -117, Viton (Between Body and Nozzle)		10	50
715022-204	O-Ring, -015, Viton (Between Coil and Body, All Valves)		10	50
715022-201	O-Ring, -008, Viton (Wilger & Arag), Small		10	50
715022-200	O-Ring, 2mmX4mm, Viton (TeeJet Only), Small		10	50
116189-111	Coil Assembly, 7-Watt, Overmolded		2	10
117501-005	Nozzle Harness, 8 x 20"			2
117501-006	Nozzle Harness, 4 x 20"			2
118600-050	Extension, 6 x 50'			2
118600-040	Extension, 6 x 40'			2
118600-030	Extension, 6 x 30'			2
118600-020	Extension, 6 x 20'			2
118600-010	Extension, 6 x 10'			2
116200-010	Extension, 3 x 10'			2
118604-001	Circuit Breaker Kit			2
705725-134	Fuse, 10A, ATO/ATC Blade Type, Red	2	10	50
118500-020	Switch Assembly, Rocker, PWM/PSI			1
118500-010	Switch Assembly, Rotary, 12-Position			1
118600-001	Power Hub			1