



## Musashi 5 Proto Matrix Board Instructions

### Features

- Built on the Musashi code base (hybrid debounce scheme)
- Includes 5 fire modes: uncapped semi-auto, capped semi-auto, PSP ramping, PSP burst, and NXL full-automatic
- Continuously monitors the trigger switch throughout entire firing cycle
- ABS (anti-bolt stick) programming prevents first shot drop-off
- AMB (anti-mechanical bounce) and CPF (cycle percentage filter) algorithms help to eliminate mechanical bounce and switch bounce
- Power efficient software lengthens battery life
- Programming mode allows changes to debounce, dwell, loader delay, AMB, fire mode, fire mode max rate of fire, ABS dwell, cycle percentage filter, and ramp start for PSP ramping
- All settings are stored in non-volatile memory so they are not lost when power is disconnected
- One-touch startup enables the marker to fire instantly
- Automatic 15-minute idle power down saves batteries
- Force shot allows the marker to be fired when the eyes are enabled but no object is present in the breech
- Low battery indicator software

### Installation

Removal and installation of the board on a Proto Matrix must be carefully done to ensure the electronics are not damaged. Begin by removing the grips from the marker. This will expose the entire circuit board. Remove the two mounting screws, eye harness, power/trigger switch harness, and solenoid harness. Remove the old board. Place the M5 Proto Matrix board in the grip frame and replace the two mounting screws. Plug in all the connections. If the marker will not turn on, it may be due to a low battery or broken battery harness.

### LED Indicator

The multi-color LED that shines out the back of the grip frame shows which mode of operation the marker is currently in:

Solid Green	Ball in breech, ready to fire
Solid Red	No ball in breech
Slow Blinking Green	Eye malfunction, max rate of fire reduced
Slow Blinking Red	Eyes disabled, rate of fire limited to 20 balls per second in uncapped semi-auto; otherwise fire mode max rate of fire for fire modes 2-5

### Power Operation

Pressing and releasing the power button turns the marker on. A solid red or green LED in the grip frame indicates that the marker is ready to be fired. To turn it off, press and hold the power button until the LED turns off, then release. Every time the marker is turned on, the eyes are enabled. The marker can be turned off regardless of the state of the eyes. Additional details about the battery indicator can be found below.

### Eye Operation and Logic

The eyes are enabled when the marker is first turned on. To disable the eyes, use the eye button. To change modes, press and hold the eye button for 1 second. The LED will change colors to indicate the mode change.

To determine if the eyes are working correctly, insert an object into the breech. Check to see if the LED changes from red to green, and then back to red once the object is removed.

When the eyes are enabled, they watch the bolt return after every shot, maximizing the speed of the marker. If the eye system becomes permanently blocked (either from paint, debris, or your finger) it will slow down the rate of fire to 12.5 bps to prevent additional chopping. The true speed of the marker can only be determined by firing with paint and air.

### Battery Indicator

The battery indicator software is standard in the M5 Proto Matrix software. When the marker is turned on, the LED will briefly flicker red to indicate a low battery. If it flickers red, the battery should be changed as soon as possible. Your battery may last for another case of paint, but it is close to failing. If the battery is fine, the software will go directly into the firing mode.

### Programming

The tournament lock must be disabled in order to change settings on the chip. The 2<sup>nd</sup> dip switch functions as the tournament lock. To disable the tournament lock, make sure the 2<sup>nd</sup> dip switch is in the on or up position. While the marker is turned off, pull and hold the trigger and turn the marker on. This will initiate the programming mode, showing a rainbow color sequence. Then the LED will settle on green. Pulling and releasing the trigger quickly will toggle between the different programming modes:

Green	Debounce
Red	Dwell
Orange	Loader delay
Flickering Green	Anti-mechanical bounce
Flickering Red	Fire mode
Flickering Orange	Fire mode max rate of fire
Alternating Green/Red	ABS dwell
Alternating Orange/Red	Cycle percentage filter
Alternating Green/Orange	Ramp start point

When the LED is lit for the desired setting, press and hold the trigger until the LED goes out. When you release the trigger, the LED will blink to show the current setting. For example, if the current setting for debounce is 5, the LED will blink green 5 times. Once the LED stops blinking, you have 2 seconds to begin entering the new setting.

To enter the new setting, pull the trigger the desired number of times. For example, to set the debounce to 2, you must pull the trigger 2 times. Every time you pull the trigger the LED will light. After all settings have been changed, turn the marker off, using the power button.

### Programming Example

If you want to set the dwell to 20, you should:

1. Make sure the marker is powered off and the tournament lock is disabled (2<sup>nd</sup> dip switch in the on/up position).
2. Pull the trigger and push the power button to turn on the marker.
3. The LED shows green. This is the debounce mode.
4. Quickly pull and release the trigger one time to switch to the dwell mode. The LED will show red.
5. Pull and HOLD the trigger until the LED turns off.
6. Release the trigger. The LED will blink out the current setting.
7. When the LED stops blinking, enter the new setting by pulling the trigger 20 times.
8. Wait until the LED turns back on, indicating programming has been completed.
9. Turn the marker off.

### Program Reset

To reset all settings to factory defaults, hold down the eye button for 10 seconds while in programming mode. The LED will rapidly cycle through every setting color to indicate that the process has completed.

### Settings

**Debounce** – The Musashi software features a hybrid debounce scheme that uses microcontroller cycles to debounce the pull of the trigger and ½ ms time increments to debounce the release. This results in a very effective debounce algorithm that does not hinder the user at any setting. At low debounce settings, however, it may cause the marker to read switch bounce as additional pulls, falsely generating shots or near full-automatic fire. The setting ranges from 1 to 50 and is defaulted at 10.

**Dwell** – The amount of time the solenoid is energized each time the marker is fired. The default is 18 ms. The range is 10 to 30 ms. Too low of a dwell may lead to inconsistency or drop-off. Too high of a dwell can cause bad air efficiency.

**Loader Delay** – Adds a slight delay after the eye has seen a ball and the bolt is cycled, causing the gun to fire. If not using force fed loaders, it may be necessary to increase this setting to prevent chopping. A setting of 1 means no loader delay, which is the fastest. The default is 2 and may be set from 1 to 30.

**AMB** – Allows the user to adjust the anti-mechanical bounce feature. Mechanical bounce occurs due to the kick generated during each shot and can cause the marker to “run away” on the first few shots. AMB helps stop markers from going full-auto when the trigger is pulled very slowly. The default is 2 and may be set from 1 to 5

(1 being off). AMB is only used in fire modes 1 and 2 (semi-automatic unlimited and adjustable). In PSP ramping, PSP burst, or NXL mode AMB is disabled.

**ABS Dwell** – Amount of dwell time added for an ABS shot. The range is from 1 to 15 additional milliseconds of dwell. The default is 10. For a more detailed explanation of ABS see the “Additional Features” section. Setting the 1<sup>st</sup> dip switch to the on/up position enables ABS.

**Fire Mode** – Included are 5 different fire modes (default is 1):

1. Semi-automatic, unlimited rate of fire
2. Semi-automatic, adjustable rate of fire
3. PSP ramping, adjustable rate of fire
4. PSP burst, adjustable rate of fire
5. NXL full automatic, adjustable rate of fire

Setting 1 is normal semi-automatic with an unlimited rate of fire while the eyes are enabled. When the eyes are turned off, the max rate of fire is set to 20 balls per second.

Setting 2 is semi-automatic with a capped rate of fire. It limits the maximum balls per second that can be fired. The cap is set by the Max ROF setting.

Setting 3 is the first PSP fire mode that works as follows:

- The first 3 shots of a string are semi-automatic
- After the 4<sup>th</sup> shot the marker will add shots as long as the user fires faster than the ramp start setting. For instance, if the ramp start setting is 5, then the user must pull 5 times per second or faster for the software to add additional shots.
- If the trigger is released, the marker will stop firing immediately
- If the trigger is not pulled again within 1 second of release, the 3-shot semi-automatic count starts over

Setting 4 is the second PSP fire mode that works as follows:

- The first 3 shots of a string are semi-automatic
- After the 4<sup>th</sup> shot the marker will fire 2 or more shots per pull as long as the user continually pulls and releases the trigger
- If the trigger is released, the marker will stop firing immediately
- If the trigger is not pulled again within 1 second of release, the 3-shot semi-automatic count starts over

In normal operation, continually pulling the trigger faster than 5 to 6 pulls per second will effectively give the user full automatic at the max rate of fire. If the user stops shooting then resumes within 1 second, the marker will return to the max rate of fire. If the user stops shooting for more than 1 second, the next 3 shots will be semi-automatic. On the 4<sup>th</sup> shot it will resume a faster fire rate.

PSP ramping and PSP burst differ in that PSP ramping requires the user to maintain the ramp start rate of fire for software assistance, whereas the PSP burst mode will fire at least 2 shots per pull, regardless of rate of fire. Some players prefer multiple shots every time they pull the trigger after the initial 3 semi-automatic shots, while others like to be able to shoot 1 ball at a time until they achieve a certain rate of fire.

Setting 5 is the NXL full-automatic fire mode. It functions similarly to the PSP fire modes except after the 3<sup>rd</sup> semi-automatic shot the user may pull and hold the trigger to have the marker fire in full-automatic.

**Fire Mode Max ROF** – The maximum rate of fire setting only applies to the 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> fire modes. The max rate of fire is adjustable from 14 to 20 balls per second in ¼ balls per second increments, and has an unlimited setting. The default is 4, which is roughly 14.75 balls per second. Oscillator inconsistencies from chip to chip make it impossible to time perfectly, so the only true way to check rate of fire is to use a Pact Timer or ballistic chronograph. The red radar chronographs commonly found at fields are NOT reliable.

Setting	BPS	Setting	BPS	Setting	BPS
1	14.0	9	16.0	17	18.0
2	14.25	10	16.25	18	18.25
3	14.5	11	16.5	19	18.5
4	14.75	12	16.75	20	18.75
5	15.0	13	17.0	21	19.0
6	15.25	14	17.25	22	19.25
7	15.5	15	17.5	23	19.5
8	15.75	16	17.75	24	19.75
				25	20.0
				26	Unlimited eyes on 20 bps eyes off

**Cycle Percentage Filter (CPF)** – The cycle percentage filter allows adjustment of the point within the current firing cycle that a new buffered shot is allowed. Almost all electronic paintball markers allow a single shot to be buffered in the event the user is fast enough to release the trigger and pull again during the current firing cycle. The CPF setting is adjustable from 1 to 10. Setting 1 turns the CPF off, allowing buffered shots at any point in the firing cycle. Settings 2 through 10 set the percentage of the firing cycle that must pass before shots may be buffered:

1	CPF turned off
2	10% of the firing cycle must pass before a buffered shot is allowed
3	20%
4	30%
5	40%
6	50%
7	60%
8	70%
9	80%
10	90%

A higher CPF setting results in less unintentional bounce. For instance, it is possible that if your debounce setting is border line, you can fire the marker a few times, then hold it loosely and allow it to brush against your finger, going full-automatic. Since most switch bounce from either a low debounce setting or mechanical bounce occurs almost immediately after the trigger is released, CPF can be very effective in eliminating falsely generated trigger activity.

**Ramp Start** – The ramp start setting is only used for the PSP ramping fire mode (mode 3). It sets the minimum pulls per second that must be maintained for the software to add shots, or ramp up to the maximum rate of fire setting. The default is 5 and is adjustable from 4 to 12 pulls per second.

### Additional Features

**Force Shot** – In the event the eyes are enabled, the breech is empty, and the user wants to fire a clearing shot, a force shot can be initiated by pulling and holding the trigger for ½ second. This is useful with force fed loaders that sometimes push a ball slightly into the detents where the eyes are unable to see it. After force firing, the next ball will load and operation will continue as normal.

**ABS** – ABS (anti-bolt stick) programming helps to eliminate first shot drop-off. First shot drop-off occurs when the lube and o-rings settle or “stick” inside the marker after it has been sitting. The next shot fired will be lower in velocity because the bolt has to break free. ABS will slightly increase the dwell to compensate if the marker is left sitting for 15 seconds.

**A tip for setting the debounce, AMB, and CPF** – This only applies to semi-automatic fire modes (modes 1 and 2), since AMB is disabled in the PSP fire modes or NXL mode.

Debounce, AMB, CPF setup steps, while using air (no paint):

1. Turn AMB and CPF off (set both to 1).
2. Starting at debounce 1-3, raise the debounce setting a notch at a time until excessive trigger bounce goes away. The goal is to have one pull, one shot, regardless of rate of fire. Do NOT slow pull test for bounce during this phase. Instead, pull the trigger rapidly or walk it, listening for double or triple fires.
3. When it appears that it is only one pull, one shot for solid trigger pulls, try the slow pull test. Holding the marker steady, slowly pull the trigger and see if multiple shots can be generated from the single pull.
4. Increase the CPF setting a notch at a time until the slow pull bounce starts to disappear. An additional test is to fire a few rounds quickly, then hold the trigger right on the activation point to see if the marker will run away.
5. If you reach setting 10 with CPF and the marker can still be slow pulled to fire full-automatic, then your debounce setting is probably too low. Go back to step 2.
6. AMB should not be set above 3, if possible, since it is not as transparent to the user as CPF. Even a CPF setting of 10 will not be noticed by the user.

**Additional Information**  
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