OKO M3 Initializer

The OKO Initializer M3 is an initializer for use on FPV Kamikaze type drones.

The M3 Initializer is intended to be attached to an igniter or electronic match. The OKO M3 Initializer's main function is to source a continuous current exceeding 500mA for a minimum 2 milliseconds duration after the detection of an impact or operator command. The M3 Initializer can be connected electrically to the drone through its onboard flight controller, to allow for manual arming and detonation via handheld controller.

The M3's manual detonation capabilities are an addition to what can be found on the OKO M1. The manual detonation, or "Permit Switch" feature is optional, as the M3 can function independently of the drone (not connected to the flight controller), exactly like the OKO M1. However, in order to achieve the full functionality of the M3, the "Permit Switch" must be setup (see the "M3 Permit Switch Setup" document). Alongside it's state machine, the M3 uses a separate algorithm (shown in the "M3 Initializer Flow Chart") to evaluate whether the "Permit Switch" feature should be activated or not. This evaluation is also used as a safety mechanism, and wont allow the initializer to arm and fire unless specific conditions are met.

The OKO M3 Initializer is designed to maximize the safety of the operator while maximizing lethality for the target. The operator safety measures center around avoiding unexpected initialization by usage of a progressive state machine while allowing for very precise impact detection.

The state machine states must be traversed in sequence. States cannot be skipped unless overridden by the programming interface. The complete transition of all states terminates with the final discharge state. The state machine is presented as part of this document in Appendix A.

The OKO M3 Initializer has an auto destruct function, which is time based and user programmable and is independent of the state transitions, meaning that after a certain time has expired, the device will issue the initialisation current irrespective of current state. The auto destruct timer is always started at power on and is only restarted if the device is powered off. There is no other way of restarting or stopping the timer. The auto destruct function is intended to prevent the capture and reverse engineering of the drone system as a whole, in the event that a kamikaze drone fails to reach its target or is brought down by enemy action.

Operational Sequence (states)

1) State 10 – immediately after Power ON,
    a. Green LED – Slow Blink. Red LED is OFF.
    b. If Yellow status LED displays the slow blinking pattern, this indicates a low battery condition; battery should be replaced to ensure proper detonation.
    c. The initializer is in a wait state. The CPU is waiting to detect vibration induced by the drone motors.
    d. The state is exited if Motor Vibration is detected and exceeds a minimum threshold.
    e. The minimum Motor Vibration threshold for level 1 is programmable via P1/S1, allowing for fine tuning for Drone Frame size and Motor size.

2) State 20 – Motor Level 1 Detected
   a. Green LED – 2 Blinks then Pause. Red LED is OFF.
   b. The initializer has detected motor vibration. The CPU is waiting to detect a second, higher motor vibration, created typically from a drone in hover.
   c. The state is exited if Motor Vibration is suddenly not detected, in which case it will return to State 10, or if Motor Vibration exceeds the level 2 threshold.
   d. The minimum Motor Vibration threshold for level 2 is programmable via P2/S2, allowing for fine tuning for Drone Frame size and Motor size.
3) State 21 – Motor Level 2 Detected
   a. Green LED – Medium Blink. Red LED is OFF.
   b. The initializer has detected level 2 motor vibration. The CPU is waiting to detect flight. Flight is defined as a velocity measurement over time.
   c. The magnitude of the velocity over time can be programmed via P21/S21. The larger the value the further the drone must travel before transitioning to Flight Detected status.
4) State 30 – Flight Detected
   a. Green LED – blinking very fast rate. Red LED is OFF.
   b. The initializer has detected flight meaning that the drone has accelerated to a given velocity and has travelled a minimum distance from the launch point. The CPU has started a programmable timer and is counting down.
   c. The delay time can be programmed via T1.
5) State 39 – Arming Control
   a. Green LED – slow blinking. RED is OFF.
   b. Arming Control is entered only when the Permit Switch is enabled. To understand the Permit Switch activation process, see Appendix B for the "M3 Initializer Flow Chart".
   c. If the Permit Switch is disabled, the device will bypass State 39 and immediately transition to State 40.
   d. M3 is awaiting manual arming and detonation commands. At this point, both ARM and DETONATION switches are OFF, meaning the explosive can be safely disarmed by placing the red pull pin back into the M3 and disconnecting the igniter connector from the M3 green terminal connector.
   e. Manually arm the M3 by toggling the ARM switch to ON on your handheld controller (order of switches does not matter, the first switch will always be used for arming, and the second for detonation).
   f. If the M3 receives both ARM and DET switches ON commands instantaneously, it will arm and fire in exactly 2 seconds. This process is irreversible.
6) State 40 – Arming Cycle
   a. Green LED blinking very fast rate. Red LED blinking slowly.
   b. The timer after Flight Detection has expired and the Initializer is now charging the Discharge Capacitor and circuit. The CPU is reading a feedback loop and waiting for the circuit to reach a minimum of Varm Volts (default 6.0v).
   c. The minimum voltage is programmable and if higher will increase the time of transition to the subsequent state. The upper limit is set to 14 Volts and is fixed.
7) State 50 – Armed, Ready for Impact

- a. Green LED OFF. Red LED blinking quickly.
- b. The Initializer is armed and ready and waiting for impact detection or operator command.
- c. The impact required can be set via P4/P5/P6.
- d. The magnitude and window length can be set to very slight to very forceful impacts and are only limited by the g forces produced by the drone in flight which is a function of the operator – (we have never seen a drone, in flight, experience a g-force greater than 2g's – the minimum level)
- e. If Permit Switch is enabled, the operator can also manually detonate the explosive by toggling the DET switch to ON.
- f. If Permit Switch is enabled, the operator can manually reverse the arming sequence back to State 39, "Arming Control", by flipping the ARM switch to OFF.
8) State 51 – Delay Before Fire
    - a. Green is OFF. Red LED is solid ON.
    - b. A timer can be set once impact has been detected to delay the explosion for T2 in milliseconds.
    - c. T2 is by default set to 0 milliseconds (no delay before firing), and can be set to a maximum of 65535 milliseconds, or 65.5 seconds after impact.

Intermediate Actions

By factory default, if in State 20, 21, or 30 the drone has stopped moving and has had its motors turned off, it will immediately return to State 10. This is a preventive action as the drone has not flown far enough from base but has landed and had its motors turned off. This return to State 10 ensures that defective or accidentally crashed drones can still be recovered safely by friendly forces, without the risk of premature or wrongful detonation.

Note, this is only possible if Enabled via B0 (default) and if State 40 has not been entered.

IMPORTANT – returning to state 10 does NOT restart Ttot Timer (self destruct).

Self Destruct

As mentioned previously the initializer includes a self destruct timer that is started at power on. This timer is set to a default of 30 minutes but can be programmed for a minimum of 10 minutes and up to 300 minutes (6 hours). It is imperative to understand that the self destruct timer is not reset in any state and can only be restarted by powering off the device via the manual start switch.

Power On

The OKO M3 Initializer is equipped with a manual start switch. The manual start switch has a plastic tab that has a looped string attached to it. The manual start switch is engaged by removing the plastic tab from the unit. The plastic tab string is intended as a pull point so that the switch can be initiated by drone flight, meaning the string is attached to the ground and the action of flight pulls the tab and closes the switch.

OKO Systems strongly recommends not using this method. It has gone to great lengths to ensure that initializer function is not possible until the unit is well in flight and away from base.

OKO Systems however does recognize that unfortunate past experiences may cause some personnel to insist on this method. As such, the method will work and it is possible to further enhance it's functionality by disabling certain parameters.

OKO Systems recommends that the pull tab system be used to initially turn on the initializer from a distance (as a final step prior to drone lift off) by using the pull tab string or attaching an additional string to the pull tab. This also ensures that aside from the drone operator another observer is monitoring the initial activation sequence of the initializer, from the safety of a covered position.

Power-Off Safety

When opened, meaning the switch is depressed, the device has an active bleed of power to ground so as to eliminate any possibility of an accidental discharged from the charged capacitor. OKO would like to stress that the current design with active bleed to ground means that any charge remaining in the capacitor will be immediately dissipated, inactivating the capacitor.

Bypassing Initialisation States

Each state has a Boolean bypass flag (B0, B1, B2, B21, T1=0, B4) meaning that it is possible to go from power on to explosion without reaching any thresholds. This situation and setup should ONLY be used for test purposes and without an active device attached.

State 41, Await Free Fall is intended to be used only for "bomb drop mode", meaning once flight is detected, it will wait until free fall is detected (when an object reaches 0g's). Once it is detected, it will arm and fire on impact. To enable this feature, B41 must be enabled – and by factory default is disabled.

State 51 can be used to create a "Delay Before Firing" once impact has been detected. This delay can be adjusted with the T2 parameter. By default it is set to 0 milliseconds (no delay), and can be set to a maximum of 65535 milliseconds (65 seconds).

By Enabling Boverride, the Initializer will pass through states 34/35/36/37; using B34, Toverride, P3/S3, and BATlow. This is intended to be used for "booby trap mode", meaning the device is placed in a non flight situation on the ground. For the first 10 seconds, the Initializer will report battery using the 3 blinks & pause pattern. If no Yellow status LED is seen, the battery is OK. The report battery feature can be skipped by enabling B34. The unit will initiate its safety timer "$T_{OVERRIDE}$" in the Override state, and display the green medium blink pattern. Once the $T_{OVERRIDE}$ Timer is reached, it is reset and begins its countdown again. This time, it must remain in the steady motionless state to complete its timer. In this state, the initializer will display the Red LED medium blink pattern, and will fast blink when 30 seconds remain in the repeated $T_{OVERRIDE}$ Timer. If it detects motion in this secondary safety timer, it will automatically go back to the Override state and begin the same sequence again. If $T_{OVERRIDE}$ is successfully reached, the LED's are turned off and the initializer becomes sensitive to movement. Movement sensitivity can be adjusted via P3/S3. At this point, if the slightest of movements is detected, the battery drops under the low battery voltage (BATlow), or T_{TOT} is reached, the initializer will arm and fire. Once initiated, there is no way to disable this mode.

The OKO M3 initializer is intentionally extensively programmable allowing for operator and situation fine tuning. The device is programmed using an Android Application and a dedicated programming dongle. NOTE: the USB connector is not a real USB device and will not react if connected to a real USB port (phone, laptop etc.). If you have established the connection and no status LEDs are displayed on either

the Programming Board or the M3, try unplugging the USB Type-C connector from the android device, flip it, and then reconnect.

Bomber Mode

Enable B41 to activate Bomber Mode. This mode uses the Initializer's State 41 to detect when it is in a free falling state (0g's). This occurs after the Initializer has armed in State 40 and has charged the capacitor to VARM Voltage. When free fall is detected for the duration of P41 (default 300 milliseconds), the Initializer will immediately enter State 50, Ready To Fire.

FPV Booby Trap Mode

Disable B0, adjust the T1 timer to 300 seconds (5 minutes), P4 = 1000, P5 = 30, P6 = 150, and enable B5 "Dark Mode". By enabling B5 "Dark Mode", all LED's will remain OFF 30 seconds after the Initializer has armed. To use this effectively, operators can fly the drone into enemy territory and land the drone. Once the T1 timer has expired, the drone is effectively an explosive device highly sensitive to movement. If it moves or is attempted to be retrieved, it will detonate immediately.

Additional Safety Features

The OKO M3 incorporates additional hardware protections to ensure that the firing discharge capacitor is not charged or discharged until all states have been achieved.

- A blocking transistor keeps any power from the step up inductor and diode until the Arming State 40 is reached.
- The firing or discharge of the device is both source and ground disconnected until state 50 meaning there is no electrical path to ground or to power until State 50.
- If power is removed by depressing the power switch, a transistor bleeds all power from the charge capacitor via a 100 ohm resistor to ground and keeps the positive side grounded until power is applied.

Permit Switch Flow Chart

The Permit Switch is set to allow spare PWM input pads from the flight controller to be used as Arming and Detonation controls from the toggle switches on the handheld radio controller. The "M3 Permit Switch Setup" document explains how two spare PWM pads on the flight controller can be repurposed as general purpose inputs for arm and disarm.

To prevent PWM false signal detonation, the M3 requires the toggle switches to be silent for at least 5 seconds (factory default) before it reaches State 39 (Arming Control) for them to be permitted to be used for arming and detonation. The Permit Switch Evaluation Time can be changed via the T3 parameter. The purpose of this feature is to compensate for the scenario where the motors/PWM play a "jingle" on power on. Please see the Flow Chart Diagram in Appendix B for details.

Appendix A
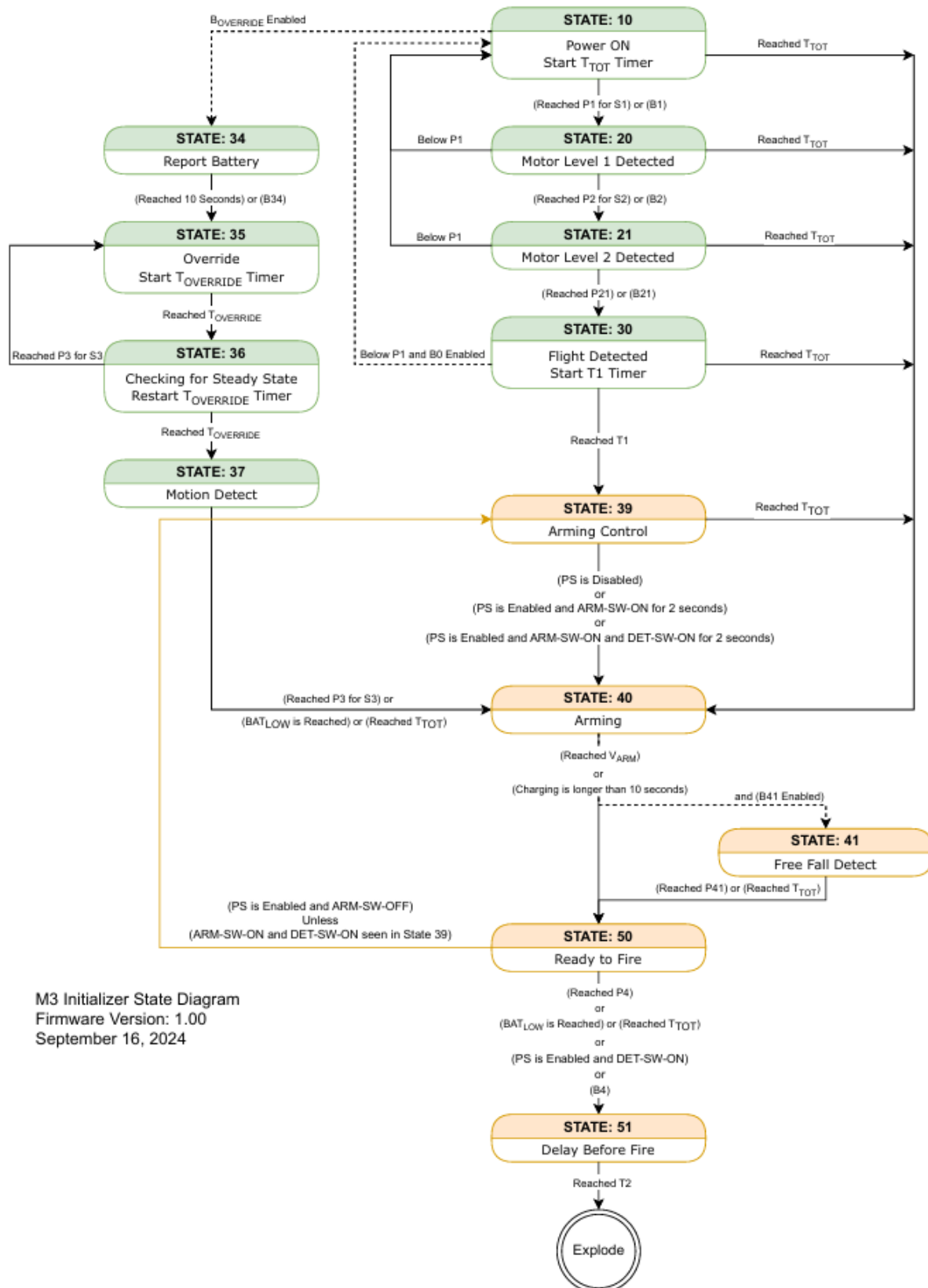
M3 Initializer State Diagram
Firmware Version: 1.00
September 16, 2024

Parameter	Unit	Description	Default	Min:Max
T_{TOT}	minutes	Self Destruct Timer	30	10:300
P1	level	Motor Spin 1 Detection Sensitivity	45	10:200
S1	seconds	Motor Spin 1 Detection Sample Interval	3	1:30
P2	level	Motor Spin 2 Detection Sensitivity	150	50:500
S2	seconds	Motor Spin 2 Detection Sample Interval	2	1:30
P3	level	Motion Detection Sensitivity	50	10:500
S3	seconds	Motion Detection Sample Interval	1	1:30
P21	m/s	Flight Velocity	3	1:30
T1	seconds	Delay from Flight Detect to Arming	30	0:600
P41	milliseconds	Free Fall Detection Duration	300	100:1000
P4	level	Impact Level	1500	1000:7900
P5	milliseconds	Impact Detection Window	20	2:40
P6	0.1%	Sample Weight for Impact Detection	10	1:1000
T2	milliseconds	Delay Before Fire	0	0:65535
B0	bool	Flight Stop Detection Permission	1	0:1
B1	bool	Bypass Motor Detection	0	0:1
B2	bool	Bypass Motor Detection 2	0	0:1
B21	bool	Bypass Flight Detection	0	0:1
B34	bool	Bypass Report Battery	0	0:1
B41	bool	Enable Free Fall Detection	0	0:1
B4	bool	Ignore Impact Detection	0	0:1
B5	bool	Dark Mode	0	0:1
V_{ARM}	1/10 volts	Arming Voltage	60	40:140
BAT_{LOW}	1/10 volts	Low Battery Voltage	23	23:25
$B_{OVERRIDE}$	bool	Motion Detection Trigger	0	0:1
$T_{OVERRIDE}$	seconds	Motion Detection Safety Delay	300	0:1800
T3	seconds	Permit Switch Evaluation Time (M3 ONLY)	5	1:60

Status LED's			
State	Green LED	Red LED	Yellow LED
Config	1 Blink then Pause	OFF	OFF
10	Slow Blink	OFF	See Note 1
20	2 Blinks then Pause	OFF	OFF
21	Medium Blink	OFF	OFF
30	Fast Blink	OFF	OFF
34	3 Blinks then Pause	OFF	See Note 1
35	Medium Blink	OFF	OFF
36	OFF	See Note 2	OFF
37	See Note 3	See Note 3	OFF
39	Medium Blink	OFF	OFF
40	Fast Blink	Slow Blink	OFF
41	Fast Blink	Fast Blink	OFF
50	OFF	Fast Blink	OFF
51	OFF	Fast Blink	OFF
Explode	OFF	OFF	OFF

Note 1: The Yellow LED blinks if the battery is low

Note 2: The Red LED is medium blinking. It will fast blink when 30 seconds remain in the $T_{OVERRIDE}$ Timer.
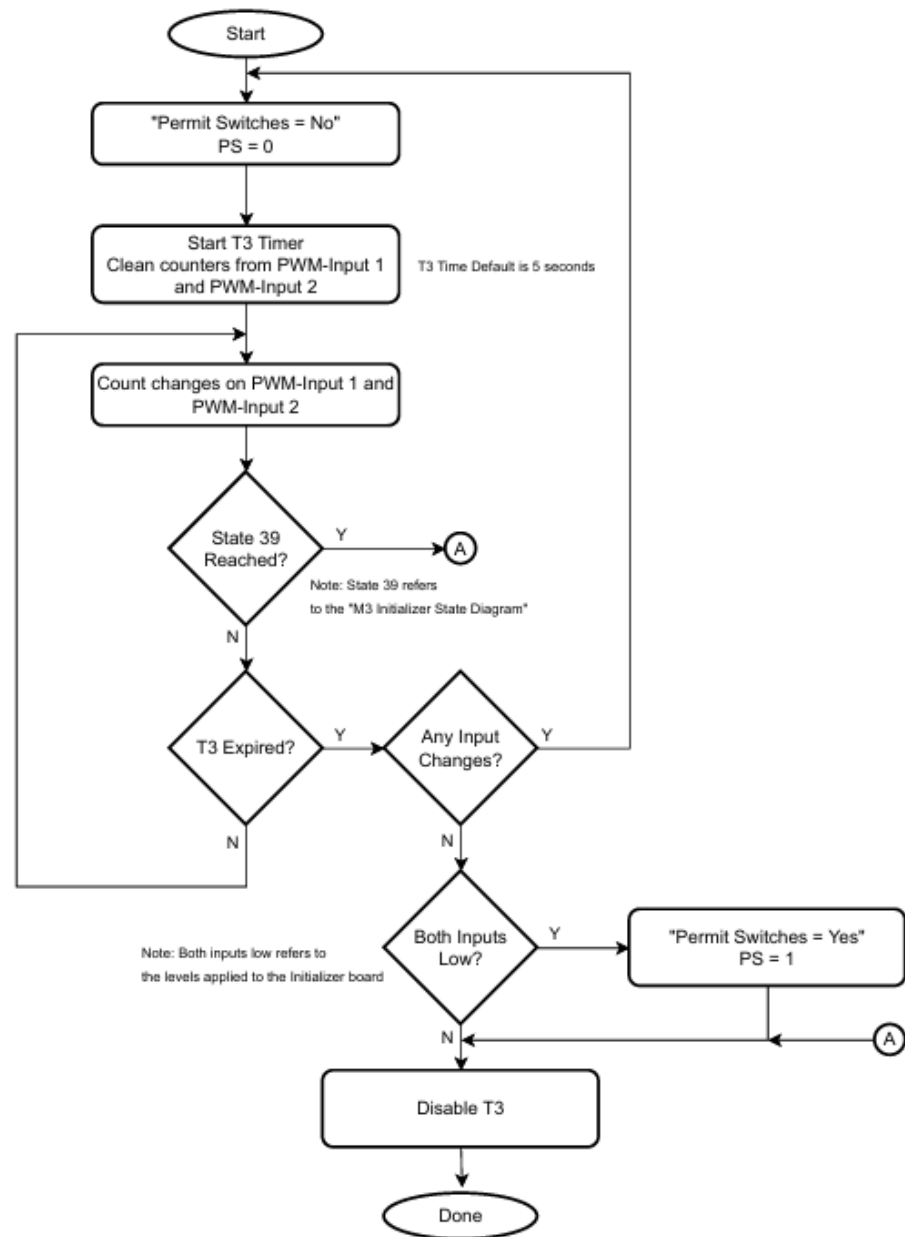
Note 3: If State 37 is achieved, all LED's will remain OFF indefinitely

Note 4: If B5 "Dark Mode" is ENABLED, all LED's will remain OFF 30 seconds after State 40 is reached.

PS: "Permit Switch" flag evaluated on start depending on PWM Inputs. (See Flow Chart 1)

Appendix B

M3 Initializer Flow Chart V1.00
August 22, 2024
Determine if Arm/Detonate Switches are Active

Start

"Permit Switches = No"
PS = 0

Start T3 Timer
Clean counters from PWM-Input 1
and PWM-Input 2

T3 Time Default is 5 seconds

Count changes on PWM-Input 1 and
PWM-Input 2

State 39
Reached? — Y → A

Note: State 39 refers
to the "M3 Initializer State Diagram"

N

T3 Expired? — Y → Any Input Changes? — Y →

N   N

Any Input
Changes?

Both Inputs
Low? — Y → "Permit Switches = Yes"
PS = 1

Note: Both inputs low refers to
the levels applied to the Initializer board

N ← A

Disable T3

Done

Legend		
Name	Type	Description
PS	bool	"Permit Switches" is set to allow the two spare PWM input pads to be used as Arming and Detonation controls from the switches on the RC.
T3	seconds	A counter used by the algorithm, default is 5, range is 1 to 60.
PWM-Input 1	bool	Two spare PWM pads on the flight controller which are repurposed as general purpose inputs for arm and disarm.
PWM-Input 2	bool	
State 39	state	Refers to State 39, "Arming Control" in the "M3 Initializer State Diagram"