Bally®

GAME 1215

Flash Gordon
Arduino Game Version FG2025.03
by Dave's Think Tank

Flash Gordon 2025.03

Flash Gordon 2025.03 completely re-imagines the original Bally pinball game, with all new rules, goals, music, light patterns, and sound clips from the film! Just plug it in, and get ready to experience Planet Mongo like you've never seen it before!

Notes: Some new sound features require the latest Geeteoh sound board.
This version replaces the BSOS (Bally/Stern OS) operating system with its successor, RPU (Retro Pin Upgrade), for ongoing maintenance purposes.

New Rules

- **Skill Shot:** Shoot to hit the three shooter lane rollovers without entering the playfield, and return to the shooter. Higher rollovers score more points.
- **Final Battle:** Drop 11 targets (adjustable in self-test game settings) to qualify for the Final Battle. Now re-enter the shooter lane, or send the ball down the lit outlanes, to meet Ming in the Final Battle!
- **4 Drop Target Bank:** Hitting any of the four drop targets while flashing will light the colored insert of the target with the corresponding color. These are the lower playfield right-side targets and the flipper feed lanes.
    - **Lower Playfield Right-Side Targets:** Once flashing, the targets on the right side must be hit to build towards the 3X points. Hit them within 15 seconds for an additional 50,000 points!
    - **Flipper Feed Lanes:** The flipper feed lane targets must also be hit while flashing. Once hit, you have 5 seconds to hit the opposite spinner for 15000 points immediately, plus 2000 points a spin.
    - Hitting all four colored targets will light the 3X arrow for 15 seconds of 3X points. Hit the up / down kicker to collect!
- **Wood Beast**: To get to the Wood Beast you must knock down the three inline targets. Hitting the Wood Beast now resets these targets, so you can knock them down again!
- **Drop Target Banks:** Completing each drop target bank lights one of the up / down kicker inserts (4 bank - 10k, inline - 20k, and 3 bank - 30k). Light all three inserts to light the extra ball. The up / down kicker always collects any and all lit awards.

Final Battle - Defeat Emperor Ming

- Shoot the spinners for 4 attack power per spin, pop bumpers for 20 attack power per pop, and the up / down kicker for 35 attack power. Build your attack power to 140 (adjustable in self-test game settings) to attack Emperor Ming.
- You can monitor your progress toward full attack power in the Credit display, and in the kicker lights (10K –> 20K –> 30K –> Extra Ball!)
- Once you are at full power, attack Ming by entering the up / down kicker.
- You need to build up full power and attack through the kicker three times to defeat Emperor Ming. Ming's remaining lives are displayed using the lower drop-target lights.

Familiar Rules from the Original Game

- Dropping the 2nd and 3rd inline targets lights the 2X and 3X bonus multipliers. Knocking down all three will light the Wood Beast "Extra Ball" target.
- Dropping the 1-2-3 arrow targets:
    - the first time lights the top pop bumper for 5000 points. 2nd and 3rd times light and advance the top target's blue "Collect Bonus" and red "Special" lights.
    - Dropping the 1-2-3 targets also lights 4X bonus after 3X is lit.
    - Hitting while flashing will light the 1-2-3 arrows. Lighting all three lights the mini-bonus for 50,000, and up / down kicker 2X arrow for 15 seconds of 2X points.
- Dropping 4 targets the first time lights the left spinner. The 2nd time lights the right spinner. Dropping 4 targets also lights 5X bonus after 4X is lit.
- Lighting the flashing amber, yellow, blue, and white inserts next to the 4 drop targets, followed by the 2 right targets and flipper return lanes, lights the super-bonus for 100,000 and the 3X arrow. Hit the up / down kicker to collect 3X points for 15 seconds.
- Ball shooter lane scores the super ring bonus points (single drop target must be down).
- 100,000 Super-bonus and 50,000 mini-bonus scores are collected in outhole only.
- Landing in the up / down kicker when the 2X or 3X arrows are lit lights the 15 second timer lights to increase playfield scores 2X or 3X. When both are lit 5X value is scored.
- Tilt Penalty is the current ball in play.

Rule Changes and New Features Since 2021

- The 2021 version required the player to collect the Wood Beast extra ball before you could collect the up / down kicker extra ball. This requirement seemed unnecessarily restrictive, and so has been eliminated.
- 2021 rules required you to hit the flashing lower right targets within 15 seconds of hitting the corresponding flashing left-side drop target, or else you needed to start over with the drop target. This seemed overly punitive. The new rule gives you 50,000 points if you hit the target within 15 seconds, but you do not need to hit the left-side drop target again if you miss.
- Previously you had two seconds after hitting the flashing flipper feed lanes to hit the opposite spinner. This has been increased to 5 seconds, and 15000 points is now awarded.
- Previously after knocking down Ming's guards, you had to go down the lit outlanes to meet Ming in the final battle. Now re-entering the shooter lane will also get you there!
- The spinners were worth 1 point per spin toward defeating Ming. This has been increased to 4 points, as one point provided little incentive to hit the spinners.
- The number of drop targets required to qualify for the Final Battle (11), and the number of points required to defeat Ming (140), have been made into user-adjustable values and so can be reduced or increased to provide a different level of difficulty.
- FG2024 now has a ball-save feature! If you score less than 1500 points, or play for less than 15 seconds before losing a ball, you will automatically be given "Same Player Shoots Again". These values can be set in the code (look for "Operator Game Adjustments"), as well as the number of ball saves allowed per game. Note that, any points you earned will be taken back.
- You can set a personal goal; a score that you consider a good game. If you achieve it, the game will end with an encouraging remark. If you fail, it will be less kind. Note: This feature only works with the latest Geeteoh board.

- In addition, if you have the latest Geeteoh sound board you can set different music for the Skill Shot, regular game play, the 15-second alarm, and the Final Battle!
- FG2024 introduces a "Kids' Mode"; a mode where all the easiest settings are used. Flash Gordon is a difficult game, so starting in Kids' Mode makes it a lot more enjoyable for younger, inexperienced players. Just go into either Self-Test or Attract Mode, and press both the Game Button AND the Coin Slot 3 switch[*] at the same time (hold until you hear the sound). To go back to regular game mode, repeat the process. Audio cues let you know which mode you have entered. Turning off the machine will always reset the game to regular play mode.
- The original game only allowed you to collect the 2X and 3X points once per ball. This is now optional. By setting the self-test game setting number 25 (Original Rules) to zero, the 2X and 3X goals will reset following the 15-second timer.
- The Original Rules game setting, when set to zero, also allows the mini and super bonuses to be retained following collection by hitting the upper-level target, or entering the shooter lane, respectively. They must be re-earned though, by hitting the required drop targets, and will also be given out at the end of ball.

Large Scoring

- 10000 – Single drop target, inline drop targets, 3 drop targets (flashing), 4 drop targets (flashing/lit), flipper feed lane (lit), lower right targets (lit), kicker + 10K 4 drop target goal
- 15000 – Drop target 3 completion, drop target 4 completion, bottom skill shot, spinner within 5 seconds of hitting flashing flipper feed lane on opposite side
- 20000 – Kicker + 20K inline drop target goal
- 25000 – Wood Beast target (plus extra ball if Player Shoots Again not already lit)
- 25000 – Flashing flipper feed lanes
- 30000 – Middle skill shot
- 30000 – Kicker + 30K 3 drop target goal
- 50000 – Fast-flashing lower right targets, 15 seconds only!
- 50000 – Top target special (if Player Shoots Again already lit)
- 50000 – Outlanes (if lit and Player Shoots Again already lit)
- 50000 – Mini-bonus
- 75000 – Top skill shot
- 100000 – Super-bonus

Final Battle Scoring

- 1000 – Spinner
- 2000 – Any pop bumper
- 3500 – Up / down kicker
- 50000 – Start Final Battle
- 50000 –Ming attack
- 150000 –Ming kill (3rd attack)

[*] If you have an external switch attached to your machine's Coin Slot 3 switch, kids can change the game to Kids' Mode on their own without opening the pinball. I have always added a switch like this to all my machines, hidden unobtrusively in the coin return slot, for the purpose of allowing free games. A switch is no longer necessary for that purpose, but works great for this one!

Getting Started
Purchase Arduino: https://pinside.com/pinball/market/shops/1304-roygbev-pinball/by-game/185-flash-gordon
Purchase Arduino IDE: https://www.arduino.cc/en/software
Purchase Geeteoh: https://geeteoh.com/squawktalk.shtml (optional, but recommended)

Install Arduino as per instructions included with device (Note: Arduino can be programmed as per instructions below before installing in the pinball, if you prefer).
Install Geeteoh as per instructions included with device.

Create a folder named FG2025p03 on your computer. Download the latest release(!) of the software from https://github.com/DavesThinkTank/Flash-Gordon-2024 to this folder. Make sure it is the latest release! The main page on GitHub gives you the original release, not the latest!

Transfer the included sound files to the micro-SD card for your Geeteoh board (into the root directory). Set up your Geeteoh DIP switches to use Sound Bank 6.

TURN OFF your pinball machine! Make sure "Switch" connectors on Arduino are connected with jumper.

Plug the Arduino into a USB port on your computer with an appropriate cable. You need a cable with a USB micro connector on one end, and a USB A or C on the other end, whichever your computer needs. Ignore the LED lights on your pinball's circuit boards. It's normal for some LEDs to come on.

Open the file FG2025p03.ino (in the FG2025p03 folder) with the IDE by double-clicking on it.

Click on the Verify checkmark (top left of IDE) to make sure software compiles properly.

Click on the white box beside the checkmark. Click on "Select other board and port". Select "Arduino Mega or Mega 2560", and the port your Arduino board is plugged into.

Click on the Upload arrow (also beside the checkmark) to compile the software and upload to the Arduino.

Unplug cable from computer. The game should now run on your pinball.

When you turn on the pinball, the first thing you should see is the version number; 2025 in the player 1 display, and 03 in the credit window. This will last for about four seconds. If you don't see this, you haven't got the software running yet! Also, if it's not the latest version number, go back to GitHub and find the latest release.

Run through all the self-tests and game settings before playing your first game, to make sure everything is set the way you want it. See the self-test section below.

Read the included manual, and the included readme.md file, and watch the following YouTube videos for more assistance.

https://youtu.be/hn4zS7xABDA
https://youtu.be/Tmc6EeCaIOU
https://youtu.be/8T7ZMEYDwRg
https://youtu.be/2D8GICzDkJk
https://youtu.be/8aF7jNNfIHE

Arduino Self-Tests

The Arduino self-test is similar to the regular Bally self-test. You begin by pressing the red self-test button inside the coin door.

There are getting to be a LOT of tests, audit settings, and game settings. You can now use the slam switch (on the inside of the coin door) to end self-test at any point (other than during the switch test), and return to attract mode.

At any point within the Self-Test or Attract Mode (again, other than during the switch test), you can enter the new Kids' Mode by pressing the Game Button and Coin Slot 3 switch at the same time (hold until you hear the sound). Kids' Mode changes all the DIP switch and self-test game settings to easy levels. Put the game back to regular game mode by pressing the two buttons at the same time again, or by simply turning the machine off. Audio cues let you know which mode you have entered. See game setting 24 below for more information.

Light Test

Ball in Play: Test #01
Display #1: Light number, or 99 for all lights
Game Button: Cycle through switched Illumination lights. Hold to cycle continuously.

The first test will repeatedly flash all the switched illumination lights on the playfield and in the backbox. This is similar to the regular Bally light test, except the Arduino allows you to now press the game button on the front of the coin door. When you do so, all the lights will stop flashing except one. By continuously pressing the game button, the pinball will cycle through all the lights, displaying each, one at a time. Display #1 shows the corresponding light number. A table of all the lights and the sequence in which they appear is included below.

Display Test

Display #1-5: All digits cycle through numbers 0-9
Game Button: Cycle through individual digits. Hold to cycle continuously.

Pressing the self-test button again will then take you to the display test. Again, this is similar to the Bally display test in that it cycles all digits in all five displays through the numbers from 0 to 9 repeatedly. It cycles quite a bit faster than the Bally test though, making this a much less tedious review!

And again, the Arduino extends this test with use of the game button. When you press the game button, all displays will go blank except for the first digit on the first display, which will continue to cycle. Pressing it again moves this to the second digit. Pressing it again moves to the third, and so on, going through each digit of each display individually. After the final digit, pressing the game button will set all displays running through the numbers again. Holding the game button down will cycle quickly through each individual digit.

Solenoid Test

Ball in Play: Test #03
Credit Display: Switches firing due to solenoid activity (if any)
Display #1: Solenoid number
Display #4: Time in milliseconds between solenoid firing and switch activating
Game Button: Fire current solenoid repeatedly. Press again to continue cycling.
Coin 3 Switch: Stop solenoids from firing. Clear switch display (credit window).

Pressing the self-test button again takes you to the solenoid test. This runs through all the solenoids, just like the regular Bally test (except in a different order). See the table below for a list of solenoids, and the order used. Note, the Coin Door Lockout and the K1 Relay Flipper Enable are not included in these tests.

New Features:

Pressing the game button at any point will cause the current solenoid to continue firing repeatedly, so you no longer have to cycle through all of the solenoids to see the one you are interested in. Press again to continue cycling. Press the coin 3 switch to turn firing of solenoids off and back on. This allows you to make adjustments to a solenoid while remaining in test mode!

Keep an eye on the credit window during this test. If vibration from a solenoid causes a switch to misfire, the switch number will be displayed here. The time between the solenoid firing and the switch activation is displayed in Display #4 (in milliseconds). See the section “User Programmable Changes” to see how this information can be used to fix this issue.

The flippers are enabled throughout the solenoid test. This is therefore a good place to work on flipper issues.

Stuck Switch Test

Ball in Play: Test #04
Credit Display: The number of switches currently closed
Display #1-4: The lowest four stuck switch numbers
Game Button: Double-click to reset all drop targets

Pressing the self-test again takes you to the switch test. Switches that are stuck on will be identified by number in the displays, like the original test. However, the Arduino allows up to four stuck switches to be identified on four displays. The original Bally test displayed only the lowest-numbered stuck switch, making testing of multiple stuck switches and switch-matrix issues difficult. The number of closed switches is also displayed in the Credit display, for cases where more than four switches are closed at once. The same numbering system is used as the original, as in the table below.

Double-clicking the game button will reset all drop targets during the switch test. This allows you to easily test and work with drop target switches, and then deactivate them again.

Note: In order to allow testing of the slam switch, game button, and coin slot 3 switch, the special functions assigned to these buttons during self-tests do not work during the switch test.

Detecting Switch Matrix Issues

The Stuck Switch test can also be used to locate switch matrix issues. The 40 switches of a pinball are wired together in an 8x5 grid. Diodes on each switch make sure one switch closing cannot affect any other switch, but a bad diode can cause problems. If a closed switch has a bad diode, and another switch in the same row is closed, and another in the same column is closed, then a fourth switch at the opposite intersection of the row and column will also register as closed.

Testing for switch matrix issues:

1. Fix all stuck switches. Make sure all switches are open. All four displays should be blank.
2. Test all switches individually. Make sure you know where they all are. Note that the switch matrix diagram in your schematics may be inaccurate. Note any errors.
3. Start with switch 0. Close the switch, and hold it closed.
4. Choose any other switch in the same row (refer to the switch matrix chart below). Close the switch, and hold it closed.
5. Choose any other switch in the same column. Close the switch, and hold it closed.
6. Three displays should show the three switches you are holding closed. If a fourth display indicates another switch, then switch zero has a bad diode and is causing a switch matrix error. (Note, the coin slot switches do not have diodes and should register as causing a switch matrix error.)
7. There are four switches labeled zero. Be sure to test them all by opening the one you are holding, and closing the next one.
8. Open all the switches. Proceed to test switch 1, then 2, and so on to switch 39.

Switch Bounce (Double-Hit) Test

Ball in Play: Test #05
Display #1: Most recent switch hit
Display #2: The time between hits in milliseconds
Game Button: Double-click to reset all drop targets

Pressing the self-test button again takes you to the switch bounce test. Switches on your pinball machine may develop a “bounce”, where hitting them registers two or more hits. If you suspect this may be happening with a switch on your machine, this test can help you to identify the issue.

To determine whether a switch is bouncing, activate the suspected switch with a pinball. If it registers only once, the switch number will appear in the Player 1 display, and all other displays will be blank. If it registers two or more times, the time between hits will appear in the Player 2 display (measured in milliseconds). See the section “User Programmable Changes” to see how this information can be used to fix this issue.

Double-clicking the game button will reset all drop targets during the switch test. This allows you to easily test and work with drop target switches, and then deactivate them again.

Sound Test

Ball in Play: Test #06
Display #1: Sound number
Game Button: Play same sound repeatedly. Press again to continue cycling. Press within ½ second of display change to skip current sound. Hold to skip many sounds quickly.

Pressing self-test again takes you to the sound test. The original Bally test simply played a single sound. The Arduino cycles through all the sounds. Pressing the game button plays the current sound repeatedly. Pressing it again will continue cycling sounds.

Display #1 will indicate the sound number to be played. If the game button is pressed within one half second of the display changing, the current sound will be skipped. Holding the button will increase speed, skipping sounds (very useful for the long, empty stretches between 51 to 72 and 96 to 253!). See the table below for a list of sounds.

Be aware, each sound will take five seconds before proceeding to the next. This is a bit slow, but it generally prevents the sounds from running over each other. Also, many sounds are empty. In particular, the first few make no sound at all. Also, some sounds have odd effects, such as disallowing other sounds to begin until they have finished. Sound #6 is the background sound, and will repeat itself for the rest of the testing! For these reasons, the sound test begins at sound #7, but you can loop to the earlier sounds by holding in the game button.

Testing and reviewing the sounds can be challenging. If a sound is making it difficult to test subsequent sounds, try the “skip” feature.

DIP Switch Test

Display #1 - 4: DIP switch values (1 = ON, 0 = OFF), first seven digits of 4 DIP banks
Ball In Play: DIP switch values for final digit of DIP banks 0 and 1 (switches 8 and 16)
Credits: DIP switch values for final digit of DIP banks 2 and 3 (switches 24 and 32)
Game Button: Move to next DIP switch. Hold to cycle through switches quickly.
Coin 3 Switch: Change setting of current DIP switch

Pressing self-test again takes you to the DIP switch test. This completely new test shows you the setting of all 32 DIP switches, and allows you to change them until the pinball is turned off. Turning the machine off and on again restores the DIP switches to the settings on the MPU board.

All 32 DIP switches are shown in the 32 display digits as either 1 (ON) or 0 (OFF). Since the displays are only seven digits, the first seven of each bank of eight are shown in the four displays. The eighth digit of each bank is shown in the Ball-In-Play or the Credit window. The current switch is identified by a flashing number. By pressing the game button, you can scroll through switches 1 to 32. Stop on a switch and you can use the coin 3 switch to change its setting.

This can be useful to detect defective DIP switches, test different DIP switch settings, or set up an easy game temporarily for kids or guests.

Score Levels (Award Levels 01, 02, and 03, High Score, and Personal Goal)

Credit Display: Level #01, 02, 03; 04 for high score; 05 for personal goal
Display #1: Score Amount
Game Button: Increase by 1000. Hold to speed-up the process.
Double Click: Set value to zero

Pressing the self-test button again takes you to the first score level. Three score levels can be set, where you can earn extra balls or free games. Next is the high score, and then "Personal Goal", a new feature that provides a surprise ending when the set goal is achieved. Set Personal Goal to what you consider a good game.

Press the game button to increase these values by 1000. Hold the button in to increase the value continuously. This is very similar to the original Bally, except by holding the button the score will begin to increase very quickly, a definite improvement! Release it to stop, and press again to start off slowly. Double-pressing the button resets the value to zero. An award level of zero means no award for this level or higher.

Score Levels:

01: Award Level 1
02: Award Level 2
03: Award Level 3
04: High Score
05: Personal Goal

Accounting Info

Credit Display: Level #06 through 12
Display #1: Value of accounting item
Game Button: Increase value by 1. Hold to increase repeatedly.
Double Click: Set value to zero

Tests 06 through 15 cover number of credits, total number of games played, total number of free games won, number of times high score beat, and number of coins collected in chutes 2, 1, and 3. Click the game button to increase, or double-click to set these to zero.

If Free Play is selected below, the amount in Credits will still determine whether or not the credit light on the apron is lit, and there will be no other way to change it (very useful for me – this lights Ming's ring on my apron overlay!).

Accounting Items:

06: Credits
07: Total plays
08: Total replays
09: Number of times high score beat

10: Chute 2 coins
11: Chute 1 coins
12: Chute 3 coins

Game Settings

Tests 13 through 25 change certain game settings, as outlined below.

Credit Display: Game Setting Number (13 through 25)
Display #1, 2, and 3: Values of settings
Game Button: Increase value
Returns to minimum value after reaching maximum
Hold to increase repeatedly
Double Click: Set value to minimum
Coin Slot #3 Switch: Move to next value on screens with more than one value
(Sorry, I ran out of variations on the game button)

13: Number of times reaching skill shot levels 1, 2, and 3
14: Number of times reaching Final Battle
15: Number of times defeating Ming in Final Battle

16: Playfield Awards

	0	1	2	3
Left/Right Out Special	No Award	50,000	X-Ball*	One Credit**
Top Target Special	No Award	50,000	X-Ball*	One Credit**
Inline Drop-Target X-Ball	No Award	25,000	X-Ball*	X-Ball*
Up / down kicker X-Ball	No Award	25,000	X-Ball*	X-Ball*

17: Threshold Awards

	0	1	2	3
Scoring Thresholds	No Award	25,000	X-Ball*	One Credit**

* Points awarded if same player shoots again already lit, or maximum extra balls reached
** Points awarded if maximum credits reached

18: Background Sound On / Off

00: Background music or sounds will be silenced
01: Background will play

19: High Score Award

	0	1	2	3
High Score Exceeded	No Award	One Credit	Two Credits	Three Credits

20: Free Play

00: No free play. Coins must be inserted to play game.
01: Game can be started with the game button without inserting coins.

21: Personal Goal

00: Personal goal not to be used. Personal goal will not work without the latest Geeteoh board.
01: Personal goal to be used.

22: Final Battle Drop Target Goal

This is the number of drop targets (Ming's palace guards!) you must hit to activate the Final Battle. Any number from 1 to 25 can be entered. The original 2021 version set this to 16, although I find this high. I like 11, as there are 11 drop targets on the playfield, and Flash fought the guards as if they were 11 opponents on a football field. Eleven is also an achievable goal for a modest player! A lower value can also be a lot more fun for infrequent players or kids.

23: Final Battle Attack Goal

This is the number of points you must accumulate in order to attack Ming. Any multiple of 10 from 10 to 250 can be entered. The generally accepted value is 140 which is not unreasonable, although, again, you may want to lower it for more exciting play with infrequent players or kids.

24: Kids' Mode

The easy way to enter or leave Kids' Mode is to press the Game Button and Coin Slot 3 switch at the same time while in either Self-Test (other than during the Switch Test) or Attract Mode (hold both buttons until you hear the sound). This setting #24 may also be used. Set to 1 for Kids' Mode, or 0 for regular game play. To go back to regular game mode, either press the two buttons, or change setting #24 to 0. You can also simply turn the pinball off and on, as it will always start in regular game mode. Audio cues let you know which mode you are in.

Note that the high score in Kids' Mode starts at 100,000, allowing kids to compete for the day. When you return to regular game mode, through self-test or by turning the pinball off and on, the Kids' Mode high score will be gone, and the original high score as well as all the original settings will be reinstated.

Kids' Mode resets all the settings in the tables below:

DIP Switches
10K awarded for up / down kicker
Memory for up / down kicker lights
Memory for 2X / 3X bonus arrows
Memory for outlane specials
Memory for top level target lights
Memory for bonus multipliers

Memory for 2 side targets and flipper feed lane lights
Memory for drop target lights
Memory for 1 / 2 / 3 arrows
Unlimited free games
Unlimited extra balls from wood beast target
5 balls per game

Self-Test Game Settings	**Value**
High Score	100,000
Score Award 1	100,000
Score Award 2	200,000
Score Award 3	300,000
Personal Goal	150,000
Playfield Award	2 (Extra Ball)
Threshold Award	2 (Extra Ball)
Wizard Goal Targets	7
Wizard Goal Attack	100
Original Rules	0

Programmable Game Adjustments	**Value**
Ming lives in Final Battle	1
Ball Saves Allowed	5

25: Original Rules

The changes below have been made to certain game rules. However, some people may have a preference for the original rules. Self-test setting #25 can therefore be set to either zero, to follow the new rules, or 1 to keep the original rules. The rules affected currently include:

- 2X points for 15 seconds is collected by hitting all three flashing arrow drop targets on the top level. Original rules allow this only once per ball. By setting #25 Original Rules to zero, these drop targets will be reset immediately following the 15-second timer.
- Similarly, the 3X points for 15 seconds is collected by hitting all four flashing drop targets on the lower level, followed by their associated colored targets. Original rules allowed this only once per ball. By setting #25 Original Rules to zero, these drop targets will be reset immediately following the 15-second timer.
- Mini bonus points can be collected by hitting the upper-level target when lit. Original rules would then reset the points to zero, so they would have to be earned again. The new rules will retain these points, to be won again at the upper-level target, or at the end of ball.
- Similarly, super bonus points can be collected by entering the shooter lane. Original rules would then reset the points to zero, so they would have to be earned again. The new rules will retain these points, to be won again by re-entering the shooter lane, or at the end of ball.

Self-Test Information Tables

The following tables can be used, together with the self-test feature, to investigate the functioning of your pinball. These tables will assist you in determining the game feature being indicated by the values displayed during the tests.

List of Arduino Self-Tests

Ball in Play Display	Credit Display	Test / Setting
1		Lights
2		Displays
3		Solenoids
4		Stuck Switches
5		Switch Bounce
6		Sounds
7		DIP Switches
	1	Score Award Level 1
	2	Score Award Level 2
	3	Score Award Level 3
	4	High Score
	5	Personal Goal
	6	Credits
	7	Total Plays
	8	Total Replays
	9	High Score Beat
	10	Coins in Chute 2
	11	Coins in Chute 1
	12	Coins in Chute 3
	13	Number of times reaching skill shot levels 1, 2, and 3
	14	Number of times reaching Final Battle
	15	Number of times defeating Ming in Final Battle
	16	Playfield Awards - none, points, extra ball, or Credit (0, 1, 2, or 3)
	17	Threshold Awards - none, points, extra ball, or Credit (0, 1, 2, or 3)
	18	Background Sound Off or On (0 or 1)
	19	High Score Award (0, 1, 2, or 3 credits)
	20	Free Play Off or On (0 or 1)
	21	Personal Goal Off or On (0 or 1)
	22	Number of targets to hit in order to qualify for Final Battle (up to 25)
	23	Number of points required to defeat Ming (140 recommended)
	24	Kids' Mode Off or On (0 or 1)
	25	Original Rules Off or On (0 or 1)

Lights

No.	Light	No.	Light
0	Mini 1	44	10,000
1	Mini 2	45	20,000
2	Mini 3	46	Extra Ball (Up/Down Kicker)
3	Mini 4	47	5X (Drop Targets)
4	Mini 5	48	Backbox Ball in Play
5	Mini 6	49	Backbox High Score to Date
6	Mini 7	50	Backbox Game Over
7	Mini 8	51	Backbox Tilt
8	Mini 9	52	Top Pop Bumper
9	Mini 10	53	Extra Ball (Wood Beast Ramp)
10	Right Spinner Arrow	54	30,000
11	Left Spinner Arrow	55	Collect Bonus (Upper Level)
12	Super 1	56	Right Outlane Special
13	Super 2	57	Left Outlane Special
14	Super 3	58	Rollover 1
15	Super 4	59	Special (Upper Level)
16	Super 5	60	Rollover 2
17	Super 6	61	Rollover 3
18	Super 7	62	Rollover 4
19	Super 8	63	Rollover 5
20	Super 9	64	Backglass Flash 1
21	Super 10	65	Backglass Flash 2
22	Mini Bonus	66	Backglass Flash 3
23	Super Bonus	67	* not used
24	2X	68	Backglass Gordon 1
25	3X	69	Backglass Gordon 2
26	4X (Lower Level)	70	Backglass Gordon 3
27	5X	71	* not used
28	1 Arrow	72	Observers Plastic (Lower)
29	2 Arrow	73	Observers Plastic (Upper)
30	3 Arrow	74	* not used
31	4X (Upper Level)	75	Backbox Strobe
32	Target Amber	76	3X 15 Second Clock
33	Target Yellow	77	2X 15 Second Clock
34	Target Blue	78	3X Arrow
35	Target White	79	2X Arrow
36	Right Target (Lower)	80	* not used
37	Right Inner Lane	81	* not used
38	Left Inner Lane	82	* not used
39	Right Target (Upper)	83	* not used
40	Backbox Shoot Again	84	* not used
41	Backbox Match	85	* not used
42	Shoot Again	86	* not used
43	Apron Credit Indicator	87	* not used

Solenoids

No.	Solenoid
0	4 Drop Targets Down (Lower Level)
1	3 Drop Targets Down (Upper Level)
2	Inline Drop Targets Down
3	Up / Down Kicker: Kick Down
4	* not used
5	Knocker
6	Outhole Kicker
7	Up / Down Kicker: Kick Up
8	Single Target Reset (Up)
9	Left Pop Bumper
10	Right Pop Bumper
11	Single Drop Target Down
12	Top Pop Bumper
13	Left Sling Shot
14	Right Sling Shot
15	Coin Lockout Door (not included in tests)
16	K1 Relay Flipper Enable (not included in tests)

Switches

No.	Switch
0	2 Left and Right Rollover Buttons
1	3 Shooter Lane Rollover Buttons
2	Top Single Drop Target
3	Shooter Lane Rollover Switch
4	Drop Targets 50 Point Rebound (2)
5	Credit Button
6	Tilt
7	Outhole
8	Coin 3 (Right)
9	Coin 1 (Left)
10	Coin 2 (Center)
11	Bottom Right-Side Target
12	Flipper Feed Lane (Right)
13	Flipper Feed Lane (Left)
14	Top Right-Side Target
15	Slam (3)
16	4 Drop Target “A” (Bottom)
17	4 Drop Target “B”
18	4 Drop Target “C”
19	4 Drop Target “D” (Top)
20	3 Drop Target “A” (Top)
21	3 Drop Target “B”
22	3 Drop Target “C” (Bottom)
23	Top Target
24	1st Inline Drop Target
25	2nd Inline Drop Target
26	3rd Inline Drop Target
27	Inline Wood Beast Target
28	10 Point Rebound (2)
29	Up / Down Kicker
30	Right Outlane
31	Left Outlane
32	Right Spinner
33	Left Spinner
34	Right Slingshot
35	Left Slingshot
36	Top Pop Bumper
37	* not used
38	Right Pop Bumper
39	Left Pop Bumper

Switch Matrix

0: Two Left and Right Rollover Buttons (4)	8: Coin 3 (No Diode!)	16: 4 Drop Target "A" (Bottom)	24: 1st Inline Drop Target	32: Right Spinner
1: Three Shooter Lane Rollover Buttons (3)	9: Coin 1 (No Diode!)	17: 4 Drop Target "B" (Lower Mid)	25: 2nd Inline Drop Target	33: Left Spinner
2: Single Drop Target	10: Coin 2 (No Diode!)	18: 4 Drop Target "C" (Upper Mid)	26: 3rd Inline Drop Target	34: Right Slingshot
3: Shooter Lane Rollover (1)	11: Right Side Lower Target	19: 4 Drop Target "D" (Top)	27: Inline Back Target	35: Left Slingshot
4: Drop Targets, 50 Point Rebound (2)	12: Flipper Feed Lane (Right)	20: 3 Drop Target (Top)	28: 10 Point Rebound	36: Top Thumper Bumper
5: Credit/Game Button	13: Flipper Feed Lane (Left)	21: 3 Drop Target (Middle)	29: Saucer	37: Not Used
6: Tilt	14: Right Side Upper Target	22: 3 Drop Target (Bottom)	30: Right Outlane	38: Right Thumper Bumper
7: Outhole	15: Slam (3)	23: Top Target	31: Left Outlane	39: Left Thumper Bumper

Notes:

1. The coin 1, 2, and 3 switches do not have diodes. This means, if used during a game, they could cause a switch matrix issue. They are also handy for testing and understanding switch matrix issues for this reason.
2. There is no switch 37. However, it can be "switched on" through a switch matrix issue!
3. The columns are labeled ST 0 through 4 (ST for strobe), and are wired to the MPU board through connector pins A4J2-1 through 5.
4. The rows are labeled I 0 through 7 (I for input), and are wired to the MPU board through connector pins A4J2-8 through 15.

Sounds and Their Lengths (in Quarter Seconds) for Squawk and Talk

No.	Timing	Sound	No.	Timing	Sound
0	0		26	0	Crash bounce down
1	0		27	0	Crash bounce up
2	0		28	0	Outlanes
3	0		29	0	Crash
4	0	Humm (low)	30	0	Background sound 6
5	0	Sound off	31	0	Background sound 7
6	1	Background sound 1	32	0	Ding 1
7	0	Rebound hit	33	0	Ding 2
8	0	Spinner humm medium	34	0	Ding 3
9	0	Spinner humm low	35	0	Ding 4
10	1	Timer sound	36	0	Background sound 8
11	0	Background sound 2	37	0	Background sound 9
12	0	Boink up high	38	0	Background sound 10
13	0	Boink up low	39	0	Background sound 11
14	0	Background sound 3	40	15	"Ignite death ray, 15 seconds"
15	0	Background sound 4	41	52	Ming laugh five times
16	2	Alarm	42	10	"Lucky shot Earthling"
17	6	Low grumble	43	8	"Miserable Earthling"
18	0	Up / down kicker	44	8	"Emperor Ming awaits"
19	0	Background sound 5	45	6	"Flash"
20	0	Drop target hit	46	10	"Try again Earthling"
21	0	Beep beep hit	47	8	"15 seconds"
22	13	Up / down kicker	48	7	"Miserable Earthling"
23	13	Up / down kicker	49	6	"Flash"
24	0	Bong bounce down	50	10	Ming laugh (single)
25	0	Bong bounce up	51	8	"15 seconds"

Sounds, Geeteoh Board

Arduino	Gee-teoh	Sound	Ard-uino	Gee-teoh	Sound
0	255		26	229	Zap (Electric)
1	254		27	228	Look out Flash!
2	253		28	227	What a Damn Nuisance!
3	252		29	226	Zap Sound, Down
4	251	This way Flash, come on!	30	225	Match sound
5	250	Not used by Geeteoh	31	224	Your power's fading, Ming
6	249	Flash by Queen, instrumental	32	223	Tone
7	248	Blaster	33	222	Tone+
8	247	Ray Gun	34	221	Tone++

Arduino	Gee-teoh	Sound	Ard-uino	Gee-teoh	Sound
9	246	Low hum	35	220	Tone+++
10	245	15 second alarm	36	219	Oh Dear, How Pathetic
11	244		37	218	You've saved your Earth. Have a nice day. Yeah!
12	243	Ascending, low	38	217	Kid Ming laugh
13	242	Ascending, high	39	216	Kids cheering
14	241		40	215	Open fire, all weapons!
15	240		41	214	Gently Darling, it's extremely sensitive… like me!
16	239	Old Alarm	42	213	Very roughly, 14 seconds!
17	238	Switches over there, start hitting them!	43	212	The attack has begun!
18	237		44	211	Gordon's alive!
19	236		45	210	Flash!
20	235	Ming's Ring	46	209	You've saved your Earth. Have a nice day. Yeah!
21	234	Ray Gun	47	208	Gordon's alive!
22	233	Escape is impossible!	48	207	Oh dear…
23	232		49	206	Flash!
24	231	Bounce (Low)	50	205	Ming laugh!
25	230	Bounce (High)			

73	182	Oh, dear…	84	171	Background music for Skill Shot
74	181	Wood Beast roar!	85	170	Try the Wood Beast, or die!
75	180	Oh, Flash	86	169	Remove the Earth Woman. Forget it Ming, Dale's with me!
76	179	How? By Magic, of course.	87	168	This place is a lunatic asylum!
77	178	Don't kill him yet, father.	88	167	Football alarm, end
78	177	15-second hurry-up timer	90	165	Stop all sounds
79	176	5-second hurry-up timer	94	161	Oh, well. Who wants to live forever?
83	172	Background music for Final Battle	95	160	Oh, dear. How pathetic.
			254	1	This way Flash, come on!

Sounds and Triggering Events

Sound	Trigger / Switch
04	Final Battle goal (11 drop targets hit) achieved.
05	Used a lot for Squawk & Talk. Turns off other sounds. Not used for Geeteoh.
06	Background music during regular game play (see 83 and 84 below).
07	Shooter Lane during normal play (Geeteoh only). Drop target rebound. Spinners in Final Battle. Every ball except the first as it is fired into the shooter lane.
08	Start Attract Mode. Unlit left and right spinners. End of Bonus Countdown.
09	Lit left and right spinners.
10	15-second alarm. 2X / 3X Bonus activation, by falling in up / down kicker.
11	End of 15-second bonus (no sound currently assigned).
12	Mini-Bonus, Super-Bonus collection.
13	Playfield rollover buttons. Shooter lane rollover buttons. 3 Drop targets or 3 drop target rebound during skill shot. Top target during skill shot.
17	Outer 2 of 4 drop targets hit while flashing.
18	Player added (Squawk & Talk only). Shooter Lane during normal play (Squawk & Talk only).
20	Pop bumpers during normal game play. Player added (Geeteoh only).
21	Slingshots during normal game play.
22	Up / down kicker, no 15-second bonus.
24	Final Battle sound for all non-Final Battle game targets. 4 drop targets when light off. 3 drop targets when unhit.
25	Final Battle sound for up / down kicker and pop bumpers. 3 drop targets when hit. 4 drop targets hit during hurry up or later. Inline drop targets during normal game play.
26	Shooter lane in Final Battle. 4 colored targets before flashing drop target hit.
27	Inner 2 of 4 colored targets after hurry up collected. Top target during normal game play. Hitting the Wood Beast during normal game play.
28	Out lanes during normal game play.
29	Single drop target hit.

Sounds and Triggering Events (Continued)

Sound	Trigger / Switch
30	Match sound.
31	Ming loses a life (but not last life).
32-35	Ding noises. Used for Ming Defeat Celebration at end of Final Battle. Used if multiple coins charged per credit.
38	Game purchased (Kids' Mode). Game button if Free Play turned on (Kids' Mode). Change to Kids' Mode within Self-Test or Attract Mode.
39	End of game (Kids' Mode).
40	Not currently used.
41	Tilt.
42	Shooter lane after skill shot made (S&T only). 2X bonus requirements met. Up / down kicker during Final Battle, but not the final shot (S&T only).
43	3X bonus requirements met. First ball of Final Battle (Geeteoh only).
44	Every five minutes in attract mode (S&T only).
45	Right side targets hit during hurry up. Up / down kicker during Final Battle, but not the final shot (Geeteoh only). Final Battle, attack ready (spinners or pop bumpers).
46	End of game, if personal goal not set. Ming defeated (Geeteoh only).
47	First ball of game.
48	Lower right-side targets not hit within 15 seconds. Spinners not hit within 5 seconds of flipper feed lane activation. Ming defeated (S&T only). First ball of Final Battle (S&T only).
50	Game purchased. Game button if Free Play turned on. Ball lost down the out lanes during Final Battle. Enter Final Battle through out lanes. Change from Kids' Mode to regular game mode within Self-Test or Attract Mode.
74	Hitting the Wood Beast target.
75	Hitting the single drop target.
78, 79	5 and 15 second timers for lower-level drop targets. Not currently functional.
83	Background music for Final Battle.
84	Background music during Skill Shot.
85	Hitting the third inline target.
86	Up / down kicker, at start of 2X / 3X bonus, 3770 ms before alarm begins.
87	3X bonus requirements met.
88	14750 ms after 15 second alarm begins.

Sounds and Triggering Events (Continued)

Sound	Trigger / Switch
90	Stops all background sounds. Used at various times throughout gameplay.
94	End of game. Played if personal goal is met.
95	End of game. Played if personal goal not met.
254	Every five minutes in attract mode (Geeteoh only). Shooter lane after earning skill shot points. Knocking down required drop targets to enter Final Battle.

DIP Switches

The original Bally/Stern MPUs had 32 DIP switches for the purpose of customizing the games. Most, if not all, replacement boards have the same switches. The Arduino reads the settings of these switches, and uses them in similar, if not identical fashion. See the explanations and table below for information on individual switches.

No.	Switch
1	Games per coin (or coins per game) for coin chute #1. Switches 1 – 5.
2	"
3	"
4	"
5	"
6	10K awarded for up / down kicker if on. No points until lights activated if off.
7	Memory for up / down kicker lights. Off for conservative play.
8	Memory for 2X / 3X bonus arrows. Off for conservative play.

9	Games per coin (or coins per game) for coin chute #3. Switches 9 – 13.
10	"
11	"
12	"
13	"
14	Memory for outlane specials. Off for conservative play.
15	Memory for top level target lights. Off for conservative play.
16	Memory for bonus multipliers. Off for conservative play.

17	Games per coin (or coins per game) for coin chute #2. Switches 17 – 20.
18	"
19	"
20	"
21	Attract voice on or off.
22	Memory for 2 side targets and flipper feed lane lights. Off for conservative play.
23	Memory for drop target lights. Off for conservative play.
24	Memory for 1 / 2 / 3 arrows. Off for conservative play.

25	Maximum credits allowed. Switches 25 and 26.
26	"
27	Credits displayed on or off.
28	Match on or off.
29	Unlimited free games if on. One free game per game if off.
30	Unlimited extra balls from wood beast target if on. One per game if off.
31	Balls per game. Switches 31 and 32.
32	"

Payment for Games: Switches 01 – 05, 09 – 13, and 17 – 20

The first five switches are used together to set the number of credits per coin, or coins per credit, for coins dropped into coin chute #1. The original machines set up 32 different payment schemes, most of which were likely never used (seven credits for four coins? Really?), and are even less likely to be in use today, so the options have been paired down, and in some cases modified slightly.

Switches 09 – 13 are set up the same, setting the credits per coin for coin chute #3. Switches 17 – 20 are set up slightly differently, for coin chute #2.

No.	**Switches**					**Credits / Coin**	**Original Game Setting**
Chute #1	**5**	**4**	**3**	**2**	**1**	**(in bold if different**	**than original)**
Chute #3	**13**	**12**	**11**	**10**	**9**		
1	OFF	OFF	OFF	OFF	OFF	1 Credit / 1 Coin	1 Credit / 1 Coin
2	OFF	OFF	OFF	OFF	ON	2 Credits / 1 Coin	2 Credits / 1 Coin
3	OFF	OFF	OFF	ON	OFF	3 Credits / 1 Coin	3 Credits / 1 Coin
4	OFF	OFF	OFF	ON	ON	4 Credits / 1 Coin	4 Credits / 1 Coin
5	OFF	OFF	ON	OFF	OFF	5 Credits / 1 Coin	5 Credits / 1 Coin
6	OFF	OFF	ON	OFF	ON	6 Credits / 1 Coin	6 Credits / 1 Coin
7	OFF	OFF	ON	ON	OFF	7 Credits / 1 Coin	7 Credits / 1 Coin
8	OFF	OFF	ON	ON	ON	8 Credits / 1 Coin	8 Credits / 1 Coin
9	OFF	ON	OFF	OFF	OFF	9 Credits / 1 Coin	9 Credits / 1 Coin
10	OFF	ON	OFF	OFF	ON	**10 Credits / 1 Coin**	**12 Credits / 1 Coin**
11	OFF	ON	OFF	ON	OFF	**11 Credits / 1 Coin**	**14 Credits / 1 Coin**
12	OFF	ON	OFF	ON	ON	1 Credit / 2 Coins	1 Credit / 2 Coins
13	OFF	ON	ON	OFF	OFF	2 Credits / 2 Coins	2 Credits / 2 Coins
14	OFF	ON	ON	OFF	ON	3 Credits / 2 Coins	3 Credits / 2 Coins
15	OFF	ON	ON	ON	OFF	4 Credits / 2 Coins	4 Credits / 2 Coins
16	OFF	ON	ON	ON	ON	5 Credits / 2 Coins	5 Credits / 2 Coins
17	ON	OFF	OFF	OFF	OFF	6 Credits / 2 Coins	6 Credits / 2 Coins
18	ON	OFF	OFF	OFF	ON	7 Credits / 2 Coins	7 Credits / 2 Coins
19	ON	OFF	OFF	ON	OFF	8 Credits / 2 Coins	8 Credits / 2 Coins
20	ON	OFF	OFF	ON	ON	9 Credits / 2 Coins	9 Credits / 2 Coins
21	ON	OFF	ON	OFF	OFF	**10 Credits / 2 Coins**	**12 Credits / 2 Coins**
22	ON	OFF	ON	OFF	ON	**11 Credits / 2 Coins**	**14 Credits / 2 Coins**

23	ON	OFF	ON	ON	OFF	**3 Credits / 2 Coins**	**1+2 (3) Credits on 2 Coins**
24	ON	OFF	ON	ON	ON	**3 Credits / 4 Coins**	**0+1+1+1 Credits on 4 Coins**
25	ON	ON	OFF	OFF	OFF	**3 Credits / 4 Coins**	**0+1+0+2 Credits on 4 Coins**
26	ON	ON	OFF	OFF	ON	**5 Credits / 4 Coins**	**1+1+1+2 Credits on 4 Coins**
27	ON	ON	OFF	ON	OFF	**7 Credits / 4 Coins**	**1+2+1+3 Credits on 4 Coins**
28	ON	ON	OFF	ON	ON	**7 Credits / 4 Coins**	**1+2+2+2 Credits on 4 Coins**
29	ON	ON	ON	OFF	OFF	1 Credit / 1 Coin	1 Credit / 1 Coin
30	ON	ON	ON	OFF	ON	1 Credit / 1 Coin	1 Credit / 1 Coin
31	ON	ON	ON	ON	OFF	1 Credit / 1 Coin	1 Credit / 1 Coin
32	ON	ON	ON	ON	ON	1 Credit / 1 Coin	1 Credit / 1 Coin

No.	**Switches**				**Credits / Coin**
Chute #2	**20**	**19**	**18**	**17**	
1	OFF	OFF	OFF	OFF	Same as chute #1
2	OFF	OFF	OFF	ON	1 Credit / 1 Coin
3	OFF	OFF	ON	OFF	2 Credits / 1 Coin
4	OFF	OFF	ON	ON	3 Credits / 1 Coin
5	OFF	ON	OFF	OFF	4 Credits / 1 Coin
6	OFF	ON	OFF	ON	5 Credits / 1 Coin
7	OFF	ON	ON	OFF	6 Credits / 1 Coin
8	OFF	ON	ON	ON	7 Credits / 1 Coin
9	ON	OFF	OFF	OFF	8 Credits / 1 Coin
10	ON	OFF	OFF	ON	9 Credits / 1 Coin
11	ON	OFF	ON	OFF	10 Credits / 1 Coin
12	ON	OFF	ON	ON	11 Credits / 1 Coin
13	ON	ON	OFF	OFF	12 Credits / 1 Coin
14	ON	ON	OFF	ON	13 Credits / 1 Coin
15	ON	ON	ON	OFF	14 Credits / 1 Coin
16	ON	ON	ON	ON	15 Credits / 1 Coin

Switch 06: Up / down kicker 10,000 points option:

Liberal	On	10K is awarded each time up/down kicker is hit
Conservative	Off	no points for up/down kicker until lights activated

Switch 07: Up / down kicker lights memory

Liberal	On	Earned value is maintained till next ball
Conservative	Off	Value is reset for next ball

Switch 08: 2X / 3X bonus arrows

Liberal	On	Stay lit for next ball
Conservative	Off	Reset for next ball

Switch 14: Memory for outlane specials

Liberal	On	Lit outlane lights will come on for next ball (excluding Final Battle)
Conservative	Off	Outlane lights reset for next ball

Switch 15: Memory for top special

Liberal	On	Top level target lights stay on for next ball
Conservative	Off	Top level target lights reset for next ball

Switch 16: Memory for 2X, 3X, 4X, and 5X bonus multipliers

Liberal	On	Earned bonus continues on next ball
Conservative	Off	Bonus reset for each ball

Switch 21: Attract Sound

Fun Setting	On	Sound plays every five minutes in attract mode
Quiet-No Fun	Off	No sound in attract mode

Switch 22: Memory for Two Right-Side Targets and Flipper Feed Lanes *

Liberal	On	Lights remain lit on next ball
Conservative	Off	Lights reset for each ball

* Note that, since these lights work together with the four drop targets controlled by DIP switch 23, turning on DIP 22 necessarily means DIP 23 is also effectively on as well.

Switch 23: Memory for four drop targets. Off for conservative play *

Liberal	On	Drop target lights remain lit on next ball
Conservative	Off	Lights reset for each ball

* Turning on DIP 23 does ***not*** mean that DIP 22 is also effectively on. The drop target lights can be set independently.

Switch 24: Memory for Upper Level 1 / 2 / 3 Arrows

Liberal	On	Any lit arrow continues on next ball
Conservative	Off	Arrows reset for each ball

Switches 25 and 26: Maximum credits allowed (as per original Bally manual):

Maximum	**Switches**	
Credits	**26**	**25**
10	OFF	OFF
15	OFF	ON
25	ON	OFF
40	ON	ON

Switch 27: Credits displayed on or off

Switch 28: End of game match feature on or off

Switch 29: Unlimited free games (limits not applied to match and high score awards)

Liberal	On	All free games earned will be collected
Conservative	Off	Only one free game per game allowed. Points awarded thereafter.

Switch 30: Unlimited extra balls from the Wood Beast

Liberal	On	One extra ball available to be won for each ball in play
Conservative	Off	Only one extra ball per game. Points awarded thereafter.

Switches 31 and 32: Balls per game (as per original Bally manual):

Balls per	Switches	
Game	32	31
5	OFF	ON
4	ON	OFF
3	OFF	OFF
2	ON	ON

(BTW, do the values in this table look odd to you? Like, the guy who set up this table didn't really get binary? The way that, like, the guy responsible for the previous table did?)

User Programmable Changes*

The original FG2021 program included a section titled "Operator Game Adjustments", which can still be found at the top of the main program (following the version history). Most of the really useful items originally included here have been converted to Self-Test adjustments. The following items remain, or have since been added. If you are familiar with programming and are able to compile the software to your Arduino, you may want to look at these potential changes:

USE_STROBE: Usually 1, to use the back glass strobe. Set to zero to not use the strobe.
MAX_TILT_WARNINGS: Usually 1. Set higher if you wish to allow some number of tilts before ending a ball.

BALL_SAVES: The number of ball saves allowed per game. Usually 1.
BALL_SAVE_SCORE: The maximum score at which ball save is active. Usually 1500.
BALL_SAVE_NUM_MS: The maximum time during which ball save is active. Usually 15000 (i.e., 15 seconds). This may seem high, but it includes time spent on the skill shot.

STOP_THE_MUSIC: There are a number of reasons why you may find it useful to be able to stop the background music during a game. With this variable set to 1, pressing the game button during a game will handle this by ending the current background music. Note that, even with this variable set to 1, pressing the game button before a game has begun will add players as usual.

MAX_HEALTH: Number of times Ming must be defeated in Final Battle. Usually 3, maximum 4.
ATTRACT_SPEECH_TIMER: Time between attract mode callouts. Usually 5 minutes.
RPU_OS_USE_GEETEOH: If defined, the program will expect a Geeteoh sound board. Comment out this line if you do not have this board.

* This section assumes some minimal programming skill on your part. If you are uncomfortable with making changes to the program, maybe skip this section! In any case, always save a copy of the program before making changes.

VERSION_NUMBER: The program expects a version number in the format yyyy.mm, representing the year and month of your changes. This version number is displayed when the pinball is turned on. If you are modifying the program, you should likely copy the software to a new directory named FGyyyypmm, and rename the two files that use this naming format. Then change this version number in the software to make clear which version is running.
DEBUG_MODE: There are a number of programmable features available to assist you in identifying and possibly eliminating some common pinball issues. Currently there are three debug modes, available by setting DEBUG_MODE to one of the following values:

0. Set to zero to indicate no debug messages are required (regular game play).
1. Monitor the switches as they are hit. The most recent nine switches are scrolled through the player 2, 3, and 4 displays.
2. Display the number of times per second the switches are monitored. Player 4 display is used. (I found the result to be about 180 to 200 times a second).

By playing a single player game with debug mode 1 set, you can monitor the switches being activated in real time. This can be very useful if you are experiencing switch issues. Note that it must be a single player game, as the player 2, 3, and 4 displays are used to display the switch values. Each 7-digit display will show three two-digit switch numbers. The most recent switch is displayed in the last two digits of Player 4, and will scroll left and up as new switches are hit.

Pressing and holding the game credit button will stop the monitoring of new switch hits, for as long as you hold the button. This allows you to stop the numbers from scrolling away, so you can review them more closely.

Debug mode can be used to track down issues with switches misfiring. Depending on the problem, the following may be helpful in eliminating the issue. Try cleaning and re-gapping the switches first, but if this fails to resolve the issue you may want to try the following:

SwitchDebounce[]: This variable can be found near the top of the main program, shortly following the Operator Game Adjustments. It contains 40 rows, one for each switch, and two columns. It is used in monitoring the switches for multiple hits. Occasionally, a switch can develop a “bounce”, where it registers two or more times for a single hit by a pinball. By setting a value from 0 to 255 in the second column, the pinball will ignore any hits on that switch for that number of milliseconds following an initial hit.

For example, I was having trouble with the left outlane rollover (switch 31) registering multiple times whenever it was hit. This messes up the scoring, giving the player thousands of points they did not earn. To fix this I set column 2 of row 31 to 250. So now, after the switch is hit it will not register another hit for at least 250 milliseconds.

The Switch Bounce Test can be used to test switches for bounce. See the Switch Bounce Test documentation in the Self-Test section of this document. This test will also tell you the time between double-hits, which can be used as a minimum value in setting the second column of this variable.

ResetHits[]: This variable can also be found near the top of the main program, right after the SwitchDebounce[] variable. It contains 17 rows, one for each solenoid, and 2 columns. It is used to eliminate switches from activating due to vibration from solenoids firing. Similar to SwitchDebounce[], a value from zero to 255 can be set in the second column, causing the pinball to ignore hits to specific switches for the indicated number of milliseconds following a solenoid firing.

To make this work, you also need to indicate which switches are to be ignored following which solenoid firing. This is done by adding code to the function ResetHitFix(). There are several examples of the required code in the function already, which you can use to model your own.

For example, suppose the upper-level pop bumper (SO_POP_TOP, solenoid 12) seems to be setting off the target next to it (SW_TARGET_TOP) every time it is hit. You've tried cleaning and re-gapping the target switch but can't seem to get it to stop. To fix this you can set row 12 (SO_POP_TOP), column 2 of ResetHits[] to 250. Then add the following code to ResetHitFix():

```
case SW_TARGET_TOP:
    if (CurrentTime < ResetHits[SO_POP_TOP].start) return false;
    if (CurrentTime - ResetHits[SO_POP_TOP].start
            < ResetHits[SO_POP_TOP].wait) return true;
    return false;
```

This says, if the upper-level target is hit, and the firing time of the upper-level pop bumper is passed, check how long it has been since the pop bumper fired. If less that 250 milliseconds ago, the switch hit is to be ignored (return true).

There are several examples like this in the function, so a user with very basic programming skills should be able to follow. Coding has already been added to prevent any drop target solenoid from setting off its own drop target switches.

Setting the Wait Time: Both SwitchDebounce[] and ResetHits[] depend on you setting a "wait" time. This is the time between events during which the pinball will ignore specific switches. The wait time must be longer than the time it takes for vibration to set off the second switch hit, but shorter than the time it can take for a switch to be hit legitimately, with a maximum of 255ms.

250ms, or a quarter of a second, is generally a good choice.

The time between a solenoid firing, and a switch being activated by vibration, can be determined in the Solenoid self-test. The time taken for a switch bounce can similarly be determined in the Switch Bounce self-test. The results of these tests would be the absolute minimum value you should use for the wait time, although you likely want something higher.

For example, I had a drop target that would frequently set off a target switch on the other side of the playfield. It would be impossible to activate the drop target solenoid and then the target switch in less than several seconds, much longer than the maximum 255ms. The solenoid test showed that it took about 133ms between the drop target reset until the switch would activate. The wait time could then be an absolute minimum of 133, up to a maximum of 255. I therefore set the wait time to 250, allowing extra time over and above the absolute minimum.

Generally, a longer time is better, since the wait time could be longer than that given by the Solenoid or Switch Bounce test. Where it could be more difficult is when the solenoid and the target switch are close together. For example, a pop bumper that can shoot the ball directly into a switch. If the pop bumper is sometimes setting off the switch without hitting it, you will need to determine not only the minimum time from the solenoid test, but also a maximum time based on how long it can take the ball to travel from the pop bumper to the switch. If this is less than a quarter second, you may need to do some careful timing calculations.

Other Programming Changes

Use Squawk and Talk:

The software is designed to be used with either an original Bally Squawk and Talk sound board, or a Geeteoh replacement sound board. It is usually provided with the Geeteoh option turned on, as the sound options available with the Geeteoh board are one of the main reasons people want to use this software. However, if you do not have a Geeteoh board and are unhappy with the sound, try the following change:

In the file FGyyyypmm.ino, find this row (very close to the top, in the Operator Game Adjustments):

```
#define RPU_OS_USE_GEETEOH
```

Change this to read:

```
//#define RPU_OS_USE_GEETEOH
```

Kids' Mode:

Kids' Mode is described above in Self-Test section 24, and is meant to allow you to convert the game to easy settings, primarily for kids to play. However, another use of this might be to allow players with different setting preferences to share a pinball machine. In this case, you might not want ALL the settings at easy levels, only some of them.

This would be easy to do. There is a function KidSettings() at the end of the main program file. By commenting out or rewriting the lines in this function, Kids' Mode can be adapted to the alternative game settings you prefer. Comparing the variable names in the software to the items in Self-Test section 24 should make it obvious what changes need to be made.

Notes

DIP Switches: The DIP switches for the Arduino have been set up to be as identical to the switches for the regular game as possible. So simply installing the Arduino in your pinball should have it run according to the rules you are familiar with. See the original Bally Flash Gordon manual for more information on the DIP switches, and on the self-tests and game settings.

A new test has been added to the self-tests, to display and change the DIP switch settings easily, but temporarily. See the Self-Test section above for more information.

Self-Test Settings: The original self-test settings, set on your Flash Gordon MPU, are not used by the Arduino. The first thing you should do after installing the Arduino and before playing a game is to enter Self-Test, and update all the game settings to the values you desire.

Final Battle Drop Target Goal (Self-Test #22): This is the number of drop targets (Ming's palace guards!) you must hit to activate the Final Battle. Any number from 1 to 25 can be entered. The generally accepted value is 11, although lower can be a lot more fun for infrequent players or kids. I like 11, as there are 11 drop targets on the playfield, and Flash fought the guards as if they were 11 opponents on a football field.

Final Battle Attack Goal (Self-Test #23): This is the number of points you must accumulate in order to attack Ming. Any multiple of 10 from 10 to 250 can be entered. The generally accepted value is 140, although, again, you may want to lower it for more exciting play with infrequent players or kids (or try Kids' Mode).

Match Feature: Flash Gordon has a ball-match feature at the end of game, to win a free play. The original game played a sound several times in an echo-effect while determining the match. The 2021 code attempted to replicate this, but instead creating a sound I felt was simply annoying. I was also unable to reproduce the original, but have created something I hope is acceptable. If you are a match-sound purist, please feel free to reprogram it and let me know how you do!

Kids' Mode: A new feature has been added known as Kids' Mode, that changes all game settings to their easiest settings temporarily. See the Game Settings section above for more information.

Switch to Original: It is possible to add a switch to the Arduino, on long wires running from the 2-pin connector labeled "Switch", and then out the air vents at the back, so that you will be able to easily switch back and forth between the new and old rules. But don't bother. You are never going to want to play the old rules again!