



Bally
(R)

GAME 1215

FLASH GORDON
ARDUINO GAME VERSION FG2025.12
BY DAVE'S THINK TANK

Table of Contents

INTRODUCTION TO FLASH GORDON 2025.12.....	1
IMPORTANT NOTES!	1
SOUND BOARDS.....	1
ADDING MUSIC FROM THE FILM.....	1
USING A STROBE	1
NEW RULES.....	2
THE BASICS	2
SKILL SHOT.....	2
FINAL BATTLE - DEFEAT EMPEROR MING	2
FAMILIAR RULES FROM THE ORIGINAL GAME.....	3
RULE CHANGES AND NEW FEATURES SINCE 2021.....	3
LARGE SCORING	4
FINAL BATTLE SCORING	5
GAME INDICATORS	5
CREDIT DISPLAY	5
LIGHT RINGS.....	5
FLASHING LIGHTS	6
LIGHT PATTERNS	6
MUSIC	6
VOICES.....	7
INSTALLING, COMPILING, AND UPLOADING TO THE ARDUINO	8
HARDWARE REQUIREMENTS.....	8
SOFTWARE REQUIREMENTS.....	8
HARDWARE INSTALLATION	8
SOFTWARE AND SOUND FILE INSTALLATION.....	8
COMPILING AND UPLOADING THE SOFTWARE	9
BEFORE YOU PLAY	10
ARDUINO SELF-TESTS	11
THE GAME BUTTON, AND THE COIN SLOT 3 SWITCH.....	11
LIGHT TEST.....	11
DISPLAY TEST.....	12
SOLENOID TEST	13
<i>New Features:</i>	13
STUCK SWITCH TEST	13
DETECTING SWITCH MATRIX ISSUES.....	14
SWITCH BOUNCE (DOUBLE-HIT) TEST	14
SOUND TEST.....	15
DIP SWITCH TEST.....	15
SETTING AWARD LEVELS 01, 02, AND 03, HIGH SCORE, AND PERSONAL GOAL	16
ACCOUNTING INFO	17
ACCOUNTING ITEMS (6, 7, 8, AND 9)	17
10: COIN COUNT FOR COIN CHUTES 1, 2, AND 3	17

GAME SETTINGS.....	18
11: BALL SAVE SETTINGS	18
12: RELATIVE VOLUME SETTINGS (BACKGROUND MUSIC, SOUND EFFECTS, AND VOICES)	18
TESTS 13 THROUGH 25 CONTROLS	19
13: Number of times reaching skill shot levels 1, 2, and 3	19
14: Number of times reaching Final Battle.....	19
15: Number of times defeating Ming in Final Battle	19
16: Playfield Awards	19
17: Threshold Awards	19
18: Background Sound On / Off.....	19
19: High Score Award	20
20: Free Play	20
21: Personal Goal.....	20
22: Final Battle Drop Target Goal.....	20
23: Final Battle Attack Goal.....	20
24: Kids' Mode	20
25: Original Rules.....	22
SELF-TEST INFORMATION TABLES	23
LIST OF ARDUINO SELF-TESTS	23
LIGHTS	24
SOLENOIDS.....	25
SWITCHES	26
SWITCH MATRIX	27
EXTENDED SOUNDS FOR GEETEOH AND WAV TRIGGER BOARDS.....	28
SQUAWK AND TALK SOUNDS AND THEIR LENGTHS (IN TENTHS OF A SECOND).....	30
DIP SWITCHES	31
PAYMENT FOR GAMES: SWITCHES 01 – 05, 09 – 13, AND 17 – 20.....	32
SWITCH 06: UP / DOWN KICKER 10,000 POINTS OPTION:	33
SWITCH 07: UP / DOWN KICKER LIGHTS MEMORY	33
SWITCH 08: 2X / 3X BONUS ARROWS.....	33
SWITCH 14: MEMORY FOR OUTLANE SPECIALS.....	33
SWITCH 15: MEMORY FOR TOP SPECIAL	33
SWITCH 16: MEMORY FOR 2X, 3X, 4X, AND 5X BONUS MULTIPLIERS.....	33
SWITCH 21: ATTRACT SOUND.....	33
SWITCH 22: MEMORY FOR TWO RIGHT-SIDE TARGETS AND FLIPPER FEED LANES *.....	34
SWITCH 23: MEMORY FOR FOUR DROP TARGETS. OFF FOR CONSERVATIVE PLAY *.....	34
SWITCH 24: MEMORY FOR UPPER LEVEL 1 / 2 / 3 ARROWS	34
SWITCHES 25 AND 26: MAXIMUM CREDITS ALLOWED (AS PER ORIGINAL BALLY MANUAL)	34
SWITCH 27: CREDITS DISPLAYED ON OR OFF	34
SWITCH 28: END OF GAME MATCH FEATURE ON OR OFF	34
SWITCH 29: UNLIMITED FREE GAMES (LIMITS NOT APPLIED TO MATCH AND HIGH SCORE AWARDS).....	34
SWITCH 30: UNLIMITED EXTRA BALLS FROM THE WOOD BEAST	34
SWITCHES 31 AND 32: BALLS PER GAME (AS PER ORIGINAL BALLY MANUAL)	35
USER PROGRAMMABLE CHANGES	35
OPERATOR GAME ADJUSTMENTS	35
SWITCHDEBOUNCE[]	37
RESETHITS[]	37
SETTING THE WAIT TIME	38
ALTERNATIVE GAME SETTINGS USING KIDS' MODE.....	38
SELECTING YOUR SOUND BOARD.....	39

NOTES	40
DIP SWITCHES:	40
SELF-TEST SETTINGS:	40
FINAL BATTLE DROP TARGET GOAL (SELF-TEST #22):.....	40
FINAL BATTLE ATTACK GOAL (SELF-TEST #23):	40
KIDS' MODE:.....	40
SWITCH TO ORIGINAL:.....	40
WHAT IS THE DIFFERENCE BETWEEN RPU_OS_USE_WAV_TRIGGER AND RPU_OS_USE_WAV_TRIGGER_1P3?.....	40
STROBE LIGHT:.....	41
ARDUINO INSTALLATION INSTRUCTIONS	42
ADDITIONAL INSTALLATION INSTRUCTIONS FROM DAVE'S THINK TANK	49
WAV TRIGGER INSTALLATION	49
POWERING YOUR SPEAKER BAR FROM THE VOLTAGE REGULATOR BOARD.....	52
UPDATES TO THE VOLTAGE REGULATOR BOARD	52
MAKE A CONNECTOR	53
THE FINAL SETUP	55
SHOPPING LIST	56
BASIC REQUIREMENTS.....	56
WAV TRIGGER REQUIREMENTS	56
SPEAKER POWER REQUIREMENTS.....	56
MORE STUFF	56

Introduction to Flash Gordon 2025.12

Flash Gordon 2025.12 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!

Important Notes!

Sound Boards

This software will work with any of the following sound boards:

- Geeteoh,
- WAV Trigger, or
- The original Bally Squawk & Talk.

Even if you have a Geeteoh board, you may need the latest software update. This can be obtained at a reasonable price by contacting Geeteoh.com.

The Geeteoh sound files included are meant to be used in Geeteoh sound bank 6, but can be renamed for any other bank if needed. See your Geeteoh manual.

When you turn on the pinball you should see a 3, 6, or 5 (W, G, or S) in the Match window, indicating the software is set up for a WAV Trigger, Geeteoh, or Squawk & Talk. If it is set up for the wrong sound card, there is a simple change you can make. Check out the section titled "Selecting Your Sound Board" below to find out how.

Adding Music from the Film

The sound files do not include any of the music from the movie, for copyright reasons. I used "In the Space Capsule" during the Skill Shot, "Flash's Theme" for regular game play, and "Battle Theme" during the final battle. All three are available from online music streaming services, for as little as a dollar. Create a wav file and name it 1785_0249_FlashsTheme.wav. You will also want to create two music files, 1707_0171_SpaceCapsule.wav and 1708_0172_BattleTheme.wav. See the following YouTube video for step-by-step instructions:

<https://youtu.be/CJBlf6C11SE?si=8CX0rF0vCIO9eKpC>

Using a Strobe

Many of the new light patterns include the strobe light in the backbox. If your pinball has a strobe light, you will have to tell it what type (see the section titled "Operator Game Adjustments" below for details). If it doesn't have a strobe, you can watch my video on how to build an LED strobe out of spare parts you probably have lying around the house:

https://youtu.be/VCKcB5TzOqM?si=1H3Oql_PQe3d2cmk

New Rules

The Basics

- **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 per spin.
 - Hitting all four colored targets will light the 3X arrow for 15 seconds of 3X points. Hit the up / down kicker to collect!
- **3 Drop Target Bank:** Hitting all three of the upper-level drop 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.
 - 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.
- **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.

Skill Shot

Every ball starts with a skill shot. Try to hit the three shooter lane rollovers without entering the playfield, and return to the shooter. Higher rollovers score more points: 15,000 for one, 30,000 for 2, or 75,000 for 3!

Final Battle - Defeat Emperor Ming

- 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!
- 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 (shown as 12 reducing to zero), 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 over the game to defeat Emperor Ming. Ming's remaining lives are displayed using the upper-level numbered arrow 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 targets lights 4X bonus after 3X is lit.
- Dropping 4 targets lights 5X bonus after 4X is lit.
- Dropping 4 targets the first-time lights the left spinner. The 2nd time lights the right spinner.
- 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. The 140 points are shown in the credit window as a value of 12 reducing to zero.
- Ming must now be defeated three times (adjustable from 1 to 4) OVER THE ENTIRE GAME. Previously, he needed to be defeated three times in a single battle. Ming’s remaining lives are displayed using the upper-level 1-2-3 arrow lights (and 4X, if you’ve adjusted number of lives to 4 or more).
- Flash Gordon now has a ball-save feature! If you score less than 5000 points, or play for less than 15 seconds before losing a ball (and earn less than 25000 points), you will automatically be given “Same Player Shoots Again”. These values can be changed (see self-test #11, “Ball Save Settings”), 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 Geeteh board or a WAV Trigger board.

- In addition, if you have the latest Geeteoh sound board or a WAV Trigger you can set different music for the Skill Shot, regular game play, the 15-second alarm, and the Final Battle!
- Flash Gordon 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. The easiest way to get into Kids’ Mode is to turn the machine on while holding the game button (hold until you hear the Kid Ming sound). Or you can go into either Self-Test or Attract Mode, and press both the Game Button and the Coin Slot 3 switch* at the same time (again, hold until you hear the sound). To go back to regular game mode, press the buttons at the same time again. 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.
- If you return to the shooter lane without knocking down the single target during regular game play, you will receive 5000 points.
- Pushing the game button during ball 2 or later will end your game.

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 (or 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

* 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!

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)

Game Indicators

The current version of this Flash Gordon pinball machine has come a long way since the original Bally version. There are more game elements, such as the skill shot and the final battle. There are a lot of combination shots, requiring you to know what shots have been made and what shot needs to be made. In order to help keep track of all these things, extensive use has been made of game indicators. These include the lights, light patterns, sounds, and numeric displays. Some of the more useful indicators are reviewed below.

Credit Display

The credit display serves a number of purposes during the game:

Purpose	Explanation
Skill shot score	Score received from skill shot. The numbers are solid until earned, and then flash until the ball enters the playfield.
Drop target count	Final battle is earned by hitting 11 drop targets. A count is maintained in the credit display during regular game play.
Ming attack progress	140 points must be earned during the final battle to defeat Ming. This is displayed in the credit window as a value of 12, reducing to zero.
Credits available	Updated if you add credits or players during a game.

Light Rings

The two light rings are primarily used for displaying and scoring the bonus points awarded from the upper playfield (the top bonus circle), and the lower playfield (the bottom bonus circle). A maximum of 19 bonus points can be displayed on both rings. This is the same as the original Bally usage.

In addition to this, the Arduino uses these rings to display five and 15-second countdowns. Five second countdowns are displayed using the upper ring, and 15-second countdowns are displayed using the lower ring. If more than one timer is activated at the same time, the first timer ends before the second is displayed, mid-cycle. The ring will flash to indicate it is being used as a timer.

Flashing Lights

Flashing lights generally indicate an important target, or a series of targets. For example, two of the four drop targets on the left will be flashing at any given moment. By hitting the flashing targets, you set up another target on the lower playfield of the same colour to flash, making this your next target. If this is one of the flipper lanes, hitting it will start the spinner on the opposite side flashing for five seconds, making it flash as your next target. If you're not sure what to do, aim for a flashing light!

Fast-flashing lights generally indicate a valuable target, available for a limited amount of time. In the above example, the spinner is fast-flashing, and on a 5-second timer.

Solid on or off lights, when they are associated with a switch, generally indicate the number of points awarded for hitting the switch. On is generally more valuable than off. The number of points awarded will match the values printed on the playfield, if any.

Light Patterns

Pattern	Purpose
Spiral Infinity	Indicates you are in Skill Shot
Battle Sweep	Indicates you are in the Final Battle
Ming's Defeat	Plays when all three of Ming's lives are defeated
Saucer Up	Shows direction ball will pop out of up/down kicker: up
Saucer Down	Shows direction ball will pop out of up/down kicker: down
Ming Energy	Watch the saucer lights during the Final Battle to indicate Ming's life force. Also watch the 1-2-3 arrows for the number of Ming's lives remaining.

Music

Flash Gordon has four different background music files (see the section titled, "Adding Music from the Film"), used to identify the part of the game you are currently playing. You can actually add any music you want, but the following music is recommended, and available for purchase from many streaming services:

Music	Plays During
In the Space Capsule	Skill shot
Flash's Theme	Regular game play
Battle Theme	Final battle
Football Fight	15-second 2X and 3X award

There is a step-by-step video on YouTube that shows you where to obtain this music, and how to add it to your Arduino: <https://youtu.be/CJBIf6C1lSE?si=8CX0rF0vCIO9eKpC>

Voices

There are lots of voice clips from the movie in the game. Most indicate you have won something, or achieved something, or have an opportunity. Here are a few you should know:

Voice	Indicates
Switches over there, start hitting them!	Amber and white drop targets will start a 15-second timer for 50,000 points (aim for lower playfield, right-side targets).
Look out Flash!	Yellow and blue drop targets set up corresponding flipper lanes. This then starts a 5-second timer to hit the opposite spinner.
Very roughly, 14 seconds	Aim for the up/down kicker for 15-seconds of 2X/3X/5X points.
The attack has begun	Start of Final Battle.
Your power's fading, Ming	You have taken one life from Ming in the Final Battle.
Flash!	Regular game: 50,000 points for beating 15-second timer Final Battle: 140 points collected. Aim for up/down kicker.
Oh dear	Five or 15-second timer missed.
This way Flash, come on!	Requirements fulfilled to proceed to next section of game (regular game from skill shot, or Final Battle from regular game).
Pathetic Earthlings	Upper-level target hit, including Collect Bonus and Special.
Don't kill him yet, father	Ball Save: Rescuing you from a disastrous ball!
Oh dear. How Pathetic.	Indicates you have failed to achieve your personal goal.
Oh well. Who wants to live forever?	Indicates you have exceeded your personal goal.
You've saved your Earth. Have a nice day!	You have defeated Ming in the Final Battle!

Installing, Compiling, and Uploading to the Arduino*

Hardware Requirements

Purchase Arduino: pinside.com/pinball/market/shops/1304-roygbev-pinball/by-game/185-flash-gordon

Or Build Your Own: www.pinballrefresh.com/blog/how-to-install-on-your-machine

Purchase Geeteoh: geeteoh.com/squawktalk.shtml, **or**

Purchase WAV Trigger: www.robertsonics.com/wav-trigger

Note: The Geeteoh and the WAV Trigger are optional. Only one is needed in any case. The program will run on your pinball with just the original Bally Squawk and Talk, but the extended sounds including quotes, sound effects, and music from the film will not run.

Software Requirements

Download FG2025p12: <https://github.com/DavesThinkTank/Flash-Gordon-2024>

Download Arduino IDE: www.arduino.cc/en/software

This software does not come with music from the film. However, there is a step-by-step video on YouTube that shows you where to obtain this music, and how to add it to your Arduino:

<https://youtu.be/CJBIf6C11SE?si=8CX0rF0vCIO9eKpC>

Since you have this manual, I assume you already have the FG2025p12 software it comes with! If not though, you definitely need to download it. You only need the Arduino IDE if you need to modify the software for your pinball. The software is free, although there is a donation request.

Hardware Installation

Install the Arduino as per instructions included with the device (Note: The software can be compiled and uploaded to the Arduino as per instructions below before installing in the pinball, if you prefer). Detailed installation instructions are also included at the end of this manual.

Install Geeteoh or WAV Trigger, if you have one of these sound boards, as per instructions included with the device. Detailed installation instructions are also included at the end of this manual. If you purchased a WAV Trigger separately (i.e., not as part of a kit from RoyGBev), you will need to review these instructions!

Software and Sound File Installation

The following video demonstrates how to install or upgrade the Flash Gordon software and sound files: <https://youtu.be/r4PpJglYBh4>

If your Arduino came with the FG2025.12 software included, and you have no need to make changes to the software, you're done! Otherwise, perform the following instructions to upload the software to your Arduino.

* See also the sections titled *Arduino Installation Instructions* and *Additional Installation Instructions* below.

Create a folder on your computer named FG2025p12. Download the software from github.com/DavesThinkTank/Flash-Gordon-2024 to this folder, by clicking on the green “Code” button, then clicking on “Download ZIP”.

Download and install the Arduino IDE from www.arduino.cc/en/software.

Transfer the included sound files to the micro-SD card for your Geeteoh or WAV Trigger board (into the root directory). If using a Geeteoh board, set up the Geeteoh DIP switches to use Bank 6.

This software does not come with music from the film. However, there is a step-by-step video on YouTube that shows you where to obtain this music, and how to add it to your Arduino:

<https://youtu.be/CJBlf6C11SE?si=8CX0rF0vCIO9eKpC>

Compiling and Uploading the Software

TURN OFF your pinball machine (if programming the Arduino after installation)! Make sure the "Switch" connectors on the Arduino are connected with a 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.

Run the Arduino IDE software. Open the file FG2025p12.ino (in the FG2025p12 folder created above).

Click on the white box labeled “Select Board” at the top left of the IDE. Click on “Select other board and port”. Select “Arduino Mega or Mega 2560”, and the port your Arduino board is plugged into. If you’re not sure which port to select, unplug the Arduino. The correct port is the one that disappears!

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

Click on the Upload arrow (also to the left of the white box) to compile the software and upload to the Arduino.

Once the program has compiled and uploaded you can unplug the cable from your computer. The game should now run on your pinball.

Before You Play

When you turn on the pinball, the first thing you should see is the version number; 2025 in the player 1 display, and 12 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.

During these four seconds you should also see a 3, 6, or 5 (W, G, or S) in the Match window, indicating the software is set up for a WAV Trigger, Geeteh, or Squawk & Talk. If it is set up for the wrong sound card, there is a simple change you can make. Check out the section titled "Selecting Your Sound Board" below to find out how.

RUN THROUGH ALL THE SELF-TESTS AND GAME SETTINGS BEFORE PLAYING YOUR FIRST GAME! 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.

Arduino Upgrade: <https://youtu.be/hn4zS7xABDA>

Arduino Upgrade 2: <https://youtu.be/Tmc6EeCaIOU>

Arduino Upgrade 3: <https://youtu.be/8T7ZMEYDwRg>

Arduino Upgrade 4: <https://youtu.be/2D8GICzDkIk>

Arduino Upgrade 5: <https://youtu.be/8aF7jNNfIHE>

Adding Music to the Arduino: https://youtu.be/CJBlf6C11SE?si=XrKO_I5-LyZGp0f7

How to Update Your Software: https://youtu.be/r4PpJglYBh4?si=fmr99n3UeNldb_0T

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.

The Game Button, and the Coin Slot 3 Switch

In the original Bally pinball self-test, there was only one switch available to run the tests – the game button. Pressing this button generally stepped through the current test, increased a value, changed a setting, etc. But whatever it did, it did just that one thing, severely limiting what the self-test and game settings could do for you.

If only there was just one more button, the tests could be expanded significantly. For comparison, most modern pinball machines have a panel of four extra buttons for these tests. In order to expand the tests, it was therefore decided to assume one more button was available. The coin slot 3 switch is readily available inside the coin door, and was therefore selected.

This switch by itself is not really convenient. It is difficult to activate by hand. It is therefore recommended that you solder a button to the coin slot 3 switch connectors for use in these tests. This is inconvenient, but the added functionality of the tests will definitely make it worth your while.

You can review the use of the coin 3 switch in the test descriptions below, to see if this is something you want to do. If you don't add a button, you will still have at least the functionality of the original Bally self-test (and usually much more).

See the following video for more information:

https://youtu.be/OC1NtW9DG_Q

By mounting this button on the outside of your pinball, it also makes Kids' Mode available easily to kids. Enter the new Kids' Mode by pressing the Game Button and Coin Slot 3 switch at the same time. 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. Pattern number in light pattern mode.

Game Button: Cycle through switched Illumination lights. Hold to cycle continuously.
In light pattern display screens, returns to light display.

Coin 3 Switch: Change between light display patterns.

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.

If you have a xenon strobe, it will NOT flash with the other lights. However, by pressing the game button and counting up to lamp #75, it will flash, allowing you to test this type of strobe.

Pressing the coin 3 switch shows you different light display patterns from the game. The following light displays are included:

1. Attract Retro
2. Attract Up / Down
3. Attract Sweep
4. Saucer Up
5. Saucer Down
6. Ming's Defeat Lights
7. Battle Sweep Pattern
8. Spiral Infinity Pattern
9. Backglass Lamps, Center Out
10. Backglass Lamps, Bounce
11. Backglass Lamps, Left to Right
12. Backglass Lamps, Center Bounce
13. Backglass Lamps, Loop

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 Flipper Relay alternately either turn off or on, each pass through the solenoids.

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. Hold the flipper buttons in during the K1 relay test to check for vibration issues from flippers.

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 self-test again takes you to the switch test. Switches that are stuck on will be identified by number in the displays, with up to four stuck switches to be identified on four displays. 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.

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

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 reset them.

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.

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.

Setting Award Levels 01, 02, and 03, High Score, and Personal Goal

Credit Display: Level #01, 02, 03 for award levels; 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

Set Score Value One Digit at a Time:

Coin 3 Switch: Move to next digit.

Game Button: Increase current digit

Coin 3 Double Click: Return to increase-by-1000 method

Pressing the self-test button again takes you to the first score award level. Three award 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.

These values can also now be increased, or decreased, one digit at a time. This is a very simple alternative to the previous method, which has been in place since the 1970s. Press the coin 3 switch to go to the first digit. The 10s digit will flash. Press the game button, or hold it, to increase the value. After reaching 9, it will circle around to 0. Set the digit you want, then press the coin button again to go to the next digit. Once you exceed the 100,000s digit, the numbers will shift right to allow you to change values in the higher digits. You can enter score numbers up to 999,999,990. If you try to go to the 10th digit, you will be returned to the increase-by-1000 method. Or double-click the coin 3 button to return at any time.

For anyone who has spent 10 minutes or more holding in the game button while watching these values scroll, or held the game button an instant too long and had to start over, or tried to find kludgy ways to reproduce a high score, especially the lower digits, this new method of setting score levels will be a welcome relief!

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 09
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 09 cover number of credits, total number of games played, total number of free games won, and number of times high score beat. 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 (6, 7, 8, and 9)

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

10: Coin Count for Coin Chutes 1, 2, and 3

Credit Display:	Level #10
Display #1:	Number of coins counted through coin chute 1
Display #2:	Number of coins counted through coin chute 2
Display #3:	Number of coins counted through coin chute 3
Game Button:	Increase value. Hold to increase repeatedly. Double-click to reset to zero.
Coin 3 Switch:	Move to next displayed value.

Coin count for coin chutes 1, 2, and 3 was previously entered on three separate screens. The total number of data screens was up to 25, and I wanted to add six more items! To simplify things, all three coin counts have been combined on a single screen. If you need to change the values, you can use the coin 3 switch to move between them. The current value will flash. Pressing or holding the game button increases the current value, while double-clicking will reset it to zero.

Game Settings

11: Ball Save Settings

Credit Display:	Level #11
Display #1:	Number of ball saves per game
Display #2:	Maximum score to invoke ball save
Display #3:	Maximum play time to invoke ball save
Game Button:	Increase value. Hold to increase repeatedly. Double-click to reset to zero.
Coin 3 Switch:	Move to next displayed value

“Ball Save” is a feature that will let you play a ball over again, under certain circumstances. This screen allows you to set the number of ball saves allowed per game (maximum 5), the maximum score at which ball save will be invoked (maximum 25000), and the maximum play time at which ball save will be invoked (maximum 25 seconds). The default values are 1, 5000, and 15, respectively. Note that, the time limit is not invoked if you have earned more than 25000 points.

If you have a particularly bad ball with score or time less than the set values, your score will be reset to the beginning of the ball, “Same Player Shoots Again” lights will come on, and Princess Aura will say, “Don’t kill him yet, Father”.

If you do not want ball save, set the number per game to zero, but leave the other values non-zero! Setting all three values to zero will cause the program to think you have not set any values yet, and it will reset them to the default values.

12: Relative Volume Settings (Background Music, Sound Effects, and Voices)

(WAV Trigger only)

Credit Display:	Level #12
Display #1:	Volume adjustment for background sounds (0 – 100)
Display #2:	Volume adjustment for sound effects (0 – 100)
Display #3:	Volume adjustment for voices (0 – 100)
Game Button:	Increase or decrease value. Hold to increase / decrease repeatedly.
Double-Click:	Switch game button between increasing or decreasing values.
Coin 3 Switch:	Move to next displayed value.

This allows you to adjust the relative volumes of the background music (display 1), sound effects (display 2), and voices (display 3). In general, you want sound effects to be quieter, voices to be louder, and background music to be somewhere in the middle. The volume levels have already been set in this way, and to leave them alone, simply set all three values to 50. Values above 50 will raise the volume for sounds of that type, and values below 50 will lower those volumes.

Please note this screen is used to set the *relative* volume for the three sound types! It therefore makes little sense to raise all the values above 50, or to lower them all below 50. To raise or lower all three, you are far better off using the volume control on your speaker!

Also keep in mind, raising the volume too high on one or more sound types could cause a problem called “clipping”, where the highs and lows of the sound are lost or distorted. This can be very evident if you’ve raised two or all three types too high, and they are all played at the same time and added together. So don’t do this.

A piece of background music will play throughout this test, and you can adjust its volume up or down to hear the effects. When adjusting the sound effect or voice setting, a sound effect or voice will play repeatedly over the background music, allowing you to hear the relative effects.

Note that, at first, pressing the game button will raise the volume, and holding it will raise the volume repeatedly. To lower the volume, double-click the game button. Now pressing or holding the game button lowers the volume. Double-click a second time to increase the value again.

Tests 13 through 25 Controls

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

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.

01: Personal goal to be used. Personal goal will not work without the latest Geeteh or WAV Trigger board.

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 hold the Game Button when turning the machine on (hold until you hear the Kid Ming laugh). Or you can press the Game Button and Coin Slot 3 switch at the same time while in Attract Mode (again, hold both buttons until you hear the Kid Ming 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
Ball Saves Allowed	5
Ball Save Score	7000
Ball Save Time	20 seconds

Programmable Game Adjustments	Value
Number of Ming's lives in Final Battle	1

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	Coin count for coin chutes 1, 2, and 3
	11	Ball Save settings
	12	Relative volume settings for WAV Trigger (music, FX, and voices)
	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
16	K1 Flipper Relay

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	1 st Inline Drop Target
25	2 nd Inline Drop Target
26	3 rd 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: 1 st 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: 2 nd Inline Drop Target	33: Left Spinner
2: Single Drop Target	10: Coin 2 (No Diode!)	18: 4 Drop Target "C" (Upper Mid)	26: 3 rd 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.

Extended Sounds for Geeteoh and WAV Trigger Boards*

Arduino	Geeteoh	Sound	Arduino	Geeteoh	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		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++
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)	51	204	Saviour of the Universe!

* The software assigns each sound a number from 0 to 255. The Geeteoh uses these numbers to determine what sound file to play, but first inverts them by (effectively) subtracting the value from 255. Each sound therefore has two numbers; the sound played by the software, and the sound file number. The reason for this is technical, but important to keep in mind when dealing with sound files. The WAV Trigger also uses these same numbers to determine what file to play, but does not invert them, and so the subtraction is done in the software. The S&T uses only the first value.

Extended Sounds for Geeteoh and WAV Trigger Boards (Continued)

Arduino	Gee- teoh	Sound	Ard- uino	Gee- teoh	Sound
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	93	162	Pathetic Earthlings
80	175	Single clock tick	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!

Squawk and Talk Sounds and Their Lengths (in Tenths of a Second)

No.	Timing	Sound	No.	Timing	Sound
0	0		26	22	Crash bounce down
1	0		27	22	Crash bounce up
2	0		28	36	Outlanes
3	0		29	18	Crash
4	17	Humm (low)	30	0	Background sound 6
5	0	Sound off	31	0	Background sound 7
6	0	Background sound 1	32	5	Ding 1
7	2	Rebound hit	33	5	Ding 2
8	16	Spinner hum medium	34	5	Ding 3
9	15	Spinner hum low	35	5	Ding 4
10	57	Timer sound	36	0	Background sound 8
11	0	Background sound 2	37	0	Background sound 9
12	39	Boink up high	38	0	Background sound 10
13	46	Boink up low	39	0	Background sound 11
14	0	Background sound 3	40	34	Ignite death ray, 15 seconds
15	0	Background sound 4	41	118	Ming laugh five times
16	50	Alarm	42	21	Lucky shot Earthling
17	14	Low grumble	43	17	Miserable Earthling
18	34	!!!!!!... @#%&#... Flash!	44	19	Emperor Ming awaits
19	0	Background sound 5	45	14	Flash
20	9	Drop target hit	46	23	Try again Earthling
21	9	Beep beep hit	47	17	15 seconds
22	34	Same as 18	48	17	Miserable Earthling
23	34	Same as 18	49	14	Flash
24	11	Bong bounce down	50	24	Ming laugh (single)
25	11	Bong bounce up	51	17	15 seconds

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	Number of 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.

Chute	Switches					Credits / Coin	Original Game Setting
#1	5	4	3	2	1	(in bold if different than original)	
#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

Chute #2	Switches				Credits / Coin
	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 Credits	Switches 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 Game	Switches	
	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:

Operator Game Adjustments

MAX_TILT_WARNINGS: Usually 1. Set higher if you wish to allow some number of tilts before ending a ball.

MAX_HEALTH: Times Ming must be defeated in Final Battle. Usually 3, maximum 4.

ATTRACT_SPEECH_TIMER: Time between attract mode callouts. Usually 5 minutes.

USE_EXTENDED SOUNDS: If defined, the program will expect a Geeteoh or WAV Trigger sound board. Comment out this line if you do not have one of these boards. See the section “Selecting Your Sound Board” below for more information.

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.

* 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.

RPU_STROBE_TYPE: This game adjustment is NOT found in the Operator Game Adjustments. For technical reasons, it has been included in the file RPU_Config.h (down about 90 lines).

The code for the strobe light accommodates any of the following five types of strobe:

- 0 = Strobe signal always off
- 1 = Strobe signal always on
- 2 = Original xenon tube strobe
- 3 = Incandescent / LED light(s)
- 4 = Incandescent / LED light(s) with inverted on/off signal

Options 3 and 4 give you a variety of effects, coordinated with the other lights in the backbox. This is likely too much for an original xenon tube strobe! If you have one of these, or an exact replacement, select option 2, which reproduces the strobe effects from the original game. If you've purchased an LED strobe, you most likely want option 4.

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 four 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).
3. Monitor the sounds as they are played. The most recent nine sounds are scrolled through the player 2, 3, and 4 displays.

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 than 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.

Alternative Game Settings using 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 the Self-Test section titled “24: Kids’ Mode” above should make it obvious what changes need to be made.

To start in the alternative setting, just turn on the pinball while holding the game button. You can then switch back and forth by holding in the game button and the coin slot 3 switch at the same time, while in Attract mode.

Selecting Your Sound Board

The software is designed to be used with either an original Bally Squawk and Talk sound board, a Geeteoh replacement sound board, or a WAV Trigger sound board. To determine which sound board your software expects, turn on your pinball. For about four seconds you should see either a 3, 6, or 5 (W, G, or S) in the Match window, indicating the software is set up for a WAV Trigger, Geeteoh, or Squawk & Talk.

If it is set up for the wrong sound card, there are a couple of very simple changes you need to make.

In the file FG2025p12.ino, find this row (very close to the top, in the Operator Game Adjustments):

```
#define USE_EXTENDED_SOUNDS
```

And in the file RPU_Config.h, find these rows (down about 60 lines from the top):

```
//#define RPU_OS_USE_S_AND_T  
//#define RPU_OS_USE_WAV_TRIGGER  
#define RPU_OS_USE_WAV_TRIGGER_1p3
```

If your pinball has a new WAV Trigger sound board, then set these lines exactly as you see above. If your WAV Trigger is a few years old, you may need to change the lines as follows:

```
#define USE_EXTENDED_SOUNDS  
  
//#define RPU_OS_USE_S_AND_T  
#define RPU_OS_USE_WAV_TRIGGER  
//#define RPU_OS_USE_WAV_TRIGGER_1p3
```

If your pinball has a Geeteoh sound board, then change the lines as follows:

```
#define USE_EXTENDED_SOUNDS  
  
#define RPU_OS_USE_S_AND_T  
//#define RPU_OS_USE_WAV_TRIGGER  
//#define RPU_OS_USE_WAV_TRIGGER_1p3
```

If your pinball has an original Bally Squawk & Talk then make the following changes:

```
//#define USE_EXTENDED_SOUNDS  
  
#define RPU_OS_USE_S_AND_T  
//#define RPU_OS_USE_WAV_TRIGGER  
//#define RPU_OS_USE_WAV_TRIGGER_1p3
```

Once you have made the changes, use the Arduino IDE software to compile and upload the software to your Arduino. For more information on how to do this, see the section titled “Compiling and Uploading the Software” above.

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).

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!

What is the Difference between RPU_OS_USE_WAV_TRIGGER and RPU_OS_USE_WAV_TRIGGER_1p3?

The WAV Trigger allows up to 14 sound files to play at the same time. If you try to exceed that number it looks for a file to end, so it can add the new one. Starting with version 1.3, the WAV

Trigger firmware included a feature called “locking”. This allows you to lock certain sounds so they cannot be ended in this way. In our case, this is applied to all background music.

Unless you know that your WAV Trigger is several years old, you almost certainly want to use `RPU_OS_USE_WAV_TRIGGER_1p3`. It should make little difference, however. I have tested both on my (new) WAV Trigger, and it compiles either way. I can get the WAV Trigger up to the maximum sounds by flipping a spinner hard, by hand. The background music does not stop if I use 1p3 but it does with the other. But this is unlikely to occur during game play.

I don’t have an older WAV Trigger to test, so I can’t say for sure what it would do if you used 1p3. My guess is it would give a compile error, which would be a good indication that you should use the other!

Strobe Light:

The strobe uses a signal from the auxiliary lamp driver board to make the strobe flash. However, contrary to what most people would expect, an “Off” signal causes the strobe to flash, while an “On” signal turns it off.

These strobe lights had a limited lifetime. Most have failed long ago and have been removed from their pinballs. Exact replacements are available, as well as replacements using LEDs. These generally replicated the “Off” = “On” signaling of the original. Alternatively, you could simply replace the strobe with a lamp socket, however this would invert the original signaling.

The original FG2021 software was written to turn the strobe on with an “On” signal, and off with an “Off” signal. It therefore worked very well with simple, homemade solutions using a lamp. But it did not work well with the original strobe, or purchased replacements.

The code for the strobe light now accommodates any of five types of strobe, by defining the variable `RPU_STROBE_TYPE` in the file `RPU_Config.h` as follows:

- 0 = Strobe signal always off
- 1 = Strobe signal always on
- 2 = Original xenon tube strobe
- 3 = Incandescent / LED light(s)
- 4 = Incandescent / LED light(s) with inverted on/off signal

Options 3 and 4 give you a variety of effects, coordinated with the other lights in the backbox. This is likely too much for an original xenon tube strobe! If you have one of these, or an exact replacement, select option 2, which reproduces the strobe effects from the original game. If you’ve purchased an LED strobe, you most likely want option 4.

If you find that your strobe light is on when it should be off, try choosing a different option. Options 2 and 4 invert the on/off signal while option 3 does not. Option 2 has limited the number of flashes to preserve the xenon tube while options 3 and 4 flash off and on constantly as part of the light patterns.

Arduino Installation Instructions *

Part Description	Qty
Bally/Stern Arduino adapter PCB	1
Push-release IRQ wire harness	1
(Optional) WAV Trigger sound board	1
(Optional) 6-pin ribbon cable 1	1

The Arduino adapter in your kit will be one of two types: The REV 1 board (Figure 1), or the REV 3 board (Figure 2).

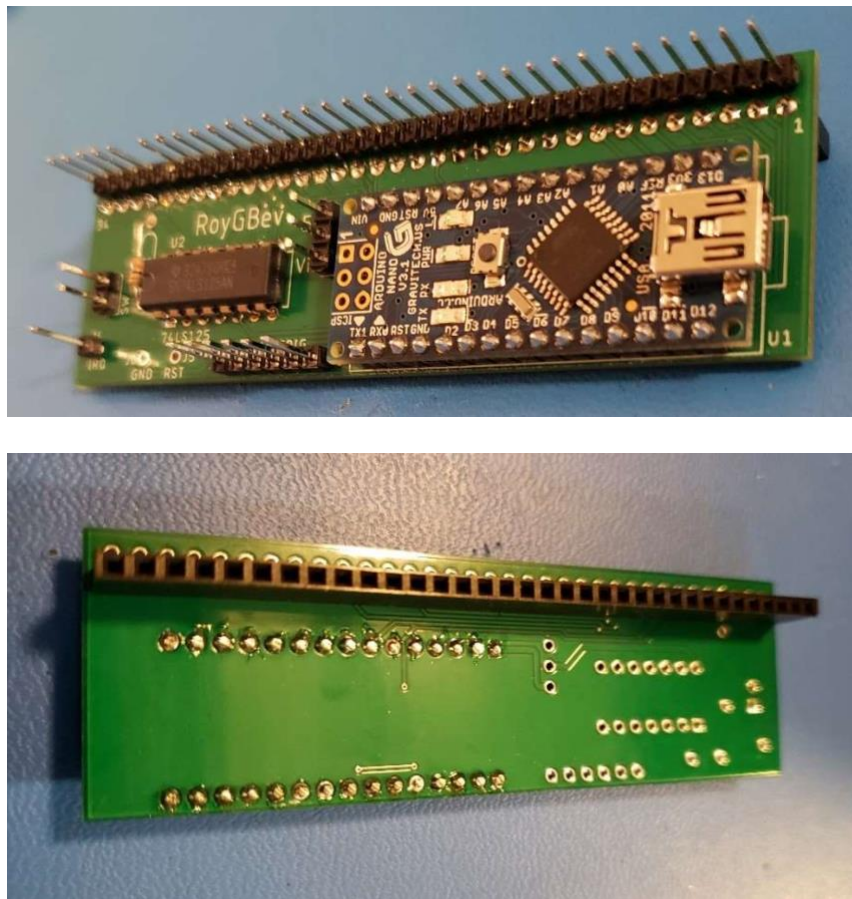


Figure 1

* These are the complete installation notes provided with an Arduino Mega 2560 REV 3. They are unedited, and so may contain extra information not needed in installing your Arduino. It also includes full instructions for installing and connecting a WAV Trigger sound board. Additional notes of my own are included at the end.

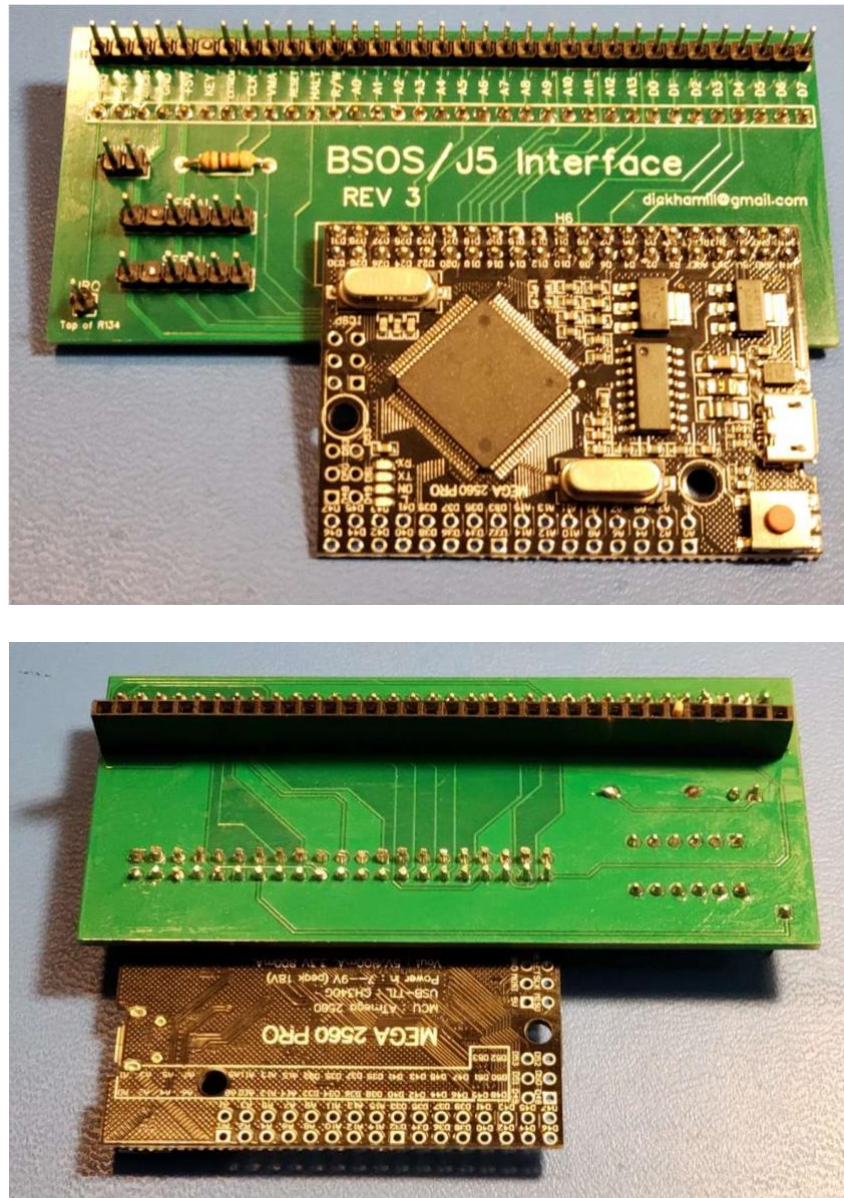


Figure 2

IMPORTANT: TURN OFF POWER TO THE GAME BEFORE INSTALLING THE ARDUINO ADAPTER.

1. Verify that the game's MPU board is in good working condition. Verify that the game powers up and works.
2. If the game has a ribbon cable connecting a sound board to J5 on the MPU, note the orientation of the cable, then remove it.
3. Verify that the MPU connector J5 is in good condition, with good solder joints. Also verify that key pin 29 of J5 has been removed. J5 pins are numbered from pin 1 on the right.
4. If your kit uses the REV 1 Arduino board, install a 0.1" jumper between the Vin and middle pins of the 3-pin header, as shown in Figure 3. The pin labeled 5V should be unconnected.



Figure 3

5. The 34-pin female connector on the bottom of the adapter will be plugged into J5 on the game's MPU board. If you are using an Alltek or Stern MPU-200 board, J5 will have 34 pins. On other boards, J5 may have 32 or 33 pins. In all cases, pin 1 on the adapter will align with pin 1 on J5, and the blocking pin at pin 29 of the adapter will align with the missing pin 29 on J5.
6. Line up pin 1 and carefully install the adapter board onto connector J5. If the connector won't go, don't force it. Verify that pin 1 is lined up, and that there are no bent pins preventing engagement. Push the adapter down onto J5 until it is fully installed. Figure 4 shows an adapter installed on an MPU board.

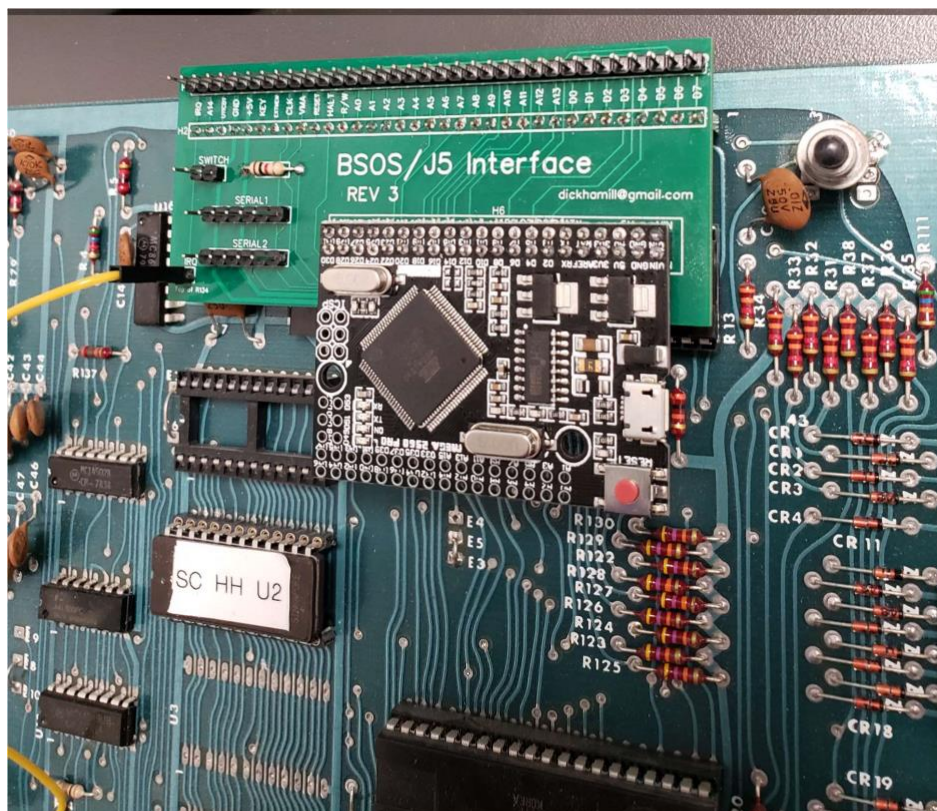


Figure 4

7. If a sound board ribbon cable was removed from J5 in step 2, install the cable onto the 34-pin connector on the Arduino adapter.

8. If your MPU board is a Bally AS-2518-17, Bally AS-2518-35, or Stern MPU-100, the push-release IRQ wire harness will need to be installed. To install:
 - a) Push the single pin female connector onto the pin labeled IRQ on the Arduino adapter.
 - b) Connect the push-release probe to the top lead of R134 on the MPU board. Figure 5 shows this in detail.

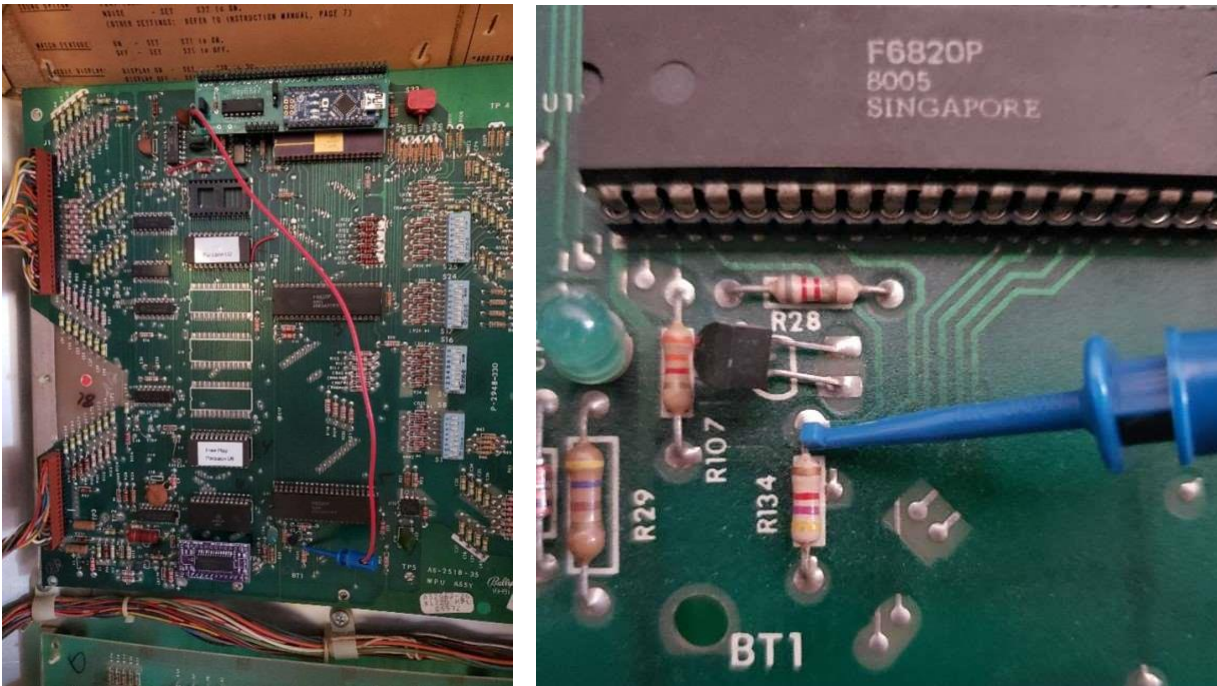


Figure 5

9. The two-pin header labeled SWITCH on the adapter board should not have a jumper installed. Verify this, and remove the jumper if it is installed.
10. At this point the game should be ready to power up. Watch the diagnostic LED on the MPU board while powering up the game. The game should power up normally, to the original 6800 game program, and into attract mode. If it does not, turn the game off and check the installation. If a sound board ribbon cable was attached to the Arduino adapter's 34-pin male header, unplug the cable, then power up the game again. If it powers up normally, there is an issue with the sound board ribbon cable installation.
11. Turn off the game, then install a jumper between the two pins of the connector labeled SWITCH. **IMPORTANT: THE GAME MUST BE TURNED OFF BEFORE THE SWITCH JUMPER IS INSTALLED OR REMOVED.**
12. Turn on the game. It should boot up to the new Arduino code. Check that the displays show digits, and that the game enters attract mode.
13. If the game does not boot to the Arduino software version, turn off the game and check that the IRQ wire harness is properly installed.
14. If desired, a remote switch may be connected to the pins of the SWITCH connector, allowing the user to select between standard and Arduino versions. As with the jumper, **TURN OFF THE GAME BEFORE CHANGING THE SWITCH SETTING.**
15. The new Arduino software may support configuration settings that can be selected using the game's self-test switch inside the coin door. Refer to the user documentation for the Arduino pinball software for details.

16. If the Arduino installation kit includes a Robertsonics WAV Trigger sound board, refer to the following steps for installation.
17. TURN OFF POWER to the game before proceeding.
18. Refer to Figure 6 for the next few steps.
19. Verify that the Load/Run switch on the sound board is in the Run position.
20. The sound board has a Micro SD card socket with a memory card installed in it. Confirm that the memory card is installed in the socket.
21. Install one end of the 6-pin ribbon cable to the 6-pin connector labeled SERIAL1 (REV 3 board) or J7 WAV TRIG (REV 1 board). The cable has a black stripe on the connector, designating pin 2. Install the cable with the black stripe lined up with pin 2 (the missing pin) on the 6-pin connector.
22. Connect the loose end of the 6-pin ribbon cable to the male header on the sound board. Note that the ribbon cable's connector has a black stripe designating pin 2 on the connector. Line up the black stripe with pin 2 (the missing pin) on the sound board's connector.
23. The sound board has a piece of foam mounting tape attached to the back. This tape can be used to temporarily mount the sound board. Place the sound board in a location close enough that the 6-pin ribbon cable can easily reach. Refer to Figure 7 for an example. For a more permanent installation, the use of mounting screws and standoffs is recommended.
24. The sound board has a 3.5 mm stereo jack for use with speakers. Connect a pair of wired powered speakers, or other wired device (earbuds / headphones) to the jack.
25. To test that the sound board is working, turn the game on. The sound board should play a power up sound when the Arduino game code boots up.
26. If the sound board does not play a sound at power up, test the sound board by pressing the test button. The sound board should make a sound. If it does, but there is no sound during gameplay, the game software may not be configured to use the sound board. Refer to the user documentation for the Arduino pinball software for details.

27.

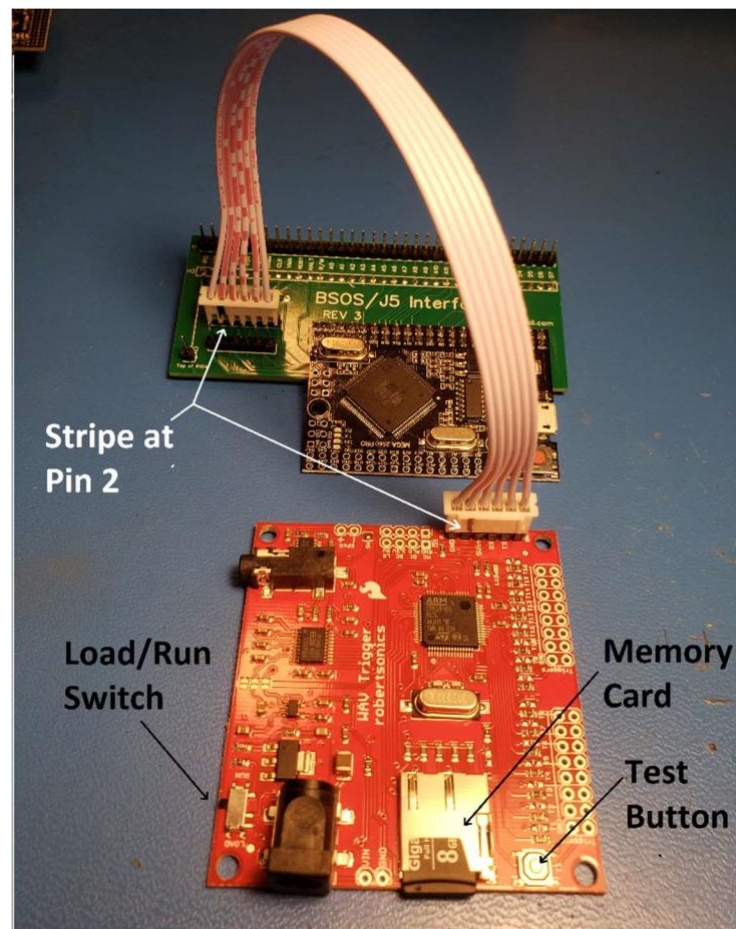


Figure 6

28. Suggested installation: Figures 7 and 8 show an installation for Stern Trident, with powered speakers mounted on top of the game's backbox.

29. Refer any questions regarding this document and installation to roygbevdotcom@gmail.com.

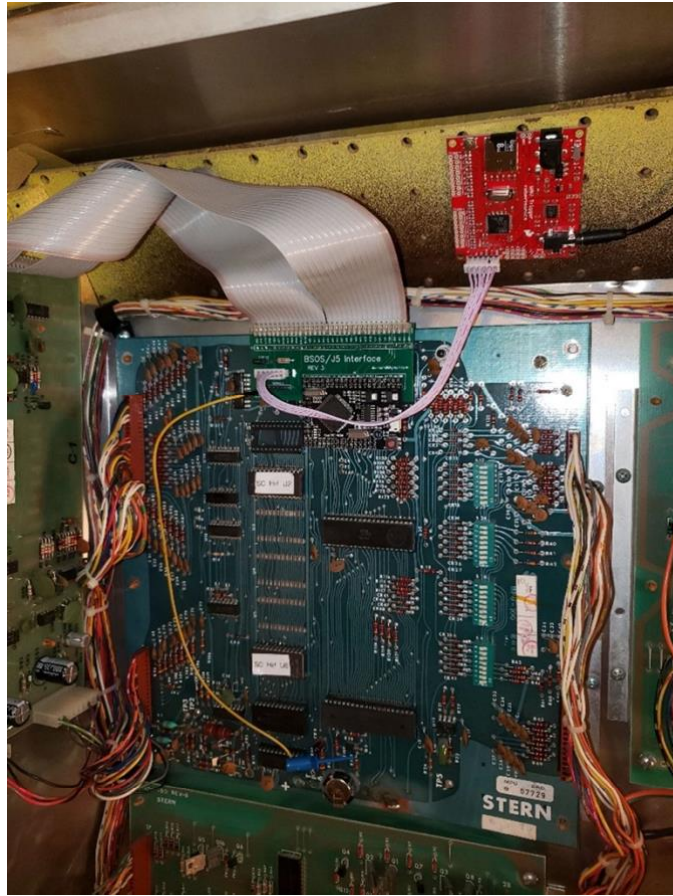


Figure 7

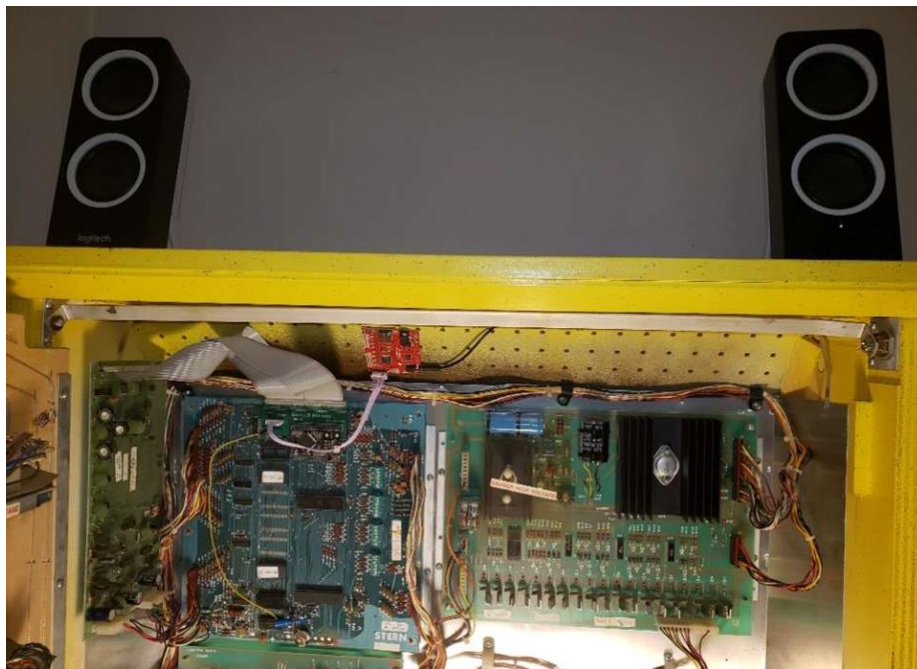


Figure 8

Additional Installation Instructions from Dave's Think Tank

WAV Trigger Installation

If you've purchased an Arduino kit from RoyGBev and it came with a Robertsonics WAV Trigger, then you can follow the instructions he gives you to install it, no problem. However, if you purchased your WAV Trigger separately from another source, then it probably did not come fully prepared. In that case you will likely want to read the following instructions! But, even if you have the prepared kit, there is additional information in this section you may find useful.

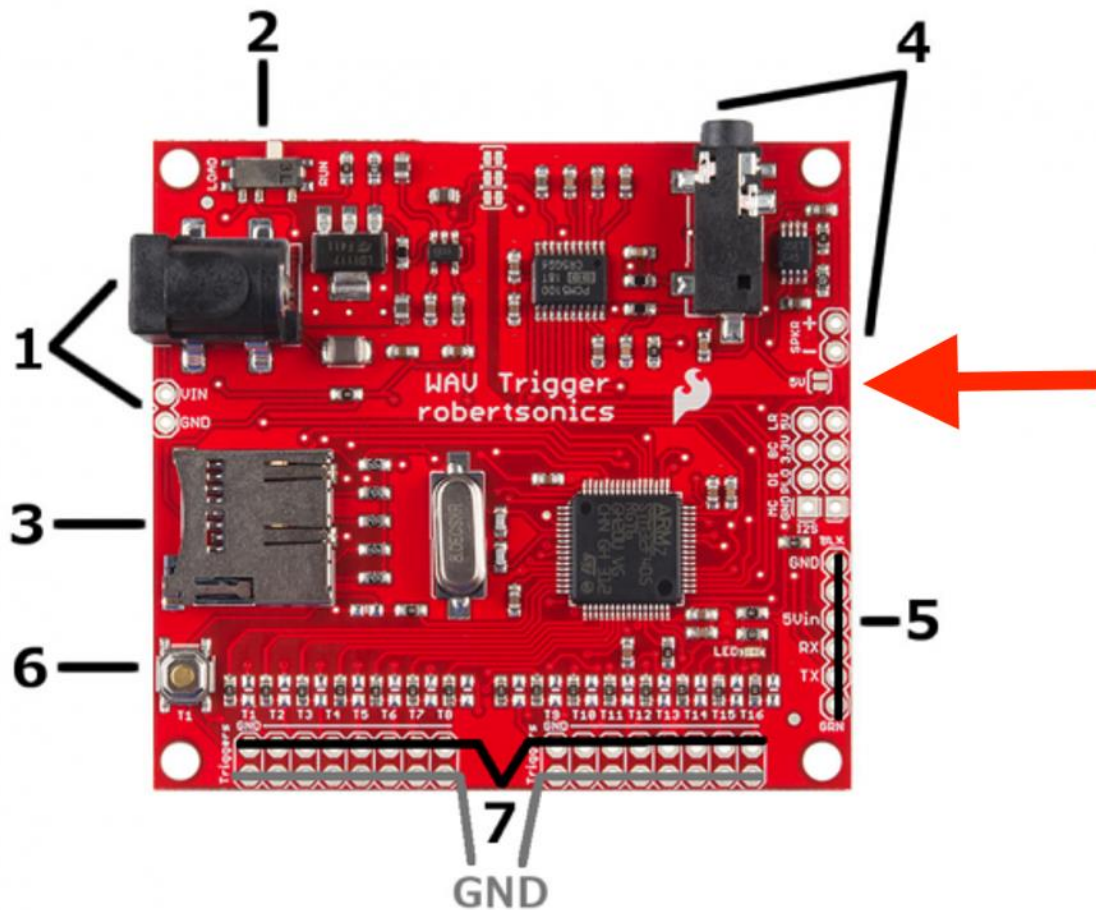


Figure 9

1. The first thing you need to do is purchase a few more items. You are going to need:
 - a. A 6-pin ribbon cable. The specs are: Ribbon Cables / IDC Cables Slim Body Single-Row IDC Socket Assemblies / 6 position / Female to Female. This cable should be ten inches or longer.
 - b. A 0.1" 6-pin vertical male through-hole header (often sold with 40 pins, which can then be trimmed to six). The ribbon cable attaches to the board at #5 in the diagram above (known as the FTDI port), except the board is sold without pins soldered here. The required pins have 0.1" spacing, which is the same as used in many pinball board connections, so you may have some of this already.
 - c. A 32GB or less micro-SD card. Class 10 SD cards with a FAT16 or FAT32 file system format and a 32kB file allocation size are recommended. The card needs to

be formatted to 32GB or less, which is plenty for this purpose (generally less than 100 MB). Buy a card 32GB or less, or else format a larger card to 32GB using MS-DOS FAT32.

- d. A computer speaker bar. You can pick one up anywhere for around \$20, so not expensive. It should have a 3.5mm stereo jack to connect to the WAV Trigger, as well as a USB connector to power the speaker.
 - e. Four really narrow screws, and eight plastic washers. These are for mounting the WAV Trigger in your backbox. If purchasing, #4 wood screws are what you want. Also, I didn't have tiny washers, so I cut the end rings off some plastic screw anchors and used them.
2. First thing to do, move the switch at #2 on the WAV Trigger to RUN (to the right in the diagram). You will never need it set to LOAD.
 3. Place the 6-pin header into the six holes at #5 in the diagram. Turn it over, and solder one pin on the bottom. Turn it over again, and while re-heating the solder, adjust the header to be perfectly vertical. Now finish soldering all six pins. Don't solder all six pins before getting the header upright, or you'll be stuck with it on an angle forever!
 4. This is very important, but it is information that is very hard to find! The red arrow in the diagram above is pointing to a "solder bridge", which is two metal pads side by side (labeled 5V). It is sometimes referred to as the "SJ2 solder jumper". The WAV Trigger will not work unless you place a drop of solder across these two traces, connecting them (harder to do than it sounds).
 5. Check all your solder connections using your multimeter in continuity mode:
 - a. Try connecting the GND pin at #5 to any of the GND pins at #7. They should be connected.
 - b. Test to ensure that the 5Vin pin from #5 is connected to the solder bridge.
 - c. Test the solder bridge by connecting the 5Vin pin at #5 to the four top pins on the small chip in the #4 corner. I'm not sure which of the pins is the right one, and I haven't been able to find a better place to test!
 - d. Try connecting the TX pin at #5 to the large square chip in the lower right quadrant. The correct chip pin is on the right side, about half way up, with a red line connecting it to a tiny hole in the board.
 - e. You do not need to test the RX pin, as it is not used by the Arduino. I also do not know where it connects!
 - f. Test each of the six pins to make sure they are not accidentally soldered to a neighbouring pin.
 6. Your WAV Trigger can now be installed using the four narrow screws through the (very small) holes at the corners of the board. I recommend using plastic washers on top and bottom of the board. On the bottom, to keep the exposed metal connectors on the bottom from touching anything they shouldn't. On top, because the screw heads are likely wide enough to reach exposed parts of the board and you don't want to short them. I now only use three screws, because the hole at the #4 corner is so close to a board component, I am worried about damaging it. I do not recommend attaching the WAV Trigger to the metal sheet on the back of the backbox, as this could easily short out the board if anything touched it. Find a space for it on wood.

7. Copy all sound files to the Micro-SD card (into the root directory!), and insert it into #3, the Micro-SD card reader. Insert carefully until it passes the side spring, then push down to lock the card in place.
8. Your WAV Trigger is now ready to be installed. Connect #5 to the Arduino Serial 1 port with the ribbon cable, and plug the speaker bar in at #4, the 3.5mm jack. Be careful to line up all 6 pins at both ends of the ribbon cable. There is no key on this cable to help orient it! Refer to the photo to make sure you do not get the cable on backward. Note that the red wire in the diagram attaches to the left end of the Arduino, and the right end of the WAV Trigger.

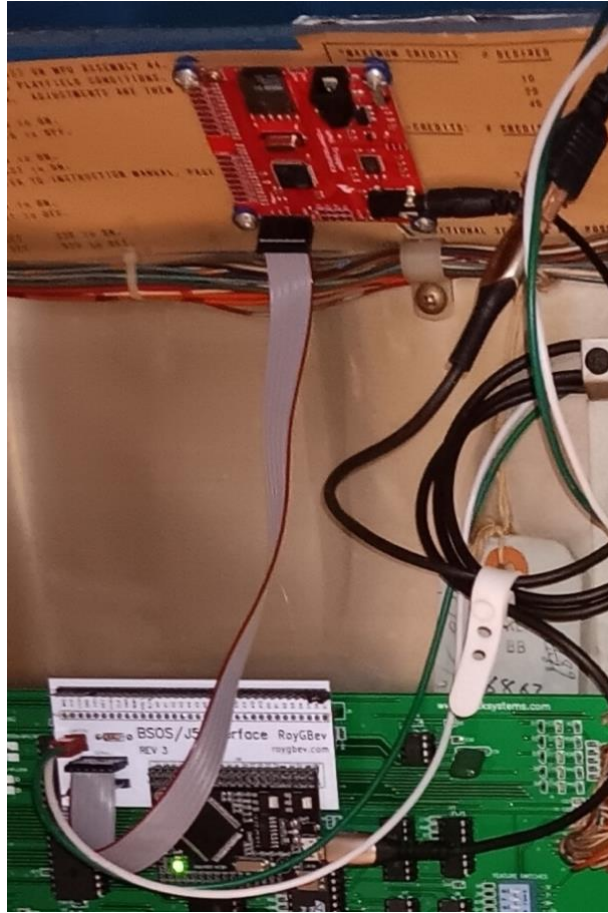


Figure 10

9. I recommend you purchase a stereo computer speaker bar, to be used as the speakers in the above setup. They cost about \$20, so not expensive. It should have a 3.5mm stereo jack to connect to the WAV Trigger, as well as a USB connector to power the speaker. Whatever speakers you use, the WAV Trigger does not power the speakers, so external power is required. The USB connector on the computer speaker can be plugged into an old phone charger to complete the setup, or you can tap into the voltage regulator board's 5-volts by following the instructions below.

Powering your Speaker Bar from the Voltage Regulator Board

If you want the speakers to turn off when you turn off the pinball, it is possible to power a small (around 1 amp usually) computer speaker bar using a 5-volt source in your pinball. This may require some modifications to your voltage regulator board. The method I used is documented below.

Updates to the Voltage Regulator Board

Have you ever noticed on the J3 connector for the voltage regulator board, there is a loop of wire that connects pin 13 to pin 25 (see Figure 11)? This takes 5 volts from one section of the board to another. But if we were to connect those sections directly, this loop could be removed, freeing up two sources of 5 volts which could then be used to power our speaker.

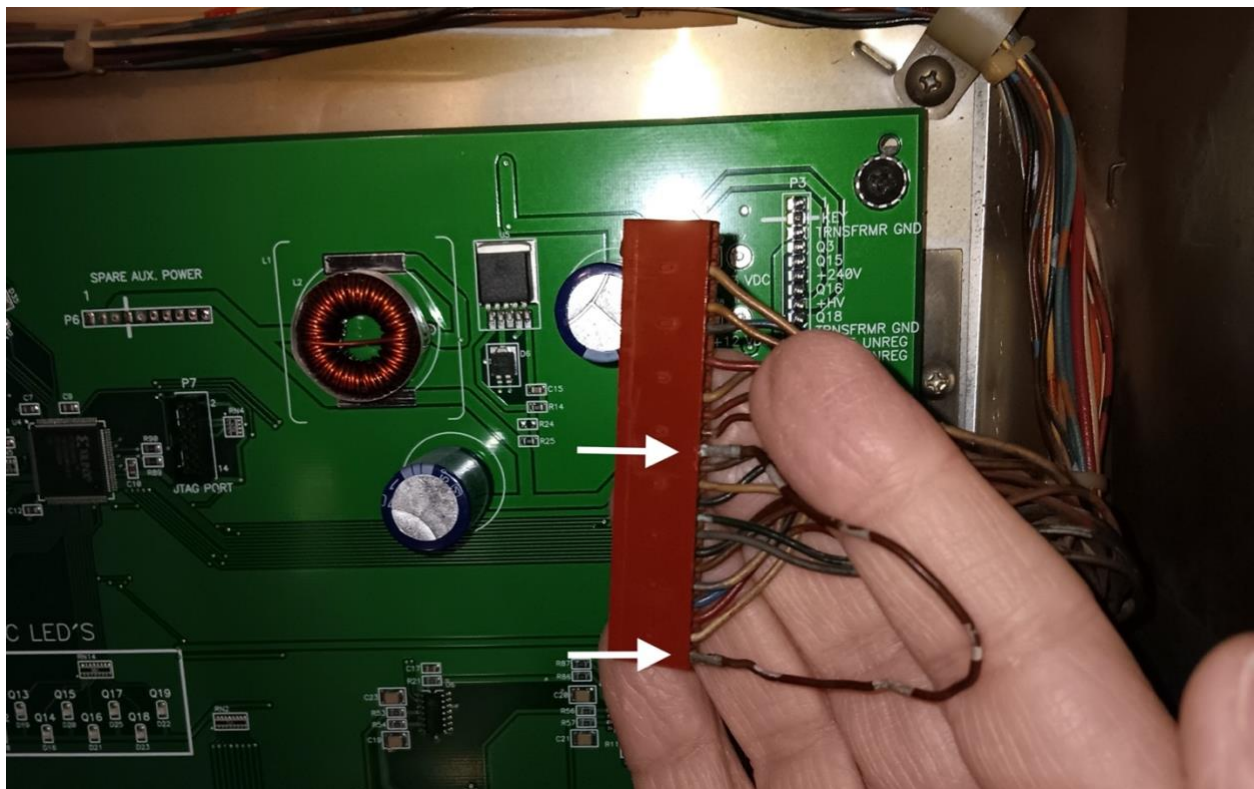


Figure 11

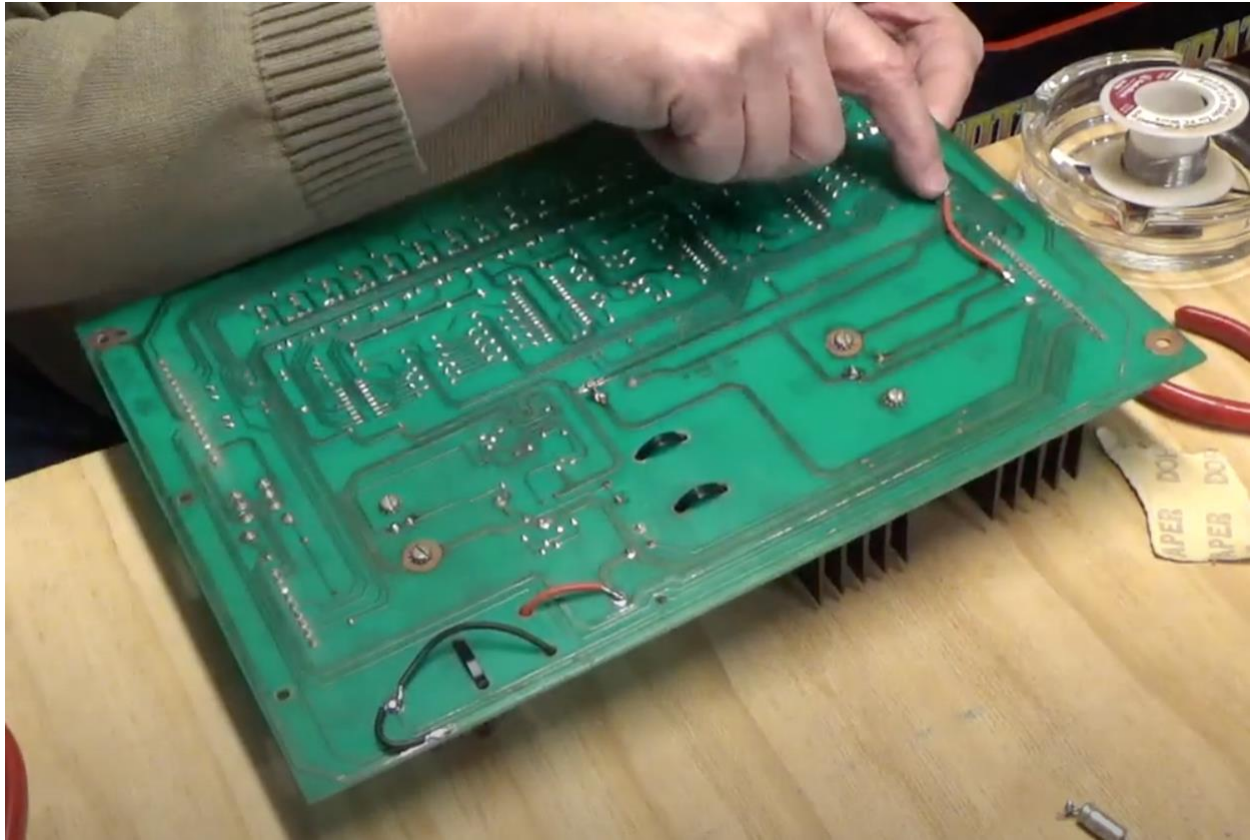


Figure 12

If you have an Alltek voltage regulator board, you do not need to make any modifications. Just remove the looping wire, and you're ready to connect your speaker. But if you are still using the original board, you'll have to make this modification. In Figure 12 you can see I have soldered a wire on the back of the voltage regulator board, connecting TP1 to TP3. This is a recommended modification in any case. TP1 and TP3 are directly connected to J3 pins 13 and 25, and so the loop connecting these pins can be removed.

See this video for additional information: <https://www.youtube.com/watch?v=VWA-4wWTFIQ>

Make a Connector

Next, you need to make a special connector (see Figure 13), starting with what is known as a USB Female Pigtail connector. It has a regular USB female plug on one end, and bare wires on the other. The red wire is your 5-volt line. Crimp a standard 0.1-inch connector to the red wire. The black wire is your ground. There are no spare ground connectors on J3, but we can connect this wire to ground at the corner of the voltage regulator board. Solder a metal washer to the black wire.

There may be two additional wires, that are usually green and white. These are data lines, and not needed for this purpose. Clip them off or tie them back out of the way.



Figure 13

In Figure 14, you can see the connector installed. The red wire is connected into pin 25 of J3, and the soldered washer is held under the corner screw of the board. I have placed it on top of the board, but you may need to place it under the board to get a good connection. Notice also that I have secured the connector's wire using a cable clamp, to eliminate any strain on the connections.

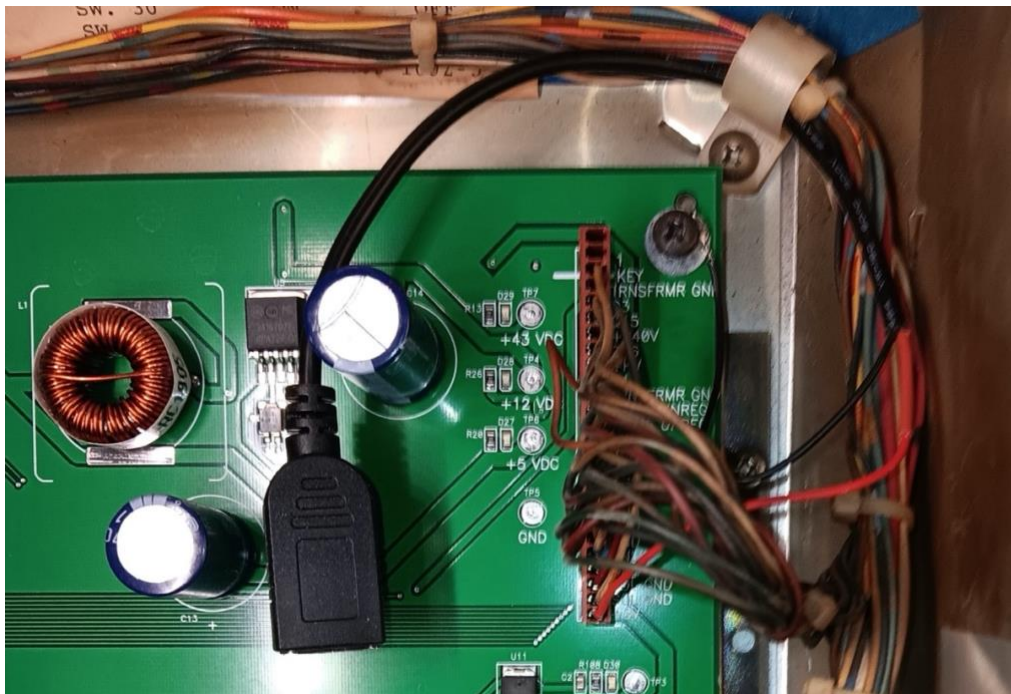


Figure 14



Figure 15

The Final Setup

Figure 15 shows the entire setup, including the Arduino board on the MPU, connected to the WAV Trigger board at the top of the backbox, with the speaker bar at the bottom plugged into the WAV Trigger with a 3.5mm stereo jack (bottom right of the board), and plugged into the pigtail connector with a USB connector for power (above the voltage regulator board).

Other wires you can see in the photo include:

1. A pair of green and white wires attached to the Arduino's "Switch" connector, curling up and over the top before exiting through the back vents.
2. A black cable connected to the Arduino's programming port, coiled around the top of the circuit board bracket before going up and over the top to the back vents.

You will likely not want the speaker to be inside the backbox! It is a simple task at this point, though, to move the speaker bar to the top of the backbox, and snake the wires through the vents at the back, into the backbox, to make the necessary connections.

For additional information please see:

<https://learn.sparkfun.com/tutorials/wav-trigger-hookup-guide-v11/all>
https://cdn.sparkfun.com/assets/1/c/9/a/9/WT_UserGuide_20230114.pdf
<https://www.youtube.com/watch?v=VWA-4wWTFIQ>

Shopping List

This section pulls together everything mentioned in the manual that you might have to purchase in order to complete the project. Note that, you might get away with just purchasing and installing the Arduino, or Arduino with WAV Trigger. But in case you really get deep into the project, these are all the items you might need!

Basic Requirements

Arduino: pinside.com/pinball/market/shops/1304-roygbev-pinball/by-game/185-flash-gordon

Arduino IDE: <http://www.arduino.cc/en/software> (only if you need to modify the software)

Geeteoh sound board: geeteoh.com/squawktalk.shtml, or

WAV Trigger board: www.robertsonics.com/wav-trigger or
maybe you're happy with just the original Bally Squawk & Talk?

Note that the Geeteoh and the WAV Trigger are optional. Only one is needed in any case. The program will run on your pinball with just the original Bally Squawk and Talk, but the extended sounds including quotes, sound effects, and music from the film will not run.

Programming 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.

Micro-SD Card: The Geeteoh and the WAV Trigger both require a 32GB or less micro-SD card.

WAV Trigger Requirements

6-pin IDC ribbon cable: Single-Row / 6 position / Female to Female / ten inches or longer.

0.1" 6-pin vertical male through-hole header: Often sold with 40 pins, which can then be trimmed.

Computer speaker bar: Must have 3.5mm stereo jack and USB power connector.

Four narrow screws, and eight plastic washers.

Speaker Power Requirements

Old USB phone charger or

USB female pigtail connector

Standard 0.1" crimp connector

Metal washer

More Stuff

Micro-SD to USB card reader

Wire

Soldering iron

Solder