Sega/Stern White Star Repair

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1 Introduction

2 Games

2.1 Sega

- Apollo 13
- Goldeneye
- Twister
- Independence Day
- Space Jam
- Star Wars Trilogy
- The Lost World Jurassic Park
- The X Files
- Starship Troopers
- Viper Night Driving
- Lost in Space
- Godzilla
- Harley-Davidson

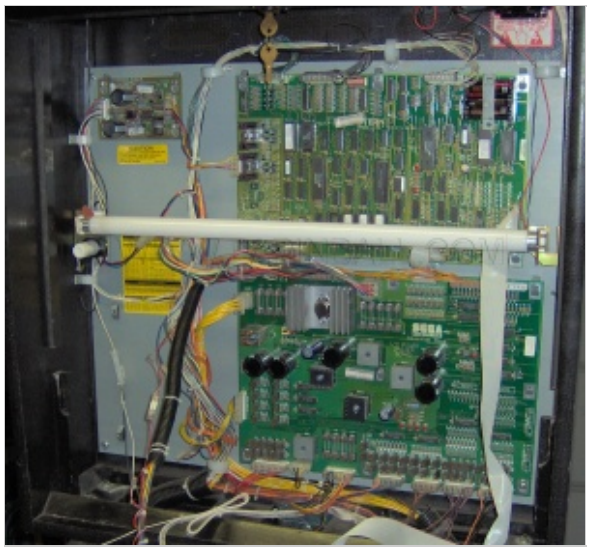
- South Park

2.2 Stern

- Striker Xtreme
- Sharkey's Shootout
- High Roller Casino
- Austin Powers
- Monopoly
- NFL
- Playboy
- Roller Coaster Tycoon
- The Simpsons Pinball Party
- Terminator 3: Rise Of The Machines
- The Lord Of The Rings
- Ripley's Believe It Or Not
- Elvis
- Grand Prix
- The Sopranos
- NASCAR

3 Technical Info

3.1 The White Star Board Set



Typical Early Stern White Star Boardset (Monopoly)

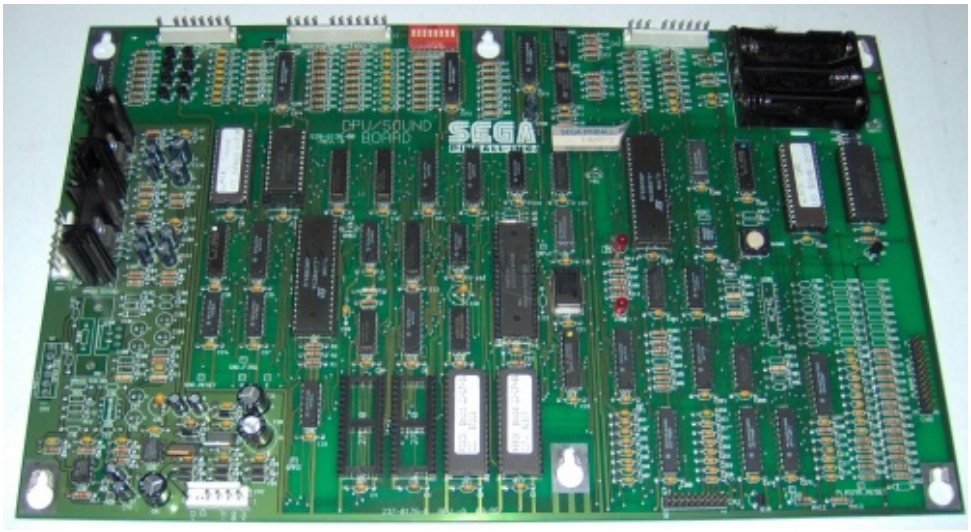
The White Star System board set consists of three boards mounted to the the back box, but four boards total. The CPU / Sound board, I/O Power Driver board and the Display Power supply. Additionally, there is a dot matrix display controller mounted to the backside of the dot matrix display. On some games, the dot matrix display controller is mounted to the backbox instead.

The first two White Star games, Apollo 13 and Goldeneye, both used an additional solid state flipper control board. Starting with Twister, the solid state flipper board was abandoned, and flipper control became an additional duty for the I/O power driver board.

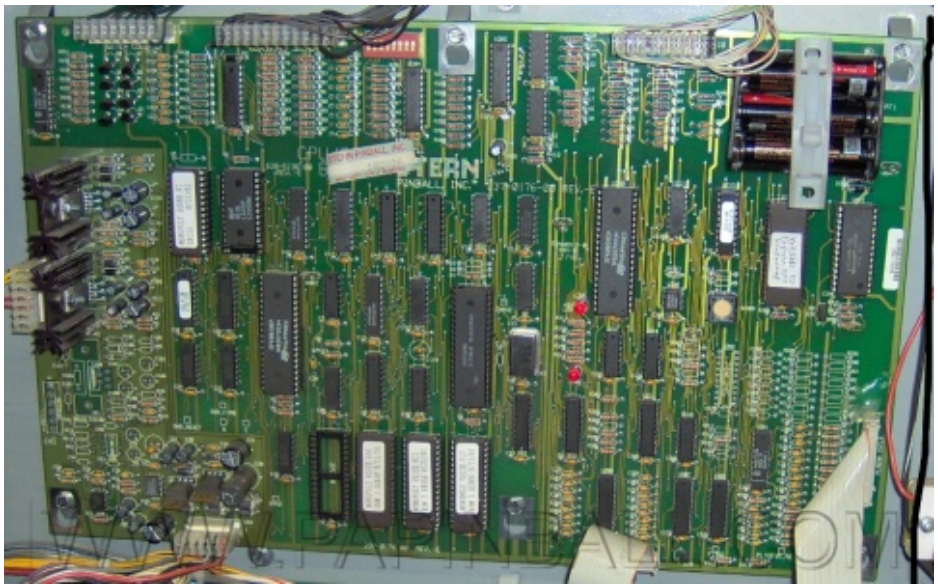
In addition to pinball machines, the White Star board set was used in several redemption games made by Sega and Stern. Some of the games are Wack-A-Doodle-Doo, Sega Sports, Titanic, and Monopoly redemption.

3.1.1 CPU / Sound Board

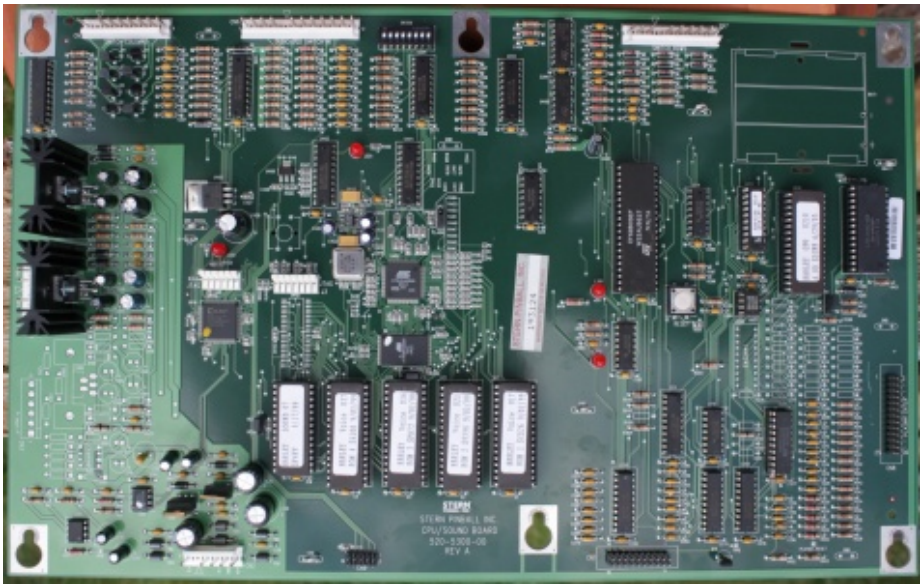
The two generations of the Sega/Stern White Star MPU



Sega White Star CPU/Sound Board 520-5136-16 Rev. D (Wack-A-Doodle-Doo)



Stern White Star CPU/Sound Board 520-5136-16 Rev. E (Monopoly)



Stern White Star CPU/Sound Board II 520-5300-00 (LOTR and forward). U201, U213, and U413 are socketed on this board as a result of alkaline damage abatement.

There are two versions of the White Star CPU/Sound board. The board as used in Sega machines starting at Apollo 13 (A13) and Stern machines up to Terminator 3 (T3) are the standard version as shown above which is part #520-5136-16. There were different revisions of this board, which included slight component changes and modifications. However, there were some distinct changes to the board from revision D to revision E. The Q9 transistor located just below U212 (RAM memory) was removed, and jumper JP1 was added. Additional circuitry allowed for increased RAM memory from 8K to 32K. The JP1 jumper was used to choose between the installation of 6264 and 62256 RAM.

Stern machines starting from Lord of the Rings (LOTR) used a different version of the White Star CPU/Sound board called White Star CPU/Sound Board II, part #520-5300-00. Stern had this in-between version made because the BSMT2000 audio chip wasn't available anymore and having it reproduced was too expensive. The White Star II therefore uses an BSMT2000 emulation circuit consisting of an Atmel AT91R40008 microcontroller and an Atmel AT49BV1614-11TC 16Mbit flash memory. Later boards use a AT49BV162AT-70TI flash memory chip. Both flash chips are obsolete now. The boards are known for sudden sound failures usually because of a bad flash chip and it is advisable to buy a spare.

Note: Stern states that the Atmel version board is backwards compatible with the standard (BSMT2000) version, so it can be used in *some* White Star based games (in most cases, Stern branded White Star games only - including South Park and Harley Davidson) prior to LOTR as well. However, the only games which the board can be installed in must use 8mb EPROMs for the sound section versus the 4mb EPROMs more commonly found on Sega White Star based games. If the CPU/Sound board II is used in early games, Starship Troopers for instance, some sounds may not render correctly.

The BSMT2000 based White Star sound system is basically the same as the sound circuitry on Data East/Sega soundboards 5020-5050-0x, 5020-5077-00 and 5020-5126-02.

There are some programmed TIBPAL16L8 PAL chips on the board. These are programmable logic chips. They have a colored dot on them so they can be distinguished. U213 is one of these chips and it's right in the battery corrosion area. It is readily available, already programmed under part number 965-6504-00 (blue dot), the only exceptions to that are

Sharkey's Shootout using part number 965-5023-00 (gold dot) and Lord of the Rings LE with a shaker motor installed using a different part number (the standard LOTR without a shaker motor uses the standard 965-6504-00 but the software version supporting the shaker motor will only run on the alternative U213).

There are two more PAL chips on the board at U19 (yellow dot, 965-0136-00) and U20 (white dot, 965-0137-00). These aren't needed very often for repairing sound boards but they do go bad now and then. Data retention for these programmable logic chips is generally specified at 20 years or more. The first White Star boards are from 1995 so from 2015 they start exceeding the data retention period and although big problems are not to be expected it wouldn't be unlikely when more of these start to fail.

The programmable logic in the board design makes it harder to repair the boards because of the grey area it causes in the schematics as there aren't any logic diagrams of these available. In short; you don't know what they do so you don't know what the output should be.

"Blink Codes" do not exist for the 68B09E or the Atmel based MPU. With one exception (Atmel based board) anything blinking is a side-effect of improper board operation. The blinking may help you diagnose the actual board problem, but blinking LEDs are not driven with intent by the processors. i.e. There are no "Bally -17-like Blink Codes".

The single exception to this is LED1 on the Atmel based MPU. LED1 on this board will blink anywhere from 5 to 8 times to indicate the sound operating system version contained in the flash memory at U8. Stern has provided a good explanation within Service Bulletin # 157. This service bulletin also describes the process to update flash memory to a newer version of the sound operating system (which is not recommended unless you encounter sound issues after moving an MPU from one game to another).

There are two JTAG (http://en.wikipedia.org/wiki/Joint_Test_Action_Group) (Joint Test Action Group) connectors available on the Atmel based board. One connects to the Xilinx CPLD (http://en.wikipedia.org/wiki/Complex_programmable_logic_device) (Complex Programmable Logic Device). The other connects to the Atmel R40008 processor. The JTAG interfaces to this board and their use have not been documented publicly.

As of April 2014, schematics for the 520-5136-16 board are no longer available from Stern's website.
As of April 2014, schematics for the 520-5300-00 board are no longer available from Stern's website.

3.1.1.1 BSMT2000 DSP Info

BSMT2000 audio chip

Like the earlier Data East boards, the first White Star generation uses a TI DSP for sound processing. The chip is just a relabeled mask programmed stock Texas Instruments TMS320C15NL-25 DSP. The 8K mask programmed ROM is custom programmed during manufacturing and can not be read out, reprogrammed, or altered in any way. Only the ones labeled BSMT2000 will work in a pinball. For prototyping, the TMS320P15NL-25 and TMS320E15NL-25 were available which included a more-or-less standard 27C64 EPROM. The pictures on the left shows a BSMT2000 and a TMS320P15NL-25 out of a Sega board. The hand labeled chips are rare but if you have one in your pin, you can read it out. The security fuse was not set on the device in the picture. If you build an adapter using a 27C64 and some logic which puts the DSP in microprocessor mode and does the address decoding it might even be possible to use the C10 and C15 devices because the internal ROM is not used in this mode.

3.1.2 Power Driver Board

Power, fuses, bridge rectifiers. GI relay, coil and flasher drivers.

++ Need pic of the Sharkey's Shootout (Tournament Ed.) driver board inserted here +++

Stern White Star I/O Power Driver Board

As of April 2014, schematics for the 520-5137-01 board are no longer available from Stern's website.

As of April 2014, schematics for the 520-5137-64 board (Sharkey's Shootout Tournament Edition only) are no longer available from Stern's website.

As of April 2014, schematics for the 520-5137-01 board (100 ohm resistors added on J2 aux. port lines) are no longer available from Stern's website.

High current coils (50vdc) 1-8 (group 1) and 9-16 (group 2). Q15 and Q16 typically drive the left and right flippers respectively.
Low current coils (20vdc) 17-24 (group 1) and 25-32 (group 2).

Please be advised that four revisions of these board exist. The letter after the number indicates the revision. Only the latest revision G is compatible with the Stern tournament system (TOPS). With earlier revisions while everything including the tournament sign seem to work ok a tournament can not be started. Pressing the tournament button will result in a 'Tournament Game Paused' message displayed on the DMD. The tournament button itself will also not light up during normal operation. The J3 Aux In connector has an additional pin instead of the key pin on these boards. Because of this the LST line to the lamp drivers goes nowhere on this revision. See below. All existing Stern schematics are wrong.

Revision D: First revision

Revison E: Second revision

Not fully stuffed. Parts for flipper boards connector J4 and J5 are not stuffed.

Revision F: Third revision

C25 changed from 470µF 100V to a 330µF 160V Snap-In capacitor

U210 pin 3 cut to allow for a 10% input voltage tolerance before resetting

J2 modified and 100 Ohm resistors R258 to R260, R273 -R277 added (see schematics)

Revision G: Fourth revision not documented by Stern

This is the only version working together with the TOPS system.

Deleted parts:

Original R256, D228, R255 and C236 above U210 were removed

Modification 1:

J3 Pin 8 is no longer a key pin and connected to R255 and to C236 and to R256

The other side of these parts is connected to:

R255 to D217 banded side like R245 to R251

C236 to GND like C229 to C235

R256 to U203 Pin 11 (LST lamp status)

The LST trace to D221 to D227 is missing. The diodes are still connected to the status output line of the VN02 solid state relays. It seems that this status is not queried by the game software or can just be ignored.

Modification 2

U210 Pin 3 to R257.

R257 to GND but not stuffed!

Second modification not necessary see schematics for revision F. Just cut Pin3 of U210

New parts:
R255 1K
R256 39K
R257 NS
C235 470pfd

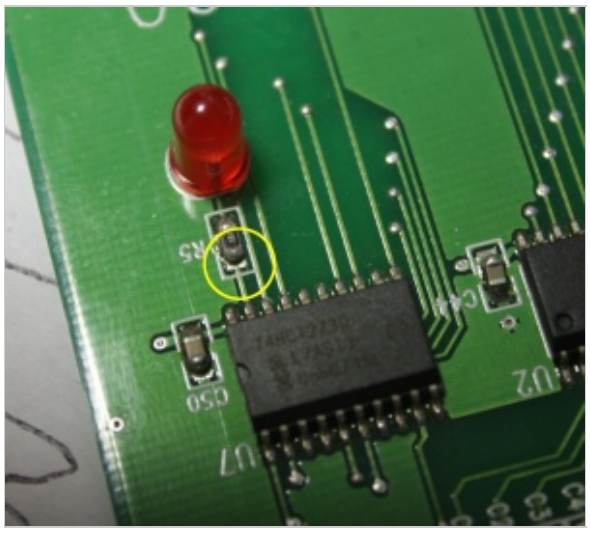
3.1.3 Display Controller Board

Sega White Star Display Controller Board

As of April 2014, schematics for the 520-5055-00 DMD controller board (through hole components) are no longer available from Stern's website.
The display controller board doesn't contain circuitry to provide the on board 68B09E with a "reset" pulse. The reset signal is provided from the games MPU via a pin at the ribbon cable connection (J1 pin 20). The surface mount version of the board has provisions to provide a reset signal at U10, but the necessary components are not stuffed.

As of April 2014, schematics for the 237-0255-00 DMD controller board (primarily surface mount components) are no longer available from Stern's website.

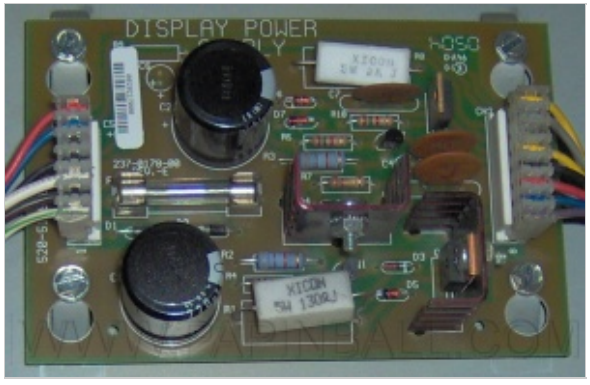
Stern White Star Display Controller Board, surface mount version.



A fractured solder joint (circled) on this board prevented the "power on" LED from ever lighting.

The surface mount version of this board sometimes has dubious solder connections at some of the surface mount resistors and capacitors. The picture at left shows a fractured solder joint on the resistor in series with the "power on" LED. The LED would never light. Another fractured solder joint on the same board prevented the reset pulse from the MPU board from ever reaching the on board 68B09E.

3.1.4 Display Power Supply



Stern 520-5138-00 Display Power Supply

The output voltages of this board should be approximately: Measured from GND on CN2 pin 4/5

-110V on CN2-1

-98V on CN2-2

+5V on CN2-6 (directly from the input on CN1-7)

+12V on CN2-7 (+20V comes from CN1-6 and is regulated on +12V by VR1 (L7812CV)

+68V on CN2-8

Fuse type on the board: 0.75A SB

Common failures:

Fuse blowing

-110V missing or too low

-98V missing or too low

+68V missing or too low

Solutions:

A blowing fuse is often caused by a defect rectifier diode D1 or D2 (1N4004, can be replaced by 1N4007). When D1 was defect and replaced there's a big chance that Q1 and Q3 are defect as well. When D2 was defect and replaced often Q2, Q4 and Q5 are defect too.

-120V problems are often caused by a defect transistor on Q2 (MPSA42) and/or Q4 (MJE15031) when one of the transistors is defect there's a big chance the other is defect as well. Replace zener diode D4 (3.9V), D6 (100V) and D7 (13V) as well.

-100V problems are often caused by a defect transistor on Q5 (MJE15030) or zener diode D6 (100V), it's best to replace both. The 2k/5W resistor on R8 might also cause the problem, mostly because of bad solder contacts.

+60V problems are often caused by a defect transistor on Q3 (MJE15030) and/or Q1 (MPSA92) when one of the transistors is defect there's a big chance the other is defect as well. Replace zener diode D3 (3.9V) and D5 (68V) as well.

As of 2014, schematics for the display power supply board are no longer available from Stern's website.

3.1.5 128 x 32 Dot Matrix Display

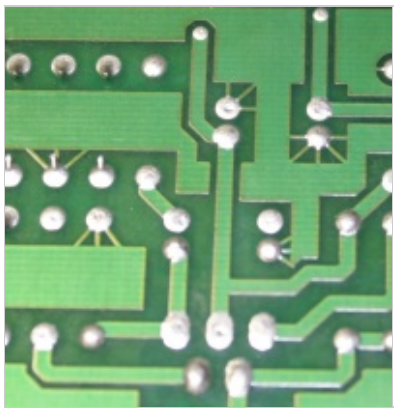
All Sega or Stern White Star games make use of a 128 x 32 "standard" dot matrix display.

3.1.6 White Star Manufacturing Quality

Generally, White Star boards are manufactured quite well. The traces are very fine, making alkaline damage repair difficult. But, those batteries shouldn't be on the board, should they? The Atmel based MPU board uses a multi-layer PCB, which increases the need for clean component removal and replacement.

Pictured at left, are two factory updates to the original Sega/Stern White Star MPU (BMST2000 version). These are normal, and not "hacks".

Factory updates to the Sega/Stern White Star MPU.



Small traces lead to some components on White Star boards, enabling better manufacturing quality.

By the time White Star boards were being manufactured, improved methods of controlling solder temperature and junction temperature at the through-holes was much better understood. In the picture at left, the "spider" connections at some through-holes, allow less heat to be used to create quality solder joints.

3.2 Recommended Documentation

As always, it is highly recommended to possess a game manual. Every game manual is full of detailed information regarding game specific switch, lamp, and coil assignments. Equally, details for maneuvering through test, audit, and bookkeeping screen menus, schematics for all boards used, and game specific mechanical assemblies are included. Hard copy game manuals can be purchased through several of the recommended pinball parts suppliers (http://pinwiki.com/wiki/index.php?title=Pinball_Parts_Suppliers) . Some Stern White Star Game manuals are available in PDF form on the Stern Pinball website. They are on the game specific pages of the Stern website. An index of games can be found in the right margin here (http://sternpinball.com/game-code) .

As of April 2014, the Stern Pinball website no longer archives theory of operation and board schematics in PDF format.

Likewise, Stern Pinball no longer keeps an online archive of service bulletins for Sega and Stern.

3.3 The Wire Coloring Code

White Star games do not use color coding system. Instead, the wire color was marked accordingly in the associated documentation, (ie. a green wire with a brown trace is referred to as GRN-BRN, orange with violet is ORG-VIO, white is just WHT, etc.).

3.4 Switch Matrix

The White Star system uses an 8 x 8 (8 switch columns, 8 switch rows) switch matrix. Outside of the switch matrix, there is an extra column of switches, which are the dedicated switches on all White Star games.

A combination of microswitches, opto switches, leaf switches (on most drop target assys.), and reed switches are used. Stand up targets are comprised of traditional targets, 3D targets, and modular targets.

3.5 Dedicated Switches

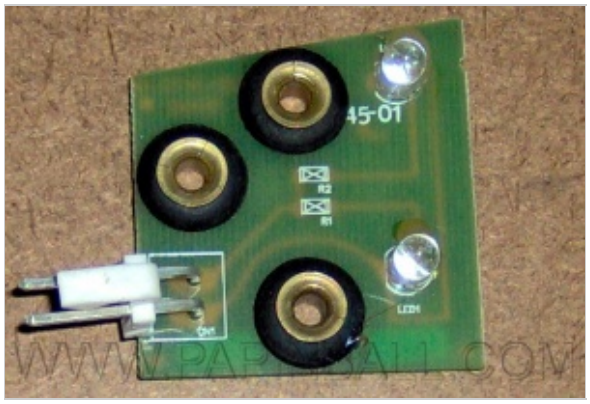
A column of switches outside of the switch matrix is used for dedicated switches with the White Star platform. These switches include coin door test switches, plus flipper cabinet and EOS switches on games after Goldeneye.

3.6 Lamp Matrix

The White Star system is somewhat like previous switch matrices from DE / Sega and Williams. The main difference is instead of only using 8 lamp columns and 8 lamp rows (the typical 8 x 8 matrix), 2 additional lamp rows are used, extending the matrix to 8 x 10.

3.7 Trough Opto Boards

++++ Need pics of the single opto transmitter and receiver boards ++++++



Stern White Star Trough Opto Transmitter (Later Games)

All White Star Games use trough opto boards at the location of the trough VUK which feeds the ball to the shooter lane. Earlier White Star games (Apollo 13 to Viper Night Drivin') use only a single opto above the VUK plunger. Later White Star games (Lost in Space to NASCAR / Grand Prix) use a two opto system. The lower opto serves a dual purpose. It is the opto just above the VUK plunger like earlier games, but is also designated as trough switch #4. The upper opto is designated as the "stacking opto". Its purpose is to identify when a ball inadvertently gets "stacked" above a ball located at the VUK plunger.

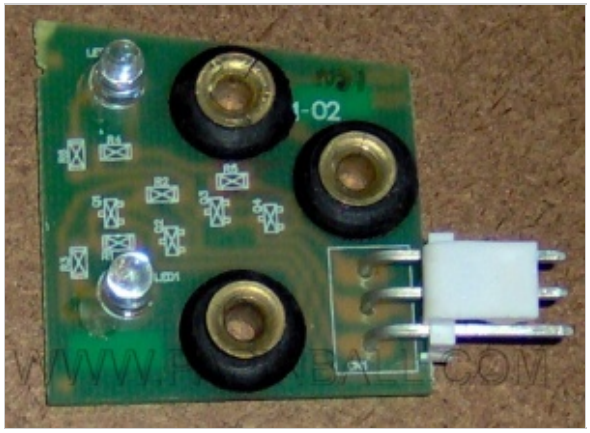
To briefly summarize the operation of White Star VUK opto boards, if an object is blocking the light beam between the transmitter opto LED and the receiver opto LED, the CPU detects this as a switch closure. When an object is not present to break the light beam, the CPU detects this as an open switch. The components used on the opto receiver board are designed to do as such.

The transmitter side is simply an ultra-red LED with a current limiting resistor. The receiving opto is the same style ultra-red LED, and is able to detect the light wavelength emitted from the transmitting LED. By using discrete components on the receiving side, the appropriate signal is sent to the CPU via the switch matrix return (row). When LEDs are paired together in this type of fashion, the receiving LED emits a very small amount of voltage, when the proper light wavelength is present. By employing such a design, failure on the receiver opto side is more common.

This particular system is contrary to how Bally / Williams WPC CPUs handle opto pairs. Equally, WPC games employ infrared (IR) opto switch pairs. If interested in learning the theory of operations for the White Star opto trough upkicker boards, please consult the manual. Sega / Stern have included some excellent, detailed, technical documentation within their manuals.

As of April 2014, schematics and troubleshooting info for the trough upkicker dual opto boards are no longer available from Stern's website.

Once significant source of trouble with these trough boards is fractured header solder joints.



Stern White Star Trough Opto Receiver (Later Games)

3.8 Magnet Processor Board

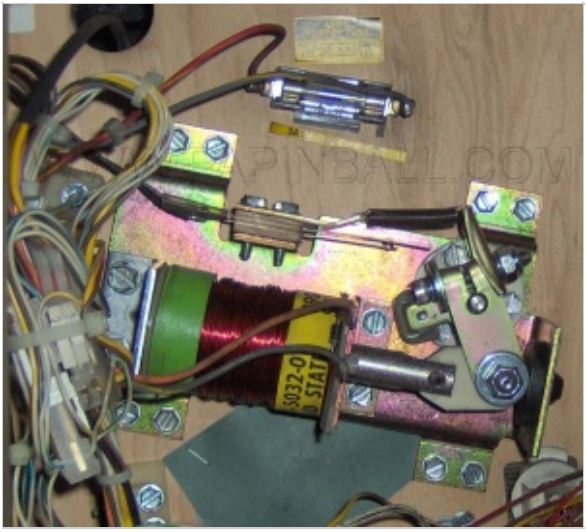
Sega 520-5143-00 Magnet Processor Board

Only two Sega games used this style of magnet processor board - Twister and Goldeneye. When U1 for Twister is installed in the board, the board's part number is 520-5143-01. The part number for the board when U1 is written for Goldeneye is 520-5143-02. Difference between the board used on each game is the different custom PIC / GAL chip used at position U1 and the Goldeneye board has R10, R11, R12, R13, D11 and D12 stuffed. This is not always the case with boards for Twister.

3.9 Flippers

All Sega / Stern White Star flipper assemblies are solid state controlled. Apollo 13 and Goldeneye are the only two White Star games which use a separate solid state flipper control board located in the game's lower cabinet. Starting with Twister, the flipper board was abandoned, and circuitry to control the flippers was incorporated into the power driver board.

Please note that the adjacent pic of the White Star flipper assembly has a Williams flipper link / plunger installed.

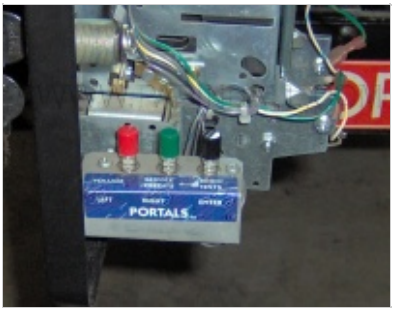


Typical White Star Left Flipper Assembly (Monopoly)

3.10 Accessing Bookkeeping, Settings, and Diagnostic Modes

Solid state pinball machines typically have a built in system for audits and adjustments. All White Star based machines use a system called "Portals". The Portals interface is a carry over from the last two Sega games (Baywatch and Batman Forever) which used the Data East board set.

3.10.1 Portals (Coin Door Test Buttons)

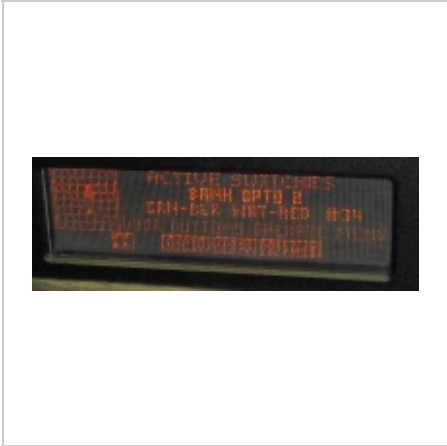


The Portals control panel used on most White Star games (Monopoly)

The Portals system has a very user friendly, simple navigation system. Unlike previous Data East / Sega games, having to scroll through all of the audits and adjustments is a thing of the past. Diagnostic testing (including game specific assembly tests), audits, and adjustments can all be quickly accessed via the initial display menu graphical interface. The 3-button control panel (in most cases, except some earlier White Star games) used to access Portals is located on the coin door.

DMD Screens during Various Tests in Portals

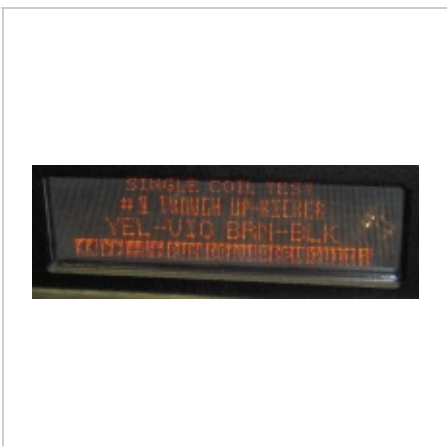
Switch test (similar to switch edge test in Williams speak)



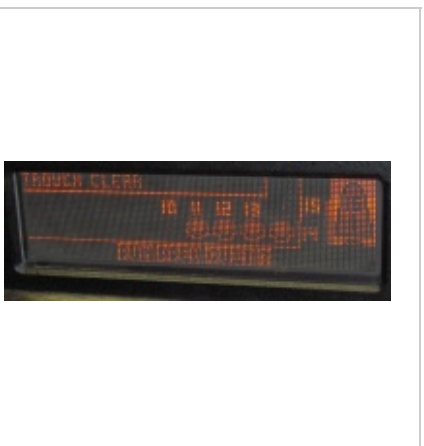
Active switch test (similar to switch level test in Williams speak)

Dedicated switch test

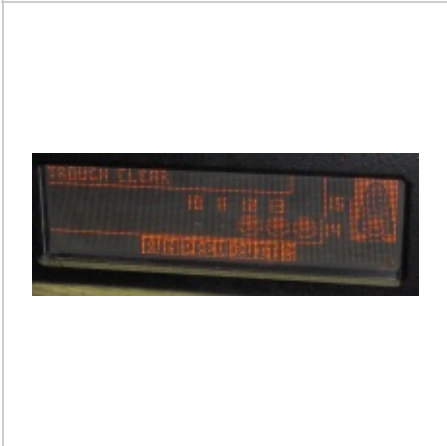
Very flexible lamp test options



Coil test



Trough clear, but equally a good test for the trough and shooter lane switches



Advancing through trough clear

3.10.1.1 Setting Free Play

3.11 Coin Door Switches

Coin door Switches Located Inside a White Star Game (Monopoly)

Most White Star games have two switches located on a bracket inside the coin door (hinge side). The upper switch is the memory protect switch. This switch is used so that nothing can be written to the memory, unless the coin door is open. The memory protect switch is not part of the switch matrix, nor is it one of the dedicated switches. Although it does connect to the CPU / Sound board via the same connector as the dedicated switches, its state is processed by a different chip (U213) versus the dedicated switches (U206).

The lower switch is an interlock style "kill" switch. This kill switch is used to kill all power to the solenoids, when the coin door is opened. Since it is an interlock style switch, it can either be depressed (when the coin door is closed), or it can be extended outward to turn the switch on. To extend the switch to the on position when the coin door is open, grasp the switch, and gently pull it out to the lock position.

The kill switch is a double pole switch. Wiring to one pole of the kill switch is BLK-YEL and BLK-YEL, while the other is RED-WHT to WHT-RED (yes, the colors do not match!)

4 Problems and Solutions

4.1 Power Problems

4.2 MPU boot issues

4.2.1 Relocating the Battery from the MPU board


The aftermath of batteries which leaked. This board is beyond repair, and good only for salvage parts.

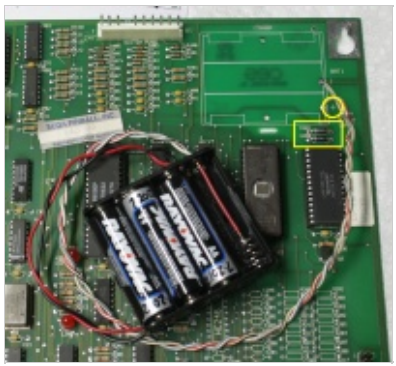
Relocating the 3xAA batteries off the MPU board or installing other alternatives for memory retention is always a good idea. Leaky alkaline batteries are the #1 killer of pinball boards.

One option is to install a remote battery holder, and place the battery holder somewhere below all the other boards. This ensures that even if the remotely located batteries leak, they won't leak onto (or even drip onto) components of the MPU board. Use good quality alkaline batteries, mark the date of replacement with a Sharpie, and replace the batteries annually.

Another option is to install a memory capacitor. This method is considered to be better than a remote battery holder, because memory capacitors are not prone to leakage like alkaline batteries. The only drawback is that the memory capacitor has to be properly recharged to be effective. If a game has the potential of sitting dormate without being turned on for extended periods (typically months), the memory capacitor may not hold the memory.

A third option is to install a lithium battery with a battery holder. Lithium batteries are much less likely to leak than alkaline batteries, and they do not need to be recharged.

Whatever you do, GET THE BATTERIES OFF THE BOARD! It's not a matter of if they will leak, it's a matter of when. White Star boards are pricey to replace, and repair is difficult/expensive/even impossible due to the very fine traces used on the board.



A White Star MPU Board with Remote Battery Pack Connected. The Positive (+) terminal is circled. D200 and D201 are highlighted inside the rectangle. Note that the battery installation date is recorded with a Sharpie. Also note the **long** wires, allowing the holder to hang well below the backbox boards, another precaution for leaky batteries.

Adding a connector between the battery pack and the MPU board is a good idea. In doing this, the battery pack can easily be removed from the MPU board. Plus, if the batteries are forgotten, and do leak, the MPU board may not have to be removed to add another battery pack. A 3 x AA battery holder is the typical recommended replacement. If only a 4 x AA battery holder is available, a jumper can be soldered in the first battery position. Likewise, a diode can be placed in this position instead. Using a diode instead of a jumper will prevent the batteries from being charged and 'cooked' by the game if blocking diode D201 on the MPU board fails. Keep in mind that a second (redundant) diode added to the circuit will reduce the backup voltage to the RAM memory by .5 to .7 volts. Install a 1n4001 or 1N4004 diode in the position closest to the last + terminal (where the Red Wire exits). The banded side of the diode must be pointing in the direction of current flow, which is towards the (+) terminal marking on the MPU board, and away from the battery pack.

On the MPU, solder the battery cables: positive (red wire) to the "+" pad and ground (black wire) to the "-" pad.

Since the MPU board is already out, another good practice is to check the D201 blocking diode. An open blocking diode will not allow the battery pack voltage to pass through to the non-volatile memory, and the newly installed battery pack will be ineffective. Conversely, a shorted blocking diode will allow the board's +5vdc logic power bus to pass through to the battery pack. This in turn, will charge the batteries, while the game is turned on. Alkaline batteries do not like being charged. They will heat up, and fail rather quickly. In worse cases, the new batteries can even leak or explode if charged. Testing the D201 diode is quick and easy, and worth the trouble checking it out. When in doubt, replace the D201 diode with a 1N5817 (a 1N4004 will work in a pinch), or add a redundant 1N4004 to the battery pack. Once again, if a second (redundant) diode is added to the circuit, it will reduce the backup voltage to the RAM memory by .5 to .7 volts

Testing the D200 diode is a good idea too. The D200 (1N5817) diode is used to keep the backup batteries from powering the complete MPU board when the power is off. A symptom of a failed D200 diode are batteries which deplete rapidly.

After adding a remote battery pack, and while the board is still out of the game, it is a good practice to measure the battery pack's voltage at the **VBATT** test point on MPU board. All battery packs are pretty cheaply made, and failures "out of the box" are somewhat common. Checking to make certain the battery pack is functioning before reinstalling the MPU board in the game will save some headaches.

4.2.2 Installing a Memory Capacitor Instead of Batteries

Installation of a Memory Capacitor

A memory capacitor is a great choice for memory retention, provided that the game will be turned on more frequently than not. If the game will not be turned on for several months, the memory cap may not stay charged. In turn, the memory may not be retained.

It is recommended to use a 1F (Farad) 5.5v memory capacitor. The lead centers on a common, button memory cap are shorter than the "+" and "-" through holes where the factory battery holder was installed. To overcome this, solder a short wire onto the negative lead of the cap. Then, bend the lead at a 90 degree angle, so

it is now parallel to the bottom of the memory cap. Place the positive lead of the memory cap into the "+" of the board, and then place the wire from the negative lead into the "-" of the board. Solder both leads in place.

Please note that when using a memory cap, the D201 diode must be removed (or jumped), and a 0 ohm jumper should be installed. This purpose of removing the D201 diode is so the memory cap can be properly charged when the game is on.

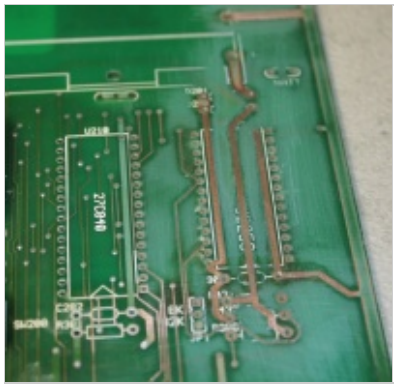
4.2.3 Repairing Alkaline Corrosion

Sega/Stern White Star boards are well known for issues with leaky batteries. This is because the batteries are mounted on the top of the board with plenty of board beneath it for the corrosion to leach onto. Components well below the battery holder are often damaged.

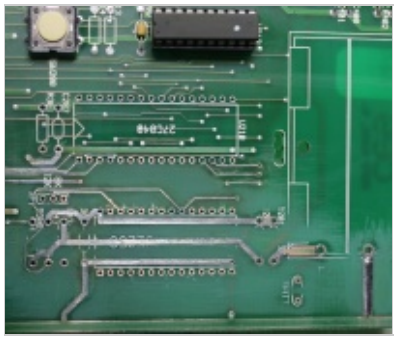
Remember, battery corrosion is alkaline. Harkening back to the dim and distant past, remember your Chemistry 101. Alkaline is neutralized with acid. Most commonly used is vinegar, since it is an acid. Diluting the vinegar to half strength by adding an equal amount of water (50/50) is a good idea to prevent adverse impact to adjacent areas of the board.

This MPU sustained alkaline damage. Sockets for the 68B09E processor and the 6264 RAM have been removed.

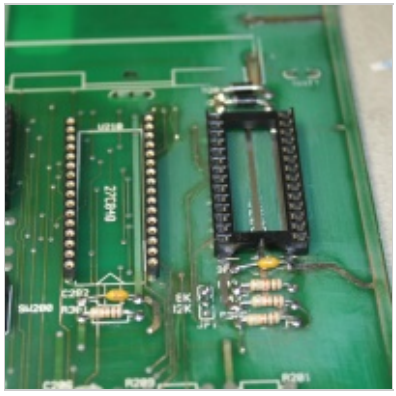
Argh! The MPU pictured at left has sustained alkaline damage. In this case, the damage was repairable. Most of the time, alkaline damage to White Star MPUs is more substantial and beyond economical repair.



More components removed, the alkaline damaged traces sanded, and the damaged area treated with 50/50 vinegar and water.



Bare copper traces tinned.



Bare copper traces tinned.

The completed board shown on the left took a few hours to cleanup, repair, verify, and game test.

4.2.3.1 Continuity Chart of Pin Outs in Battery Damaged Area

Just below the battery holder, the CPU EPROM and RAM both reside. Both of these chips and their sockets are susceptible to battery damage. Provided that the alkali damage breached the chip sockets, it is always best to check continuity on the new work performed. Below is a chart of the pin outs between the RAM (U212), EPROM (U210), and CPU (U209) chip. This chart will hopefully come in handy should repair of this area is necessary.

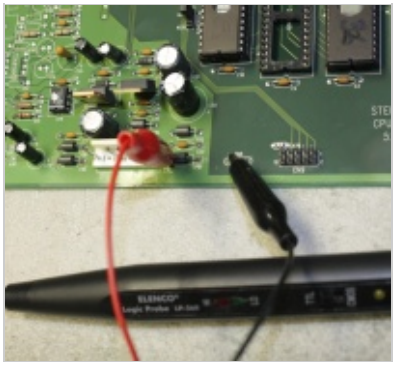
Signal	U209 Pin	U210 Pin	U212 Pin	Other
Vcc	7	32	28	
GND	1 & 39	16	14	
A0	8	12	10	
A1	9	11	9	
A2	10	10	8	
A3	11	9	7	
A4	12	8	6	
A5	13	7	5	
A6	14	6	4	
A7	15	5	3	
A8	16	27	25	
A9	17	26	24	
A10	18	23	21	
A11	19	25	23	
A12	20	4	2	
A13	21	28	26	
A14	22	29	---	U211-2 (XA0)
A15	23	3	---	U211-5 (XA1)
A16	31	13	11	U211-6(XA2)
A17	31	13	11	U211-9 (XA3)
A18	31	13	11	U211-12 (XA4) - Prior to rev. E boards
D0	31	13	11	
D1	30	14	12	
D2	29	15	13	
D3	28	17	15	
D4	27	18	16	
D5	26	19	17	
D6	25	20	18	
D7	24	21	19	
/ROMCS	---	22	---	U213-9
/RAMCS	---	---	20	U213-18
/E	---	24	22	U1-6
/CS	---	---	26	Q9-1 - rev. D or JP1 (8K) - rev. E
R/W	32	---	27	U213-7

4.2.4 Connecting a logic probe to the MPU

Connecting a logic probe to a Sega/Stern White Star board set (left) is simple. Both 5V and Ground test points are made available on the MPU board.

Connecting a logic probe to a Sega/Stern White Star MPU

Connecting a logic probe to a Stern White Star (modified) board set (right) is simple too, but a 5V connection point isn't provided.
Connect the positive lead of your logic probe to either side of the inductor labeled FB1.



Connecting a logic probe to a Stern White Star (Modified) MPU

4.2.5 Using a PC Power Supply For Bench Testing

4.3 Low +5VDC and Game Resets

Some symptoms of a game which repeatedly resets upon boot up are:

1. General illumination lamps will repeatedly flash on and off (the GI relay can be heard clicking on / off).
2. The DMD will display the initial boot screen, show the display ROM revision number, go blank, and then repeat this process.
3. The sound board (depending on the age of the game) may only emit a "blip" sound or a shorter than usual initial sound clip.

In some of the above instances, the DMD display may or may not light up at all.

The +5VDC for logic power is sourced from the 8VAC secondary windings on the transformer. The 8VAC is fed to the I/O Power Driver Board, and rectified via bridge rectifier, BRDG21. The rectified DC voltage is regulated via an LM338K adjustable voltage regulator. Logic voltage can be adjusted via R116 on the driver board, which is a 50 ohm adjustment potentiometer.

U413, which is located on the CPU / sound board next to the reset button, is a Dallas Maxim DS1232 (http://datasheets.maxim-ic.com/en/ds/DS1232.pdf) monitoring chip. In theory, should the logic voltage dip to less than 5% or +4.75VDC, the DS1232 will force a reset of the CPU. However, it has been determined that most White Star board sets will not function properly below +4.85VDC.

If the voltage on the power I/O driver board is below the +4.85VDC threshold, adjustment can be made via the R116 adjustment pot, until a satisfactory voltage is achieved. The best location to measure the +5VDC is at the bottom leg of resistor R114. R114 is located in the vicinity of the R116 adjustment pot, and just below the +5VDC LED, L2. If a satisfactory voltage cannot be achieved, turn the game off. Remove connector J16, located above the LM338 regulator. Turn the game back on, and measure the +5V again. If a satisfactory voltage can be acquired with J16 disconnected, a board or component which uses the +5VDC is "dragging" it down. Turn the game off, and remove all 5V input connectors on all other boards at this time. Reconnect J16 again, and review the logic voltage on the I/O Power Driver board. Repeat the process of turning off the game, and reinstalling logic power connectors one at a time to determine the suspect board. Keep in mind that all opto switch receivers used throughout the game use the same +5VDC logic lines. If no other boards in the backbox appear to be suspect, an opto transmitter board may be at fault.

Should the game start randomly resetting, the first course of action is to measure the +5VDC on the I/O Power Driver Board. If the logic voltage is within spec., measure the +5VDC on the CPU / sound board. The +5V test point on the CPU / sound board is located just to the left of the 6809EP CPU chip (U209) on the board. If the voltage drastically differs between the measurement of the I/O Power Driver Board and the CPU / sound board, turn the game off. Remove and reseat connections CN2 on the CPU / sound board and J16 on the I/O power driver board.

4.3.1 Poor or Damaged Sockets Cause Reset

A damaged EPROM socket from a Sega/Stern White Star MPU

A damaged socket for either the game ROM or the 6264 RAM can cause a game to continually reset. This happens because the CPU can not fetch and execute instructions from the game ROM, or it is unable to read/write data to/from the RAM correctly. A simple replacement of damaged OEM sockets sometimes corrects a reset issue.

4.3.2 Game Resets with DMD Controller Board Connected

This may be a bit of an anomaly, but it is worth mentioning. If when the DMD controller board is connected without the data line ribbon cables, and the game continues to reset, replacement of BRDG21 may be required.

In one particular instance, a game was resetting continually with only the +5v / ground connection connected to the DMD controller board. If the board was not connected, the driver board would output ~+5VDC. If the DMD controller board was connected, the driver board's logic line would dip down to around +4.85VDC. Logically speaking, this type of symptom somewhat points to the DMD controller board having issue. However, the end result was replacement of BRDG21 per Stern tech support.

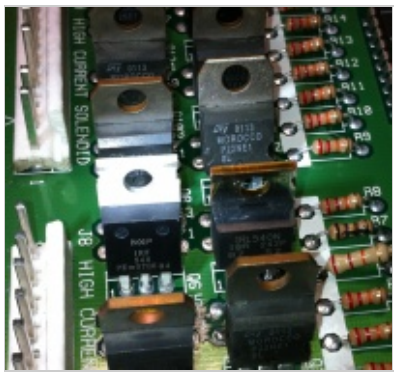
It is worth mentioning that the bridge rectifier did test correctly (using a DMM in diode test) both in circuit and out of circuit, but these tests were conducted while the bridge was not under load.

4.4 Solenoid problems

4.4.1 Can an IRF540 replace a P20N10L, P22NE10L or an IRL540?

No.

The White Star driver board first used STP20N10L FETs to drive high current circuits, like solenoids. When they were discontinued later boards used the STP22NE10L. Since the 22NE10L is obsolete and even the current replacement, the STP40NF10L is hard to find, the IRL540 or IRL540N are the recommended replacements. If available get the IRL540N because it has a higher drain current rating of 36A.
While the drive specs of the IR**F**540 seem comparable, they are in fact, not. Using an IRF540 as a substitute can cause the associated coil to lock on, toast the coil, then blow the FET. The L in all of the original parts indicate that it is a logic level FET.



Danger Will Robinson...the IRF540 installed at Q6 shown above, is the wrong part. The original 22NE10L should be replaced with an IR**L**540, like the one to it's immediate right.

Per a good friend of Pinball, Ed Krzycki, via RGP post

(http://groups.google.com/group/rec.games.pinball/browse_frm/thread/de777f6eec98a687/330e0d47fde12c6f?hl=en&lnk=gst&q=irf540#) ...

Nope -- an IRF540 is not a good sub for the IRL540 or 22NE10L.

The "L" parts have TTL compatible gate voltages. A TTL gate has a minimum high level output voltage of about 2.4 volts. To turn on any N-channel MOSFET transistor - the Gate voltage must be sufficiently high enough as listed by the spec sheets VGS(th) voltage.

The IRL540 requires a Gate threshold voltage of 1 to 2 volts. A TTL part exceeds this voltage so a TTL gate's high level output would guarantee the gate would turn completely on. The IRL540 is guaranteed to have "turn on" and "turn off" voltages that are compatible with a standard TTL device.

*The IRF540 requires a Gate threshold voltage of 2 to 4 volts. A TTL gate *might* turn this part on if the specific part being used has a threshold in the 2 to 2.4 range. If the specific part being used has a threshold closer to the 4 volt range then the MOSFET probably won't turn on properly or fully. The IRF540 *might* work or it might not work. And no guarantees that a working part would remain working if ambient temperature changes.*

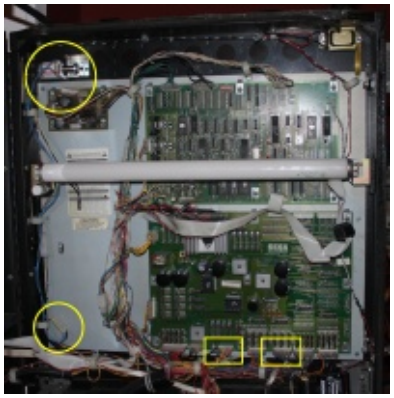
Another aspect to an IRF540: An IRL540 operates more as an on-off switch but an IRF540 does not. Depending on voltages, an IRF540 can operate as an on-off switch and can also operate anywhere in between on and off (half on) depending on input voltage. If the TTL device cannot quite drive the gate voltage high enough then the MOSFET may end up partially conducting. This can have different results depending on how much it is turned on.

The 22NE10L has similar characteristics to that of the IRL540 as far as gate threshold voltages.

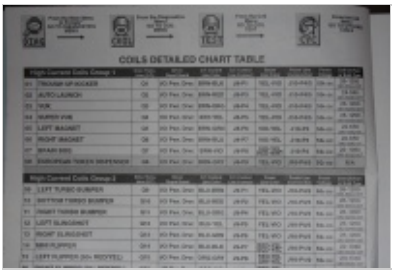
4.4.2 Adding a Real Knocker to White Star Games

Some White Star games (like StarShip Troopers) are not equipped with a real, old fashioned, knocker. We all love knockers, don't we?

To add a real knocker to your White Star game, follow this procedure. Note: in this procedure, we locate the knocker to the head, attempting to increase the knocker's impact. For cabinet installation, take advantage of the wiring already provided for the European Token Dispenser.

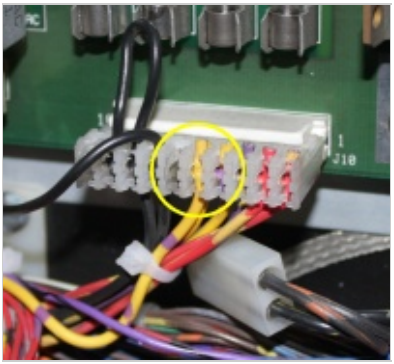


In the picture at left, we show all the components necessary to add a knocker. The new knocker is circled, top left. We've used an in-line connector along the wiring, also circled, lower left. The power and ground connections are noted by the rectangles.



A snippet from the Sega StarShip Troopers manual showing coils, and in particular, coil 8, the European Token Dispenser.

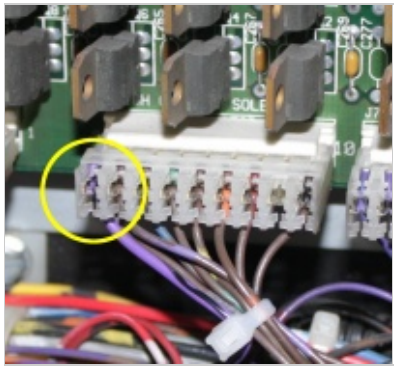
First we need note that the European Token Dispenser solenoid drive is unused in domestic (USA) games. Coil power and drive connections are wired into the game. They can be found in the cabinet bottom. We could simply connect the knocker to that connection, but in this example, we mount the knocker in the game head.



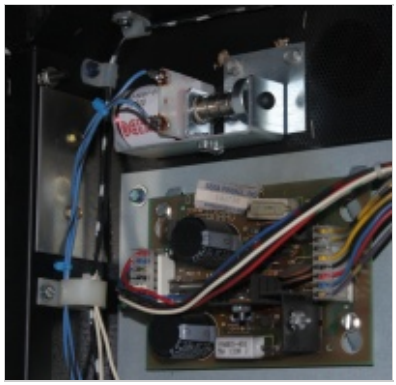
Adding a wire to provide the knocker with 50V power.

Here I've stuffed another wire (yellow with purple tracer) on top of the solenoid power supply at J10, pin 5. This wire will eventually be connected to the banded side of the knocker coil.

Here I've stuffed another wire (purple with black tracer) on top of the solenoid 8 drive connection at J8, pin 9. This wire will eventually be connected to the non-banded side of the knocker coil.



Adding a wire to provide a path to ground for the knocker, typically called the solenoid drive.



The new knocker, screwed to the cabinet upper left corner...not much room there. Also add the "strike plate" to the cabinet side.

Of course, you need to procure the actual knocker hardware, and connect it as shown in the prior pics. In the picture at left, we've added a Sega knocker assembly and strike plate.

The last thing to do is to enter the game adjustments and turn the electronic knocker sound and the European Token Dispenser settings to off. On StarShip Troopers, Enter Portals, Adjustments, Sega, and then adjustment 33 (Knocker Volume - set to OFF) and adjustment 40 (European Token Dispenser - set to OFF).

That's it. Enjoy those knockers!

4.5 Flasher problems

One of the 4 sets of 4 colored flashers on Starship Troopers.

More regarding flashers to be added later...

Starship Troopers, and perhaps other White Star games, drives 4 flash lamps via a single TIP-122 transistor. As the transistor ages, it can fail in such a way that when all 4 flash lamps are in circuit, each flashes weakly. Removing one of the flash lamps from it's socket will result in the remaining 3 flash lamps flashing with normal brightness. Replace the failing TIP-122 with a TIP-102.

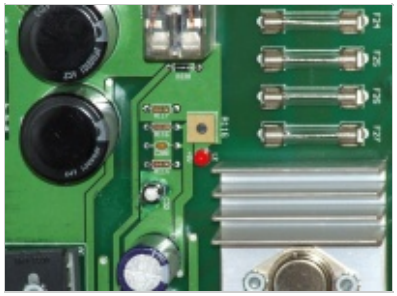
4.6 Controlled lamp problems

If one of the STP19N06L transistors fail you can replace it with the IRL540N. For an explanation which type of FET you need see the solenoid section. If someone tries to sell you a non logic level FET like the IRF640 or BUZ22 as a replacement do not use it as a replacement here!

4.7 General illumination problems

The four general illumination (GI) strings are turned on and off via the relay on the power driver board. This is more or less the same setup like in earlier Data East and Williams System 11 games where the relay can be found on the power board. On the White Star board the relay is controlled via transistor Q200 and latch U206. They both seldom fail.

If one or more GI strings are out check fuses F24 to F27 and then connector J15. Like in earlier games this one tends to burn up over time.



Picture of leaking cap C32

If the GI goes out during game play and turns back on when opening the door check capacitor C32 on the power driver board. It normally has nothing to do with either the GI circuit or the relay voltage but a leaking cap can short the trace coming from Q200 to ground. In this case the relay pulls in and disconnects the GI. When you open the door the game cuts the coil power for the relay coil and the GI turns back on. This has been observed in a Twister game.

4.8 Switch problems

4.8.1 Playfield Switch Problems

4.8.1.1 Modular Stand Up Targets

The following Sega games employ unique playfield "Stand Up" targets:

- Goldeneye
- Twister
- Space Jam
- Star Wars Trilogy
- The Lost World Jurassic Park
- Starship Troopers
- Viper Night Drivin'
- Lost in Space
- Godzilla
- Harley-Davidson
- South Park
- Playboy (used behind the "Peek-A-Boo" stand up)

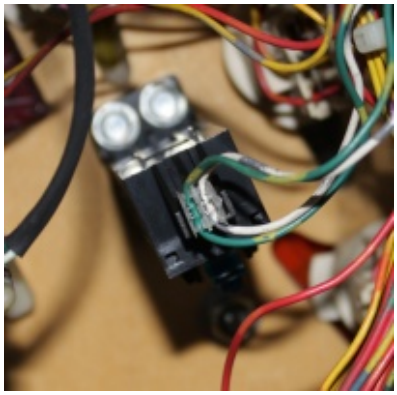
They are self-contained modular targets, made by Happ Controls, that are quite easy to remove or replace. The target "faces" may be purchased separately and may be interchanged easily. The unit has a self-contained diode, like all switches that are sensed via a switch matrix. It also contains a small micro-switch, that the "tail" of the target face actuates. The "Achilles Heel" of this target system is the IDC connector. As with all IDC connectors, the wires can pull out fairly easily.

Detailed disassembly / assembly instructions can be reviewed in Stern Service Bulletin 110 (http://www.sternpinball.com/downloads/sb110.pdf) .

Sega Modular Targets (from Starship Troopers)

An example target. The target "faces" are interchangeable.

"Exploded" target parts. The gray switch part must be oriented correctly. Note the integrated diode just under the micro-switch, center/bottom.



The Achilles Heel of a Sega target...the IDC connector.

The first step to disassemble a target. Slide the rear face of the target assembly up.

Testing a closed target switch, step 1. In diode test, with the switch closed, your meter should read 0 or null.

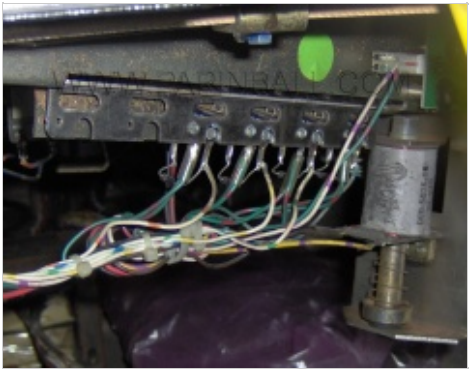
Testing a closed target switch, step 2. In diode test, with the switch closed, your meter should read .5 to .7, the nominal voltage drop across a diode.

4.8.1.2 Magnetic Reed Switches

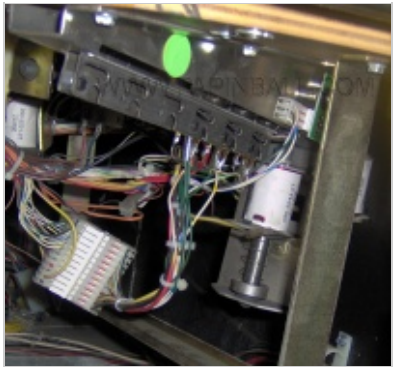
Sega Magnetic Reed Switch (from Space Jam)

Starting with Space Jam, Sega introduced magnetic reed switches. This type of switch is a sealed, non-serviceable switch. Theory of operation of the reed switch can be reviewed in service bulletin 89 (http://www.sternpinball.com/downloads/sb89.pdf) . Replacement part number is 180-5145-XX.

4.8.1.3 Ball Trough Switch Problems



Typical Sega ball trough assy. using 1/8" screws heads



Typical Stern ball trough assy.using 3/16" screws heads

As with any sub microswitch, the switches can become sporadic or fail over time. Another thing that can happen is the switch arm can break at its pivot point. This happens with this style of switch more frequently than other styles, because the metal arm is placed between two plastic ears. With nearly every other style of sub microswitch, the arm has the metal ears which go over plastic nubs on the switch body. The correct replacement switches are 180-5119-00 roller arm switches. Over the years Sega / Stern used both 1/8" and 3/16" screw heads on the screws which secure the trough switches. At this time, it is uncertain when Sega / Stern changed the screw size.

There may be other issues, which appear to act like ball trough switch failures. One of the problems is divots in the ball trough itself. After many iterations of the balls slamming into the trough over and over, divots start to develop. This divots can keep balls from rolling down the trough assembly. In turn, the balls will not be closing the proper switches in the trough. The end result is a game that "loses its mind". If the balls are not where they are expected to be in the trough, the game cannot function as intended.

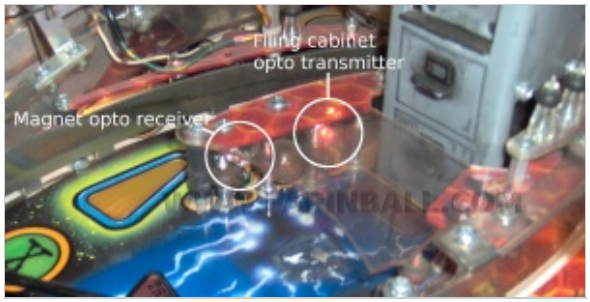
A similar issue to divots in the trough is magnitized balls. This occurs primarily in games where a magnet captures a ball and holds it for a length of time. Some examples of games with magnets that hold the ball are Apollo 13, Goldeneye, Twister, Space Jam, and X-Files. This problem typically happends when two or more balls are grouped together in the trough. They will literally be held in place and stick to the trough. This happens to the balls located furthest from the ball trough VUK. To determine if a ball or balls are magnetized, remove the lower apron, and the top bracket over the trough. Gently place a non-metallic object between the balls to see if they separate themselves.

Ball trough assembly with divots. Although it's not a White Star game, Jurassic Park is used for this example.

For ball trough switch issues pertaining to the opto boards, see the section below.

4.8.2 Opto Switch Problems

A little background regarding how White Star games handle opto switch pairs is necessary. With White Star games, opto switch pair closures are analyzed by the CPU in the same manner as leaf switch pairs or normally open (NO) microswitches. In other words, when a leaf or NO microswitch closes, the end result is identified by the CPU as a valid switch closure.

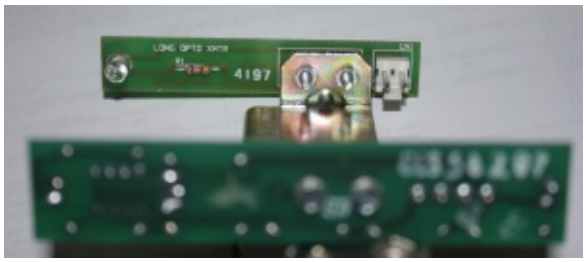


Two sets of opto pairs installed in a Sega X-Files

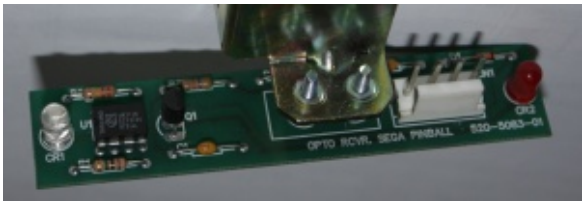
Again, to briefly summarize the operation of White Star opto boards, if an object is blocking the light beam between the transmitter opto LED and the receiver opto LED, the CPU detects this as a switch closure. When an object is not present to break the light beam, the CPU detects this as an open switch. The components used on the opto receiver board are designed to do as such.

The transmitter side is simply an ultra-red LED with a current limiting resistor. The receiver opto is an identical ultra-red LED. As the receiver LED, when light of the appropriate wavelength (from the transmitter) shines on the LED, a small amount of voltage is "excited" in the LED. By using discrete components on the receiver side, that small voltage is detected and the appropriate signal is sent to the CPU via the switch matrix return (row). By employing such a design, failure on the receiver opto side is more common. The transmitter LED will be lit (and visible with the naked eye), while the receiver LED will not be lit.

Sega/White Star Transmitter, Receiver, and Opto 'Long Hop' Board Pair, as found on Starship Troopers. Note that these ultra-red LEDs aren't red until power is applied.



The opto transmitter side.



The opto receiver side, with accompanying electronics. The red colored LED is a diagnostic aid to indicate a detected switch closure.

An opto pair. The pair must be in perfect alignment or the opto switch will operate unreliably.

This particular system is contrary to how Bally / Williams WPC CPUs handle opto pairs. Equally, WPC games employ infrared (IR) opto switch pairs. If interested in learning the theory of operations for the White Star opto trough upkicker boards, please consult the manual. Sega / Stern have included some excellent, detailed, technical documentation within their manuals. Stern Service Bulletin #67 (http://www.sternpinball.com/downloads/sb67.pdf) includes detailed theory of operation of these opto switches too.

4.8.2.1 Two Balls Served, Continuous Balls Served to the Shooter Lane, or the Trough VUK Fires Repeatedly

Common problems with some White Star games are:

1. Two balls are served to the shooter lane.
2. Balls are continuously served to the shooter lane.
3. The trough VUK repeatedly fires, when there are no balls above the VUK trough plunger.

The first test is to determine if the balls are sliding down the trough. If they are repeatedly magnetized they tend to stick to the side of the trough and not slide down. Replacing the balls with will fix this. There are balls available which are low magnetic, but you can also line the floor of the ball trough with a thin sheet of PETG breaking the magnetic contact.

Depending on the exact circumstances, and the era of the White Star game, one or two of these symptoms can occur. The crux of the problem is either one or both of the two trough LED opto transmitters or receivers is failing. Rarely do the components on the trough opto boards other than the red LEDs actually fail though. And in most cases, it is not the LED itself, although, there are some instances when the problem is a failing LED. It is noteworthy that the issue is more common to the opto receiver side more so than the opto transmitter side.

A Stern Monopoly in "Clear Ball Trough" Mode Identifying One Ball in the Trough

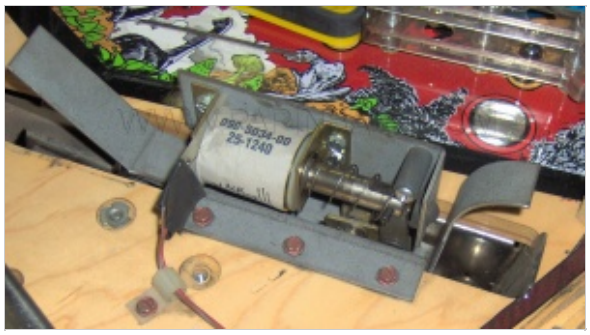
A Stern Monopoly in "Clear Ball Trough" Mode Identifying One Ball in the Trough and One Ball Stacked

If the any of the previously mentioned symptoms are evident, the best approach is to first put the game into "Clear Ball Trough" mode via the Portal buttons on the coin door. Consult the manual documentation for details how to enter this test. Once all of the balls are removed from the trough, no balls should display on the DMD display. If either of the two images shown to the left are displayed on the DMD, and the ball trough no longer has any balls present, there is a problem with either the transmitting or receiving opto boards.

The first thing is to observe the two red opto LEDs on the transmitting board. This board is located on the backside of the ball trough. If the transmitting LEDs are lit, there probably is not a problem with them. However, this is not always necessarily the case. Secondly, inspect the opto LEDs on the receiving board. To do this, the game will have to be turned off, and the receiving opto board removed via the three screws which attach it to the trough. Look for hairline cracks around the .100" angled header pin solder joints. Likewise, inspect the solder joints around the opto LEDs. If cracks are evident in any of these locations, remove, and apply fresh solder to these connections. Reinstall the receiver board, and observe the results. Conversely, if hairline cracks are not found, or if the same symptoms are still evident after reflowing solder joints, replacement of the LED optos is suggested.

White Star games initially used MT5000UR ultra-bright red LEDs, while later games used TLRH180P ultra-bright red LEDs for both the transmitter and receiver boards. Both styles of LEDs have become expensive and fairly difficult to source. Great Plains Electronics offers the MV8114 (http://www.greatplainselectronics.com/search.asp?pg=1&stext=MV8114&sprice=&stype=&scat=) as viable replacement for either original, factory LED. The only caveat is that both the transmitter and receiver opto LEDs must be replaced in pairs to ensure proper function.

When replacing the opto LEDs, make certain the base of the LED is placed squarely on the PCB. An LED which is poorly installed may result in sporadic switch closures.



Lock Ball Assembly (from Jurassic Park - used for illustrative purposes)

Please note that a "Lock Ball Assembly" was employed in the trough design on early White Star games. The lock ball assembly is a unit, which was carried over from later Data East and early Sega games. It consists of a coil mounted horizontally above the left side of the trough VUK. This assembly was later removed presumably either due to cost factors, or so this coil assignment could be used as a playfield coil feature elsewhere instead.

If a lock ball assembly is used in the game, and trough opto failure has occured, the symptom will more than likely be that the trough VUK will fire repeatedly without a ball present above the VUK plunger.

4.8.2.2 Phantom Opto Switch Closures

Similar to the discussion above, "Two Balls Served, Continuous Balls Served to the Shooter Lane, or the Trough VUK Fires Repeatedly", other opto pairs in the game may fail over time and become unreliable. Usually this manifests as phantom switch closures. Games like Starship Troopers that use an opto pair for both the left and right orbit shots may score the orbit shot randomly or even continuously. If the "long hop" opto assembly is removed, you may find that the opto pair registers correctly if the optos are aimed with great accuracy at one another. However, the slightest misalignment (like flexing the PCB) will cause the opto pair to register a "hit".

The correction for this is again to replace the original MT5000UR or TLRH180P ultra-bright red LEDs, with MV8114 (http://www.greatplainselectronics.com/search.asp?pg=1&stext=MV8114&sprice=&stype=&scat=) LEDs from Great Plains Electronics.

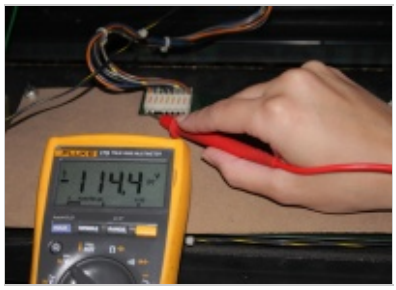
4.9 Display problems

A few of the many possible display problem root causes are...

- Failure in high voltage power supply
- Failed Dot Matrix Display
- Failed ribbon cable
- Failed power connector on display driver board
- Failed 74LS374 buffer IC on the MPU board

Each possible root cause is discussed below.

4.9.1 Measuring High Voltages for the DMD Display



Testing DMD Controller voltages at the display. Note: This picture is a Williams game, but the concept is the same.

To test for the voltages necessary for the DMD to operate, first open the backbox, and rest the DMD panel face down on the glass. Or, if the game has a "Showcase" style head (i.e. StarShip Troopers), swing the panel open to gain access to the HV connection to the DMD. The simplest place to test the voltages is at the display end of the power wire bundle as shown in the picture. **SAFETY WARNING: Your left hand should be in your pocket, to avoid a potentially serious shock. We are working with high voltages, so be VERY CAREFUL. Keeping one hand in your pocket is a good practice to follow as it eliminates the easy electric current pathway across your heart. A DMD controller provides enough electric current to kill you!**

The dot matrix display needs three voltages to operate, nominally -112, -100, and 62 VDC. All three voltages must be present for the display to operate correctly.

Place the black lead of the DMM under the ground braid in the game's head or use clip leads to secure the black lead to ground. Remember, you are working one-handed, so this becomes a necessity. Place the red lead of your DMM on each of the pins supplying power as shown in the picture. As long as there is a 12VDC difference between the Anode and 12VDC offset voltages, your DMD controller is providing correct voltage levels.

Function	Pin	Spec	nominal voltage	Notes
Anode	1	-120V	**-112V**	
12VDC Offset	2	-100V	**-100V**	Must be 12V less than anode voltage. Will be about 20V less than anode voltage if display not connected
Key	3			
Ground	4			
Ground	5			
5VDC	6	5V	**5V**	
12VDC	7	12V	**12V**	
Cathode	8	60V	**62V**	

If the high voltages are off by more than a few volts, turn the game off, disconnect the power connector at the HV Power Supply, and test the voltages at the HV Power Supply male header pins. If the voltages return to nominal values, the zener diodes on the power supply are probably OK but the resistors and transistors around them are suspect. As shown in the table above, if HV power is not connected to the display, the nominal 12VDC offset will be about 20VDC.

Note that a failing or failed DMD display glass can drag these voltages down. Before you begin any work on the HV Power Supply board, perform the above test with the DMD display power disconnected. If the voltages return to nominal values, it's possible that your display is the culprit. Test the high voltages with a known good display to isolate the fault to either the HV Power Supply or the display panel.

Should your HV Power Supply fail, the circuit is almost identical to the circuit used by Williams in their WPC DMD Controller. Similar parts are required to rehab the Sega/Stern HV Power Supply.

As of April 2014, schematics for the HV Power Supply are no longer available on Stern's site.

4.9.2 Failed Dot Matrix Display

A failed Dot Matrix Display will obviously cause display problems. Once you've tested for proper voltages, swap in a known good display, and swap the suspect display into a known working game. If the suspect display doesn't work in the known working game, it's time for a new DMD display.

4.9.3 Failed ribbon cable

The ribbon cables on Sega/Stern White Star games connecting the CPU to the display controller are particularly long and twisted. There is ample opportunity for the ribbon cable to be damaged.

You should reseat the ribbon at both ends several times to knock off accumulated corrosion. This might temporarily solve the issue.

A simple test of the ribbon cable integrity would be to reverse it, causing the conductors used within the ribbon to be "swapped". Remove the ribbon from both ends, and instead of seating it with the red stripe at pin 1, seat the ribbon with the red stripe at the opposite end from pin 1. Make sure you reverse both ends of the ribbon. If the results witnessed on the display are then different, there is a good chance you need a new ribbon cable.

Gently bending and twisting the ribbon cables may help uncover intermittent connections and a compromised cable. Don't bend/twist too vigorously as this in itself may compromise the cable.

4.9.4 Failed power connector on display driver board (CN2)

Sega/Stern (and even Data East) chose a very odd power connection to the display controller. CN2 is a .156, 3 pin connector, which is the +5v and ground connection for the display controller. It can be inadvertently and easily reversed. The solder joints for these header pins fracture often, or the pins in the female housing lose their grip (and hence connection). It's good practice to repin both sides of this connection, using crimp-on TriFurcon pins in the female housing.

4.9.5 Failed 74HCT273 buffer IC on the MPU board

The 74HCT273 at U201 on the CPU board buffers the output to the display controller via the ribbon cable. Should this IC fail, incorrect or no data will reach the display controller. This IC can be tested with a DMM following the process described here.

4.10 Sound problems

Before going any further, check all of the basics in the Basic Sound Troubleshooting (http://www.pinwiki.com/wiki/index.php?title=General#Basic_Sound_Troubleshooting) section.

Basic operation (simplified) of the White Star CPU/Sound board audio part: The main CPU (U200) makes sound calls to the sound CPU (U6) which instructs the BSMT to play a certain sound. The BSMT fetches the required data (sound sample) from the ROM memory (U17-U21-U36-U37) and feeds the 16-bits wide parallel data to a conversion circuit which makes it serial data (shift register, U23-U24). The serial data is fed into a DAC (U26, Digital to Analogue Converter) that outputs to a pre-amplifier (U30, OPAMP). The output from the pre-amplifier is fed into the TDA2030A amplifiers at U101/U102 and sometimes U100 (some boards have 3 amplifiers, one for each speaker) and from there the audio signal goes to the speakers.

The sound section is quite reliable, the failure occuring most is a failed TDA2030A amplifier.

Sound missing from one of the speakers: Most likely a failed TDA2030A amplifier.

No sound at all: Check the voltages on the board. On the DC input connector CN2 there should be approx. +12V DC between pin 2 (ground) and pin 6 (+12V) and -12V between pin 2 (ground) and pin 3 (-12V), these voltages come from the Power Supply Board. On the board itself are two voltage regulators to convert the +12V and -12V to +5V and -5V for the pre-amplifiers, check these voltages by measuring between the ground (GND test point) and U30 pin 8 for +5V, U30 pin 4 for -5V.

Other causes of no sound at all are the U7 game ROM being corrupted or improperly seated. You can re-seat this ROM and it often solves the issue. If any of the voice ROMs (U17, U21, U36, U37) are corrupted or improperly seated, the sound will still work but will be corrupted or have intermittent issues such as scratchy sounds or improper sounds at specific times.

Finally, if you have no sound at all, you might also want to check that you have the correct sound board. Some operators may have swapped the 520-5300 with a 520-5136 board for the older series White Star games. The 5300 board will work in all White Star systems. The 5136 will work but will present no sound at all in all games newer than lord of the rings (2003).

Samples playing randomly This happens on CPU boards that have the BSMT2000 emulation chip rather than the original (which Stern could not source cheaply enough at that time). You need to update the emulation using the method in Stern service bulletin 157: http://www.sternpinball.com/ROM_bootFLASH.html

Sound is distorted If the sound is distorted, the most likely problem is the TDA1543 (U26) chip. This sounds as if the volume is very over modulated and are “clipped”. Be sure to use the TDA1543 version and NOT the TDA1543A. The TDA1543A uses another protocol (Japanese). If the sound is distorted at master volume levels below 4, see the section below that explains a fix.

Loud hum/burnt speakers/12V DC coming out of the speaker connector If you have a machine with all speakers dead, check for voltage on the speaker wires. If the -12V wire from the driver board to the CPU board is disconnected, it can cause 12V DC to be sent down the speaker line, causing a loud hum and fairly quickly destroying any speakers connected!

4.10.1 Loud Hum and / or Distortion at Low Sound Levels

Stern released Service Bulletin 133 (http://www.sternpinball.com/downloads/sb133.pdf) , which discusses a fix for a loud hum and / or distortion when the master volume is set below level 4. The machines that are specifically effected are Monopoly and Austin Powers. However, it has been over 10 years since these games have been released, and boards get transplanted to other games over time. So, it is important to check the two resistors (R106 and R110) in the amplification section of the CPU / sound board to see if the correct values are installed, regardless of the game. The correct resistor values should be 33K ohms 1/4 watt for R110 (ORG-ORG-ORG-GOLD), and 10K ohms 1/4 watt for R106 (BRN-BLK-ORG-GOLD). Consult the service bulletin for more details, and the layout of the amp section. The R106 and R110 control the analog volume. When these resistors are broken (open) the analog volume goes to 100% and can't be controlled via the buttons (digital volume) on the coin door. The higher the resistor value the higher the volume.

4.10.2 Adding a Second Backbox Speaker to some Sega Games

Adding a second backbox speaker may improve the sound in games shipped with a single backbox speaker. Buy the speakers in pairs. This image shows the new speaker installed onto the left speaker bracket, and the right speaker position "blank" from a StarShip Troopers game. The "blank" must be modified so that the new speaker can be attached.

A chap named Martin Riley submitted a nice article to the PinballNews explaining how to add a second backbox speaker to games like StarShip Troopers.

From the article...
"Mid-life Sega games from Twister through to and including Viper Night Drivin' only had the left hand backbox speaker plus the cabinet speaker and only two of the 3 audio amps are populated on the CPU board.

Late Sega games from Lost in Space onwards have two backbox speakers but they are effectively mono as they are both connected to the left channel audio amp on the CPU board (the right channel amp being unpopulated)."

The complete article can be found at
http://www.pinballnews.com/learn/speaker/index.html

The article lists all components required to add the 3rd speaker channel. Some (maybe all) two channel boards are not stuffed with C122, which is not listed in article parts list. You'll need one more 0.1µF axial ceramic capacitor for C122.

Adding a 3rd speaker to StarShip Troopers improved the sound quite a bit. The sound is richer and cleaner. The emphasis on some sounds is more pronounced and easier to hear. Edit: months later, I was testing a board in my StarShip Troopers that didn't have the 3rd amp. Forgetting that I had added the 3rd amp to my MPU, I initially thought something was wrong with the sound that the MPU under test was producing. It was merely the difference between a single and dual backbox speakers.

Mounting the additional speaker to the "blank plate" (as found in StarShip Troopers) required drilling the rivets that attach the speaker grill, and replacing them with low profile head screws. This is only necessary for Sega "Showcase" backbox games. For games like Independence Day, mounting the additional speaker should be trivial.

4.10.3 Is a Second Backbox Speaker Really Worth It?

While some have reported good results adding a third amp and second backbox speaker to these early Sega games, there are questions about the efficacy of such a solution. While better speakers themselves will improve the sound, the game-specific sound samples in the ROMs are mastered as mono sound clips. There are very few sounds in the game that are true stereo sound and these are usually simple sound effects which were used in multiple games.

You can listen to and judge for yourself by running the Bridge front end and the M1 MAME music player. Bridge and links to the M1 player can be found here (http://www.e2j.net/downloads.html) .

The mono mastering continued through the White Star II and SAM systems. As David Thiel, who has created music and sound for numerous Data East and Stern pinball machines, states on this page (http://daudioguy.multiply.com/video/item/5/Family_Guy_Stern_Pinball_Music_and_Sound_Effects_by_David_Thiel?&show_interstitial=1&u=%2Fvideo%2Fitem) of his website, he "composed, arranged, performed, mixed and mastered (all the music for Family Guy) for 24 kHz 16 bit Mono."

4.11 Flipper problems

4.11.1 Non-Functioning Flippers

4.11.2 Weak Flippers

4.11.2.1 Progressively Weak Flippers

5 Game Specific Problems and Fixes

Lord Of The Rings

If your Balrog stops registering hits, a little checking will sort it out. The mini microswitch with a roller arm used to register hits may need adjusting. Known past problems are a flaky or bad switch, and/or wiring. The Balrog moves in such a way that wires can break inside where you can't readily see them. It's easy to check the switch and wires with a meter. The wires push into an IDC connector nearby; be sure they are pushed in tight.

There isn't any adjustment for the micro switch, except for bending the blade with the mini-roller; try bending the blade outwards slightly. According to the manual, sw #28 stays normally closed and then a Balrog hit opens the switch. This is not the normal target arrangement. So using the Balrog test mode in diagnostics, the switch should stay solidly closed, and then only open when Balrog is tilted forward.

The Shire and Gimli VUK switches.
These get hammered on LOTR and will eventually need replacing, There isn't any easy solution other than replacing the flaky switch. The tiny black screws on the Stern switches are 3/16". You will need a nut driver that size if you want to attempt replacement of the switches.

The Shire (and Gimli) VUK switch, are fork blade microswitches. Stern part number 180-5116-01.
Spec on side of switch says Cherry .1A 125v E63. Try parts4pinballs.com or your favorite Stern parts supplier.

The Shire VUK.
It's easiest to remove the entire Bottom Left VUK coil and bracket from under the PF (playfield) to change the fork switch.
Take out the two largest bolts first, using a cross-head (phillips) screwdriver on the top and 11/32" nut runner (or socket) on the bottom.
Remove the metal VUK arch from the top of the playfield.
Remove the two lower wood screws (1/4" drive) leaving the one on the corner near the T-nut.
Supporting the Coil Bracket, remove the last 1/4" screw.
Unclip the connector from the coil and VUK. Remove coil and bracket assembly.

Microswitch small screws are 3/16". As stated before, to remove the switch correctly you need a nut driver (or socket) that size. You should be able to slide the heatshrink tubing all the way up the wires, solder on the new switch and then slide them back down in place. If not, use new heatshrink tubing. Assembly is above steps in reverse. Test in switch tests before replacing assembly and then by throwing a ball in the Shire in attract mode one the assembly has been correctly replaced.

6 Repair Logs

Did you do a repair? Log it here as a possible solution for others.

- **Striker Xtreme:**
  - Problem: **Display is blacked out or only coming on for a few seconds before blanking out.**
  - Cause: Resistors R6 and/or R7 on the display power supply board have gone bad (open or increased in value).
  - Solution: Replace resistors R6 AND R7 on the display power supply board. Both are 330k @ 1/2 watt
- **Simpsons Pinball Party:**
  - Problem: **When last ball drains, game still thinks its in play.** Ball search or power cycle will eventually find it.
  - Cause: Cracked solder joint on trough board.
  - Solution: Pull both trough boards. A 1/4" wrench can be useful in getting the back board off. In this case, the obviously cracked solder connection was on the receiver board in front. But while the board is out, the optos were cleaned with Windex.
  - This can be verified by waiting for the problem to show up, then go into switch test. Previously, switch #5 (leftmost) had been suspected and had been re-aligned, but that was probably not necessary.
