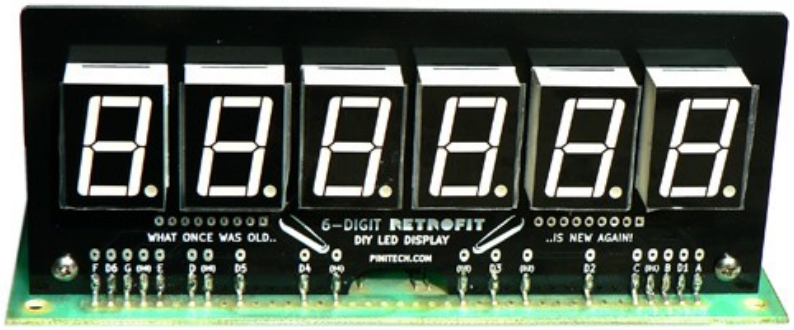
RETROFIT

DIY LED DISPLAY CONVERSION KIT



UPGRADES 6-DIGIT & 7-DIGIT PLASMA CLASSIC BALLY/STERN PLASMA DISPLAYS

This conversion kit has been created to allow people with the proper experience and tools to upgrade an original BALLY/STERN 6-digit or 7-digit display into an energy-efficient LED display. If you're up for it [we hope you are] you will be very happy with the results!

DISCLAIMER

MODIFICATIONS ARE DONE AT YOUR OWN RISK!

Due to the nature of DIY / Conversion Kits & wide range of technical abilities by the people that may be performing the upgrades, PINITECH LLC cannot be held responsible for any damages or injury that may result from modification or usage of the kit/displays. Failure to follow instructions, especially in regard to **REMOVING J1 PIN #1 FROM THE DISPLAY BOARD TO PREVENT HIGH VOLTAGE FROM ENTERING THE DISPLAY** may cause irreversible damage to your machine. Please follow the instructions carefully.

We cannot control the condition of the donor boards you select, nor do we know the quality of the tools you are using or your level of experience with soldering/desoldering. Careless use of tools, incorrect or poorly executed modifications to circuit boards or misuse of the information herein could result in material damages, losses, personal injury, property damage or death.

By choosing to modify YOUR display boards with this kit, YOU assume any and all risk of those modifications including but not limited to the risks mentioned above.

SOLDERING / DESOLDERING TUTORIALS

Consider yourself an expert? Why not take a few minutes of your time either way to brush up on some proper soldering and desoldering techniques? You might even learn about some better tools or techniques that may save you a bit of time or trouble when doing the conversions.

- **Adafruit Guide To Excellent Soldering**
  http://www.pinitech.com/docs/excellentsoldering.pdf

- **Advanced Desoldering Tutorial**
  http://pinballrehab.com/1-articles/solid-state-repair/tutorials/165-advanced-desoldering-tutorial

CAUTION!

Use care when soldering and desoldering as the solder & the tool(s) are extremely hot and can produce serious burns. Solder melts at around 400-600 degrees Fahrenheit (200-300 degrees Celsius). Make sure you use an appropriate work surface since hot solder could damage some surfaces or other materials.

- **Use an appropriate work surface since solder could damage some surfaces or other materials.**
- **Use of eye protection is recommended during any soldering or desoldering.**

We are not responsible for damage or injury as a result of assembling this kit.

KIT CONTENTS

QTY 6-DIGIT 1X DISPLAY	QTY 6-DIGIT FULL SET	QTY 7-DIGIT 1X DISPLAY	QTY 7-DIGIT FULL SET	DESCRIPTION
7	35	8	40	0 ohm resistors [single black-stripe]
7	35	8	40	270 ohm resistors (WHITE DIGIT KITS ONLY) [red-violet-brown]
7	35	8	40	470 ohm resistors (BLUE / AMBER DIGIT KITS) [yellow-violet-brown]
6	30	7	34	1.2k ohm resistors [brown-red-red] **OR 1k ohm resistors [brown-black-red]**
6	30	7	34	47k ohm resistors [yellow-violet-orange] ***OR* 100k ohm resistors [brown-black-yellow] (early kits)**
2	10	2	10	Right Angle Brackets
4	20	4	20	Screws for Brackets
7	35	8	39	2N7000 N-CHANNEL Mosfet
1	5	1	5	2N5401 (extras and used only if a digit appears “weak” or is not working)
6	30	7	34	LED DIGITS
1	5	1	5	LED PANEL PCB
1	5	1	5	Jumper Wire
1	5	1	5	Foam Tape
--	--	--	--	Color Filter Of Your Choice (WHITE DIGIT KITS ONLY)
X	X	2	8	Nylon Spacers (7-DIGIT KITS ONLY)

While we do our best to verify kit contents before they are shipped, sometimes mistakes can happen. If you do find you are missing something, please contact us at support@pinitech.com

DISPLAY BRIGHTNESS / SEGMENT RESISTORS

Included in the kit are resistors for setting brightness of the led digit segments. If you bought a WHITE display kit, it should have come with 270ohm resistors. A BLUE or AMBER display kit comes with 470ohm resistors. You can identify these resistors using the color codes in the component list on the previous page.

Below is a chart to show you expected current usage with a single "8" lit up on one digit. Current usage will change depending on the resistor value used on the segments. This would represent the "worst case" scenario since Classic Bally/Stern machines are only lighting a single digit at a time per display (multiplexed). You can refer to this chart if/when you bench test the display after it's assembled. If you're using your multimeter to measure current usage of the display, you should see that it's using about what is listed below for a single display.

CURRENT USAGE (SINGLE DISPLAY / SET OF 5X)			
Resistor Value	**Fully Replaced**	**In-Parallel 1.5k**	**In-Parallel 9.1k (Stern 7-digit)**
470 ohm	33mA single / 165mA set	43mA single / 215mA set	34mA single / 170mA set
360 ohm	43mA single / 215mA set	53mA single / 265mA set	45mA single / 225mA set
270 ohm	57mA single / 285mA set	67mA single / 335mA set	59mA single / 295mA set

**If soldering resistors in parallel on the displays, the resultant resistor value (of resistors soldered in parallel) will create a resistance lower than if you were fully removing & replacing the resistor. This will cause slightly higher current usage per display as indicated in the chart.*

Value is derived by I = V/R formula.
I = (5v – 2.8vfd of led) / 470ohm = 4.68ma
4.68mA x 7 segments = 33mA
To calculate R for parallel resistors: http://www.sengpielaudio.com/calculator-paralresist.htm

Too Bright?
If you find the displays too bright, you can always swap the resistors out with different values of your own choosing. For BLUE you may want to try 560 ohm or 680 ohm. For WHITE you could try 360 ohm or 470 ohm. Another option are "neutral density" color filters / led gels that can be added as an additional filter over top the LED digits and will tone down the brightness without affecting color – these are available from online vendors selling led color gels for photography.

Not Bright Enough?
If you find the displays aren't bright enough, you can try a slightly lower resistance value on the segment brightness resistors – just don't go too low! The values chosen for the kits were a good compromise of allowing the displays to be plenty bright enough and still efficient. BLUE digits are pretty bright with a higher resistance value. WHITE needs to be lower so that when using color filters the displays are still brighter.

If trying your own values, stay above 180 ohms on the segment resistors or you'll be wasting a ton of current without much noticeable difference in display brightness. In parallel with the 1.5k resistor, a 180 ohm resistor would put a single display around 96mA and set of 5x displays at 481mA. The lower you go in resistance, the more current that will be used & the less efficient the displays will be. Going too low could also damage the LED digits since they are rated at a max of 20mA per segment.

One additional note – there's not a consistent gain in brightness as you decrease resistance value. If you were to graph various resistor values and how it affected brightness, the most noticeable gains in brightness would be early-on in the "curve". In other words if you set the segments to values between 0-5mA and you'd notice a difference between 3mA and 5mA. But setting a segment to 15mA (not a great idea) wouldn't be noticeably brighter than a segment set at 10mA.

CONVERSION STEPS

STEP #1: VISUALLY INSPECT THE DONOR BOARD

Take a quick look at the board you've selected as the donor for the upgrade. Look for any components that are missing and will need to be replaced. Look for obvious signs of damage, prior rework or hacks that may not make the board a good selection for an upgrade. Use your best judgment here. There are no shortages of bad displays & more going bad each year, so it might be worth holding out for a better donor than to try and upgrade a board that's "too far gone" before you even get started on the conversion.

STEP #2: REMOVE PIN #1 AT THE J1 HEADER

This step is EXTREMELY IMPORTANT. You will see it mentioned a few times because it's THAT important. Please, please, please for the love of your machine & all of its circuits do not forget this step.

PULL PIN #1 AT THE J1 HEADER on your component board. Do this now. Do not cut it and risk cutting it a bit too high, you want to make sure it's completely removed and there's no chance of any connection being made.

This is the high voltage pin. Failure to remove this pin will result in high voltage making its way into the 5v circuits of your machine!! **Even if you plan to remove the high voltage fuses, do not skip this step, as damage may be caused if anyone else (including you) plugs the display into a different machine that hasn't had its high voltage fuses removed.**

TIP: It may be easiest to first cut the pin low from the top-side of the board, then fully pull the pin from the bottom (solder side) of the board. Otherwise if pulling from the top solder can cool down between the Molex connector and PCB and make it more difficult to remove the pin.

To be extra cautious, you may also want to cut the trace coming out of Pin #1. Or use a dremel with engraving bit to cut the trace. Not required if J1 Pin #1 is pulled, but it won't hurt either.

For the safety of your machine, if there are any steps that you ABSOLUTELY make sure you do every time you convert a display, this is that step!!!

STEP #3: REFLOW SOLDER JOINTS AT THE J1 HEADER IF NECESSARY

A cause of a lot of problems with these old display boards are cracked/cold solder joints at the J1 header. You'll want to check these now rather than deal with intermittent issues later on. If any look suspect, add some new solder.. or if you want you have proper equipment you can desolder the pin first and then resolder it for a stronger connection.

STEP #4: FULLY REMOVE THE SEGMENT DRIVER TRANSISTORS

There are 7-8x segment driver transistors that must be fully removed and replaced regardless of how you proceed with the conversion. These are listed on the *LIST OF COMPONENTS CHANGED PER DISPLAY MODEL* toward the end of this document. Their silkscreen markings will differ depending on the display you're working on.

Method of removal is up to you (desoldering gun, cutting the transistor off the top of the board & removing the legs separately, etc). You'll need to fully remove the transistors & clear the through-holes.

Once removed, wait to install the 2N7000 mosfets since depending on the conversion method you choose below you may just be sucking up new solder you had added.

STEP #5: DECIDE ON A CONVERSION METHOD

At this point you have two choices for the methods of modifying the component board:

1. Minimal Modifications Necessary
   - Resistors are soldered in parallel on the bottom of the board
   - Some components are clipped off the top side of the board
   - J1 Pin #1 is removed and a jumper wire is added

   TIME ESTIMATE 25-40 MINUTES PER DISPLAY ***(first display may take a bit longer)***
   DIFFICULTY: MODERATE

   ADVANTAGE: Less invasive method. Should be quicker if you're working with several of the same model displays, once you have modified one display & model off of it.

   DISADVANTAGE: Not as clean looking. Old solder may not stick well to resistor leads and require first using solder wick or a desoldering gun to clean up the joint before adding new solder.

2. Full Replacement of Components
   - Full removal of *every* component that is being replaced
   - J1 Pin #1 is removed and a jumper wire is added

   TIME ESTIMATE 45-60 MINUTES PER DISPLAY ***(first display may take a bit longer)***
   DIFFICULTY: MEDIUM TO HARD, SUCCESS DEPENDS ON TECHNIQUE AND TOOLS USED

   ADVANTAGE: Cleaner since through-holes are all utilized.

   DISADVANTAGE: Requires more patience, technique & better tools to remove the components fully without damaging pads or traces.

What method is right for you?
Some people already know where their abilities are or have a preference in how they'd like the board to look. If you're unsure of which method to choose or unsure if you have the right equipment or technique, you should first browse some of the soldering/desoldering tutorials linked on Page 2 to get an idea of what good tools/equipment and technique look like.

You may also want to practice removing components or soldering a resistor in parallel on a junkier board before getting started. That way you know what you're in for.

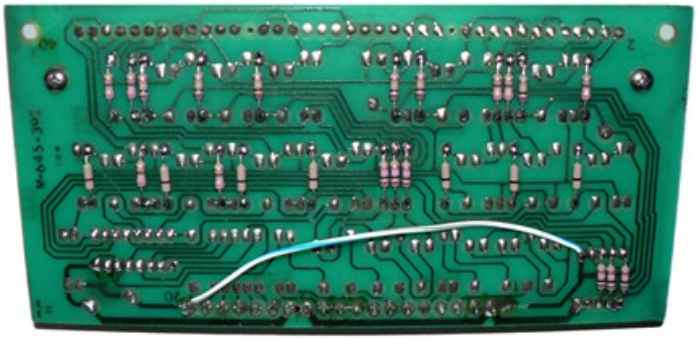
CAUTION: SINGLE-SIDED PCBS
About half of these display models are single-sided PCBs (traces only on one side). The pads and traces on single-sided boards don't put up with a lot of heat or stress, so you'll want to be extra careful and patient if you are fully removing components. Use of low temperature on soldering/desoldering equipment is recommended.

Continue on to either STEP #6A or STEP #6B depending on the method you choose.

STEP #6A: MINIMAL MODIFICATIONS NECESSARY METHOD

If you're choosing this method, resistors included in the kit are soldered in parallel on the back of the board. There are about 20-30x resistors (depending on display model). You will then clip some resistors/components from the top of the board.

A picture of what a final board may look like is below just to give an idea. Location of parallel resistors on your display model can be found in this document – **http://www.pinitech.com/docs/ballystern_retrofit_parallel.pdf**



For the list of resistors to remove for your board model, see the *LIST OF COMPONENTS CHANGED PER DISPLAY MODEL* toward the end of this document. Their silkscreen markings will differ depending on the display you're working on.

OVERVIEW OF STEPS:

1. Cut the tape for the resistors so that you leave groups of 6-7x resistors on the tape. This makes it easier/quicker to hold the resistors while soldering them.

2. On one side of the tape, cut the leads about 1/8” or 3/16” from the resistor body.

This short side will get soldered first to the top solder pad of each resistor being soldered in parallel.

<add picture>

3. Find the location of the resistor(s) being replaced for a given value (ie. 1.2k ohm). You'll need to find the resistor on the top-side and then flip the board over several times to make sure you've found the right pad. Add new solder to corresponding top pad of the resistor. Then solder the short side of the new resistor to this top pad. Repeat for each resistor of that value.

   TIP: If the solder isn't sticking to the resistor lead or the solder joint looks questionable, use desoldering braid (with flux built into it) or a desoldering iron to first remove the old solder. Although it sounds weird, you may need to add flux or new solder to the joint to aid in removal of the old solder. Removing the old solder first will create a better bond.

4. Now press the bottom lead (left hanging) down against the opposite solder pad of each resistor. Snip the leads over-top the solder pad with your cutters. Then solder each resistor's bottom lead to the bottom pad.

5. After all resistors are soldered on the bottom of the board, you will then need to cut the 2.2k pull-up resistors from the top of the board, as well as the VR1/CR1 diode and a 100k ohm resistor. For identification of these components for the model display board you're modifying, consult the *LIST OF COMPONENTS CHANGED PER DISPLAY MODEL*.

   Note: A few of the early Bally/Stern display boards do not have 2.2k pull-up resistors. There may be 2.2k pull-ups on the back of the board (one side on each of the digit drivers). If that's the case you will want to remove those & you can replace them with the 47k resistors in the kit.

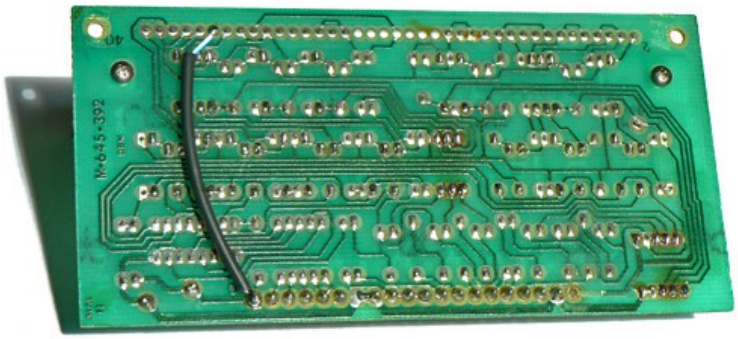
6. Now solder in the 2N7000 mosfets

7. Once these modifications are completed, follow on to STEP 7 to continue with the conversion.

STEP #6B: FULL REPLACEMENT OF COMPONENTS METHOD

If you're choosing this method, you will be fully removing all of the components being replaced. You should have already removed the segment driver transistors in STEP #4.

A picture of what a converted board may look like from the bottom is below:



TIPS BEFORE GETTING STARTED

- Use low heat settings on your soldering/desoldering equipment
- Be patient, if you don't have a good technique to minimize damage to pads/through-holes try working on your technique on a junk board first!
- For single-sided boards an easier way to minimize damage (especially if leads are bent over at a 90 degree angle, flat with the pads) is to cut the components being replaced off the top side, then add additional solder to the solder pad on the back of the board & grab the remaining component lead with micro-flush cutters, hemostats, pliers etc once it's loose. Cutting the lead a bit high on the top of the board will allow you to heat up the joint and gently push some additional lead through the board so you can more easily grab it from the bottom.
- Do not grab and pull if a component or lead is not easily coming out! It's a sure way to pull up a pad or trace, especially on single-sided boards.
- Do not allow a desoldering gun or soldering iron to rest on a pad.. instead add some new solder to the joint, then heat up the solder and keep the desoldering gun/iron above the pad. The pads are pretty fragile on some of these old boards and do not put up with a lot of heat or stress so watch how high of a temperature you're using as well.

OVERVIEW OF STEPS:
There are various tools and techniques to fully desolder components, so specific steps are not discussed here. See the tips above and consult the *LIST OF COMPONENTS CHANGED PER DISPLAY MODEL* toward the end of this document for a list of everything that needs to be replaced/removed.

Pictures of depopulated / repopulated boards for various models are located here:
http://www.pinitech.com/docs/ballystern_retrofit_depopulation.pdf

After you have finished, proceed to STEP 7 to continue with the conversion.

STEP #7: MOUNTING THE DIGIT PANEL

Mount the right-angle brackets included with the kit onto the component board. The bracket will sit on top of the PCB, while the screw will enter from the bottom of the board. The inside of the right-angle of the bracket should face the back of the board. ***On Bally 7-digit displays, use the included nylon washers between the bracket & PCB since there are traces close to where the bracket mounts.***

Now you have a choice. If your display board still has the original plasma glass on it, you can re-use the plasma glass leads if you cut them high. If someone already removed the glass or the leads are cut very short, you'll need to use the included right-angle header pins for the connections between the two boards.

STEP #8A: LED DIGIT PANEL - REUSING PLASMA LEADS

If the original plasma glass is still mounted, you can cut all of the pins high with micro-flush cutters and use them to make connections to the new LED digit panel PCB.

OVERVIEW OF STEPS:

1. Using micro-flush cutters, cut each of the plasma leads as close to the plasma glass as you can. Then unscrew the screws from the bottom of the board to detach the plasma glass panel & glass from the display. Do this over-top a table in case any of the assembly (including the plasma glass!) separates as you're removing it.

2. Mount the LED digit panel PCB to the bracket on the component board using the remaining screws included with the kit.

3. Once the LED digit panel is mounted, take a look at where the plasma leads line up with the SMD pads on the LED digit panel PCB. If they're not centered with the SMD pads you'll want to loosen the screws on both sides of the bracket some and adjust the position left-to-right to center the plasma lead to the pad.

4. You can now cut any of the unused plasma leads flat to the board. The unused leads are any that do not have any silkscreen digit (ie. D1, D2, D3, etc) or segment (A, B, C, etc) marking above them.

5. You'll now want to push the plasma leads back to the LED digit panel PCB to try and get them to lay as flat as possible to the SMD pad. Using a flat-head screw-driver, line it up at about 1/4” up from the bottom of the plasma lead and push straight back to the LED digit panel.. aiming toward the middle or bottom of the smd pad. With a little practice you should you can get them to rest fairly flat against the SMD pad, ready for soldering.

6. Any of the leads corresponding to digits with parentheses around them are OPTIONAL to solder. There's no harm in soldering them, but they're duplicate connections. In other words if you have a good connection for “D1” there's no reason to solder “(D1)” unless you really want to. Notice the parentheses.

7. Flip the board over in tee-pee position to now add solder to the SMD pads and solder the plasma leads to these pads. You may need to use the flat-head screwdriver to push the lead into the solder slightly as you're adding solder to the pad.

8. You can now [optionally] trim any plasma leads that extend past the SMD footprint if you want, just be sure to wear safety glasses and be careful not to cut too deep as you're trimming the leads. You may find it easier to trim the leads before soldering them to the SMD pad.

STEP #8B: LED DIGIT PANEL - RIGHT ANGLE HEADERS

If the plasma glass has already been removed from your board, you will need to use the right-angle header pins included in the kit.

OVERVIEW OF STEPS:

1. Clear the plasma pads of any solder using your preferred desoldering method (a desoldering gun works best). Only the pads that originally had plasma leads in them need to be cleared. You can line up the LED digit panel over-top the plasma footprint to see which holes still need to be cleared.

2. Separate the long pins out of the double right-angle header pins included in your kit. You'll need to pull the long pins out of the header. It may be easiest to first cut them into single strips and then pull the long pin from the plastic mold. You just want the longer metal pin by itself. You will need at least 13x pins for 6-digit displays and 15x pins for 7-digit displays.

3. Now set the LED digit panel on the edge of a table/workbench so the through-holes directly above the SMD pads overhang the table (you should see through them).

4. Insert the short side of the long right-angle header pins into each of the through-holes above the silkscreen segments/digit markings on the LED digit panel PCB. Push the pin all the way in. It will be somewhat loose. Don't worry too much about getting the pin centered with the SMD pad just yet.

   TIP: Any of the digits marked with parentheses around them are optional (ie. you don't have to install a pin into "D1" AND "(D1)" – you only need to make a connection to one of those.

5. Now set the old Bally/Stern component board at the edge of the table with the plasma through-holes overhanging the table so you can see through them.

6. Get a phillips head screwdriver & the remaining bracket screws ready. Pick the LED digit panel PCB carefully, tilt it backward slightly. Do not tilt it forward or the right angle pins may fall out. Lightly wiggle it from left to right. Most of the pins should drop down centered with the pads. You can brush your finger down any of the stubborn ones or tap them left to right. You'll want all of these pins centered with the SMD pads (ie. perpendicular to the board).

7. Now set the LED digit panel into the plasma footprint holes. You may not get them all inserted in the first shot, but if you have most of them lined up at the holes,

you can gently tap the few remaining pins left or right to knock them into the holes and fully seat the LED digit panel into the plasma footprint.

8. Steady the board on the bench and screw the remaining screw the LED digit panel into the right-angle bracket on the component board to finish mounting the board.

9. Once mounted, you can then adjust the position of the right-angle header pins. Many of those won't be sitting at a right-angle between the two boards because of how the mounting process was done. You can press/tap them from the back of the LED digit panel using a flat-head screwdriver or a coin. If they aren't pushing through easily, try loosening the screws at the brackets some (both sides). The aim is just to get the right-angle headers back at a right angle between the two boards.

10. Solder the right-angle pins to the back of the LED digit panel PCB. If any slip back through the board too far, heat the joint up and push them back through to make adjustments.

11. Now solder the opposite side of the right-angle pin to the plasma footprint. Be careful not to apply too much heat here because some of the boards are single-sided and pads are fragile – or may have already been reworked if plasma glass was replaced at some point.

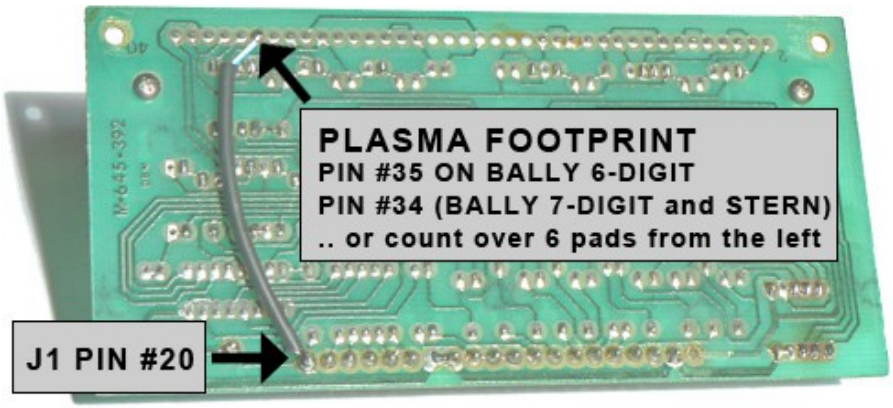
STEP #9: SOLDER THE JUMPER WIRE FOR 5V CONNECTION

You will need to add a jumper wire on the back the display to connect the 5v power to the high voltage traces on the board. The high voltages traces no longer have the ability for high voltage to go to them [YOU DID CUT J1 PIN #1 RIGHT?] and now you need to get 5v to those traces so the LED digits have power.

CAUTION!!!
BEFORE DOING THIS, ENSURE YOU HAVE PULLED PIN #1 ON J1 ON THE DISPLAY BOARD AS SHOWN IN STEP #1 OF THIS GUIDE! FAILURE TO PULL PIN #1 AND SOLDERING THIS JUMPER WIRE WILL SHORT HIGH VOLTAGE TO THE +5V IN YOUR MACHINE AND CAUSE DAMAGE TO YOUR BOARDS.

There's a bit of flexibility in where this jumper wire is ran and depending on the model of the display board you're working with some locations may be better than others. Ideally you will want to run a wire from J1 PIN #20 (+5v) to either the HV test point or somewhere that is out of the way of the rubber bumpers/feet toward the back of the mounting brackets in the backbox.

On many of the displays you can run the wire from plasma footprint PIN #34 (STERN or BALLY 7-DIGIT DISPLAYS) or PIN #35 (BALLY 6-DIGIT DISPLAYS) to J1 PIN #20 (5v connection) as pictured below. This won't work however for very early BALLY AS-2518-15 boards or early “blue” STERN DA100 boards.



The advantage to running the jumper like this is it stays clear of the rubber supports on the mounting bracket & it's also a fairly straight shot between the two. The disadvantage is early AS-2518-15 and early "green" STERN DA100 boards do not have this pad connected. Some boards may also have other components or solder points interfere with this configuration of the jumper. Some other options are below.

Other Options For Jumper Location:

- J1 PIN #20 to the HV test point
- HV test point to +5v test point
- J1 PIN #20 to the emitter of the digit driver. The emitter is the leg that has continuity to the same leg on every digit driver (ie. you should see one leg of the digit driver with a trace that runs to the same leg on the next.. and the next)
- J1 PIN #1 to J1 PIN #20 – this would be the perfect spot except the rubber bumper in the back of the metal display chassis may interfere with the wire depending how it's position. The other downside is, if you physically cut the trace coming out of J1 PIN #1 for extra safety/assurance, you wouldn't have the option of this jumper.

*Follow the traces coming out of PIN #1 and PIN #20 on your board to identify location of test points or alternate places for the jumper.

Use the heat-shrink tubing included in your kit to protect the wire further. You'll need to slip this on before soldering both ends of the wire in-place. There's no need to heat this up to "shrink" it – you can leave it as-is.

STEP #10: SOLDER IN THE LED DIGITS

It may seem odd to not have done this earlier, but with all the flipping back and forth of the displays, sometimes it's easier to solder the LED digits last to save any additional wear & tear on them. It'll should only take a few minutes to install these and solder them in, so now's the time! Make sure they're all right-side up before fully soldering them in (decimal on the bottom). You may want to solder just one lead on each one first, then make sure it's pushed flush to the board before soldering the remaining leads.

If you'd like to enable the comma on 7-digit Bally displays, there are small SMD solder pads on the back of the LED digit panel that you can bridge with solder to enable the comma. You'll also need the "COM" pin on the plasma footprint of the LED digit panel wired to the component board's plasma footprint.

STEP #11: VERIFY THE MODIFICATIONS

At this point the conversion should be completed. But rather than just tossing the display into a machine, we're going to verify a few things.

1. First verify all of the segment drivers are facing the same as the other transistors on the board (flat side toward the LED digit panel).

2. Next verify resistance values. If you fully replaced the resistors this will be as easy as consulting the list of resistors that were changed & doing a spot-check on the color. If you soldered resistors in parallel, the spot-check becomes a bit harder as you'll need to flip the board back and forth.. but you can get quick at this over time. Another option, especially if you soldered resistors in parallel is to use your multimeter on the ohms setting and verify the resistor values from the top of the board.

3. Verify the jumper you installed is connecting +5v to the High Voltage traces on the board. If you did not cut the trace at PIN #1 on J1 you can check continuity between the pad for PIN #1 and PIN #20. If you cut the trace, you can use the pad at VR1/CR1 to check continuity to PIN #20.

4. Verify VR1/CR1 is cut or removed, the 100k pull-down resistor identified for your display (R34 for all displays except STERN 7-digit which will instead be R45) is removed.

5. Do a visual check for any stray solder splashes, cold solder joints, possible shorts, pieces of component leads that may be left from modification.

6. Last but not least, again **MAKE SURE J1 PIN #1 IS FULLY REMOVED / PULLED!!!**

A few additional notes that will save you some trouble..

- Some games may have the GND wire to the display going to J1 PIN #2 instead of J1 PIN #13. If you test your display at the bench and it works, but it doesn't work in the game, check if there's a wire going to J1 PIN #13.. or if it's instead going to PIN #2.
- If using a Stern 7-DIGIT display in a Bally game, you will need to connect J1 PIN #11 to J1 PIN #12. This is because Bally used a different pin to connect the 7th digit signal to the board.

Now head over to the BENCH TESTING section to verify the board is working electrically.

BENCH TESTING THE DISPLAY

So you verified the changes as recommended in the previous section. You've done all you could short of applying electricity to the display. Now how about a way to test the display before you plug it into your machine and find out there's an issue?

If you have a bench power supply & a handful of mini-grabber test clips, you can do just that! If you won't be bench testing the display, please do everything you can to verify the display as mentioned at the end of the previous section.

Note: The mini-grabber test clips are needed since there is not the chance of connections shorting as there is with larger alligator clips. If using alligator clips be very careful that the clips do not twist and short against each other or you may be shorting +5v of your power supply to GND. If your power supply does not have a fuse or ability to set a limit on the current, this could cause big problems. Current-limit at 100mA or fuse at 1/8 to 1/4 amp.

USE THIS INFORMATION AT YOUR OWN RISK. The safer way to connect would be with mini-grabber clips or to create a small wire harness to plug into J1 (more on that below).

Below are the minimal connections needed to light an "8" on the 1s digit:

Display J1 Pin #:	Description:	Connect To:
20	*+5V*	Power Supply +5v
13	*GND*	Power Supply GND
16	*D3 (BCD)*	+5v
17, 18, 19	*D0-D2 (BCD)*	GND
15	*LATCH*	+5v
10	*BLANKING*	GND
4	*1s DIGIT*	+5v

So what can you test? Once these connections are made you should see an "8" light up on the display for the digit you're enabling (if following the chart connections exactly, the 1s digit should light up).

If you wanted to light "8" on the 10s digit instead, just connect +5v to Pin #5 instead of Pin #4. Pin #4-9 are digits 1-6 and Pin #11/12 is the 7th digit on 7-digit displays.

WIRE HARNESS PLUG-IN FOR J1

If you have Molex crimpers, some 10pos Molex connectors & 0.156 terminals, you can wire up a small plug-in harness for J1 to make testing much easier. We may have these available in the future.

ADDITIONAL TESTS

Aside from testing digits light up and then being able to troubleshoot any non-working segments or digits (if your display board has any other issues) you can also connect a meter on the Amperage setting (or mA setting) in-series with the +5v from your power supply and verify the display is reading the expected amperage. Be sure to switch the multimeter's leads to the correct placement for measuring amperage before powering things up. For expected readings, you can consult the chart on Page 4.

MACHINE TEST

So now you have your converted display. You've verified resistor values either visually or checking with your ohms meter. You've verified the jumper has continuity where it should. Hopefully you've even had a chance to bench test the display some. **And for sure, you've pulled J1 PIN #1 because at this point there is no way you should have missed that step. Right?**

Well just in case, one last time...

BEFORE PLUGGING THE DISPLAY INTO A MACHINE, check and re-check that you have pulled J1 PIN #1!!!!

You may think we're going overboard with this, but it's highly important that you verify that you've done this on every display that you convert or you will cause yourself or others some major headaches.

Now it's time to plug the display into your machine for the real test. So go ahead already! What are you waiting for?

NO ISSUES? AWESOME!

Hopefully you find the display is fully working as soon as the machine starts up and running the DISPLAY TEST shows the display is fully working. Maybe one of the digits appears quite a bit dimmer than others but it's functioning – that's okay, that issue is covered in the next section. If all your digits look pretty consistent in brightness and the display is fully function – CONTRATULATIONS!!!!

If you do have issues, we will try to help you resolve those (on the next page).

FINISHING UP

INSTALLING COLOR FILTER

There should be a few pieces of double-sided tape included with your kit. If you cut this into thin strips, you can use it to adhere the color filter at the left and right edge of the filter. You can also use scotch tape. You may need to cut the color filter to size further.

INSTALLING FOAM LIGHT BLOCK

The foam strip(s) that came with the kit are optional. These will need to be cut and fit around the edges of the display PCB (bordering the digits). The foam is a bit wide, but if you pinch / squeeze it over to the LED block as you're adhering it, you should be able to get the adhesive part so that it doesn't overlap the PCB edge. Stretch the foam slightly as you're putting it down, snip at the edges & work around the digit blocks.

REMOVE HIGH VOLTAGE FUSE(S)

If you're replacing all the displays in your machine, it's a good idea to remove the High Voltage fuse from the rectifier board & optionally the SDB since high voltage is no longer needed for the displays.

WHAT IF YOUR DISPLAY HAS ISSUES?

Digit not lighting? Is a segment on every digit completely out? Or maybe the display is completely dead even though the machine is booting. We'll try to help you out..

The best way to catch major issues is by bench testing the display. It takes a little extra work to setup, but if you're modifying a lot of displays it will make it a lot easier to catch issues before trying the display in a machine.

SCHEMATICS
Updated schematics showing the conversion display changes can be found at:
http://www.pinitech.com/retrofit/schematics.php

BIGGEST CULPRIT – BREAK IN CONTINUITY
You'll probably find many issues are going to be related to either a break in connections or inadvertent shorts on the component board (or possibly the LED digit panel PCB). To isolate the issue, you'll need to "follow the connection". In other words if a segment isn't lighting up, follow the connection from the SMD pad marked on the LED digit panel, through the plasma footprint – verify continuity between the SMD pad and plasma footprint. Then from the plasma footprint to the next component. Use the schematics listed above to work through the circuit with the issue. Keep lookout for stray solder blobs on nearby components or pads/traces that are no longer connected. Do this before attempting to replace any components, as you problem may simply be a break in connection between components or an inadvertent short between components.

BAD COMPONENTS
It happens. The donor boards you're using may have had issues before you even touched them – bad level shifters or digit drivers that lock on a digit, a bad 4543 that can cause some odd display issues. If you've already rechecked your work & verified continuity (as above) you can start suspecting a bad component.

NORMAL DISPLAY ISSUE TROUBLESHOOTING RULES APPLY

- Make sure the solder joints on the J1 header aren't cracked – or better yet, reflow these joints. Often these can cause intermittent or bad connections.
- A bad 4543 can cause all sorts of odd issues, however a single digit or segment that's locked on or missing is likely the transistor or something isolated in that circuit. A bad 4543 would likely cause issues across all digits.
- Make sure if you're testing displays in a 7-digit game, that you are testing the 6-digit display in the credit position only. Some of the 6-digit displays have J1 pin #10, #11 and #12 tied together. If you attempt to test a 6-digit display in a 7-digit player position, it will short the BLANKING and DIGIT 7 strobe and cause weird issues. You'll be chasing a problem that isn't really a problem. Only test a 6-digit display in the credit display position on 7-digit games!
- Very early STERN DA100 boards (pcbs are blue in color) did not have their J1 pin #13 (GND) connected to pin #2 (GND). We do not have a list of games that utilized GND at pin #2 but you can check if a wire is going to pin #2 instead of pin #13 on the J1 connector if the display isn't working in your Stern game.
- Check that you have +5V at the appropriate test point(s) on your display.

DIGIT DRIVER ISSUES

- **A digit doesn't light** – could be a bad digit driver, but many times is a missing signal between the digit driver and the LED digit panel or other circuitry on the component board. With the display pulled from the game, you'll need to use a multimeter on continuity setting to verify connections between the digit driver & other circuitry (using a schematic). If the continuity is good, try replacing the 2N5401 digit driver. We've included extras with the kit.
- **One digit is noticeably dimmer than other digits** – this can sometimes happen if the 2N5401 digit driver is weak or transistor gain is significantly different than the other digit drivers. Replace the corresponding 2N5401 digit driver and the digit should no longer be weak.

SEGMENT DRIVER ISSUES

- **Missing segment** – since you should have replaced the segment drivers with the included 2N7000 mosfets, it's highly unlikely any segment issues are going to be caused by the segment drivers themselves. More likely you will find a break in continuity causing a non-working segment.
  Locked on segment or segment that lights when it shouldn't – it's highly likely there's a solder bridge somewhere there shouldn't be. Two of the led digit solder points accidentally connected on the LED digit panel PCB with stray solder or a short between components on the component board. This is probably more likely if you soldered resistors in parallel – you may even find the resistor was soldered in the wrong place! If it's just one segment lighting when it shouldn't, follow the connections as previously mentioned – from the segment pad on the LED digit panel.. to the plasma footprint.. and so on, using the continuity on your meter to verify connections.

DISPLAY ISN'T LIGHTING UP AT ALL?

If the display isn't working at all, or no displays work – first try a different display – or a plasma display. Also try the display in a different position on a game (but don't try a 6-digit display in a 7-digit player position – see note in the bullet point list on the previous page). If other displays work & you've reflowed the J1 header solder points on the display & have rechecked your work – suspect a bad 4543. A dead 4543 will not send signals to the segment drivers. You should see something out of the display unless the 4543 is completely shot or +5v isn't getting to the display. Issues across all digits or segments are likely caused by the 4543 – issues on only one digit are likely caused by a problem isolated to THAT digit's circuit. Issues on all segments may be caused by either a partially bad 4543 or a bad segment circuit.

STILL HAVING ISSUES?

Hopefully some of these troubleshooting tips have helped you to find your issue. If not, you can try contacting support@pinitech.com and let us know what your symptoms are and we will try to offer some suggestions to get you going.

QUICK CHEAT-SHEET STEPS FOR CONVERSIONS

This is a very basic overview of the steps to convert a display. Once you've done a few, there's no need to read through this entire guide, you'll have an idea of things & between this outline of the steps & the list of components being changed out per model display, you'll be covered.

1. Visually inspect the donor board
2. Remove / Pull J1 PIN #1 (high voltage pin) from the display **highly important**
3. Reflow the solder joints at the J1 header if necessary
4. Fully remove the segment driver transistors
5. Decide on a conversion method (consult list of components replaced per model)
    - If soldering resistors in parallel, clip the 2.2k transistors from the top of the board after you've soldered all the resistors in-place. Also clip CR1/VR1 and the 100k pull-down as indicated on the list of components being replaced. Install the 2N7000 mosfets.
    - If fully removing components, consult the component list for your display model to identify all the components to remove & replace.
6. Mount the digit panel
    - If using existing plasma leads, cut the pins high.
    - Be sure to pre-mount the right-angle header on the component board.
    - Follow the steps in the guide per each method (using existing plasma leads or right-angle header pins).
7. Solder in the jumper wire for the 5v connection
8. Solder the LED digits to the LED digit panel
9. Verify the modifications visually before testing
    - Check resistor values
    - Check 2N7000 mosfets are facing the correct direction
    - Verify the jumper is installed correctly
    - Check for stray solder splashes, shorts, component legs, connections that you missed soldering.
    - Verify CR1/VR1 is cut or removed.
    - Verify the 100k pull-down is cut or removed (R34 for all displays except STERN 7-digit which will instead be R45)
    - ***HIGHLY IMPORTANT*** VERIFY J1 PIN #1 IS PULLED!!
10. Bench test the display & fix any issues noticed
11. MACHINE TEST!!! Be sure J1 PIN #1 is pulled before machine testing!!

CAUTION!!!

DO NOT UNDER ANY CIRCUMSTANCE LEAVE J1 PIN #1 CONNECTED ON THE COMPONENT BOARD!! EVEN IF PULLING THE HIGH VOLTAGE FUSES. YOU DO NOT WANT TO TAKE A CHANCE OF YOU OR ANYONE ELSE PLUGGING THE DISPLAY INTO A DIFFERENT MACHINE AND SENDING HIGH VOLTAGE DOWN THE +5V CIRCUITS.

LIST OF COMPONENTS CHANGED PER DISPLAY MODEL

6-DIGIT DISPLAYS (BALLY & STERN)
MODELS: AS-2518-15, AS-2518-21, A434, B434, DA100

DIGIT DRIVER CHANGES
R1, R3, R5, R7, R9, R11 (100K → 1.2K)
R2, R4, R6, R8, R10, R12 (2.2K → 47K) *WARNING: See Model Specific Notes Below!
EARLY MODEL DISPLAYS LACK THE 2.2K RESISTORS LISTED ABOVE (AS-2518-15 and early Stern DA100)
Resistor numbers above exist, but they are used for a different purpose. Do not remove.
The early Stern DA100 boards have traces on both sides & traces are curvy.

SEGMENT DRIVER CHANGES
Q13, Q14, Q15, Q16, Q17, Q18, Q19 (MPSA42 → 2N7000)
R13, R15, R17, R19, R21, R23, R25 (1.5K → 270/470 OHM) *these set led brightness
R27, R28, R29, R30, R31, R32, R33 (1K/1.2K → 0 OHM)

OTHER CHANGES
Remove R34 (100K)
Remove VR1 (ZENER)
PULL J1 PIN #1
Add jumper wire for 5v connection. See guide for details.

MODEL SPECIFIC NOTES:
Bally AS-2518-21
26 resistors replaced, 7x transistors
Bally AS-2518-15, Early Stern DA100 (bluish-green board with curvy traces top-side)
20 resistors replaced, 7x transistors
*Does not have 2.2k pull-up resistors footprints. May have 2.2k resistors soldered on back of board between digit driver emitter & base. Remove these & install 47k pull-ups in their place.
Stern A434/B434/DA100 single-sided boards
26 resistors replaced, 7x transistors

BALLY 7-DIGIT DISPLAYS
MODELS: AS-2518-58

DIGIT DRIVER CHANGES
R1, R3, R5, R7, R9, R11, R56 (100K → 1.2K)
R2, R4, R6, R8, R10, R12, R57 (2.2K → 47K)

SEGMENT DRIVER CHANGES
Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q22 (MPSA42 → 2N7000)
R13, R15, R17, R19, R21, R23, R25, R61 (1.5K → 270/470 OHM) *these set led brightness
R27, R28, R29, R30, R31, R32, R33, R60 (1.2K → 0 OHM)

OTHER CHANGES
Remove R34 (100K)
Remove VR1 (ZENER)
PULL J1 PIN #1
Add jumper wire for 5v connection. See guide for details.

MODEL SPECIFIC NOTES:
Bally AS-2518-58
30 resistors replaced, 8x transistors

STERN 7-DIGIT DISPLAYS
MODELS: DA300, A645

DIGIT DRIVER CHANGES
R26, R30, R32, R33, R34, R39, R44 (100K →1.2K)
R3, R7, R10, R12, R14, R19, R23 (2.2K →47K)

SEGMENT DRIVER CHANGES
Q8, Q9, Q10, Q11, Q12, Q13, Q14 (MPSA42 →2N7000)
R1, R5, R6, R16, R17, R20, R21 (9.1K →270/470 OHM) *these set led brightness
R25, R28, R31, R36, R38, R41, R43 (1K →0 OHM)

OTHER CHANGES
Remove R45 (100K)
Remove CR1 (ZENER)
PULL J1 PIN #1
Add jumper wire for 5v connection. See guide for details.
Connect PIN #11,12 of J1 if using on a BALLY machine.

MODEL SPECIFIC NOTES:
Stern DA300, A645
28 resistors replaced, 7x transistors

Highly unlikely to be mixing & matching these larger Stern 7-digit displays with BALLY 7-digit displays, but if so & you're soldering resistors in parallel you will notice the digits are not as bright due to the 9.1k resistor on the segment drivers. To fix this you would need to clip the 9.1k resistors indicated in the list above from the top of the board. See the chart on Page 4 for what happens with the display current with resistors soldered in parallel to the 9.1k resistor.

SCHEMATICS
Updated schematics showing the conversion display changes can be found at:
http://www.pinitech.com/retrofit/schematics.php