Stern Star Trek
PWM GI Dimmer
Installation and User Guide

The following document walk you through the installation of Pinball-Mods.com's Star Trek GI Dimmer for the Stern Star Trek Premium and Limited Edition Pinball Machines. This upgrade is a bolt-on modification which requires no irreversible changes to your pinball machine. This guide will initially walk you thru the installation for this board set and provide you with a general user guide should you need it.

Please **note**: The Author of this document is not responsible for any damage you do to yourself or your property.

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Tools/Materials Needed:

- Philips Screw driver
- A soldering iron
- Some Solder
- A Windows PC or Android Cell phone to program settings

Kit Contents:

- Stern Star Trek GI Dimmer PBA.
- Laser Diode cable
- two Standoffs
- two #6x1.25" screws
- 1 qty 0.156" 8pin IDC connector for J5.
- 1 qty 0.156" 3pin header for Stern Board

NOTE: The pictures in this document may swap between the prototype Purple PBAs and the production White PBAs as much of this document was written prior to receiving the production PCBs. The color of the PBA doesn't matter; only the connections / instructions in the document.

Overview / Introduction:

The process to install these boards is simple and should only take about an hour if you perform every step. The kit is designed to be a bolt-on upgrade which allows you to control the four GI strings (**GI0-3**) present in the Machine with a percentage programmed into the board. The board can be programmed with either USB, a Bluetooth LE [BLE] wireless connection using an Android Cell Phone, or manually using two onboard variable resistors. Additionally; the board set provides 9 auxiliary ports (**GI4-12**) so that the user can control and power mods.

The main board provides 6 GI channels which can be varied by any percentage between 0 and 100% - 4 of the channels being the main GI (**GI0-3**) and two **GI4** and **GI6**. The remaining channels are on/off. Settings for these channels are stored in an onboard eeprom and are retrieved each time the board receives power from the machine. The board provides setting for "normal operation" and Klingon Multiball which is detected by the laser being active in Klingon Multiball.

Programming the board can be done with two onboard resistors (**R13**, **R14**) but for best results you should initially program the board using a Windows PC or an Android smartphone. Pinball-Mods.com provides programming software on our product page for both Windows and Android.

If you choose to use USB; Pinball-Mods recommends a laptop or tablet running off battery to program the PWM setpoints. This is recommended to avoid ground loops between the pinball machines and the usb host. If you are going to use a machine powered by the wall outlet; make sure it's plugged into the same outlet as pinball machine.

Android BLE compatibility *requires* Android 4.3 or better with appropriate Bluetooth 4.0 hardware. Please consult your phone manufacturer to determine if you have the appropriate hardware to connect with the nRF8001 chipset in our product.

Finally; Settings can be saved and shared from our control software to allow for collaboration between users. To prevent another user from hacking your machine's setting; we provide a physical jumper (**JP1**) which you move to **[2-3]** to lock the BLE radio so a user cannot change your settings without the machine key. Please make sure you "lock" the BLE radio when you have finished configuring the board.

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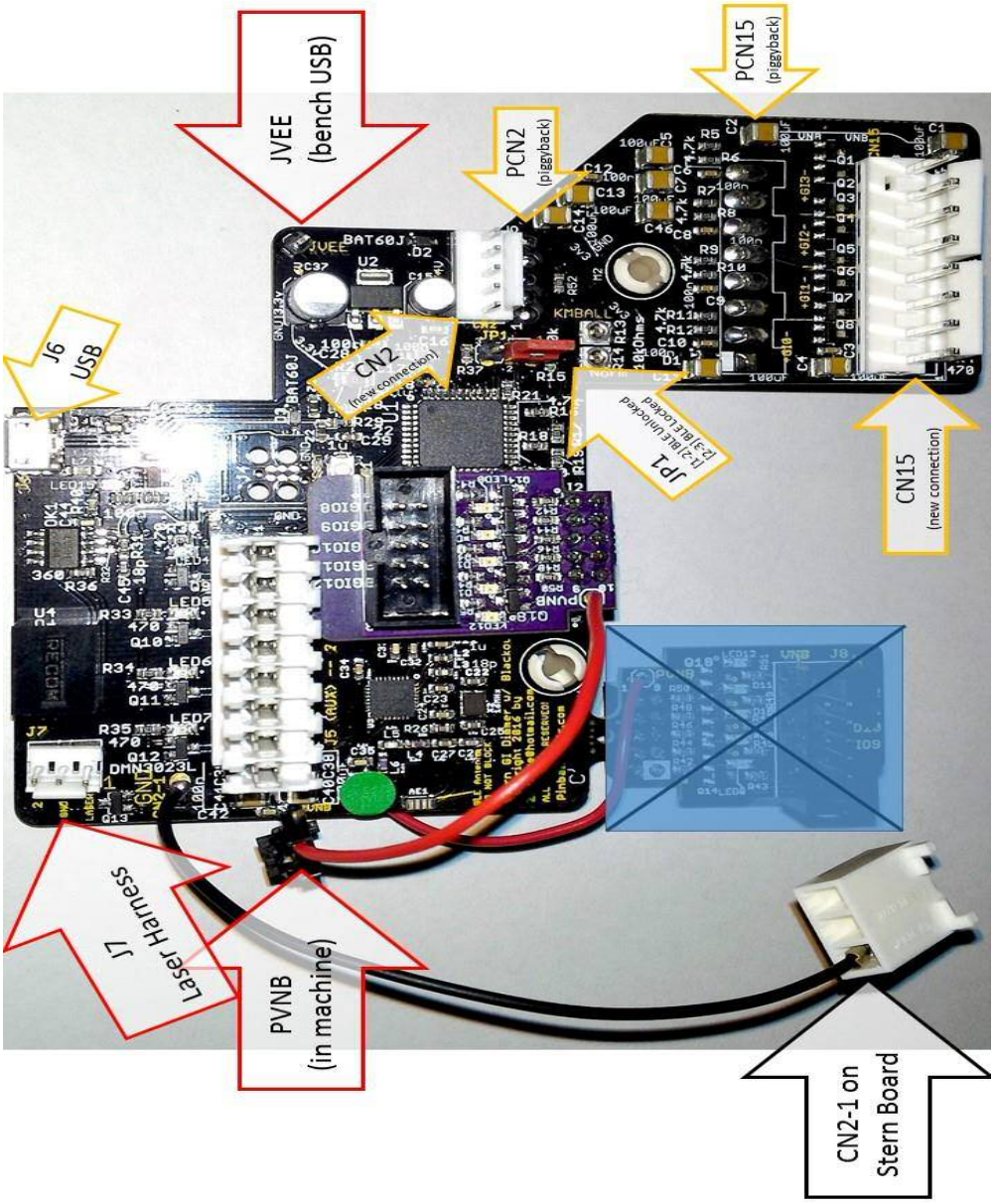

Figure 1 Important PBA Connections

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Installation (Step-By-Step):

1) (*optional* – but recommended) Begin by locating the main GI & RGB controller board in your machine. It is attached on the backside of your playfield and controls the GI channels located just above the center inserts. It is labeled #520-6812-00A.

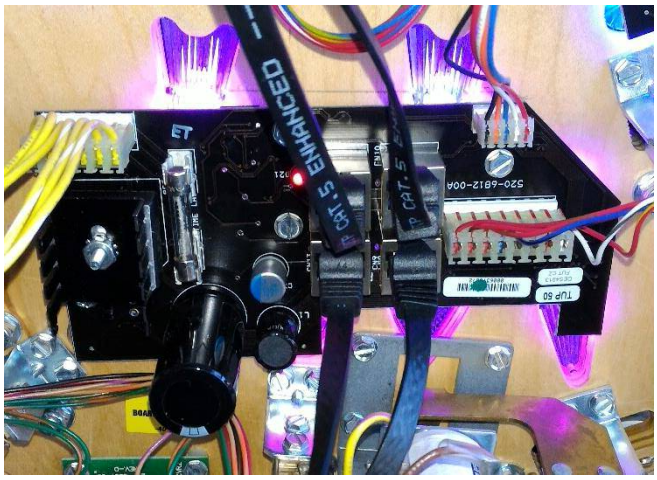

Figure 2 Locate Stern's GI board #520-6812-00A

Carefully Remove this board and take it to your soldering iron. This will likely void the warranty of your machine because we are about to solder a header to this board so we can get an additional ground. This is highly recommended because the main board you are installing only has a single Ground connection to the machine at CN2. Pinball-Mods.com is concerned that this could lead to excessive current on that connector – which would lead to premature aging of the connection (think: crispy, burnt connectors) This also help improve the Equivalent series resistance of the Stern's DC-DC converter to help reduce RGB insert flicker. If you are concerned about the warranty of your machine; feel free to delay the installation of this additional ground. For long term stability – we recommend you eventually do this mod when your machine is no longer under warranty.

   a. Loosen the heatsink of the bridge rectifier using the nut seen in the picture below. Rotate the heatsink 90 degrees so that you have an unobstructed access to the backside pads of CN2. We rotate the heatsink so the tabs face outside the board and you still have easy access to the fuse. Secure the heatsink by tightening the nut.

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b. Included in the Kit is a 3pin 0.156" header. Install this on the Capacitor/Bridge side of the board at the empty header location labeled CN2. Place it so the ramp is nearest the large C29 capacitor. Pin 1 of this connector is our extra ground.

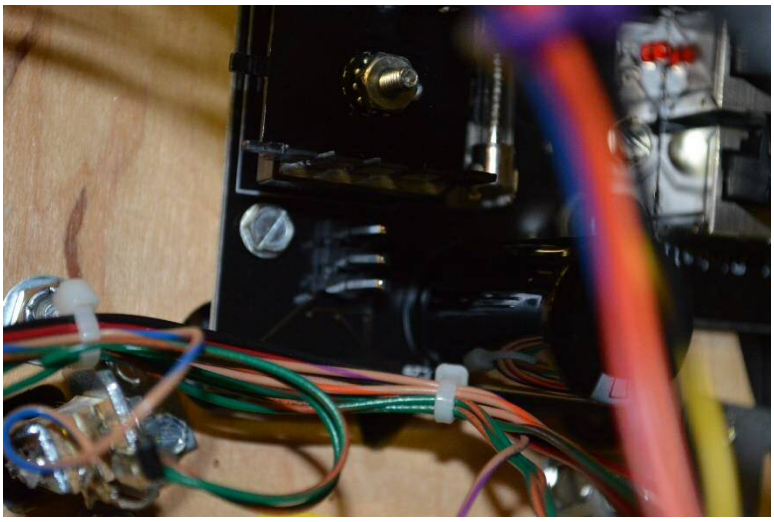

Figure 3 Solder CN2 connector to Stern board

c. Reinstall the Stern board in your machine.

2) Next we need to prepare the daughterboard for installation to the main board. This daughter board provides GI channels 8-12 and is attached to J2. This board is currently attached to the main board with some mouse bites.

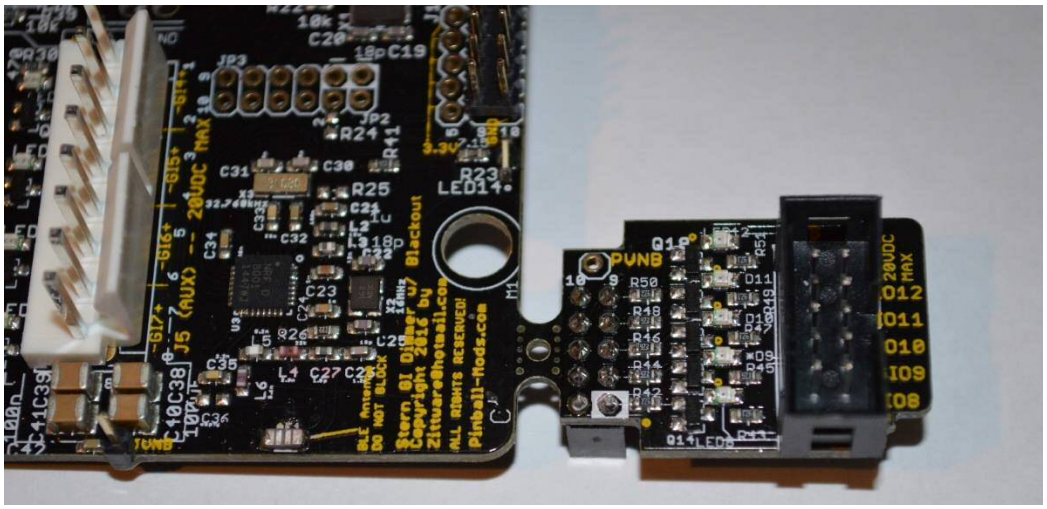

Figure 4 GI8-12 Daughter board

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3) Snap the boards apart and clean the mousebites off of each board. I use a dremel; but you could also use a belt sander or a new/sharp exacto knife.

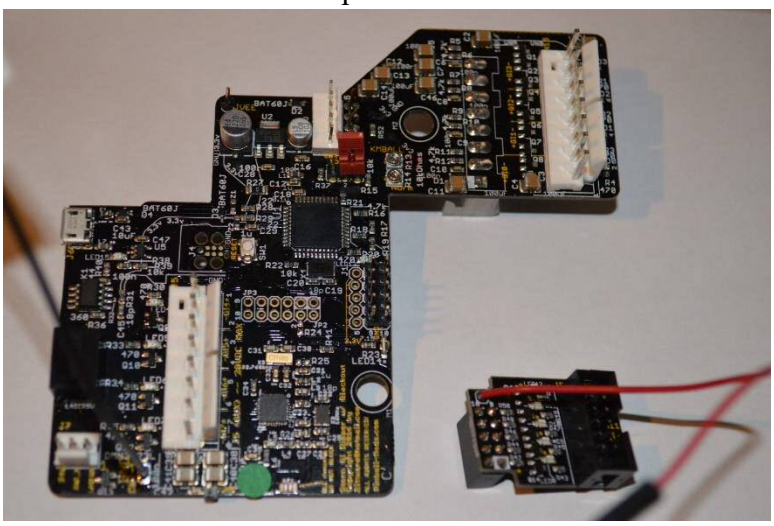

Figure 5 Snap off Daughter board and clean

4) Install the daughterboard on J2, making sure to match pin1 to pin1 on the connector. It should be positioned as seen in the picture.

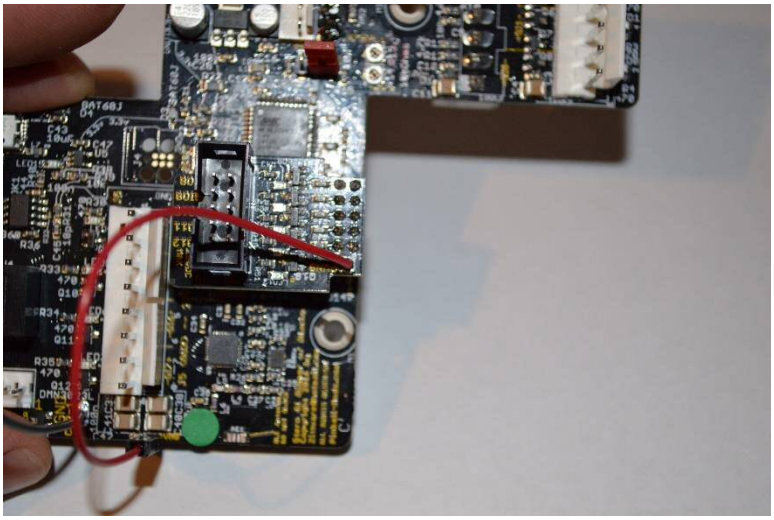

Figure 6 Install Daughterboard at J2

Attach the red wire (PVNB) to JVNB on the mainboard. This is the normal operating position which supplies "hot" to the LEDs and header at J8. When in the pinball machine; you want the red PVNB wire getting power from that rail.

When benchtop testing outside of the machine, you want to get "hot" from the 3.3V regulator at JVEE which is almost directly opposite of the JVNB connector near C28/CN2. I use the JVEE when I'm benchtop testing the boards outside the machine or playing with certain settings in the programming software. This way I can see LED8-12 lite during testing.

Just make sure to return PVNB to JVNB before installing in your machine.

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5) Install the standoffs to the M1 and M2 holes in the main board. These standoffs are used to mechanically secure the board to the Stern board in a later step.

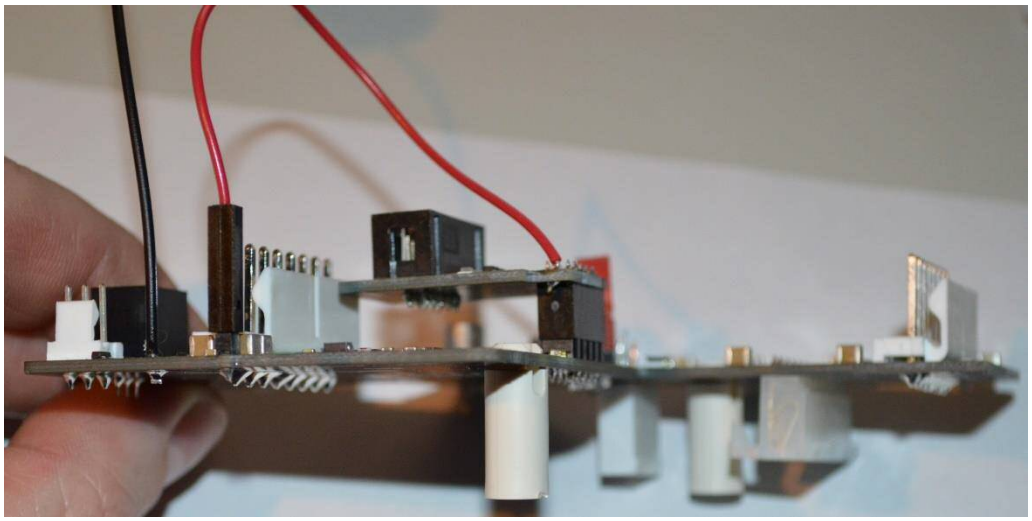

Figure 7 Install M1 & M2 standoffs

6) Now you are ready to install/piggyback the boardset onto the SternGI board. Begin by removing the screw between the two white connectors and the screw to the left of the RJ45 connectors just below D21. These holes will be used to secure the piggybacked board with 1-1/4" screws in a later step. These screws will prevent the board from installing correctly if left in place. It's ok to leave the stern standoffs in place; in fact – it's recommended.

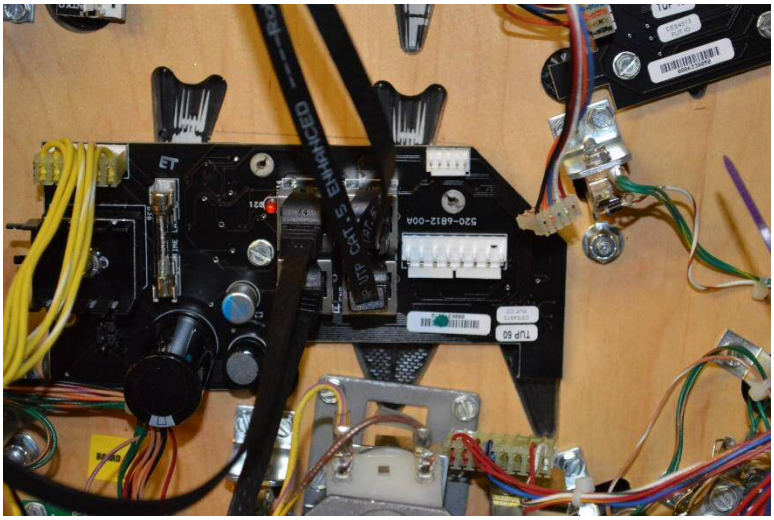

Figure 8 Remove Stern Screws and CN2 & CN15

You'll also need to remove the GI harnesses labeled CN2 and CN15. Our mainboard piggybacks to these connections.

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7) Carefully install the mainboard to the CN2 and CN15 connections. The PCN2 and PCN15 connectors on our board should be close enough to just go on fairly easily. Just make sure that the connectors line up. Make sure you don't miss or bend any pins.

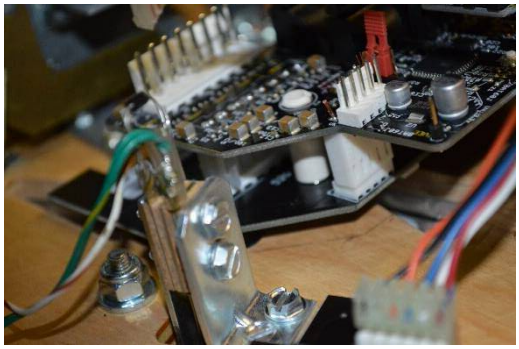

Figure 9 Piggyback boards together lining up CN2 & CN15

The standoffs should line up with the top of Stern's standoffs.

8) Attach the CN2 and CN15 cables to our board at their new connections. The connectors have the same orientation; therefore, should be obvious how to install.

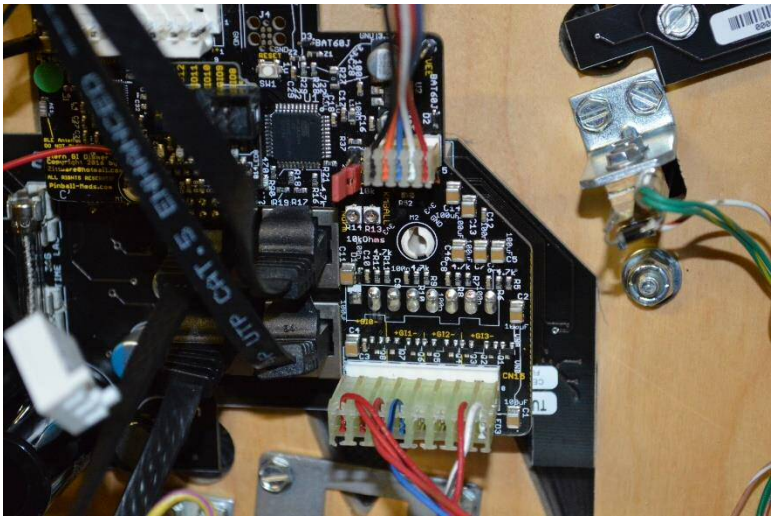

Figure 10 ReInstall CN2 & CN15 to our board

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9) Connect the Black Ground wire labeled CN2-1 to the header you soldered in Step 1. Make sure pin1 (the black wire) is at the pin nearest the bridge rectifier as pictured.

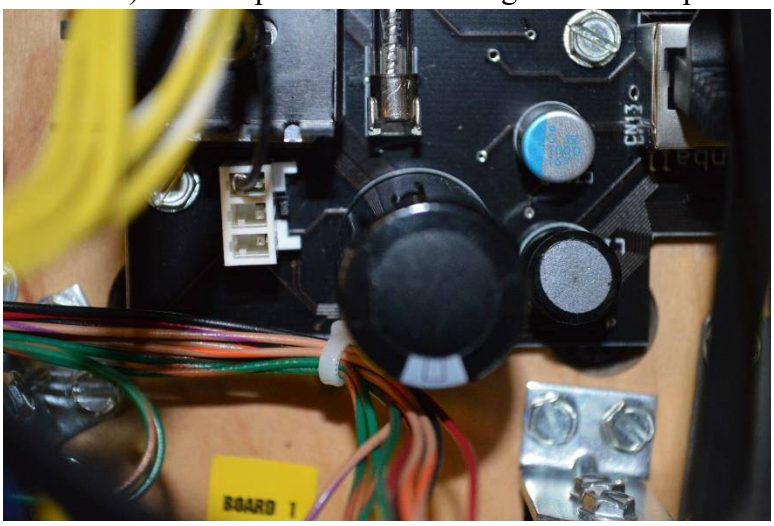

Figure 11 Install CN2-1 Ground to Header

10) Now, lift the playfield and look for the laser wiring harness. On the Author's machine; this connection was identified with two yellow dotted connectors. On one side; there is are brown and purple-violet conductors. On the other; there is a couple of white/black stripped wires crimped to the "purple side" and white/brown stripped wires crimped to the "brown side". For your reference; the Laser connections are listed on Page Y42 in the LE manual.

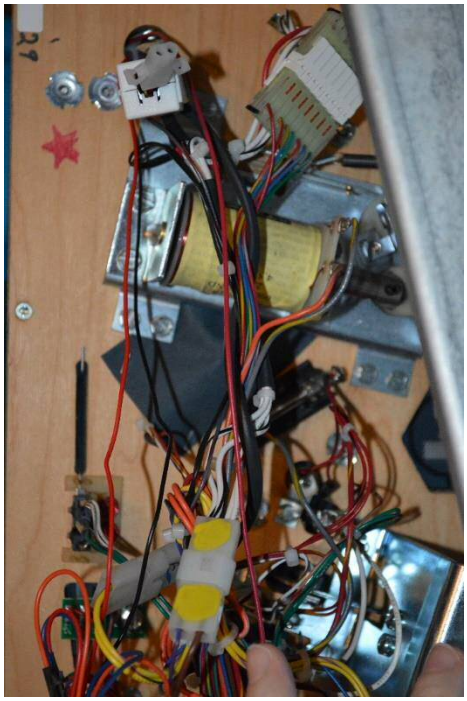

Figure 12 Locate Laser Harness

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Disconnect these connectors and connect the supplied cable harness between these two connectors.

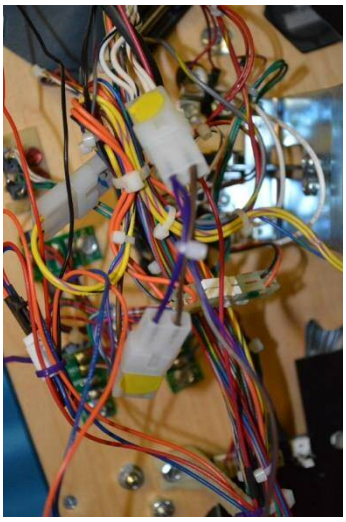

Figure 13 Insert Laser Cable in series

11) The three pin (Purple Black Brown) connector on the other end of the Laser Cable connects to **J7** on our board. Route the new cable with the main wiring harness securing with zip ties for neatness.
    a. If you do not have our laser upgrade; this connector should be free to plug into J7.

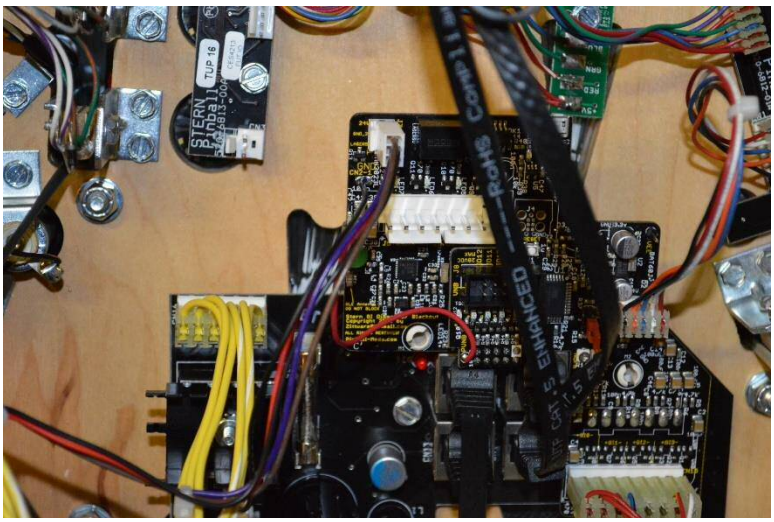

Figure 14 Install 3pin laser cable to J7

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b. If you purchased a green/blue/red laser upgrade from us in the past; you can cut away the black heat shrink and remove the old VRM to get the J7 three pin connector. The VRM is already present on our main board; so, you can remove the old VRM and use the onboard VRM.

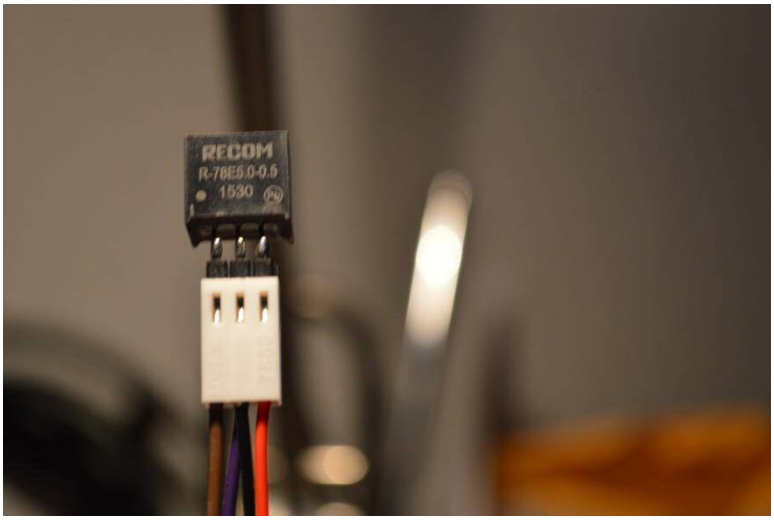

Figure 15 Remove VRM (if necessary)

12) At this point the only hardware which should be left in the kit are the 2 qty 1-1/4" screws which you use to secure the board to the pinball machine. Run these thru the M1 and M2 holes which you installed standoffs in Step #5 above. *Please* be **extra careful** here! To make sure the longer screws DO NOT punch thru your playfield. It shouldn't be physically possible; but just be careful as you don't want holes where they shouldn't be. In most cases; you don't even need the screws to be installed. The author hasn't installed the screws and the CN2/CN15 piggy back connections are strong enough to hold the board in place.

13) The last item in the kit is the 0.156" 8pin IDC connector for J5. This is the auxiliary GI connector where you'd connect your mods to the machine. We do not include any IDC tools; but the connector is kitted so you can connect things like our USS Kelvin, Klingon Ship, or Nebula Backboard.

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User Guide

With the physical connection to your machine complete; you should be able to power up your machine and the machine should function as it always did. To get the most of your new boardset; you are going to have to setup/program the board. Before we do that; let's talk about what happens in the board's firmware as soon as power is applied.

Upon exiting reset; the atmel microcontroller at U1 will begin setting up the GI channels and enabling the Bluetooth radio. It begins by toggling LED13 (yellow) on/off at about 1second intervals for about 10seconds. The order of these operations may change but as of the writing of this document basic operation is as follows:

1. All GI Channels go to 100%. Laser Override is set as output and Laser Override is disabled. LED13 toggles.
2. Initialize Bluetooth (BLE) Radio pins. LED13 toggles.
3. Initialize BLE radio. LED13 toggles.
4. Read EEPROM for programmed settings. LED13 toggles.
5. LED13 toggles over 5 seconds; busy wait.
6. Read R13 and R14 for analog control of Normal and Klingon MultiBall (KMB) modes. LED13 toggles.
7. Setup PWM timers 1&3 for 16bit PWM. LED13 toggles.
8. LED13 off.
9. GI Channels are set to their pre-programmed values (from EEPROM) or the analog reading from Step6.
10. Initialize interrupt driven KMB detector.
11. Enter into communication loop. Waiting for Input from either USB or BLE. At this point LED14 (blue) will begin to flash rapidly indicating communication polling is occurring between uC and BLE radio. At this point you can connect to either communication path and begin interacting with the board.

This is a very long way of saying that for the first 10seconds; the board is in a "setup" phase and it won't reliably respond to either USB or BLE. If watching from the top of the Playfield (PF); ALL GI channels will start at 100% brightness… and then after about 10seconds; the GI will settle on their pre-programmed values. For best results: Wait for LED13 to stop toggling before attempting to communicate with the board. If you are going to communicate via BLE; make sure LED14 is flashing rapidly as an indication you can connect via BLE.

Each GI channel is labeled on the board. GI0-3 are connected to the main GI of the Stern Star Trek pinball machine via (P)CN15. Each pin of the (P)CN15 connector is labeled with a + or a -. Plus is always "hot", and is generally connected to the VNB rail in the machine. Each channel as a MOSFET which is in series with the negative (-) pin. This MOSFET controls the "brightness" of the GI channel via a technique called Pulse Width Modulation (PWM). Additionally, there is a yellow LED in parallel to the pins which allows you to see the brightness of the channel. Like the channels; these are labeled LED0-12. Each of the MOSFETs have a maximum Drain to Source of 20VDC – making it compatible with some of the "hot" sides of low power solenoids in the machine. Do not attempt to connect more than 20VDC to the hot sides.

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R13 (normal) and **R14** (KMB) allow the user to program the "final" settings using these analog resistors. The default configuration programmed settings allow a user without a smartphone/computer to program KMB's brightness using the **R14** resistor for all channels. In normal mode; **R13** is used – but to maintain compatibility with the Stern machine **GI0-3** are set to 100% regardless of setting for **R13**. In Normal mode; **R13** only controls the brightness of **GI4-12**. The Binary channels **GI5&7** operate if the pot is less than 10% scale the channel is "off" else the channel is 100%. Binary channels **GI8-12** if the value 0 – the channel is off else on.

Setting up for USB connection to the board

The GI board can communicate with a Windows-based tablet or pc running Window7, Windows 8, or Windows 10 using the **J6** microUSB connector. The board will appear as USB serial port allowing the software to communicate with the board. Pinball-Mods recommends a laptop or tablet running off battery to program the PWM setpoints. This is recommended to avoid ground loops between the pinball machines and the usb host. If you are going to use a machine powered by the wall outlet; make sure it's plugged into the same outlet as pinball machine.

1) To use the USB port; you need to install the Windows driver for the board which is present in the Control software on our Product page. After running Setup; the driver INF file will be in the installed directory, usually:
2) Once you have the driver installed; please open the configuration page and make sure that the *UNDER* comport below com10. Ie com1 - com9. To do this open device manager:

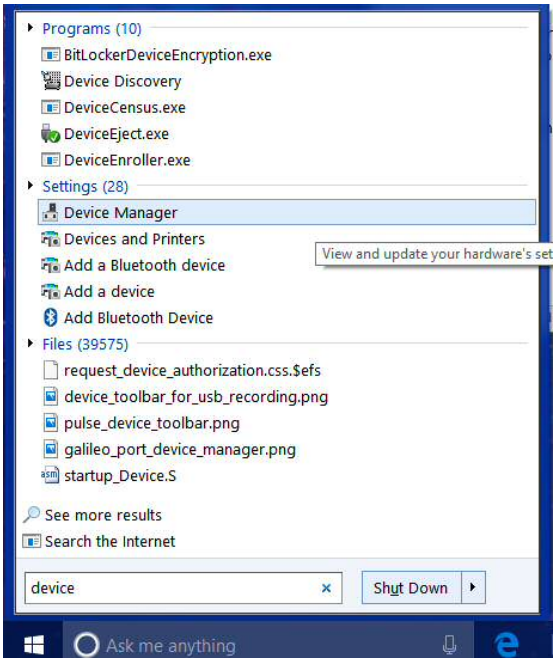

Figure 16 Start / Device manager

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3) In Device Manager; goto Ports (COM & LPT) and find *Star Trek GI Dimmer 8MHz*. Right Click Properties and click the Advanced… button.

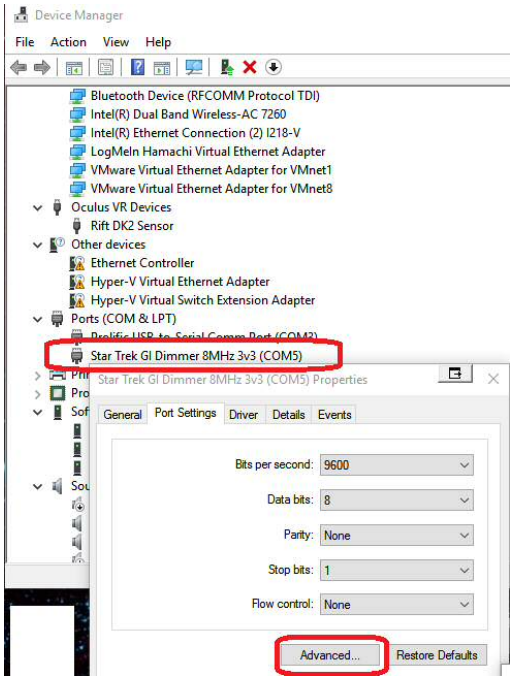

Figure 17 Right Click GI Dimmer's *Properties* and click *Advanced…* Button

4) Select a *COM Port Number* which is less than COM10. In this case; COM5 is fine as it is less than COM10.

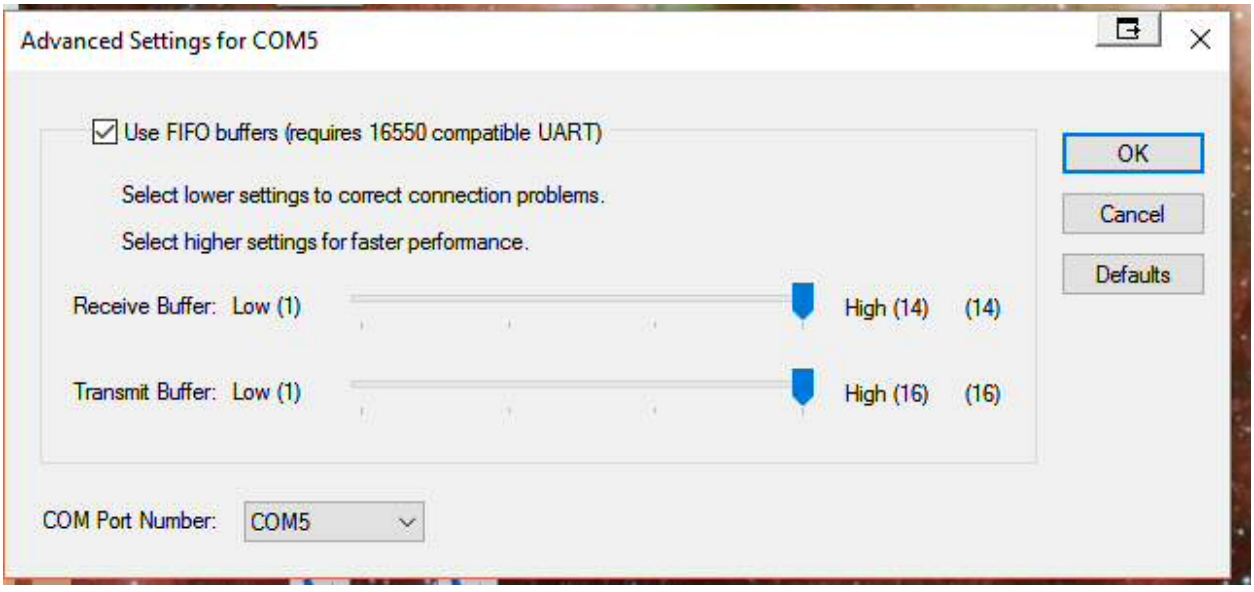

Figure 18 COM Port Number should be less than COM10

5) Follow any windows prompts to save the settings and reboot if required. If no reboot is required and you changed the COM port; make sure you disconnect and reconnect the board so the new COM Port is reflected properly.

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If you happen to be running a 64bit Windows OS; you might get some notifications that unsigned drivers are not allowed in Windows. You can follow this tutorial or look at this post by Tekman.

Setting up for Bluetooth wireless connection to the board

The Bluetooth radio on the board is compatible with the Bluetooth LE or Smart specification. As a result; configuration using an Android smartphone ***requires*** *at least* Android 4.3 or better with appropriate Bluetooth 4.0 hardware. Please consult your phone manufacturer to determine if you have the appropriate hardware to connect with the nRF8001 chipset in our product. BLE does not require "bonding" to the device… in general if your phone connects to the device … it can communicate with it. You should not need to enter any passwords or pincodes to pair with the device.

After installing the software using the Android APK on our Product page; make sure you turn on your Bluetooth radio in settings. This process varies from manufacturer to manufacturer so consult the internet to find out how. This is important as the APP will not prompt you to turn the Bluetooth radio. If you forget to turn on the Bluetooth radio; simply close the APP, enable the radio, and relaunch.

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Software User's Guide

The programming app should be fairly easy for anyone to use especially if you have experience with windows or smartphone applications. Launch the app using the appropriate icon.

This application is written in Unity; so, if you run under Windows you may have to select a video mode:

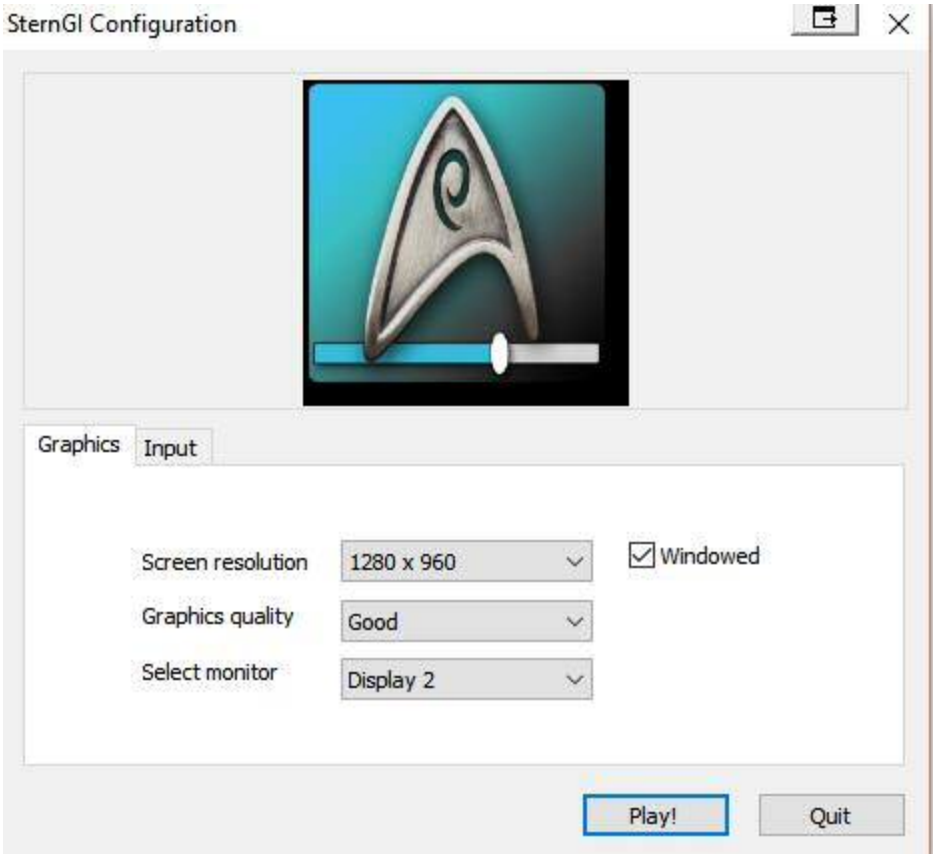

Figure 19 Select Windowed 1280x960

The application is written for "smartphone" screen sizes of 640x960 so pick a resolution which is near the "y" size for best results. In this case; I run in 1280x960 as it matches 960dpi for the y direction. In general, the app will try to scale for larger resolutions; but it won't look ideal with higher resolutions. On a smartphone; you should need to select any resolution and it should scale to your screen size.

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You'll see a unity splash screen while the application loads.

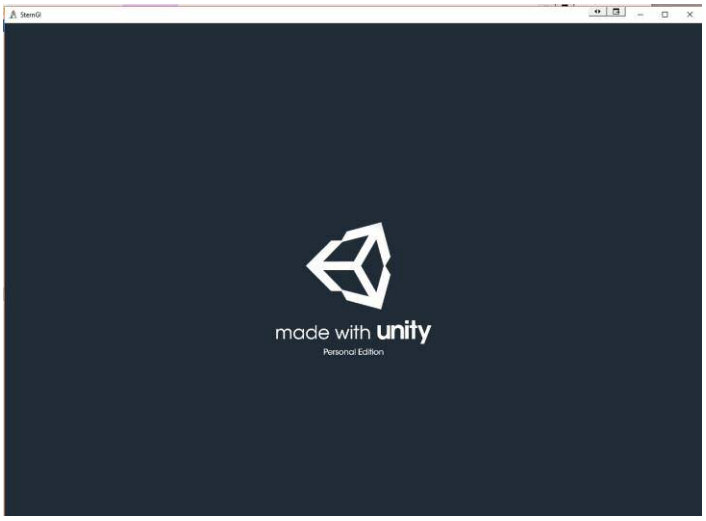

Figure 20 Unity Splash Screen

Once the application loads; you'll be presented with the Klingon Multiball screen. The application is laid out and intended to be operated with a touchscreen app but can also be manipulated with a mouse in the same way.

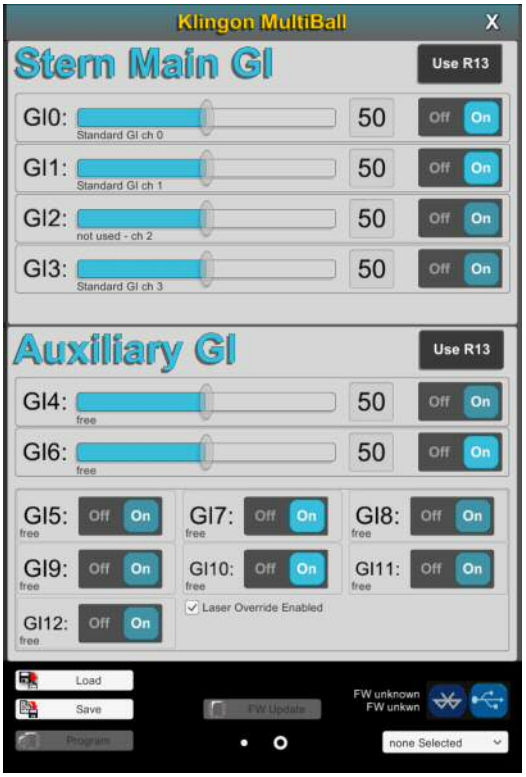

Figure 21 Klingon MultiBall Screen

The app currently presents two screens which you swipe left and right. To do this using your finger; grab the title "Klingon Multiball" and swipe to the right. The screen should snap to the "Normal GI" screen once you get past the 50% mark. Mouse Operation is the same; Click and hold while moving the mouse

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to the right. Note that the screen changes from black to grey indicating you are in “normal mode” and that the bottom panel does not change with the exception of the screen position indicator. To get back to the KMB screen, swipe left. The “X” at the top right corner is a “close” button. Use this button to notify the board that you are disconnecting.

Each screen represents a settings mode for the board. KMB is only active while the laser is on and “Normal GI” is active when the laser is off. These two settings screens are independent from each other and are only active in their respective modes.

The swipe panels are organized the same. For PWM channels; you have a box panel which has a slider, a numerical entry and a variable resistor switch labeled R13 or R14. The slider and entry controls are greyed out if you have the Resistor switch on. This indicates to you that the value is dependent on the setting of the resistor on the board. If you want to set a static value for that specific channel in this mode; you’d disable the Use R1[34] switch which enables the slider.

Figure 22 Use R1x switch off enables slider

You can click the switch off with your finger or mouse. Stern’s Main GI is made up of **GI0-GI3** and these are PWMed between 0 and 100%. On the Star Trek GI; **GI2** is not used. GI4-GI12 are free channels which you can use to power your mods based upon the various modes. The PWM channels **GI4**, **GI6** operate identically to the main GI channels. The binary channels **GI5**, **GI7**-**GI12** operate in only on/off mode which is why they lack the slider.

Each channel panel has a label associated with it. To change the label, you click the label with the mouse or your finger. This will make the label editable so you can put your own description:

Figure 23 Editable label

You can type the label freeform. To accept the new label; click the green check or to abort, click the red X. Your description will be stored on your computing device and will also be transferred to any settings files you share. Please note; due to limited EEPROM space in the board’s microcontroller – the descriptive labels are NOT transferred to the board. This means if you use a different device later; those labels will not be retrievable unless you use a saved settings file.

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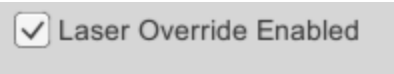
The only difference between the Normal and KMB screens is the Laser Override Enabled checkbox. This defaults on and basically forces the laser and motor to turn on when this screen is active. This allows the user to program the GI settings for Klingon multiball without actually being in that mode on the game.



Pinball-Mods.com does not recommend you leave this override in effect for more than a few minutes as the machine was not designed for lengthy runs of the motor. Limit yourself to no more than 2-3minutes. If you need to play around; uncheck the box and it will turn off the motor while you play. Only use the Laser override for final testing.

The lower static panel has global settings and action buttons. This static panel has two buttons to save

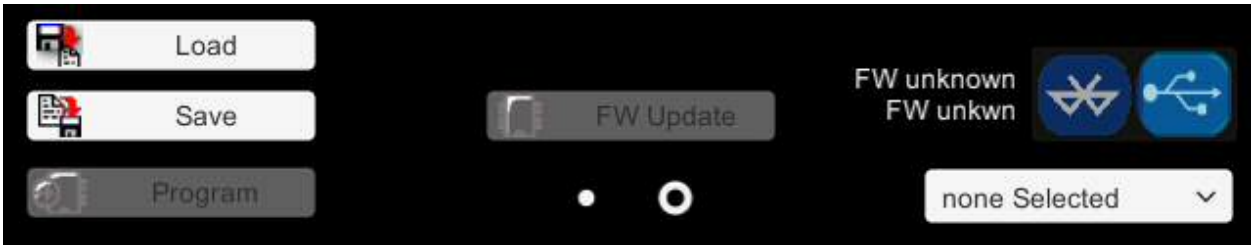


Figure 24 Static panel

and load the settings to a file so they can be shared with other users. These buttons will open file dialog buttons for you to save the files. *Please note:* due to Android file permissions; we haven't figured out how to enable non-root users to access the location where these setting files are store. Additionally, *please note:* At this time; you cannot load or save settings files without the device being connected and active. Please make sure you connect the app to the board (see below) before attempting to load a settings file.

There is a third greyed out button from Programming the values to the onboard EEPROM. This button only becomes active when the EEPROM contents differ from the runtime settings sent to the device.

The center FW Update button is only available on Windows devices running x86 processors. At this time the button is "removed" from Android builds as we do not believe this feature will be portable to that operating system. If/when a firmware update is made available; we'll post the update to our main product page along with instructions for updating the firmware.

The collection of controls on the right-hand side are uses to set the communication port for the software. If you are running on Android with BLE; you would tap the Bluetooth icon with your finger. Assuming you turned on the BLE radio for your phone; the application will enable said radio and begin transferring data between the device and app. BLE is very slow; and a progress dial will appear on the center of the screen as data is transferred. Patiently wait for the transfer to occur before using the app.

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On Windows w/ USB; you'll need to select the proper COM port in the selection box:

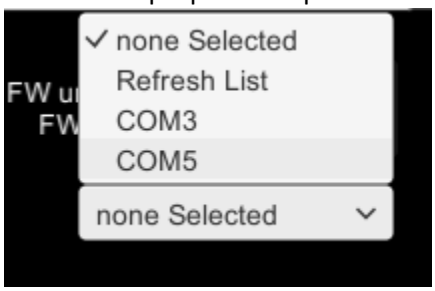

Figure 25 USB COM port selection

The application defaults to *None selected* so as to not interfere with any USB devices you may have in your computer. Use the *Refresh List* to refresh this dropdown control with available USB serial ports. Select the appropriate comport as seen in device manager and the app will automatically download the setting from the board.

In both cases; the appropriate communication icon will flash green as data is transmitted or received from the board. When communication starts; the Firmware (FW) and BLE radio version numbers are downloaded from the device and are shown. Use this to determine if you need to upgrade the firmware. Once the initial connection is established in Windows; the FW Update button will become active. Don't use it unless there is an update available.

At this point you can either load shared settings file… or begin modifying settings as you see fit. As soon as you change one of the settings; the program button should become active – indicating to you that you can program those settings to the EEPROM. Pinball-Mods.com recommends you use the program button sparingly … and the EEPROM has a limited number of write cycles. We recommend you "program" the setting to EEPROM when you've reached a good stopping point. Runtime settings not in the eeprom should remain in RAM as long as power is not lost to the main board.

The sliders will have a delayed update to the board. There is about a 1.5second delay from your first change of a setting before it is transferred to the board. This is done to prevent "swarming" the communication change with small changes.

When the board is connected; swiping between Normal and KMB screens activates those settings on the Playfields. This means you can see subtle differences between the two most; especially when it comes to your auxiliary mod channels.

Once you have the settings you want verified at "runtime"; click the program button to write the runtime settings to the eeprom so they can be retrieved automatically when the board powers up.

Finally; we recommend you disconnect the application before physically disconnecting the board by usb. Use the "X" close button to close the application. On Android, you may have to close the application in the task screen as for whatever reason the application says in memory. Using the close button will close the communication channel and return the PWM Dimmer to its normal operating mode.

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