TPC-100 Multiband Audio Processor

User Manual

Introduction

The TPC-100 is a 4 band audio processor using 4 individual PIC microcontrollers, acting independently, using PWM for audio level control, with a master PIC microcontroller updating each processor PIC with user adjustable parameters.

PWM attenuation control

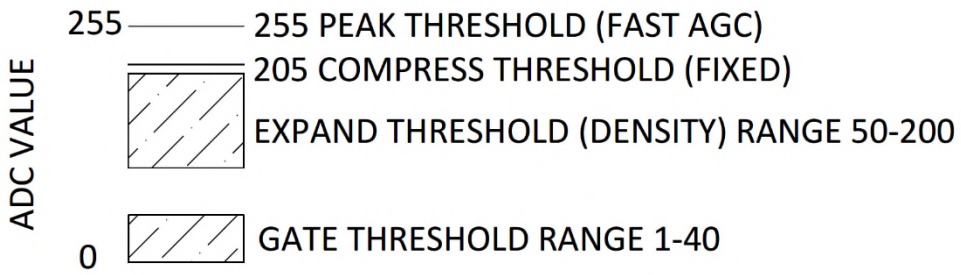
The TPC-100 uses PWM at a 125kHz frequency to control the audio attenuation level by varying the on and off time of an analog switch, thereby controlling the percentage of on time the audio waveform passes to the output stage. The PIC micro has a PWM generator built in which gives an 8 bit resolution. In PWM to achieve a given db attenuation, the required duty cycle is given by:

$$\%\, DUTY\ CYCLE = 100 \times 10^{\frac{dB}{20}}$$

So for a -6dB level the duty cycle is 50%, for -20dB it is 10%. Because it is a non-linear relationship, the PIC duty cycle for a given dB of reduction is performed using an 8 bit lookup table.

Digital operation of the compressor / expander

Similar to its analog counterpart, the control section uses a comparator to detect the average level and make decisions based on specific level thresholds. Also similar to the analog version a linear ramp and hold function is used to move toward expand, compress or hold the current level. Rather than using comparators, analog ramp generators and linear to log amplifiers, everything is done using an ADC and 8 bit integer values.



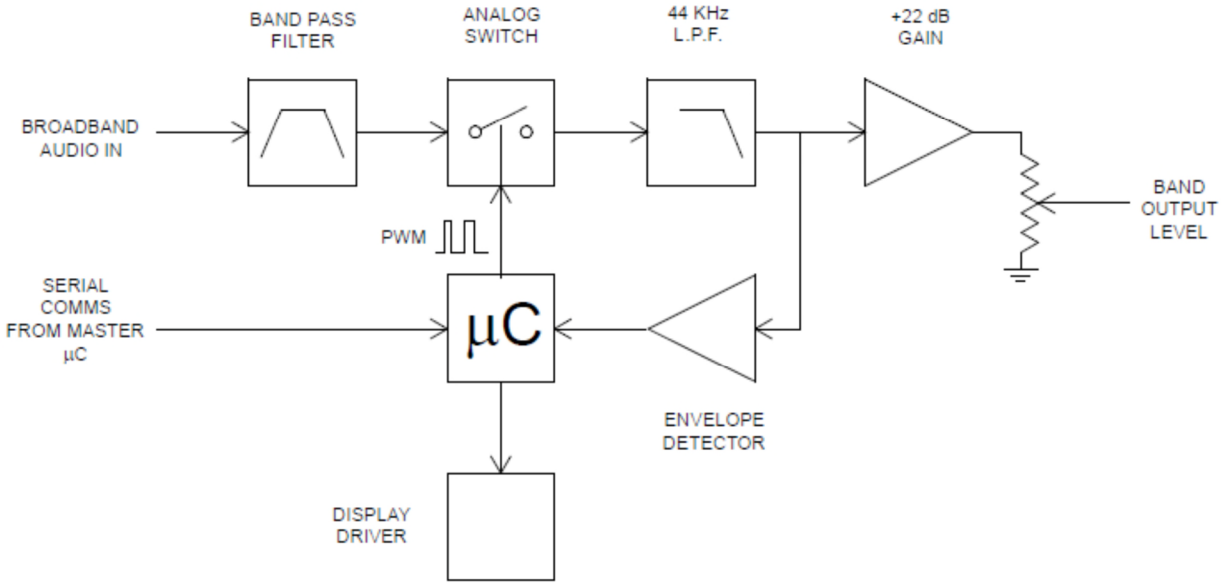
The gate threshold determines the point at which the expand or compress action begins when the RMS level exceeds a value from 1 to 40. When the signal rises above the gate level, expansion begins as long as the level is below the expand threshold level of 50 to 200 and the 8 bit integer value is stepped toward expand at a specific rate. This level is referred to as the 'density' since it determines the window between the expand and compress thresholds. When the signal is above the expand threshold and below the fixed compress threshold of 205, the ramp function stops and holds at its current value. Above the compress threshold the ramp function moves opposite toward compression at the same rate. The rate per step is the slow AGC rate and is adjustable from 2 seconds to 8 seconds, full expand to full compress or vice versa. Levels that exceed 255 are considered peak events and fast AGC moves toward compress at the processor clock speed to prevent clipping and overshoot. There is an averaging function between fast and slow AGC that modifies the slow AGC average depending on the number of and duration of peak events. When the signal drops below the gate threshold, the unit will hold its current value for 1.5 seconds, after which the gain level will to move to the quiescent point. By default, this is midscale but can be programmed to be anywhere from full expand to slightly beyond midscale. The original purpose of this was to reduce the gain during low levels to prevent the compressor from going to full expand and bring up tape hiss, however with digital audio this feature is not always necessary. Another drawback is that with the quiescent point at mid-scale the signal is attenuated -12dB, so the gate level samples at this attenuated level, meaning the operation may not begin at a sufficient level in some cases. For this reason, moving the quiescent point toward expand, allows the unit to respond to lower levels.

The linear ramp value is used to find a value in the lookup table that corresponds to the PWM duty cycle required to obtain a specific value of attenuation in dB. The attenuation range goes from -2dB at full expand to -22dB at full compress, with a -12dB at mid-scale. The output opamp stage provides +22dB of gain, so based on the full range, the compressor will attempt to maintain an output level of +10dBu over the full operating range. The display indicates this level range in approximately 1.8 dBu per LED.

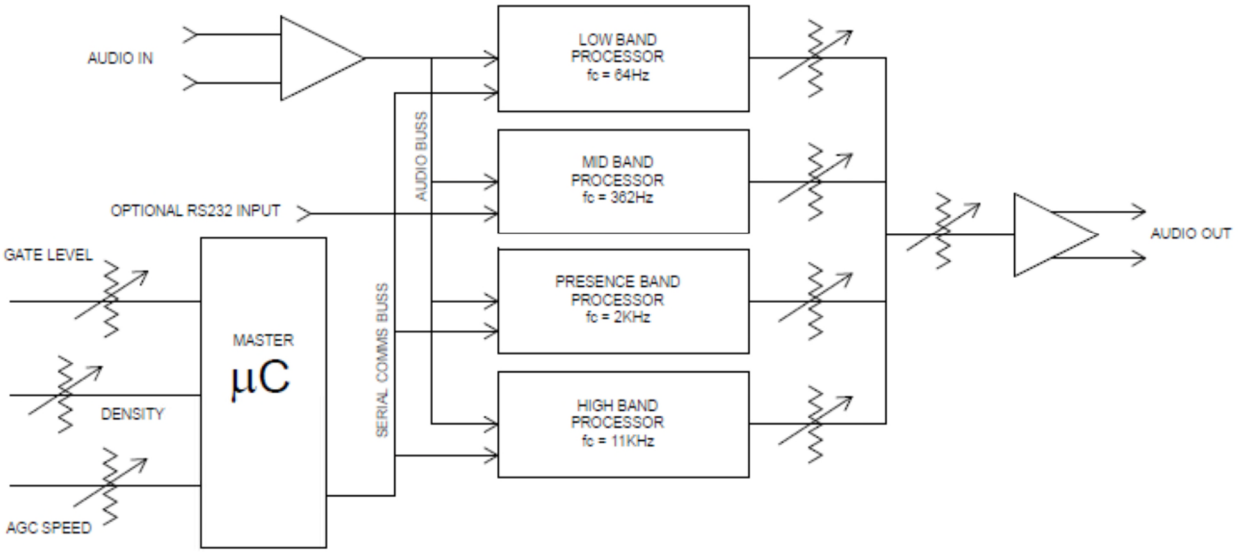
There are 4 frequency bands in the TPC-100 modeled after the analog prism. Each band is two octaves wide with center frequencies of 64Hz, 362Hz, 2kHz and 11.7kHz. The core of each band contains a closed loop processor. After filtering for the individual band the signal is sampled using an analog switch at a PWM duty cycle. After sampling, the signal is low pass filtered to remove the PWM frequency. The output of the sample filter goes to an opamp stage which amplifies the signal x8.7 and then a half wave voltage doubler average detector. With the compress threshold fixed at 4V at the ADC, the PIC attempts to maintain that level by varying PWM based on a lookup table, which yields a signal level approximately -10dBu at the post switch filter output. This -10dBu signal is amplified +22dB in another stage and then sent to a summing stage for the output.

The four band circuits are identical except for the filter components and the timing resistor in the average detector and they operate independently. Because they need to operate as fast as possible to sample, respond to peaks and update the display, all functional parameters are passed down as required from the master PIC. The master PIC scans the panel pots and serial port commands, processes these parameters and stores and sends them to the individual band PICs. Each band PIC is programmed to its unique band location to allow parameters to be changed on each band as opposed to globally.

BAND PROCESSOR



OVERALL SYSTEM DIAGRAM



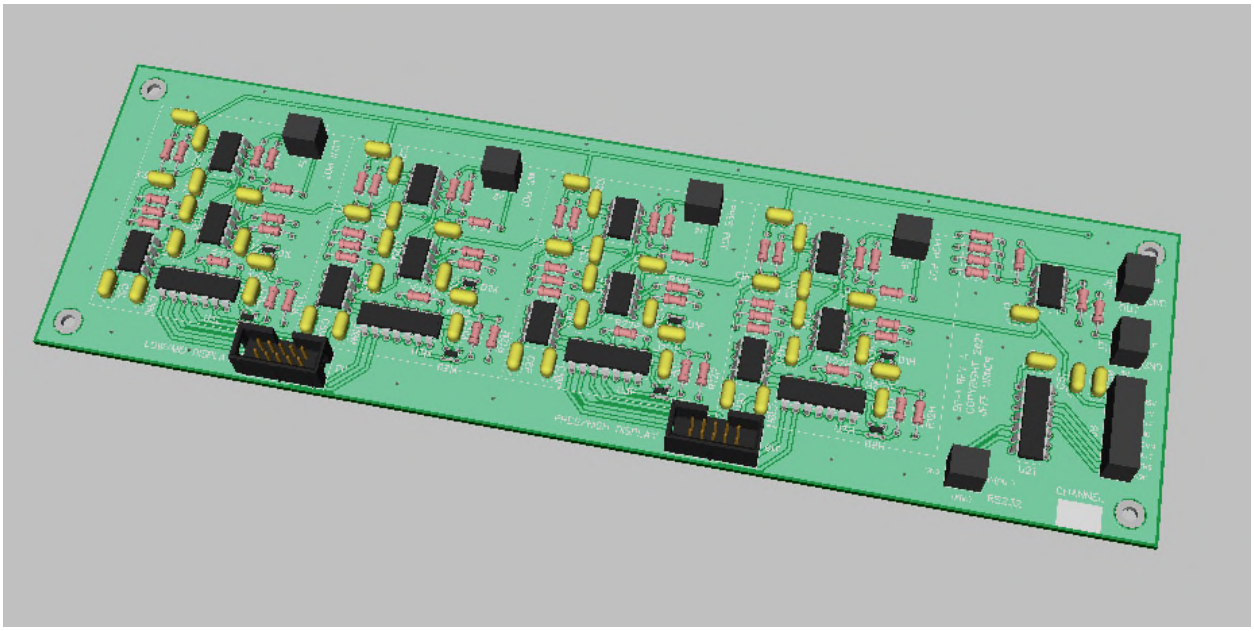
Operational Checks

There is no alignment required to adjust the TPC-100 for proper operation. There is flexibility in circuit changes that can optimize it for specific applications. The following is the functional diagnostics if required to check for proper operation.

1. Using a sine wave generator, set the frequency to 2kHz for the presence band.
2. Adjusting the generator amplitude or input amplitude, adjust the level for signal level of 0dBu (.775V RMS) at PIN 1 of U1. The display should indicate a level around midscale and the output level at the high end of the band output pot should be around +10dBu
3. Repeat Step 2 with an amplitude of -10dBu. The display should move and settle with the display at full expand.
4. Repeat Step 2 with and amplitude of +10dBu. The display should move and settle with the display at full compress.
5. Repeat Steps 1 through 4 at frequencies of 64Hz, 362Hz and 11.7kHz for each band.
6. There may be some variation in the mid and low bands with the output amplitude however the output level should be at or less than +10dBu.

   Other functional checks if the above is not working are to apply a scope probe to PIN 7 of U3 and verify a 125kHz PWM waveform is present. If the display is not functioning, double check that the ribbon cable is wired pin to pin and there is continuity from pin to pin BP1 to DS1. Probing U3 PIN 9 there should be a clock signal of several MHz to the display boards.

BP1 board assembly:



The BP1 is divided into 4 sections where each circuit is identical apart from the filter values C1, R8, C2 and R7 and the average detector resistor R12. The component suffix of L,M,P or H is used to identify which band the component resides in these 4 sections. All other components will not have this suffix.

DIP Socket Placement

1) Orient the pcb silkscreen side facing up.
2) Locate the 13 eight pin and 5 fourteen pin DIP sockets.
3) Orient the sockets to locate pin 1 per the silkscreen and install the sockets in the board. *If the SMD version of the DG418 is placed, omit the sockets at U1L, U1M, U1P, U1H.*
4) Using cardboard to hold the sockets flat to the board, flip the assembly over and tack solder two diagonal pins of the

sockets. Examine the sockets for proper placement and seating to the board surface. Solder the remaining pins.

Capacitor placement

5) Place 28pcs of the 4.7uf ceramic capacitors at C3L,C4L,C6L,C10L,C11L,C14L,C3M,C4M,C6M,C10M,C11M,C14M,C3P, C4P,C6P,C10P,C11P,C14P,C3H,C4H,C6H,C10H,C11H,C14H,C30,C49, C50 & C51
6) Place 2 pcs of the 2.2nf ceramic capacitors at C2M,C1P
7) Place 1 pc of the 180pf ceramic capacitors at C2H
8) Place 5 pcs of the 390pf ceramic capacitors at C7L,C7M,C7P,C7H,C2P
9) Place 1 pc of the 18nf ceramic capacitors at C1L
10) Place 1 pc of the 12nf ceramic capacitors at C1M
11) Place 1 pc of the 1.8nf ceramic capacitors at C1H
12) Place 5 pcs of the 3.3nf ceramic capacitors at C2L,C9L, C9M, C9P, C9H
13) Observing polarity to the silkscreen, place 8 pcs of the 4.7uf tantalum capacitors at C12L, C13L, C12M, C13M, C12P, C13P, C12H, C13H

Resistor Placement

14) Place 9 pcs of the 3.9k resistor at R1L,R5L,R1M,R5M,R1P,R5P,R1H,R5H,R12P
15) Place 1 pc of the 750k resistor at R7L
16) Place 2 pcs of the 200k resistor at R7M, R7P

17) Place 1 pc of the 75k resistor at R7H

18) Place 4 pcs of the 120k resistor at R2L, R2M, R2P, R2H

19) Place 1 pc of the 137k resistor at R8L

20) Place 2 pcs of the 36k resistor at R8M, R8P

21) Place 1 pc of the 7.5k resistor at R8H

22) Place 21 pcs of the 10k resistors at R3L,R10L,R27L ,R3M,R10M,R27M,R3P,R10P,R27P,R3H,R10H,R27H,R12L,R12M,R53,R54,R55,R56,R57,R58,R59

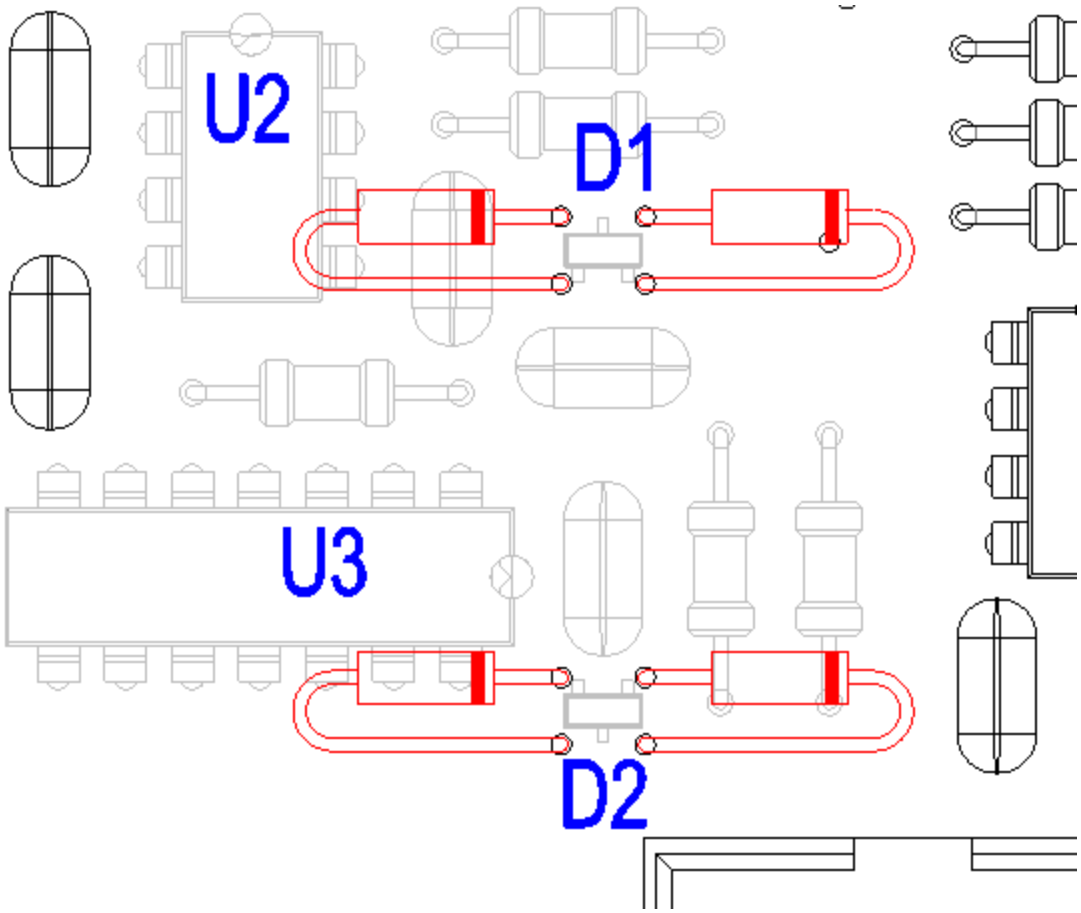
23) Place 4 pcS of the 13k resistor at R6L, R6M, R6P, R6H

24) Place 4 pcs of the 1k resistor at R11L,R11M,R11P,R11H If using linear pots (or trimpots)for level controls, place 4 pcs at R4L, R4M, R4P and R4H. If using log taper pots a wire jumper or low value resistor can be used to limit the minimum level.

25) Place 5 pcs of the 1.3k resistor at R12H, R13L, R13M, R13P, R13H

Diode Placement

26) If the PCB has the BAS40-04 SMD diodes placed omit this step. If placing the SMD diodes observe the orientation on the silkscreen. If installing through hole parts, follow the diagram below to place D1 and D2 using 4 through hole parts. The orientation is shown horizontally for clarity but the diodes should be mounted vertically.



Connector Placement

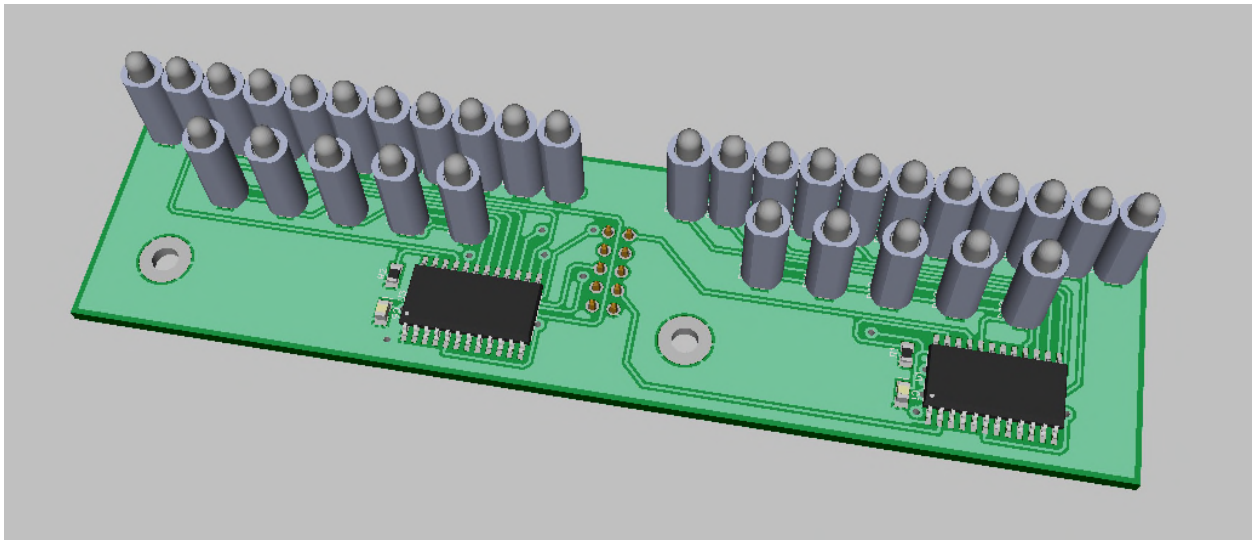
27) Place 2 pcs of the 10 pin IDC box headers with the slot oriented as shown on the silkscreen as indicated with the thick line.

28) Prior to placing the band level potentiometer terminal blocks, if you intend to set these via a panel mounted pot, proceed with placement. Alternatively a trimpot can be installed in these locations if the levels are to be set and not user adjustable. Place 7 pcs of the 3 position

screw terminal blocks with the terminal openings facing toward the board edge

29) Place 1 pc of the 8 position screw terminal block with the terminal openings facing toward the board edge
30) Install 9 pcs of the TL072 at U2L, U4L, U2M, U4M, U2P, U4P, U2H, U4H, U22
31) If the board contains the SMD version of the DG418 skip this step or place it at the following locations indicated for the DIP parts. If placing the DIP DG418 install 4 pcs at U1L, U1M, U1P, U1H
32) Install 4 pcs of the pre-programmed band processor PIC16F1825. They are unique to each band. “L” marking goes in U3L, “M” marking goes in U3M, “P” marking goes in U3P, “H” marking goes in U3H.
33) Install 1 pc of the pre-programmed main control PIC16F1825 marked with an “X” at U21. *Note: If building two BP1 boards for a 2 channel system it is only necessary to install one U21 in one of the boards, since one main controller will be linked across both boards.*
34) Clean any solder flux from the board and inspect the board.
35) Label the PCB as left or right channel

DS1 board assembly:



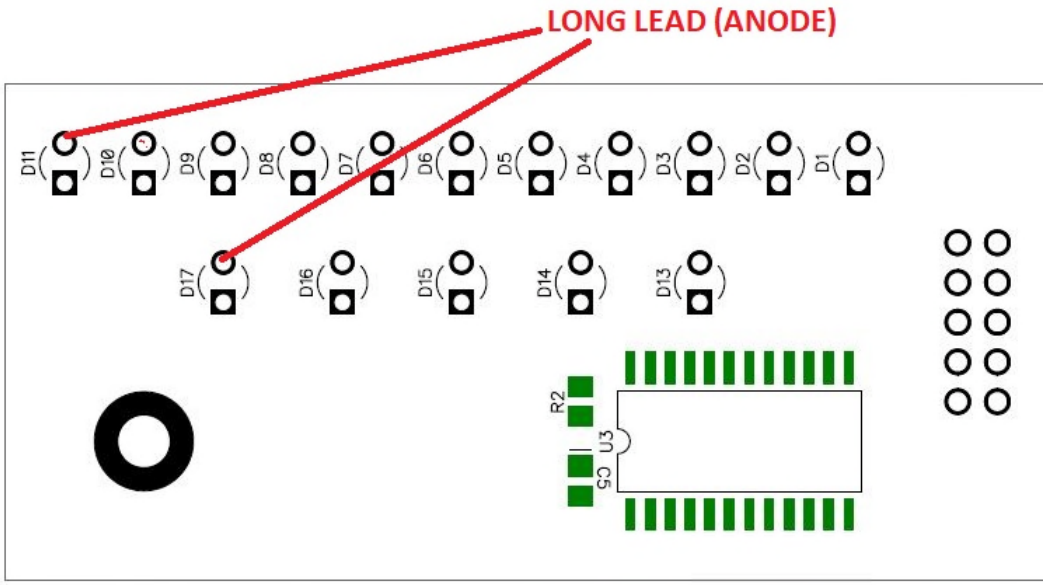
The DS1 is a two bargraph and status display for the TPC-100 Prism Clone. 11 LEDs are used for expand/compress indication and 5 red LEDs are used for status. The PCB connects to the BP1 band processor board using a 10 conductor ribbon cable with two IDC headers.

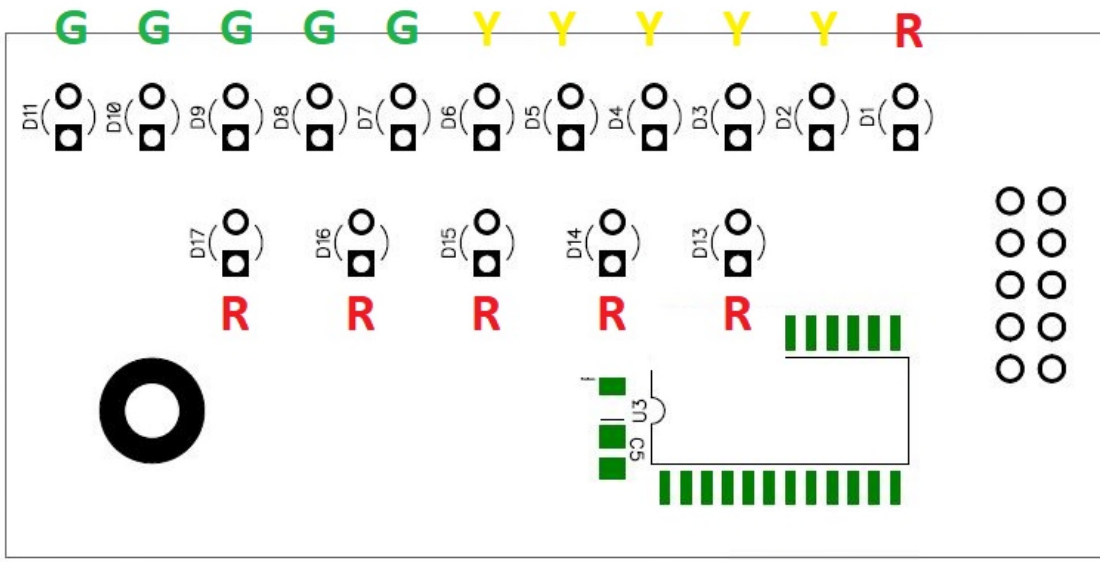
The PCB is supplied with the display ICs and supporting SMD components installed. Your board may be single or a 2-up panel however assembly is shown for a single board.

LED Placement

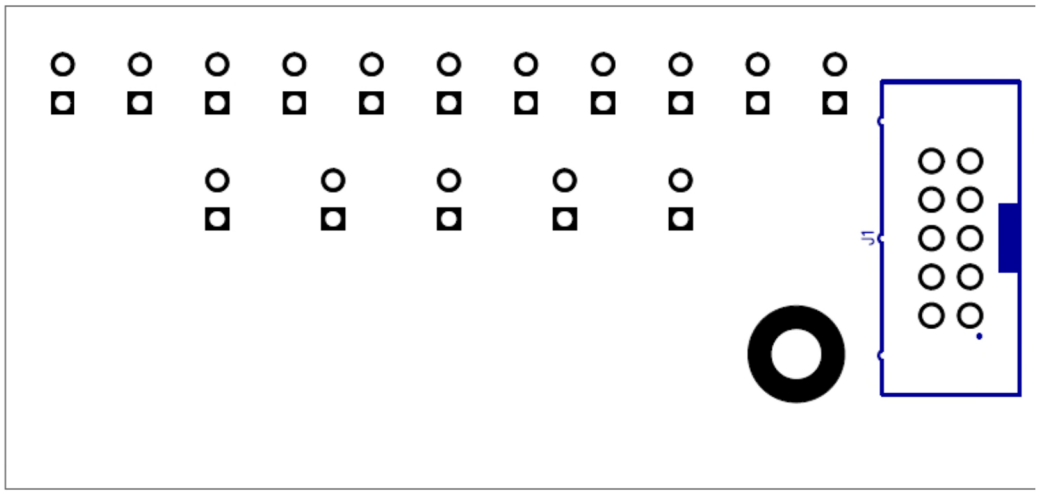
1. For each display there are 5 green, 5 yellow and 6 red leds. The long lead on the LED is the anode and is oriented to be in the upper holes as shown. Using the keystone LED spacers, place the led into the spacer on the side with the funnel lead-in. After assembling all of the spacers onto the LEDs, install them according to

color in the diagram shown. After placement, use either the front panel holes or the supplied jig to align them and hold them in place while soldering the leads.



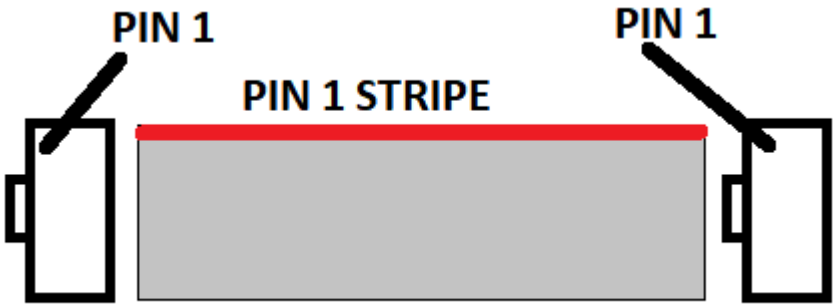


2. Flip the board over to the non-component side and align the 10 pin box header with the keying slot oriented as shown on the silkscreen pattern. Clean the PCB and inspect for any issues.

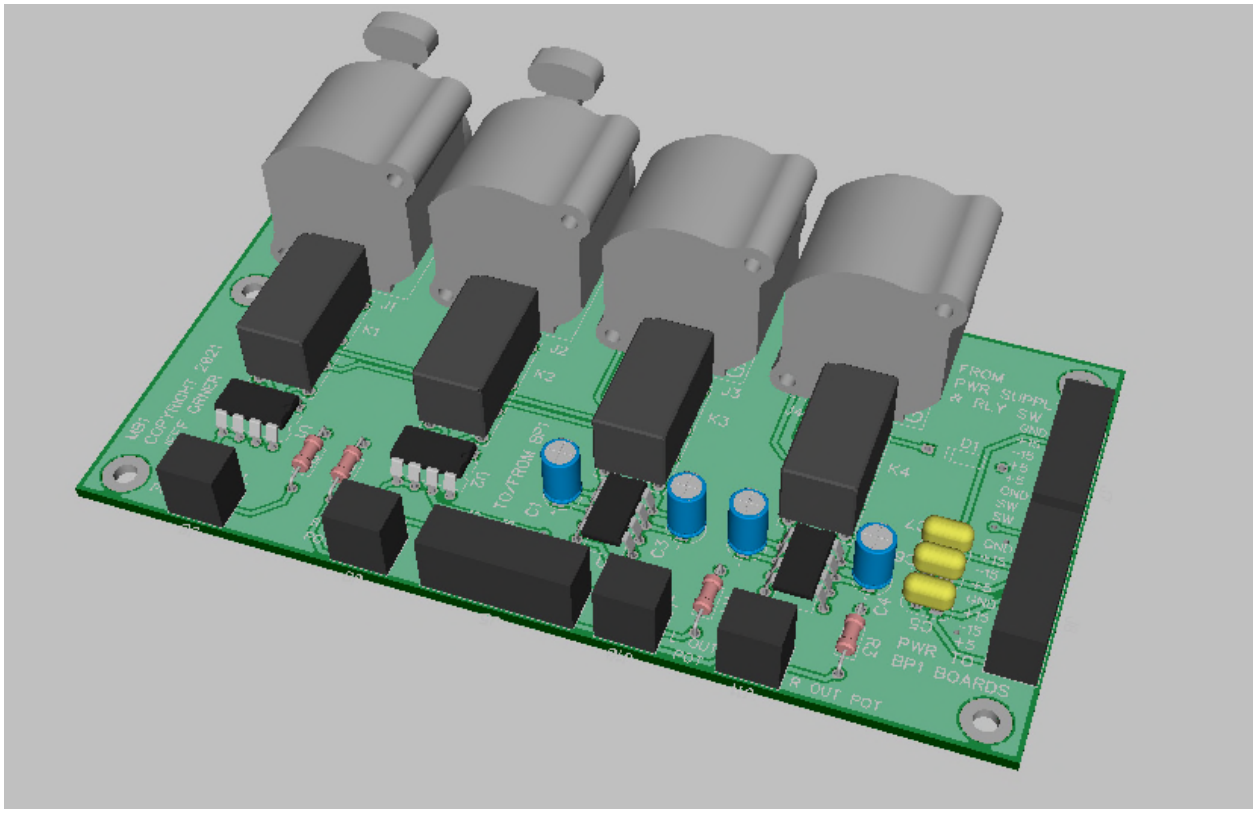


3. If the PCB is a 2-up array, it may only be necessary to remove the outermost border and leave the boards attached with the mouse bites connecting them. They should align to the panel holes and standoffs in this configuration and this makes assembly easier.

4. A suitable length for the ribbon cable is about 4 inches but not greater than 6 inches in length. Pin 1 is indicated on the cable as a single colored conductor. The connectors must be oriented pin-to-pin as shown (view is top *(ribbon)* side of connectors). Check continuity pin-to-pin after assembly.



MB1 board assembly:



The MB1 is used in the TPC-100 Prism clone to translate balanced +4dBu studio level audio to unbalanced audio with the ability to bypass the balanced inputs when powered off or by use of a switch. There are provisions for input and output level pots as well as power distribution to the BP1 processor boards. A connection allows switching for relay bypass.

DIP Socket Placement

1) Orient the pcb silkscreen side facing up.

2) Locate the 4 eight pin DIP sockets.

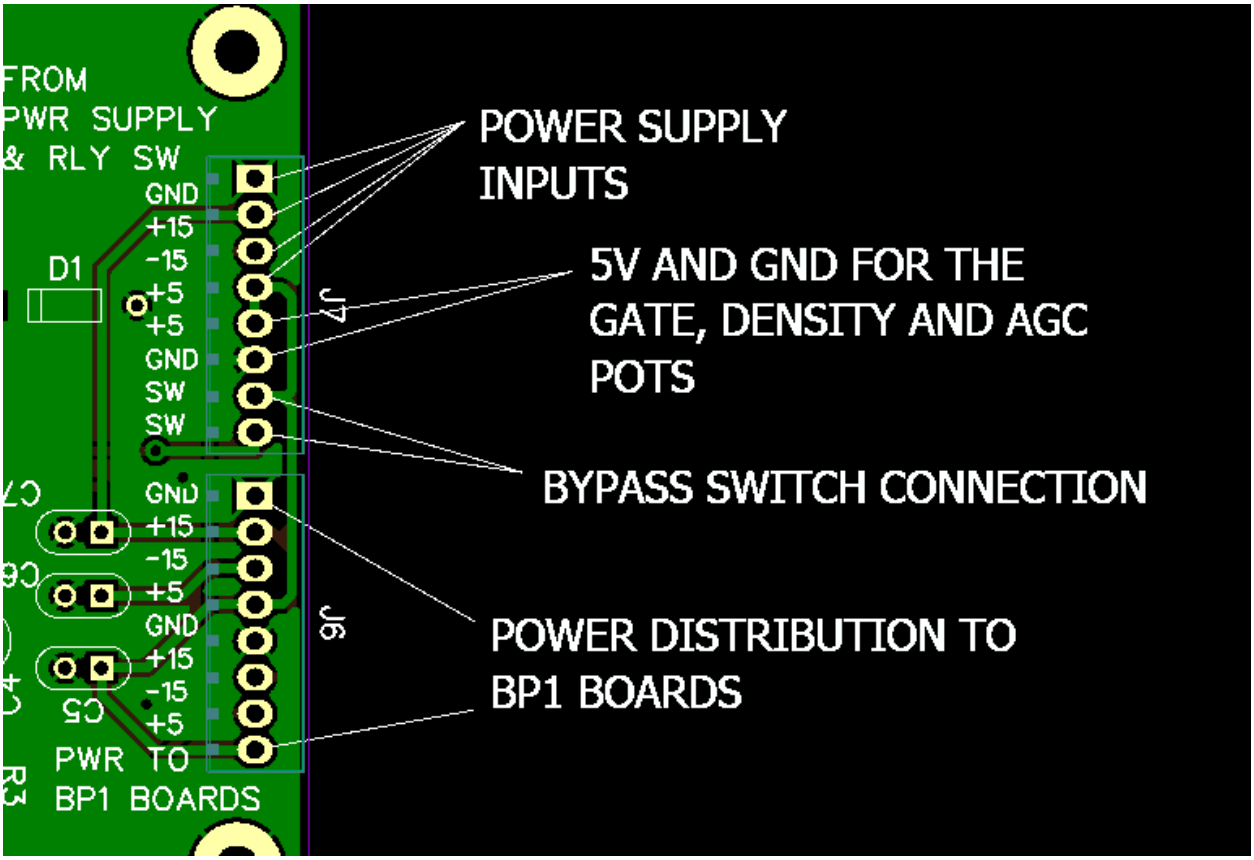
3) Orient the sockets to locate pin 1 per the silkscreen and install the sockets in the board.

4) Using cardboard to hold the sockets flat to the board, flip the assembly over and tack solder two diagonal pins of the sockets. Examine the sockets for proper placement and seating to the board surface. Solder the remaining pins.

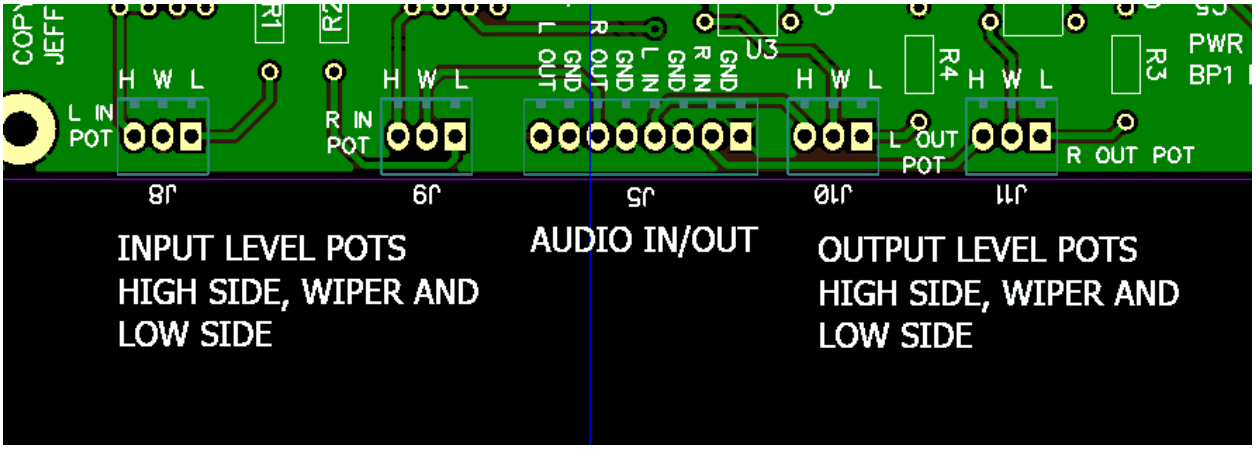
Component placement

5) Place 3 pcs of the 4.7uf ceramic capacitors at C5, C6 and C7
6) Install 4 pcs of the 10uf non-polarized electrolytic capacitors at C1, C2, C3 and C4. Ignore polarity markings on PCB.
7) Install the 1N4148 diode at D1
8) If using analog taper pots for input and output level controls use a jumper wire, or if using a linear taper pot use a 1k resistor and place it at R1, R2, R3 and R4.
9) Place 4 pcs of the relays at K1, K2, K3 and K4
10) Place 4 pcs of the 3 position screw terminal blocks with the terminal openings facing toward the board edge
11) Place 2 pcs of the 8 position screw terminal block with the terminal openings facing toward the board edge
12) Install two female XLR connectors in J1 and J2
13) Install two male XLR connectors in J3 and J4
14) Install 2 pcs of THAT1246 in U1 and U2 sockets.
15) Install 2 pcs of THAT1646 in U3 and U4 sockets.
16) Clean any solder flux from the board and inspect the board.

Below is the function of the 8 pin connections and how they are used:



Below is the function of the audio and pot connections



TPC-100 Unit Assembly Instructions

These instructions are based on a 2 channel unit using two BP1 boards, two DS1 display boards and one MB1 board. The connections are fairly straightforward and can be adapted to any configuration. It is advised to use multiconductor shielded cable for audio paths and twisted pair conductors for power supply connections. Connections are shown with wire colors, however these are visual and any color combination can be used.

1. Power supply interconnections

   The MB1 has provision for connection to the user power supply and distribution to each BP1 board. The connections are given in Figure 1. The second BP1 board connects to the lower section of J6 in a similar manner. The lower end of J7 is described in the following sections.

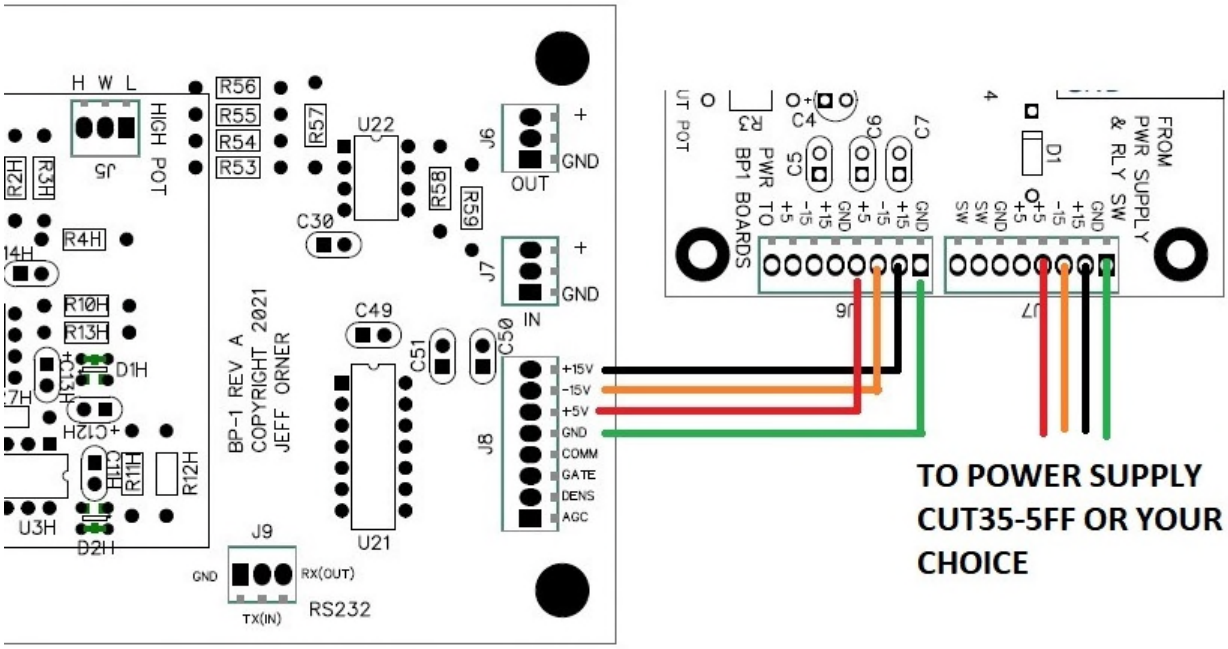


Figure 1.

2. The audio inputs and outputs connect directly from the BP1 3 terminal blocks directly to the appropriate inputs and outputs on the MB1. Shown is the right channel; the left is connected similarly. The band pot connection is shown with the pot rotation. In all cases “H” is the high or clockwise side of the pot, “L” is counterclockwise and “W” is the wiper. If using dual gang pots the other channel connects to the adjacent section in the same manner. See Figure 2.

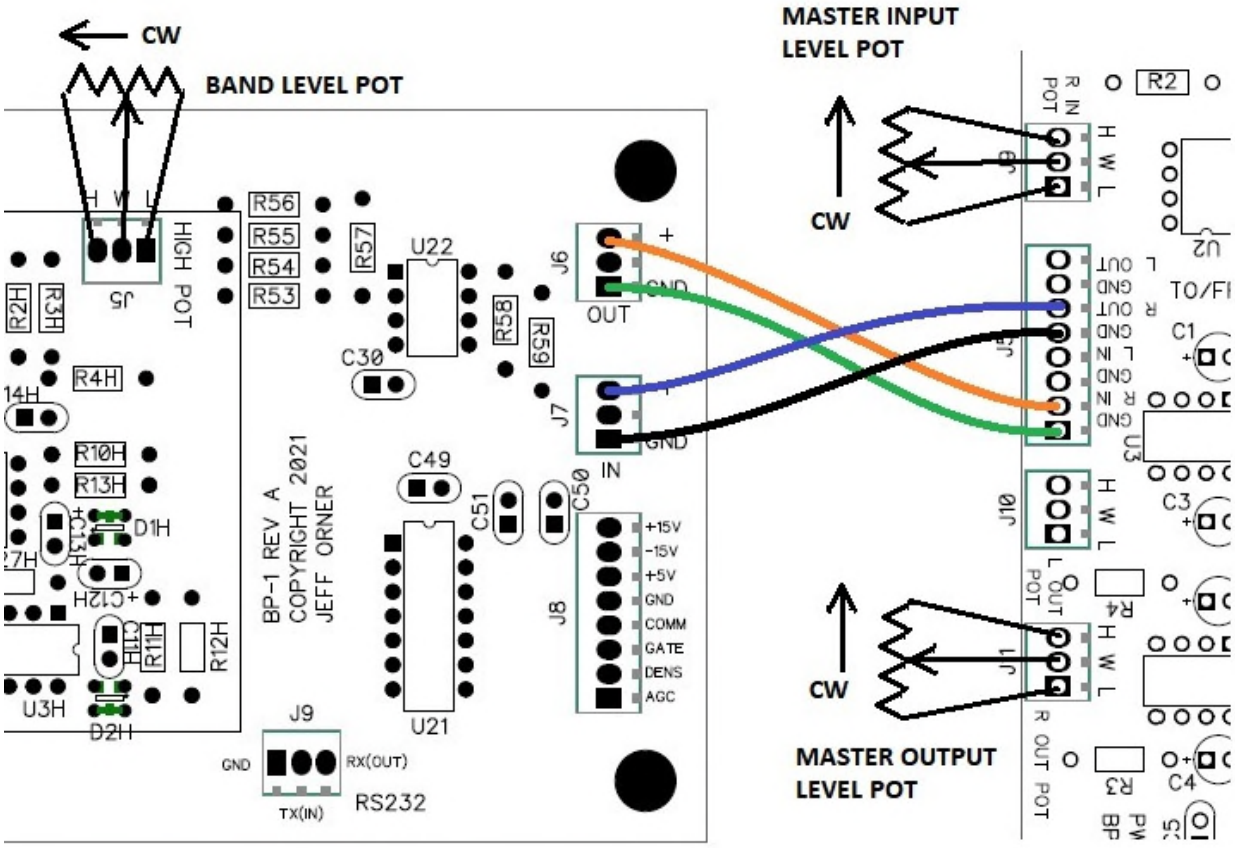


Figure 2

3. There are three linear taper pots for adjustment of the Density, Gate and AGC. Power is supplied to them from the MB1 as shown, +5V on the clockwise end and GND on the counterclockwise end. These can be daisy chained to each pot in parallel. The wipers are brought back to the appropriate connection on the BP1 as indicated in Figure 3.

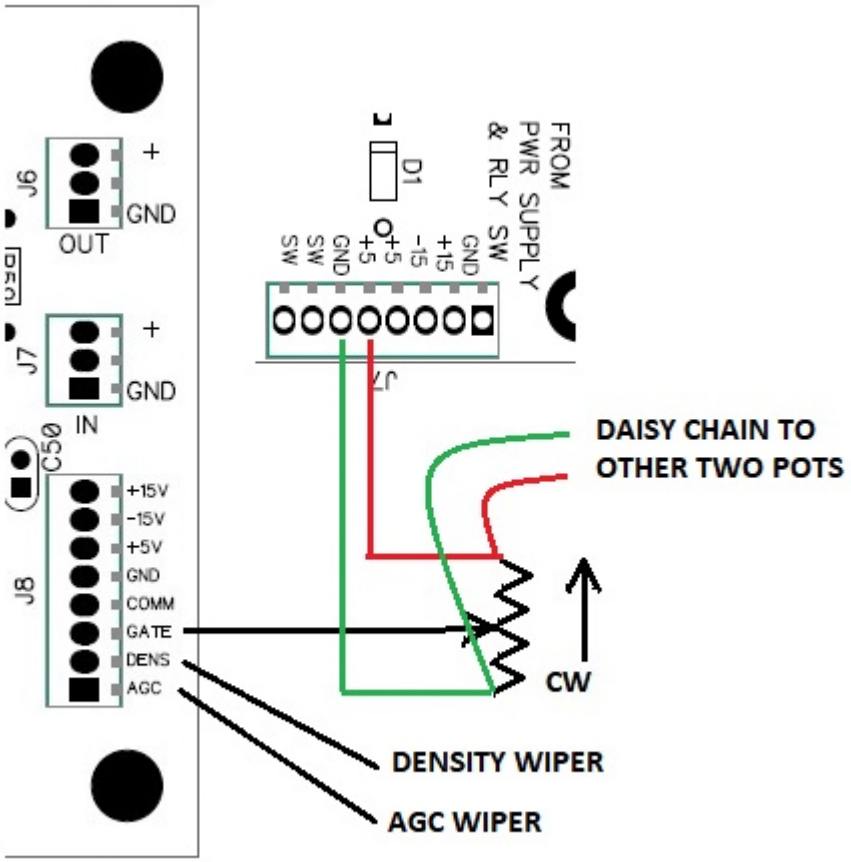


Figure 3

4. If using two BP1 boards in a 2 channel system, it is only necessary to install one PIC chip in U21 (labeled “X”). For this reason it is necessary to install a wire between boards using the “COMM” terminal to link the two together. If you want individual control two U21 chips are required, with no linking, however three additional pots are needed for Density, Gate and AGC. If stacking these boards the board containing U21 should be on top to make upgrades easier and for connection of the serial port adapter. Serial communication is optional. Typically a USB/UART adapter is used but any method of converting RS232 to 5V levels is required. Do not connect a legacy RS232 port directly as the voltage levels will destroy the PIC. The adapter can be installed in the box or wires can be routed to a rear panel connection for external use. See Figure 4.

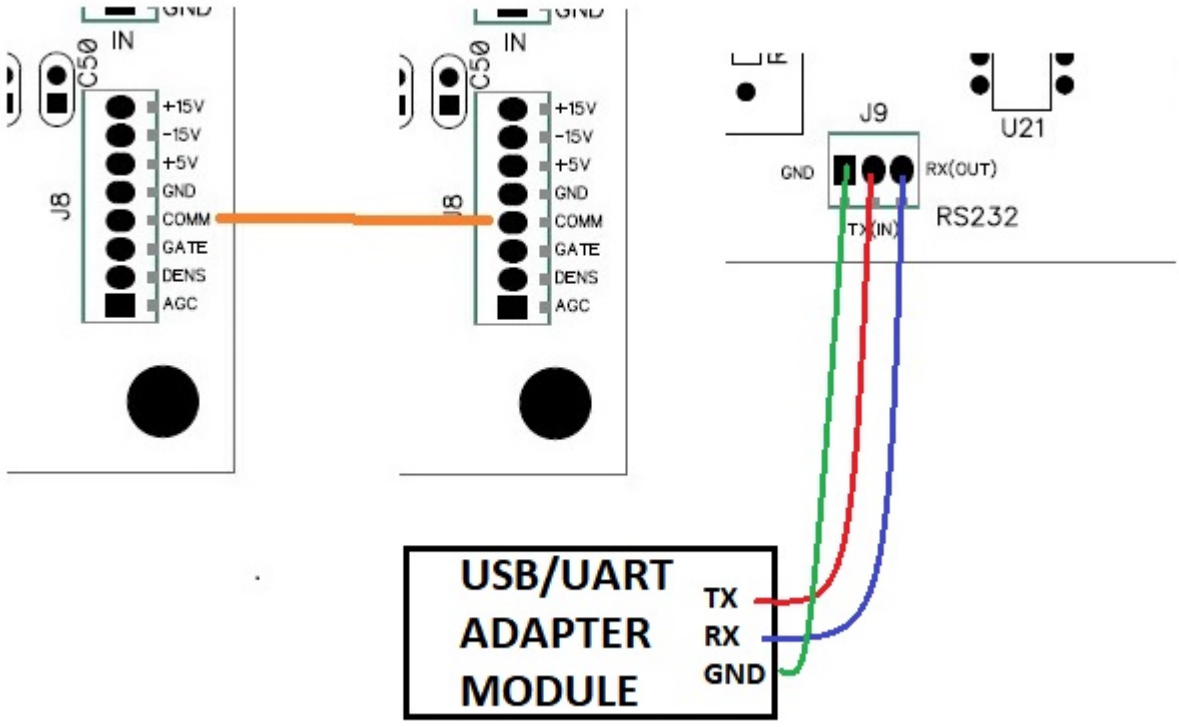


Figure 4

5. Another optional feature is the bypass function switching. The MB1 contains two terminals marked "SW". These allow connection of a switch to take the unit in and out of line. If this feature is only required when power is off, jumper these two terminals. If you want a three position switch with center bypass mode the wiring details are shown in Figure 5.

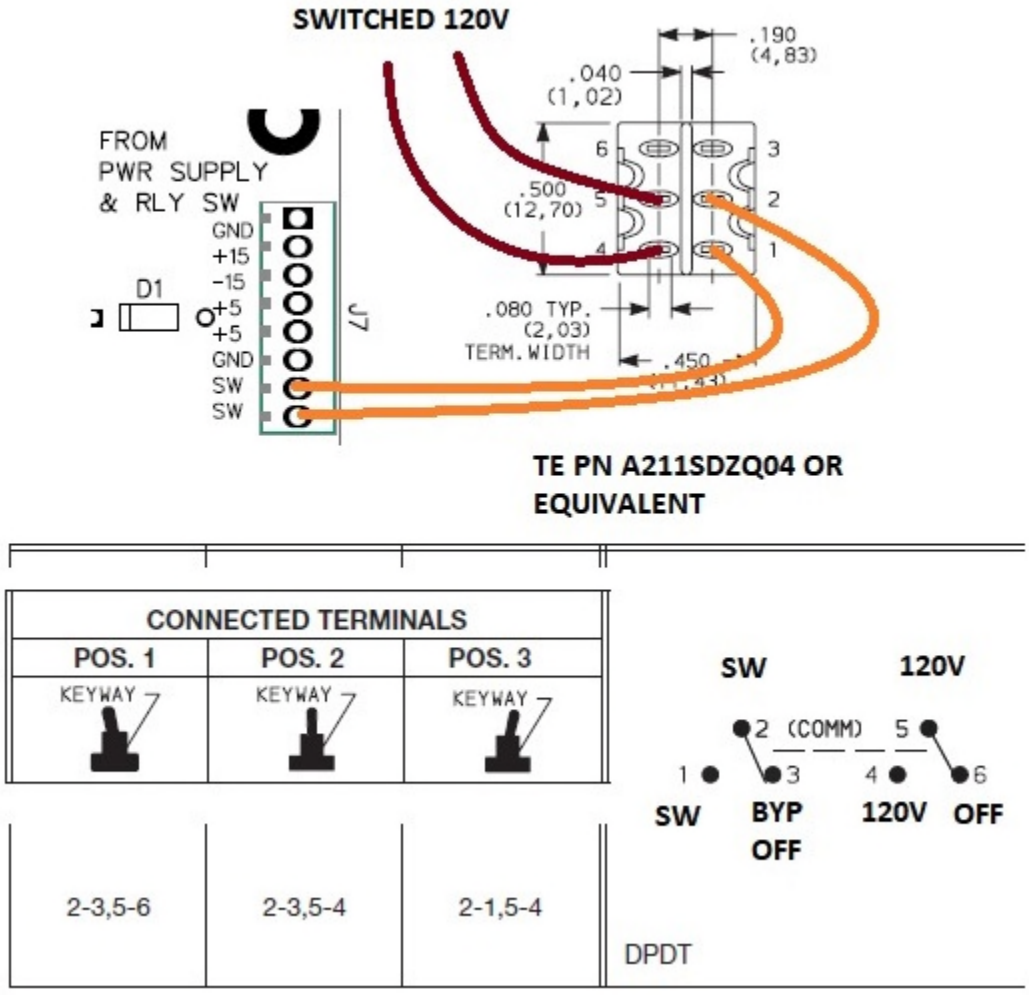
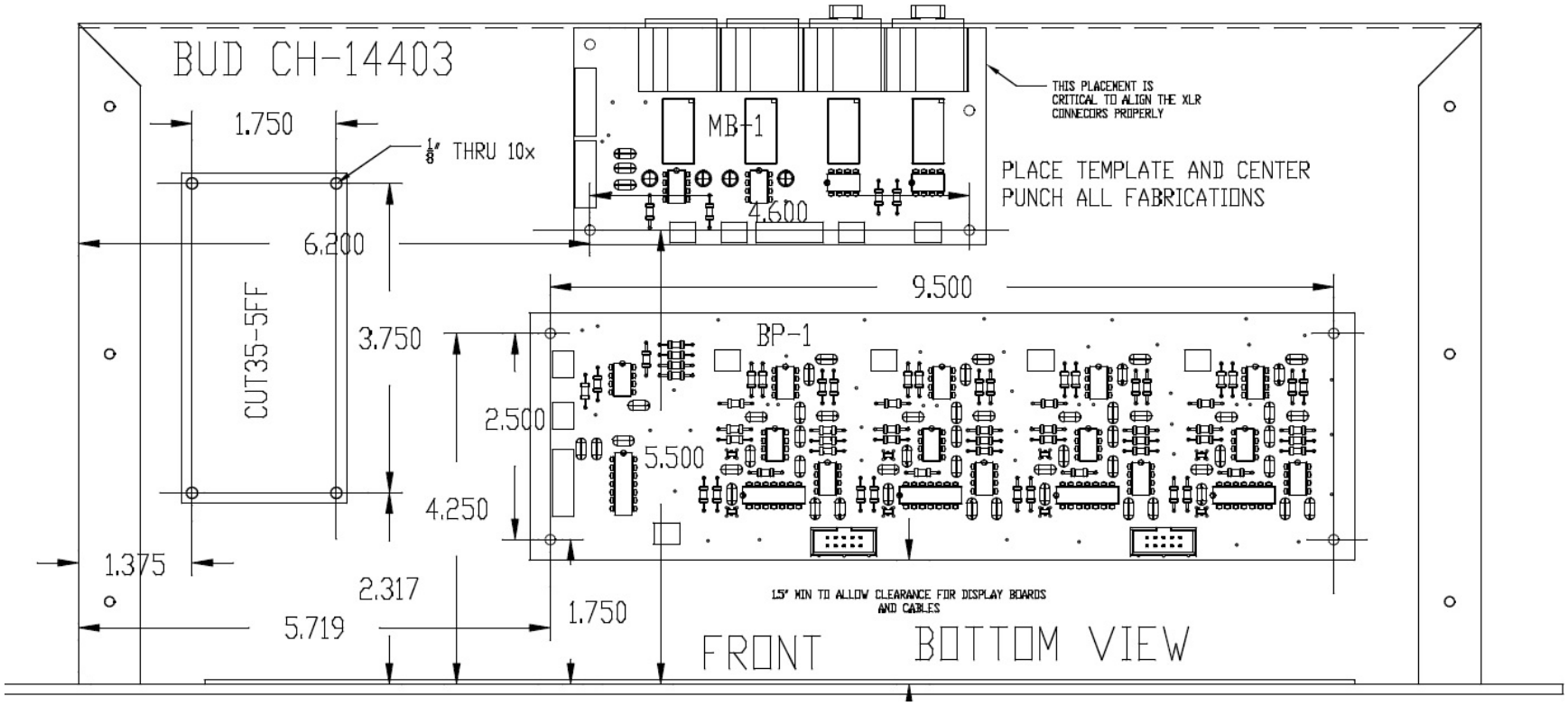
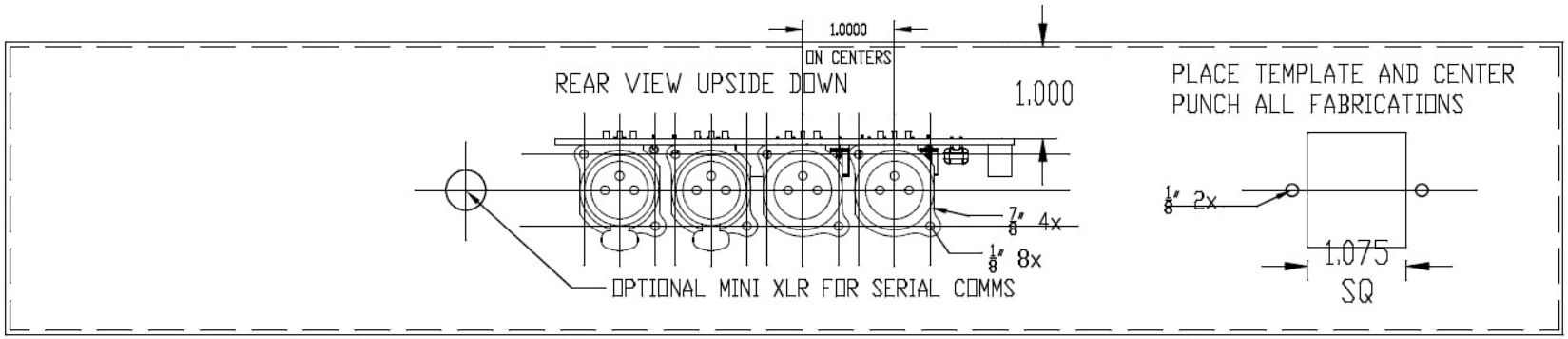
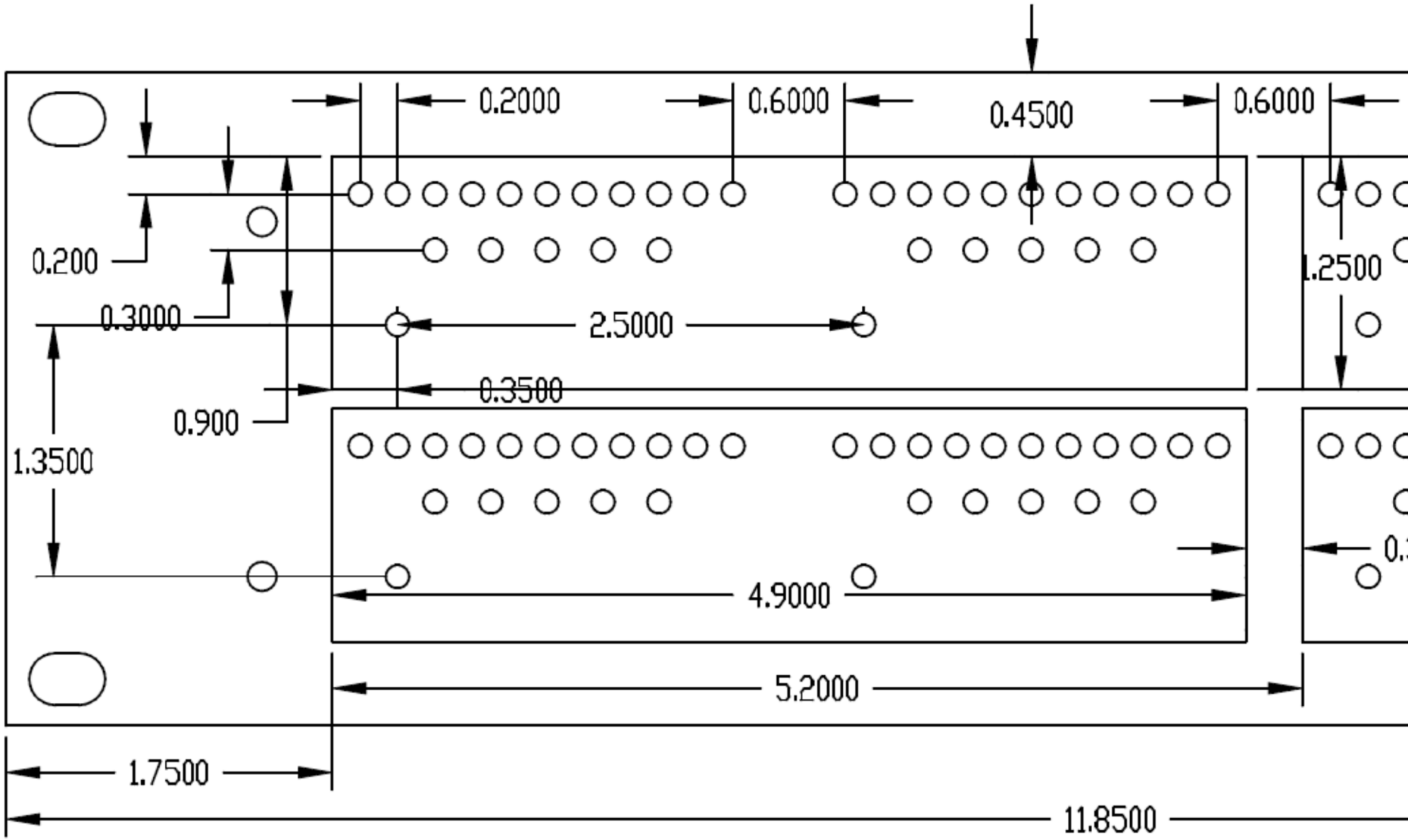


Figure 6

6. The following pages detail panel fabrications for the Bud CH-14403, however they can be used for any 2U rack enclosure.

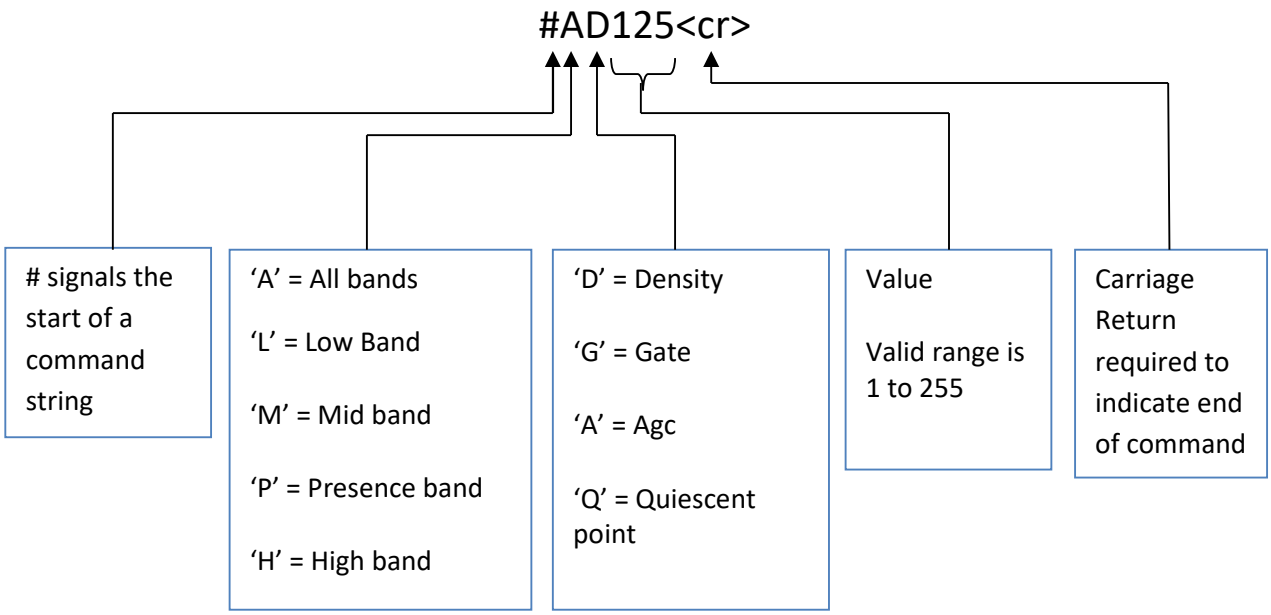

BUD CH-14403
1.750
1/8" THRU 10x
6.200
CUT35-5FF
3.750
2.500
4.250
1.375
2.317
5.719
1.750
MB-1
4.600
THIS PLACEMENT IS CRITICAL TO ALIGN THE XLR CONNECORS PROPERLY
PLACE TEMPLATE AND CENTER PUNCH ALL FABRICATIONS
9.500
BP-1
5.500
15" MIN TO ALLOW CLEARANCE FOR DISPLAY BOARDS AND CABLES
FRONT
BOTTOM VIEW


1.0000
ON CENTERS
REAR VIEW UPSIDE DOWN
1.000
7/8" 4x
1/8" 8x
OPTIONAL MINI XLR FOR SERIAL COMMS
PLACE TEMPLATE AND CENTER
PUNCH ALL FABRICATIONS
1/8" 2x
1.075
SQ


0.2000
0.6000
0.4500
0.6000
0.200
0.3000
2.5000
1.2500
0.3500
0.900
1.3500
4.9000
5.2000
1.7500
11.8500

TPC100 commands

Command format for setting control parameters



Example: To set the density to mid scale on the Presence band send -- #PD127<cr>

Stores to EEPROM and overrides the panel pots. Sets the EEPROM flag.

#SD<CR> – Store settings to EEPROM

Clears the EEPROM flag and allows local control.

#CD<CR> – Clear settings from EEPROM. This restores local control to the panel pots

Reads out the current settings and sends to all band PICS. The return data will contain the above command format but the data will be an 8 bit value as opposed to a human readable 1-3 digit value.

#RD<CR>

Software query of current parameters. This is used by the TPC100 software to grab all values sequentially. This does not program the band PICs. Format is all parameters, comma delimited.

#SQ<CR>

Valid ranges for each parameter are below. Values outside this range may result in unpredictable behavior or loss of function.

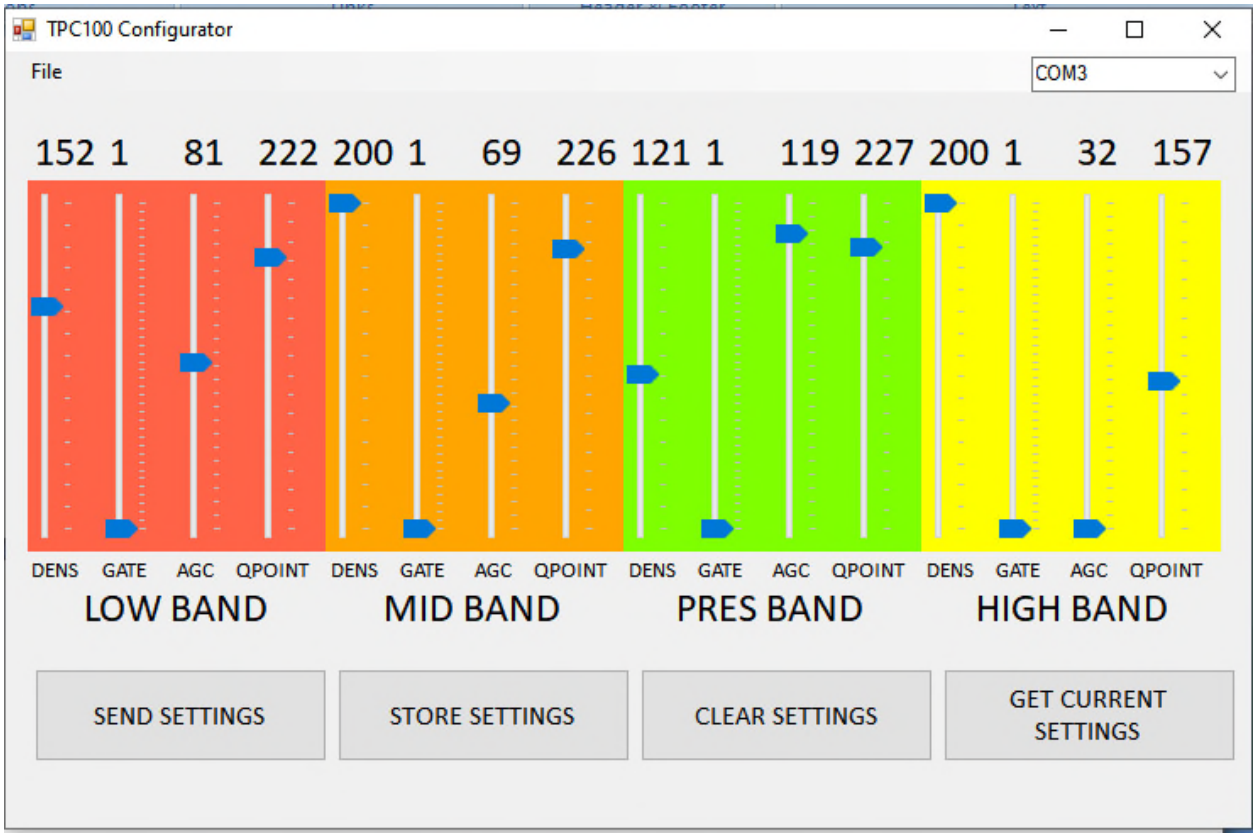
Quiescent point 80 to 250 - 80 is just beyond midscale toward compress, 250 is near maximum expand.

Density 50 to 200 - Density of 50 equals wider window between expand and compress, 200 is a narrow range between expand and compress.

Gate 1 to 40 - Sets the level at which the processor begins to work. A min level of 1 is required.

AGC 32 to 128 - Sets the slow agc speed from 2 seconds at 32 to 8 seconds at 128, where seconds is length of time to go from full expand to full compress or vice versa. The value in seconds can be derived from 256us x AGC value x 256 = Seconds

TPC100 Software



The optional software allows changing individual parameters and is fairly straightforward to operate.

- Select the COM port of your USB/UART serial adapter. The setting is saved automatically.
- To get the settings of the panel pots, click 'Get Current settings' otherwise slide each slider to the desired value and click 'Send Settings' to commit them to the unit. You should see the activity change accordingly. Sending settings does not store them in internal memory, except for the quiescent point. The qpoint setting is not panel adjustable but is a setting that may need to be set to use the unit without serial connection.
- To store settings to the unit and lock out panel adjustment, click 'Store Settings'
- To clear stored settings and restore panel control click 'Clear Settings'
- To make additional adjustments to stored settings, click 'Get current Settings', make the adjustments and click 'Store Settings'

- To save a session configuration, click ‘File’ in the menu and ‘Save’
- To recall a session configuration click ‘File’ in the menu and recall a stored file.
- The file format is comma delimited CSV and can be edited or created in Excel, however be sure to keep the header and data formatted correctly.