Building the *electro-music* Klee Sequencer

Issue: 2

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1. Planning Your *electro-music* Klee Sequencer

Before you build your *electro-music* Klee Sequencer, it's a good idea to figure out what features and functionality you may want. You will also want to give consideration to panel layout and labeling, especially as to the labeling of switch positions, etc.

Most of the electro-music Klee sequencer functions are what could be considered as "standard". In other words, without these standard functions, its functionality would be limited as compared to the concept of the operation. Other features are more malleable.

The standard features are too numerous to mention here, but, instead we'll discuss the features and functionality that are considered optional.

Optional Features

Optional Voltage Control Outputs
There are three standard voltage control outputs - Output A, Output A+B and Output B. The voltage outputs are under control of the three Glide controls - Glide A, Glide A+B, and Glide B.

The optional voltage control outputs are the same control voltages, but are tapped before the glide circuit in the *electro-music* Klee Sequencer. Therefore, the glide controls will not effect these outputs. These outputs are useful for various reasons. For example, you may wish to control the cutoff of a filter with a slewed version Output A+B, yet control the VCO passing through the filter with a non-slewed version of the same voltage.

The three optional outputs, A, A+B, and B, are provided on J3 of the Analog Board, on a six pin connector which includes the standard outputs.

Variable Range Control Options
The Range Switch of the *electro-music* Klee Sequencer is an eight position switch that allows the operator to set the maximum range of the programming pots. These ranges are tuned certain musical intervals, as well as higher voltages. There may be an instance where you would like to try other intervals other than what are supplied by the Range Switch. There are four ways to implement a variable range feature.

- Option 1: Internal Variable Range Option

  The Internal Variable Range Option consists of an additional variable range control pot. When position 8 of the Range Switch is selected, the Variable Range Pot allows you to set a continuously variable voltage as the maximum range of the programming pots – in other words, you can set your own “interval” using this pot. The maximum range of this pot can be selected by selecting a resistor of a particular value for R33 on the Analogue Board.

- Option 2: External Only Variable Range Option

The External Only Variable Range Option consists of an additional jack that accepts an external positive voltage and an additional level control pot for this voltage. When position 8 of the Range Switch is selected, the signal applied to the External Variable Range Pot, as attenuated by the External Variable Range Level Pot, is applied as the maximum voltage for the programming pots. Negative voltages can be applied without harm, but the Klee will only react to positive voltages.

- Option 3: Auto Switching Internal/External Variable Range Option

This option will only work if you use either 1/4" jacks or 3.5 mm jacks with an n.c. switch. It consists of this jack and an additional Variable Range/External Level control. With no plug inserted into the jack, it operates identically to Variable Range Option 1. When a plug is inserted into the jack, the signal level on the plug is applied as with Option 2.

- Option 4: Manually Switched Internal/External Variable Range Option

This option will work with any type of jack. It adds the jack, the variable pot, and an additional SPDT ON-ON switch. This allows the functionality of Option 3, except now the position of the SPDT ON-ON switch will determine if the maximum voltage is supplied internally by the Klee, or by externally applied positive voltage.

Optional External Load Enable Switch

The Optional External Load Enable Switch is an option that can be added to the front panel. It merely consists of connecting the external load jack to a SPST On-Off switch, and connecting the output of the switch to the External Load line. This feature makes it handy for connecting/disconnecting an external load signal that is applied to the External Load Jack.

5V Gate and Trigger Levels vs 10V Gate and Trigger Levels

The Klee's standard schematic configuration is to provide 5V range gate and trigger levels. However, many people (and systems!) require higher levels. So, before you begin to put your *electro-music* Klee Sequencer board set together, you should be sure which level you want to go with. This will determine what value of resistors you use in a certain section of the Digital Board.

Automated Range Switch Data Inputs

Pads are supplied on the Analogue PCB to allow external digital signals to select the voltage range of the Klee Sequencer, in effect "over-riding" the Range Switch. These signals would have to be 0V for low and 15V for high (12V if the Klee is operated from a twelve volt supply). The interface consists of three digital inputs which control range positions 1 through 8.

Procuring Parts

Get Good Quality Parts

Sometimes, when you're looking for and buying parts, you may see a "good" deal on surplus parts. With the ICs, you're probably OK. The pots, maybe so. The switches? Do *not* risk it. There are a lot of switches on the *electro-music* Klee. A bad switch will ruin things very quickly for you. It is highly recommended you buy good quality switches from the start from a known good manufacturer – NKK, ALPS, etc. Don't buy "generic" switches that do not have a manufacturer listed. You will regret it. In particular, don't scrimp on the momentary switches (the Manual Step and Manual Load switches). There are cheaply priced momentary switches out there, usually under a buck. There's a reason they're cheaply priced. Don't do it.

Wire is another thing to consider, quality-wise. Old corroded wire, or wire with cheap, easily melted insulation is something that should be avoided.

Jacks are another thing that should be considered on the "known" good list.

When you see a note about 0.1% resistors, we're not whistling Dixie. If you do not use 0.1% resistors where indicated, make an effort to *match* the resistors used to 0.1%.

To Use Connectors or Hardwire?

The Klee PCB board set has been set up to interface with the front panel through wire harnesses and sockets. This makes assembly and troubleshooting much more of a breeze than hardwiring the connections. It adds some time to construct the cables, but saves in a lot of time and effort down the road. The connectors do not have to be used – as indicated, things can be hardwired. But, the connector system is highly recommended.

Selecting a Power Supply

Power Requirements

The ***electro-music*** Klee Sequencer has been tested using a +/- 12V power supply. It may or may not require an adjustment of the 6K8 current limiting LED resistors – 4K7 will work if brightness is an issue. However, the Klee has been most extensively tested at +/15V operation and it is generally recommended.

The ***electro-music*** Klee Sequencer draws around 100 mA per voltage rail at +/-15V operation, with a power dissipation of approximately 1.5 Watt per rail (3W total). A linear supply can be used, but it is possible to use it with an appropriate switching supply. In the case of a switching power supply, it is recommended that one use ferrite beads on the power supply lines connecting to the Klee Sequencer.

2. Designing the Front Panel

It's Your Klee – Do What You Wanna Do

The operating console of any piece of gear is probably the most important part of the design, and, with the *electro-music* Klee Sequencer, that is left totally in your capable hands. The front panel of the Klee Sequencer *is* its operating console, and you will find that is where a good 90% of your build time is spent. After that, that's where 100% of your operating time will be spent, so think long and hard about how *you* want it to be arranged.

Give consideration to ergonomics – don't put things so close together that you have to hold your tongue just right to change one setting whilst not bumping any other settings. Don't put jacks in places where a plug inserted into one of them will inhibit your access to controls. Make sure the layout and flow makes sense to you. In general, this is the usual drill you would apply to any project of yours.

Now, you may be thinking "That's all well and good, but what flippin' controls go on the damn thing in the first place?"

That's cool. That's a cool question. The Klee Sequencer has a number of controls most sequencers have, but it has a few that are perhaps not so common.

So, we're going to introduce you to two things right now – the first thing are the controls that allow you to control your *electro-music* Klee Sequencer; the second thing is this is the first of many, many tables we're going to inflict upon you over the course of this document.

The tables consist of the types of controls, connectors and indicators that make up the Klee interface to the world. Each table will list the control, and what the function of that control is. This may help you to determine where you want to place things. Another recommended tome is the "Know the Klee" section of the *electro-music* Klee Sequencer Operating Manual. This will hopefully fill in any gaps of understanding that may arise from these short, curt tables.

So, without further ado, the tables……..

Table 2-1: Potentiometers and Their Functions

Label	Function
Stage 1	Programming Pot - Adjusts the voltage of Stage 1
Stage 2	Programming Pot - Adjusts the voltage of Stage 2
Stage 3	Programming Pot - Adjusts the voltage of Stage 3
Stage 4	Programming Pot - Adjusts the voltage of Stage 4
Stage 5	Programming Pot - Adjusts the voltage of Stage 5
Stage 6	Programming Pot - Adjusts the voltage of Stage 6
Stage 7	Programming Pot - Adjusts the voltage of Stage 7
Stage 8	Programming Pot - Adjusts the voltage of Stage 8
Stage 9	Programming Pot - Adjusts the voltage of Stage 9
Stage 10	Programming Pot - Adjusts the voltage of Stage 10
Stage 11	Programming Pot - Adjusts the voltage of Stage 11
Stage 12	Programming Pot - Adjusts the voltage of Stage 12
Stage 13	Programming Pot - Adjusts the voltage of Stage 13
Stage 14	Programming Pot - Adjusts the voltage of Stage 14
Stage 15	Programming Pot - Adjusts the voltage of Stage 15
Stage 16	Programming Pot - Adjusts the voltage of Stage 16
Glide A	Adjusts the glide of Voltage Output A
Glide B	Adjusts the glide of Voltage Output B
Glide A+B	Adjusts the glide of Voltage Output A+B
Random Level	Adjusts the level of the applied random source voltage
Random Reference	Adjusts the threshold at which the applied random source voltage, as adjusted by Random Level, will create a digital ‘1’ to be inserted into the bit pattern at the rising edge of the clock.
Optional Variable Range Control	Allows adjustment of a variable voltage range to be applied as a maximum range voltage for the programming pots.
Total Number of Potentiometers: 21 or 22 (if Variable Range Option is installed)	

Table 2-2: Toggle Switches and Their Functions

Label	Function
Pattern Switch 1	Programs a 1 or 0 for pattern bit 1
Pattern Switch 2	Programs a 1 or 0 for pattern bit 2
Pattern Switch 3	Programs a 1 or 0 for pattern bit 3
Pattern Switch 4	Programs a 1 or 0 for pattern bit 4
Pattern Switch 5	Programs a 1 or 0 for pattern bit 5
Pattern Switch 6	Programs a 1 or 0 for pattern bit 6
Pattern Switch 7	Programs a 1 or 0 for pattern bit 7
Pattern Switch 8	Programs a 1 or 0 for pattern bit 8
Pattern Switch 9	Programs a 1 or 0 for pattern bit 9
Pattern Switch 10	Programs a 1 or 0 for pattern bit 10
Pattern Switch 11	Programs a 1 or 0 for pattern bit 11
Pattern Switch 12	Programs a 1 or 0 for pattern bit 12
Pattern Switch 13	Programs a 1 or 0 for pattern bit 13
Pattern Switch 14	Programs a 1 or 0 for pattern bit 14
Pattern Switch 15	Programs a 1 or 0 for pattern bit 15
Pattern Switch 16	Programs a 1 or 0 for pattern bit 16
Gate Bus Switch 1	Directs signal to Gate Bus 1, 2 or 3 from Step 1
Gate Bus Switch 2	Directs signal to Gate Bus 1, 2 or 3 from Step 2
Gate Bus Switch 3	Directs signal to Gate Bus 1, 2 or 3 from Step 3
Gate Bus Switch 4	Directs signal to Gate Bus 1, 2 or 3 from Step 4
Gate Bus Switch 5	Directs signal to Gate Bus 1, 2 or 3 from Step 5
Gate Bus Switch 6	Directs signal to Gate Bus 1, 2 or 3 from Step 6
Gate Bus Switch 7	Directs signal to Gate Bus 1, 2 or 3 from Step 7
Gate Bus Switch 8	Directs signal to Gate Bus 1, 2 or 3 from Step 8
Gate Bus Switch 9	Directs signal to Gate Bus 1, 2 or 3 from Step 9
Gate Bus Switch 10	Directs signal to Gate Bus 1, 2 or 3 from Step 10
Gate Bus Switch 11	Directs signal to Gate Bus 1, 2 or 3 from Step 11
Gate Bus Switch 12	Directs signal to Gate Bus 1, 2 or 3 from Step 12
Gate Bus Switch 13	Directs signal to Gate Bus 1, 2 or 3 from Step 13
Gate Bus Switch 14	Directs signal to Gate Bus 1, 2 or 3 from Step 14
Gate Bus Switch 15	Directs signal to Gate Bus 1, 2 or 3 from Step 15
Gate Bus Switch 16	Directs signal to Gate Bus 1, 2 or 3 from Step 16
Merge 1 Switch	Merges Gate Bus 1 adjacent gates and triggers
Merge 2 Switch	Merges Gate Bus 2 adjacent gates and triggers
Merge 3 Switch	Merges Gate Bus 3 adjacent gates and triggers
Bus 1 Load Switch	Enables pattern re-load when Bus 1 transitions to high
Clock Enable Switch	Connects/Disconnects clock input
Rand/Pat Switch	Switches between random and programmed pattern mode
8X2/16X1 Switch	Switches between two 8 stage patterns or one 16 stage pattern
Invert B Switch	Enables inversion of Register B recirculated data
Optional External Load Enable	Enables/Disables the external load signal applied to the External Load Jack

Label	Function
Optional External/Internal Range Switch	Selects between an applied external voltage and an internal variable range voltage to be applied as the maximum range of the programming pots.
Total Number of Toggle Switches: 40 Standard, 2 more with available Options	

Table 2-3: Momentary Pushbutton Switches and Their Functions

Label	Function
Manual Load	Loads programmed pattern into shift register
Manual Step	Advances shift register one step with each key press
Total Number of Momentary Pushbutton Switches: 2	

Table 2-4: Rotary Switch and Its Function

Label	Function
Range	Selects maximum range of programming pots (eight position)
Total Number of Rotary Switches: 1	

Table 2-5: Jacks and Their Functions

Label	Function
A Output	Outputs voltage pattern generated by section A (first 8 stages)
B Output	Outputs voltage pattern generated by section B (second 8 stages)
A+B Output	Outputs summed A+B pattern signal (all 16 stages)
Master Gate	Outputs constant gate signal synchronous with clock
Master Trigger	Outputs constant trigger signal synchronous with clock
Bus 1 Gate	Outputs Gate Bus 1 gate signal
Bus 1 Trigger	Outputs Gate Bus 1 trigger signal
Bus 2 Gate	Outputs Gate Bus 2 gate signal
Bus 2 Trigger	Outputs Gate Bus 2 trigger signal
Bus 3 Gate	Outputs Gate Bus 3 gate signal
Bus 3 Trigger	Outputs Gate Bus 3 trigger signal
Clock Input	Accepts clock signal
External Load In	Accepts pulse signal to initiate pattern load on rising edge
Random In	Accepts signal from which random patterns are generated
Optional A Output	Outputs voltage pattern generated by section A (first 8 stages) Not affected by Glide Control A
Optional Aux B Output	Outputs voltage pattern generated by section B (second 8 stages) Not affected by Glide Control B
Optional Aux A+B Output	Outputs summed A+B pattern signal (all 16 stages) Not affected by Glide Control
Optional Variable Range Input	Accepts an external positive voltage input and applies that voltage as the maximum programming pot range.
Total Number of Jacks: 14 standard, 4 more available as options.	

Table 2-6: LED Indicators and Their Functions

Label	Function
Pattern Bit 1	Indicates active bit/stage 1
Pattern Bit 2	Indicates active bit/stage 2
Pattern Bit 3	Indicates active bit/stage 3
Pattern Bit 4	Indicates active bit/stage 4
Pattern Bit 5	Indicates active bit/stage 5
Pattern Bit 6	Indicates active bit/stage 6
Pattern Bit 7	Indicates active bit/stage 7
Pattern Bit 8	Indicates active bit/stage 8
Pattern Bit 9	Indicates active bit/stage 9
Pattern Bit 10	Indicates active bit/stage 10
Pattern Bit 11	Indicates active bit/stage 11
Pattern Bit 12	Indicates active bit/stage 12
Pattern Bit 13	Indicates active bit/stage 13
Pattern Bit 14	Indicates active bit/stage 14
Pattern Bit 15	Indicates active bit/stage 15
Pattern Bit 16	Indicates active bit/stage 16
Clock	Indicates clock rate
Master Gate Bus	Indicates gate present on Master Gate Bus
Gate Bus 1	Indicates gate present on Gate Bus 1
Gate Bus 2	Indicates gate present on Gate Bus 2
Gate Bus 3	Indicates gate present on Gate Bus 3
Random Reference	Indicates random signal has crossed reference and will generate a "1" if a rising clock signal is present
Total Number of LEDs: 22	

General Recommended Guidelines

We're not here to tell you how you should lay out your Klee panel. In fact, if you want to emboss strawberries and leprechauns on the panel, power to you. However, there are some things we would consider helpful:

- Try to keep the pattern LEDs clear of other LEDs. For example, if you put the gate bus LEDs in line with the pattern LEDs, it may be hard to tell where your pattern ends and the gate bus begins.
- It's helpful to align the pattern switches, programming pots, pattern LEDs, and gate bus switches in some order so you know which stage each is associated with.
- If you run out of room on your panel, the clock LED could be sacrificed – it essentially gives the same indication as the Master Gate Bus LED – there's only a 2 microsecond delay between the two, which is far less latency than anyone of non-superhuman/bionic capabilities can detect.
- Rotary pots are good for easy adjustment. Slider pots are excellent because you can spot exactly where your settings are without peering at the little dots on your rotary pot knobs. Either is good. This manual is rotary-pot heavy, but don't rule out sliders if you have the technology to put them into your panel.

3. Mounting Parts to the Front Panel

This section assumes you've already stamped, drilled, chiseled, nibbled or sledge-hammered a slab of material into a front panel. Or, perhaps, you've even ordered from a panel supply house a panel you've designed on your computer. In any event, you've got it in your mitts and you're ready to build.

Preparation

Set Some Landmarks
By now, you've probably realized that there are a *lot* of components on the *electro-music* Klee Sequencer front panel. Really, the only time during the build when you'll be looking at your panel from the pretty, labeled front side is when you're orienting the parts and calibrating the thing. The rest of the time, you'll be looking at the ugly, hidden part behind the panel. This is the side that tells you nothing and can potentially lead you into the deadly trap of Wiring Things Wrong. Why? Because, after a while, you'll begin to confuse which pot is which or which switch is what as you wire the thing up. Instead of constantly looking at the front of the panel to make sure you really are soldering wire where you want to, it's a good idea to use a permanent marker or use some other labeling method to mark the part positions on the rear of the panel. So, do it now, before you forget. Remember, the world of the back of the panel is a bizarre universe where everything is backwards – left is right, right is wrong, clockwise is anticlockwise and up is often down. Mark the stage numbers, mark the label of the switch, mark the positions of the switch ("Merge On", "Invert B", etc.). You'll be glad you did, says the Voice of Experience.

Orienting, Testing and Mounting the Parts

Some parts, particularly the SPST ON-OFF switches must be mounted with a particular orientation to match how you have your panel labeled. It's your Klee, so it doesn't matter to you, the operator, if the Gate Bus Merge 1 Switch will be flipped "up" to be in the Merge position, or flipped down to be in the Merge position, as long as it agrees with your front panel labeling. But, it matters to the switch.

The parts most sensitive to orientation, as mentioned, are the SPST ON-OFF switches, and there are a lot of them. The pattern switches, the merge switches, the enable switches, the Gate Bus 1 Load switch, and the mode switches are all of this variety. The gate bus switches don't really care at this point which way you mount them – the orientation of if they flip up or down is in how you wire the things up later. The same goes for the Invert B Switch.

So, break out your SPST ON-OFF switches and take a look at them. On the rear of each switch are two terminals. These terminals are either shorted (closed) or open (umm…open). It’s hard to tell which position is which. Some manufacturers of switches may mark it on their terminals, others may not. You decide which is right, and which in an illusion, to quote the Moody Blues.

How do you do this? It takes an ohmmeter or a continuity tester, or, better yet, a DMM with a continuity tester built in. The kind of continuity tester that beeps when you have a short (closed) circuit is by far the best, because your ears will let you know immediately which position the switch is in, instead of having to peer at a meter while holding test leads to the two terminals.

Connect one test lead of the ohmmeter/continuity tester/DMM to one terminal of the switch, and connect the other lead to the other terminal of the switch. Flip the switch into one position – if the DMM/Ohmmeter reads zero Ohms or close to zero Ohms, or your continuity tester puts out a long tone, that’s the closed position. If your DMM/Ohmmeter reads infinite resistance or your continuity tester stays silent, that’s the open position of the switch. Flip the switch to the opposite position. You should now get the opposite reaction from your instrument – if the switch was previously closed, it better now read open and vice versa. If there is no change, you either have the wrong type of switch or it’s a bad switch and a bad idea to use it. If there are more than two positions to the switch, it’s the wrong switch.

So, what better tool is there than a table to tell you what position your switch must be in to do its thing? Why, nothing, that’s what. Here’s your table:

	Closed (shorted) Position	**Open Position**
Pattern Switches 1 through 16	Bit is low	Bit is high
Merge Switches 1 through 3	Merge On	Merge Off
Random/Pattern Switch	Pattern Mode	Random Mode
8X2/16X1 Switch	8X2 Mode	16X1 Mode
Clock Enable Switch	Clock Input Enabled	Clock Input Disabled
External Load Enable (optional)	External Load Input Enabled	External Load Input Disabled
Bus 1 Load Switch	Bus 1 Load On	Bus 1 Load Off

Table 3-1: SPST ON-OFF Switch Positions

The **Manual Load** Switch and the **Manual Step** switch don’t care which terminal is connected to what, as long as the two connections are the right connections. As mentioned before, the **Invert B** and **Gate Bus** Switch positions are determined by how you wire them. There’s only one way to mount a rotary pot. Perhaps the only other components that are orientation sensitive are the LED’s and the rotary Range Switch.

In the case of the Range Switch, you will want to be sure the positions of the switch correspond to the markings on your panel.

Though the orientation of the remaining switches, aside from the rotary Range Switch, does not matter at this stage, it's best to be sure you have the *right* switches in hand when you're ready to mount the components.

The gate bus switches are SPDT ON-OFF-ON type switches. The "ON-OFF-ON" label signifies they have three positions. So, right off the bat, if your switch lever does not move through three positions, then You Have The Wrong Switch.

On the back of these switches are three terminals. The center terminal will be connected to either the upper terminal or the lower terminal if the switch level is either full up or full down. If the lever is in the center position, the center terminal is not connected to either of the outside terminals.

Go ahead and test your switches – why not now? Make sure they work before you figure it out when it can be a *real* pain. Take your handy DMM/Ohmmeter/Continuity tester and attach one lead to the center terminal on the back of the switch. Hold the switch in the position you plan to mount it on the panel, and flip the lever to the "up" position (make sure it's not in the center position). Connect the other lead of your DMM to the "bottom" terminal on the rear of the switch (opposite of the "Up" direction you just flipped the switch). You should now have a short between the "bottom" terminal of the switch and the center terminal of the switch. So, here "up is down" – with the lever of the switch pointed up, the lower terminal is connected to the center pin. This is an important fact to tuck away when it comes time to wire things up.

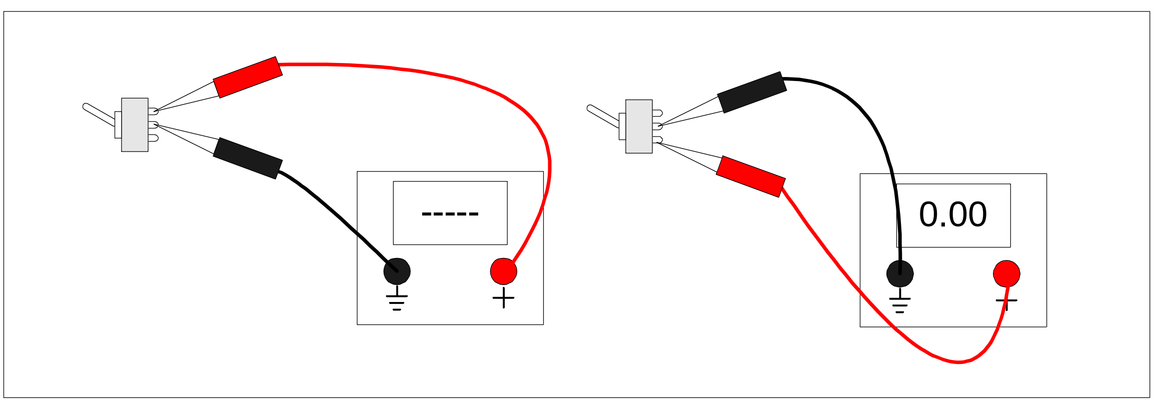


Figure 3-1: SPDT ON-OFF-ON in the "Up" Position

Now, move the switch lever to the center position. The same "lower" terminal you're connected to and the center terminal should now read "open". If not, either the switch is bad, or you have the wrong type of switch. Now flip the lever of the switch to the "down" position – you should still read open on the same set of terminals. If not, again bad switch or wrong type of switch.

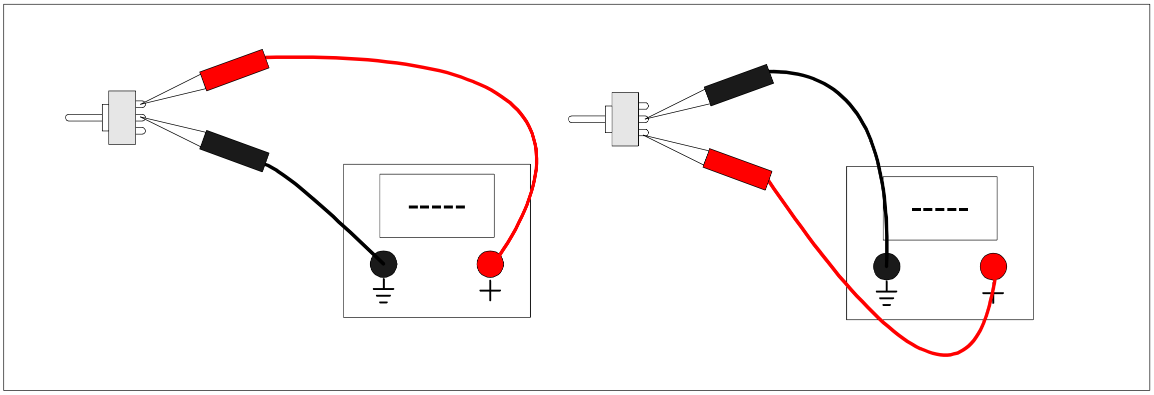


Figure 3-2: SPDT ON-OFF-ON in the Center Position

Now, without moving the switch lever position, remove the DMM lead from the “lower” terminal it’s connected to and move it to the “upper” terminal. Now the connection between the “upper” terminal and the center terminal should be shorted, while the switch lever is in the down position. If not, bad switch. Now move the lever to the center position – you should now have an open between the upper terminal and the center terminal. If not…you get the picture. Move the switch lever to the “Up” position, and again, you should still have an open between the “upper” terminal and the center terminal on the rear of the switch.

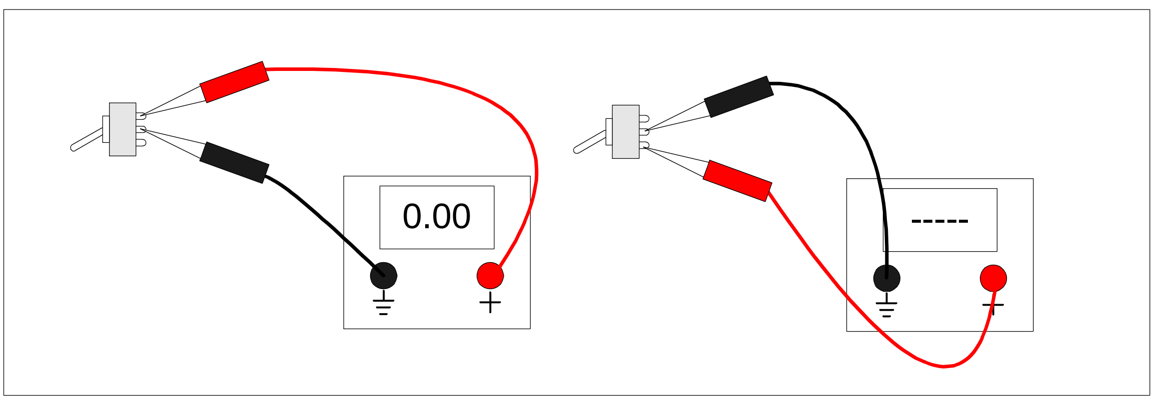


Figure 3-3: SPDT ON-OFF-ON in the “Down” position

So, once you’ve determined you have a good set of the right switches for the gate bus, group them all together and lay them aside. Let’s look at our one remaining “oddball” toggle switch – the SPDT ON-ON switch used for the Invert B Switch.

“ON-ON” means that we have only two positions for this switch. So, if you have more than two positions (all together now) – Wrong Switch. Physically, it looks the same as the gate bus switches – there are three terminals on the back. Only, because this switch only has two positions, there are only two ways it can be bad. Again, hold the switch as you would imagine it mounted on the panel. Hook one DMM lead to the center pin, and one to the “lower” terminal. Flip the switch in the “up” position. You should have continuity between the center terminal of the switch and the lower terminal of the switch. Up is down. Now, flip the switch to the “down” position. You should now have an open between the center and “lower” terminals of the switch. Now remove the DMM lead from the “lower” terminal of the switch and place it on the “upper” terminal of the switch. With the lever in the down position, you should have a short between the “upper” terminal and the center terminal. Now flip the switch lever to the “up” position; you should now have an open between the “upper” and center terminals of the switch. Once we’ve identified this switch and made sure it works, put it in its own little spot so you don’t mix it in with the gate bus switches.

As for the LEDs, it’s a good idea to mount them all in one orientation – either cathode “up” or anode “up”. This serves to make things uniform as far as not worrying which is the cathode or anode as you wire the panel up, but also, more importantly, it makes it easier to “strap” the common connections together in the next step of panel assembly. Of course, you’d want to mount at least all of the programming pots with the same orientation to make the strapping process easier as well.

So, be sure you know on your LEDs which lead is the anode and which is the cathode. Generally, LEDs will have the longer lead as the anode and the shorter lead as the cathode. The body of the LED will also give you a clue which is which – it will have a “flat” side, which will signify that’s where the cathode is.

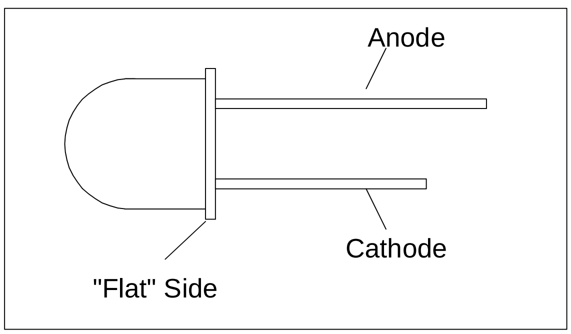


Figure 3-4: The LED Illustrated

But, let’s be habitual and double-check to be sure. You’ll need a DMM with a diode test function to figure this out. Connect the positive lead of your DMM to what you believe to be the anode of the LED. Connect the ground lead of your DMM to your idea of which lead is the cathode. A diode tester often will have enough current to slightly illuminate the LED as well – in a low light situation, you will see that. If you are using the recommended high efficiency, low current LEDs, there probably will be no doubt if the thing lights up or not.

Now, if you don’t see any illumination, you may have the leads reversed, the diode tester doesn’t have enough juice to slightly illuminate the LED or you have a bad LED. Switch the DMM leads around to the opposite legs of the LED. If you didn’t have slight illumination before, and you do now, then your LED is good. Your positive lead is now connected to the Anode and your ground lead is connected to the cathode.

If there is no change in the reading either way you switch the leads around, either your diode checker doesn't have the juice to even slightly illuminate the LED, its battery is low, or the LED is toast. Toss any bad item away and get a new one, or put in new batteries, as the situation dictates.

If your diode check function just can't even get a glimmer out of the LED, there is one other method that you can use to test your LEDs. If you have a breadboard, you can mount the LED on the breadboard, use a 6K8 current limiting resistor (the standard Klee value) and apply either 15V or 12V, depending on what power supply you intend to use.

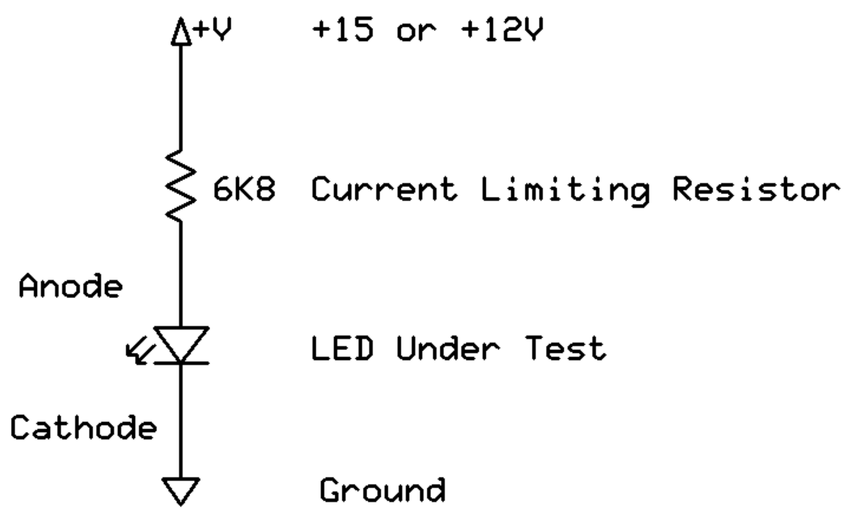


Figure 3-5: An LED Test

Now, first of all, note the value of the 6K8 current limiting resistor. You may think that is a pretty high value for an LED. In practice, many standard LEDs actually attain a very respectable brightness with that value. The recommended high efficiency LEDs certainly perform very well, also. If you should decide that you think the value is too high, and you decide you're going to lower it to get a really, really bright display, then that would be a bad decision in this case. The health and longevity of your *electro-music* Klee sequencer is dependent on this value. In other words, *don't do it*. If you have any doubt, breadboard it, and you will find the brightness is quite enough.

In the case of 12V operation, it may be permissible to lower the value to 4K7, but *only* in the instance of 12V operation. However, try the 6K8 – you'll find it performs well, especially with a high efficiency, low current LED.

One more set of components deserves our pre-mount-the-panel-frenzy attention here: the jacks. You should be sure which lugs of your jacks are which. The position of these lugs can vary from manufacturer to manufacturer, so let's be sure we know which are which.

If you’re using banana jacks, this is one of the benefits and luxuries of your jack of choice – a banana jack has only one connection, so that leaves little up to chance. But 1/4” and 3.5mm jack users must keep track which lug is the ground and which lug is the “tip”.

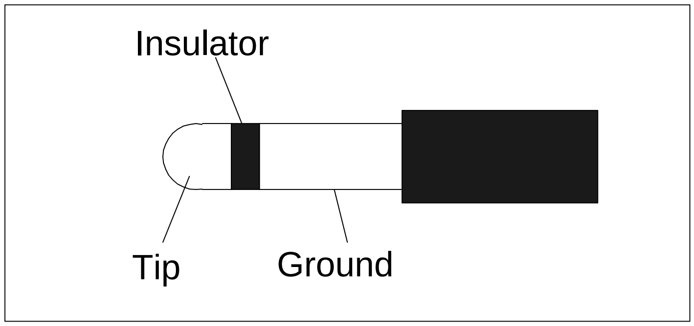


Figure 3-6: A 1/4” or 3.5 mm Cable Plug

Mono 3.5 mm and 1/4” plugs have two sections – the “tip” and ground connections. The “tip” provides the signal, and the ground provides the ground connection that mates the ground of your “send” device and your “receive” device. These two sections are separated by a non-conducting ring on the plug.

When you plug one of these plugs into a jack, the jack will provide the signal output on the “tip” lug of the jack and the ground reference on the ground lug of the jack.

So, to check which lug is which, plug a cable into your jack. Now, connect one lead of your DMM/continuity tester to the tip of your cable and probe one lug of the jack. If the lug you’re probing gives a near zero ohm reading (or your continuity tester squawks in your ear) *that* is the “tip” lug. If the reading is open, move on to the next lug – if that one gives low ohms/beeps, then *that* is the “tip” lug.

“Now….wait a minute.”, you might think, “Why don’t you just assume the other lug is the “tip” lug if the current lug is *not*?”

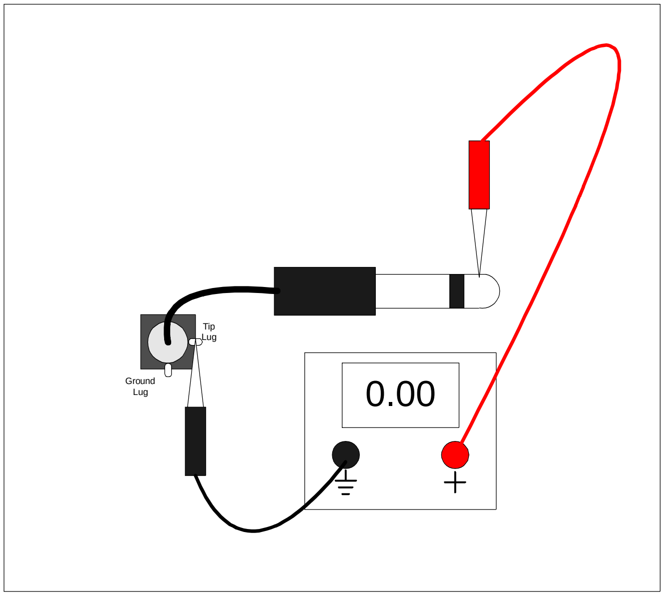


Figure 3-7: Locating the Tip Lug

Because many of these jacks will have three (or more!) lugs, depending on the type you purchased. Particularly, if it's got three lugs, we'll discuss that here in a second.

Now that you know which lug is the "tip" lug, write it down in a little diagram for yourself. Move the DMM lead from the "tip" of the cable that's still plugged into your jack to the ground of the cable that's plugged into your jack. Repeat the process until you're sure which lug is the ground lug of your jack.

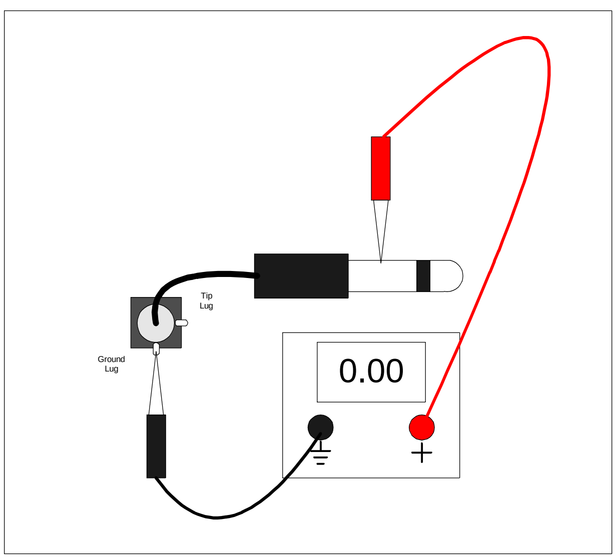


Figure 3-8: Locating the Ground Lug

Back to that "third" lug: One option of the *electro-music* Klee Sequencer, called the "Auto Switching External/Internal Range Option" (number 3 on page 9 of the front panel/interconnect schematic) requires a normally closed (n.c.) switching jack. This type of jack provides an extra lug called the "n.c. switch lug" that has continuity between the “tip” lug <u>only when a plug is *not* plugged into the jack</u>. You know which lug is your “tip” lug, so connect one lead of your DMM to that, and connect the other lead to the “third” lug. If your cable is not plugged into the jack, you should read zero ohms (have continuity) between these two lugs.

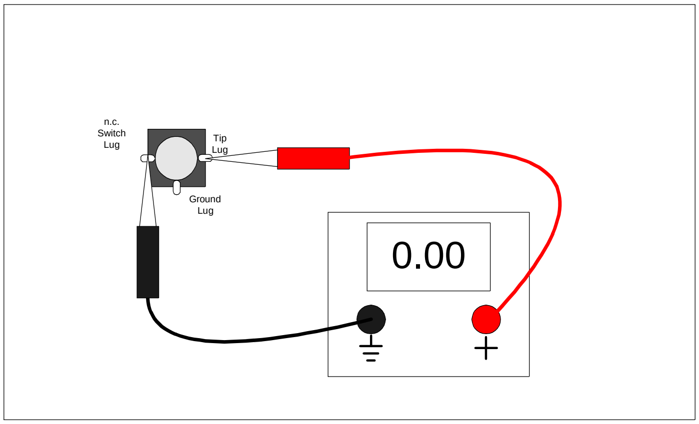


Figure 3-9: No Cable Attached – N.C. Lug Closed

Now plug your cable into the jack. You should now read “open” between these two lugs. If that’s the case, congratulations, you’ve just located the “n.c. switch” lug. If not, and there are other lugs, check those. If you don’t find such a lug, then your jack will not work with that option.

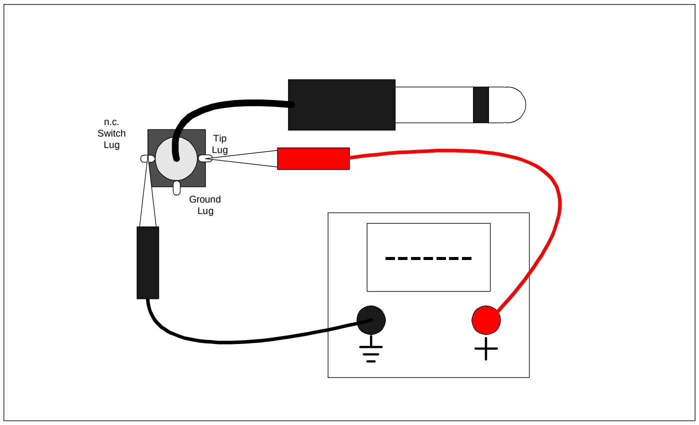


Figure 3-10: Cable Inserted – N.C. Lug Open

Now comes the time to mount the components! Keep a few things in mind – you probably want to mount the hardy components first – the jacks, switches and pots. Then you’ll probably want to attach and align your knobs and (if you’re really into this kind of stuff) those cool little colored sleeves that fit over toggle switch levers. After that, you’ll want to go back and put in your LEDs, using the mounting of your choice (which usually involves an LED holder, or, in the case of those who’ve developed a well established chrome fetish, chrome LED holders). Use the following tables to ensure that the right components are mounted in the right places.

Table 3-2: Panel Mount Potentiometer List

Label	Panel Des (300 Series)	Type
Programming Pot 1	R1	50K Linear Panel Mount Pot
Programming Pot 2	R2	50K Linear Panel Mount Pot
Programming Pot 3	R3	50K Linear Panel Mount Pot
Programming Pot 4	R4	50K Linear Panel Mount Pot
Programming Pot 5	R5	50K Linear Panel Mount Pot
Programming Pot 6	R6	50K Linear Panel Mount Pot
Programming Pot 7	R7	50K Linear Panel Mount Pot
Programming Pot 8	R8	50K Linear Panel Mount Pot
Programming Pot 9	R9	50K Linear Panel Mount Pot
Programming Pot 10	R10	50K Linear Panel Mount Pot
Programming Pot 11	R11	50K Linear Panel Mount Pot
Programming Pot 12	R12	50K Linear Panel Mount Pot
Programming Pot 13	R13	50K Linear Panel Mount Pot
Programming Pot 14	R14	50K Linear Panel Mount Pot
Programming Pot 15	R15	50K Linear Panel Mount Pot
Programming Pot 16	R16	50K Linear Panel Mount Pot
Glide A	R20	1M Linear Panel Mount Pot
Glide B	R21	1M Linear Panel Mount Pot
Glide A+B	R19	1M Linear Panel Mount Pot
Random Level	R18	100K Linear Panel Mount Pot
Random Reference	R17	100K Linear Panel Mount Pot
Optional Variable Range	R22	100K Linear Panel Mount Pot

Table 3-3: Panel Mount Toggle Switches

Label	Panel Des (300 Series)	Type
Pattern Switch 1	SW1	SPST ON-OFF
Pattern Switch 2	SW2	SPST ON-OFF
Pattern Switch 3	SW3	SPST ON-OFF
Pattern Switch 4	SW4	SPST ON-OFF
Pattern Switch 5	SW5	SPST ON-OFF
Pattern Switch 6	SW6	SPST ON-OFF
Pattern Switch 7	SW7	SPST ON-OFF
Pattern Switch 8	SW8	SPST ON-OFF
Pattern Switch 9	SW9	SPST ON-OFF
Pattern Switch 10	SW10	SPST ON-OFF
Pattern Switch 11	SW11	SPST ON-OFF
Pattern Switch 12	SW12	SPST ON-OFF
Pattern Switch 13	SW13	SPST ON-OFF
Pattern Switch 14	SW14	SPST ON-OFF

Label	Panel Des (300 Series)	Type
Pattern Switch 15	SW15	SPST ON-OFF
Pattern Switch 16	SW16	SPST ON-OFF
Gate Bus Switch 1	SW17	SPDT ON-OFF-ON
Gate Bus Switch 2	SW18	SPDT ON-OFF-ON
Gate Bus Switch 3	SW19	SPDT ON-OFF-ON
Gate Bus Switch 4	SW20	SPDT ON-OFF-ON
Gate Bus Switch 5	SW21	SPDT ON-OFF-ON
Gate Bus Switch 6	SW22	SPDT ON-OFF-ON
Gate Bus Switch 7	SW23	SPDT ON-OFF-ON
Gate Bus Switch 8	SW24	SPDT ON-OFF-ON
Gate Bus Switch 9	SW25	SPDT ON-OFF-ON
Gate Bus Switch 10	SW26	SPDT ON-OFF-ON
Gate Bus Switch 11	SW27	SPDT ON-OFF-ON
Gate Bus Switch 12	SW28	SPDT ON-OFF-ON
Gate Bus Switch 13	SW29	SPDT ON-OFF-ON
Gate Bus Switch 14	SW30	SPDT ON-OFF-ON
Gate Bus Switch 15	SW31	SPDT ON-OFF-ON
Gate Bus Switch 16	SW32	SPDT ON-OFF-ON
Merge 1 Switch	SW33	SPST ON-OFF
Merge 2 Switch	SW34	SPST ON-OFF
Merge 3 Switch	SW35	SPST ON-OFF
Bus 1 Load Switch	SW36	SPST ON-OFF
Clock Enable Switch	SW39	SPST ON-OFF
Rand/Pat Switch	SW41	SPST ON-OFF
8X2/16X1 Switch	SW40	SPST ON-OFF
Invert B Switch	SW43	SPDT ON-ON
Optional Ext. Load Enable	SW45	SPST ON-OFF
Optional Int/Ext Range	SW44	SPDT ON-ON

Table 3-4: Panel Mount Momentary Pushbutton Switches

Label	Panel Des (300 Series)	Type
Manual Load	SW38	SPST (ON)-OFF
Manual Step	SW37	SPST (ON)-OFF

Table 3-5: Rotary Switch

Label	Panel Des (300 Series)	Type
Range	SW43	SP8T Rotary

Table 3-6: Panel Mount Connectors

Label	Panel Des (300 Series)	Type
A Output	J17	Jack of Choice
B Output	J15	Jack of Choice
A+B Output	J16	Jack of Choice
Optional Output A	J11	Jack of Choice
Optional Output B	J9	Jack of Choice
Optional Output A+B	J10	Jack of Choice
Master Gate	J8	Jack of Choice
Master Trigger	J7	Jack of Choice
Bus 1 Gate	J1	Jack of Choice
Bus 1 Trigger	J2	Jack of Choice
Bus 2 Gate	J3	Jack of Choice
Bus 2 Trigger	J4	Jack of Choice
Bus 3 Gate	J5	Jack of Choice
Bus 3 Trigger	J6	Jack of Choice
Clock Input	J13	Jack of Choice
External Load In	J12	Jack of Choice
Random In	J14	Jack of Choice
Var Range Opt. 2 or 4	J18	Jack of Choice
Var Range Opt. 3	J18	1/4” or 3.5 mm Jack

Table 3-7: LED Indicators

Label	Panel Des (300 Series)	Type
Pattern LED 1	D1	High Efficiency Red LED
Pattern LED 2	D2	High Efficiency Red LED
Pattern LED 3	D3	High Efficiency Red LED
Pattern LED 4	D4	High Efficiency Red LED
Pattern LED 5	D5	High Efficiency Red LED
Pattern LED 6	D6	High Efficiency Red LED
Pattern LED 7	D7	High Efficiency Red LED
Pattern LED 8	D8	High Efficiency Red LED
Pattern LED 9	D9	High Efficiency Red LED
Pattern LED 10	D10	High Efficiency Red LED
Pattern LED 11	D11	High Efficiency Red LED
Pattern LED 12	D12	High Efficiency Red LED
Pattern LED 13	D13	High Efficiency Red LED
Pattern LED 14	D14	High Efficiency Red LED
Pattern LED 15	D15	High Efficiency Red LED
Pattern LED 16	D16	High Efficiency Red LED
Clock LED	D21	High Efficiency Red LED
Master Gate Bus LED	D20	High Efficiency Red LED
Gate Bus 1 LED	D17	High Efficiency Red LED

Label	Panel Des (300 Series)	Type
Gate Bus 2 LED	D18	High Efficiency Red LED
Gate Bus 3 LED	D19	High Efficiency Red LED
Random Reference LED	D22	High Efficiency Red LED

And, one last thing before you begin – NO GORILLA FISTING. In other words, make things tight, but don't overly wrench those things on there - especially the switches. Use lock washers, and hold the component with your fingers in its correct position as you tighten it down. If you draw blood on those fingers, that's a good indication that you are subconsciously gorilla fisting things.

- Mount the SPST switches making sure the lever while in the closed position of the switch points to the function it's supposed to point to (refer to Table 1).
- Mount the pots with the same orientation.
- Mount the gate bus switches (SPDT ON-OFF-ON) so they line up nice and tidy.
- Mount the Invert B Switch so it lines up nice and tidy.
- Mount the Push Button Switches.
- Mount the Rotary Switch, making sure it lines up with any markings on your panel (might want to put its knob on at this point just to check).
- Mount the Jacks with the same orientation (comes in handy for strapping), unless you use banana jacks, in which case, orientation does not apply.

Now, before proceeding, go back with your DMM and make sure your switches still work and are in the right position. After that's all sorted:

- Apply and align all knobs and accoutrements.
- Mount the LEDs with a common orientation.

After you're done mounting the LEDs, make sure they're oriented correctly and clip the LED leads to between one half and three quarters inch (non-American builders please calculate the metric conversion to *those* numbers – well, OK, it's actually 13 to 19 mm). The idea here is you don't want to let those LED leads to short together, which they eventually will do if they're too long, says the Voice Of Experience. You'll be soldering wires to them, and moving those wires around, which will move the LED leads around too much if they're too long.

Once this process is complete, sit down and hold the panel facing you. Imagine that, in a short time, those LEDs are going to light up like the frikkin' Fourth of July. Ensure no one is looking, then play with the switches and the pots, while making soft bleeping blooping noises under your breath. Indulge yourself, you've earned it. Don't put the panel away yet – you're not done!

4. Strap Wiring The Front Panel

What is Strap Wiring?

On the front panel, there are many connections referred to here as "common connections". A common connection is a single node more than one panel component will connect to. For example, all sixteen of the programming pots all connect to a single ground point (Analog Ground). Rather than connecting sixteen wires, one for each pot, from the Analogue Board to the front panel, it's more expedient and just as effective to connect all of the pots together, then run a single Analog Ground wire to a single point all of the pots connect to. The act of connecting all the pots together is termed "strap wiring" the pots.

Strap wiring all of the common connections together on the front panel before any board connections are made makes assembly much easier. You can lay the panel on a piece of foam, or suspend it some way above your work surface (you don't want to scrunch down on your mounted components!) and solder the strap connections on before you have to deal with any of the "dangling" wires that will connect to the printed circuit boards.

What Material Should Be Used For Strap Wiring?

Obviously, any wire can be used. If insulated wire is used, one must cut, strip and tin the ends of the wire to connect each common point together. This has the advantage of being insulated from inadvertent shorting to any other point, but, at the same time, is a lot of work. Bare bus wire, on the other hand, has the twin advantages of easily being soldered without stripping or tinning, and allowing any point to be connected when it comes time to connect the common point to the PCB. The disadvantage is it is not insulated. Insulation can be purchased for it, but that may not be all that necessary.

If a bus wire of a suitable stiffness is used, say 22 gauge bus wire, the bus wire will stay in place and will not itself "move" and short out anything else. Several strapped connections will in turn need to be connected together, and insulated wire can easily be used to do that, when the wire will need to pass close to any point you *don't* want connected together. Using bus wire, one can connect the PCB connection to a central point, so the signal flow can follow a "star" pattern. For example, one could connect the insulated PCB connection for Analog Ground in the middle of the programming pots, so the ground does not feed from one end to the other, but "spreads out" from the middle, for want of a better explanation.

What Common Connections Need to Be Strap Wired?

Most of the panel components will need to be strapped to either Digital Ground, Analog Ground, Bus 1, or Bus 3. If you look at the Front Panel/Interconnect schematic of the *electro-music* Klee Sequencer, you will notice that Analog Ground is labeled "Analog

Grnd" and Digital Ground is labeled "Digital Grnd". The Bus 1 and Bus 3 connections appear on page 3 of that schematic. There are a few "sundry" connections that can be made at this point as well – the connection from the Clock Input Jack to the Clock Enable Switch, for example, or if used, the connection between the External Load Input Jack and the optional External Load Enable Switch.

By far, the most extensive common connection is Digital Ground – the pattern switches, merge switches, mode switches (with the exception of Invert B), step and load switches, all LEDs, random input jack, reference and level pots, and gate bus jacks all connect to this point. It's a busy little ground!

Analog ground is used for all of the programming pots, the optional external range components (if used) and all of the voltage output jacks.

Bus 1 connects to either the upper or lower terminal (depending on your panel labeling) of all of the gate bus switches AND the Bus 1 Load Switch.

Bus 3 connects to either the upper or lower terminal (depending on your panel labeling) of all of the gate bus switches.

There are a few components that don't require any strap wiring at all – notably, the rotary Range Switch and the Invert B switch. And, of course, if you are using banana jacks, there are no common ground inputs for any of the jacks.

This build document provides procedures for the strap connections so that you can go through them, and, in the end, determine if you have made all of your strap connections and are ready to move on with your life. In fact, here they come now!

Digital Ground Strap Connection Procedure

- **Pattern LEDs 1 through 16**

Connect all of the pattern LED **<u>cathodes</u>** together. By now, you've probably got a pretty good idea which lead is the cathode. If not, go back and read the first sections of this document again. Connect the cathodes together about one quarter to a half inch from the rear of the LED. Don't let that LED get too hot! Snip off any excess cathode lead length. Don't connect anything to the anodes yet. That all comes later.

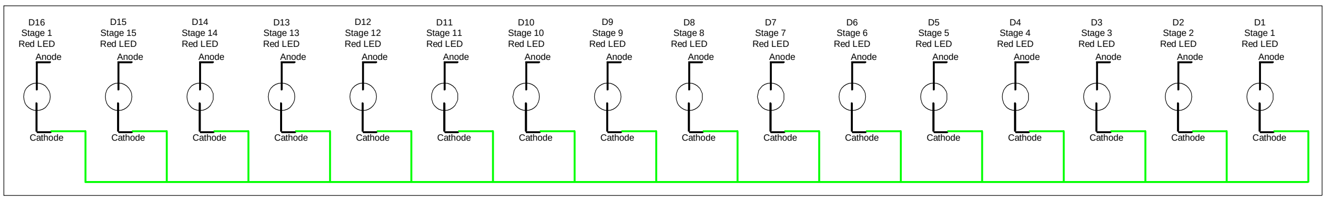


Figure 4-1: Strap Wiring Digital Ground to the Pattern LEDs

- **Pattern Switches 1 through 16.**

Connect all of either the upper or lower terminals on the rear of the pattern switches together. By now, you've already oriented them so they point to the right label on the front panel. Now, it doesn't matter if you connect the common ground to either the upper or lower terminal at the rear of the switch. Since they're all in a line (unless you have some cool circular panel going on), it's easier to connect all the terminals together in a line. Each switch will have only one of its terminals connected – don't get all crazy and solder both terminals of each switch to something yet. The unoccupied terminal of each switch will be connected to the boards later in this procedure. Be careful when soldering your switches – **<u>don't get them too hot</u>**. You'll know you did if the lug starts to "swim around" in its plastic potting material. As you string the wire along from lug to lug, give the switch time to cool off before you attach the wire from it to the next lug down the line. These switches are, if not the lifeblood of the Klee, surely its spinal fluid.

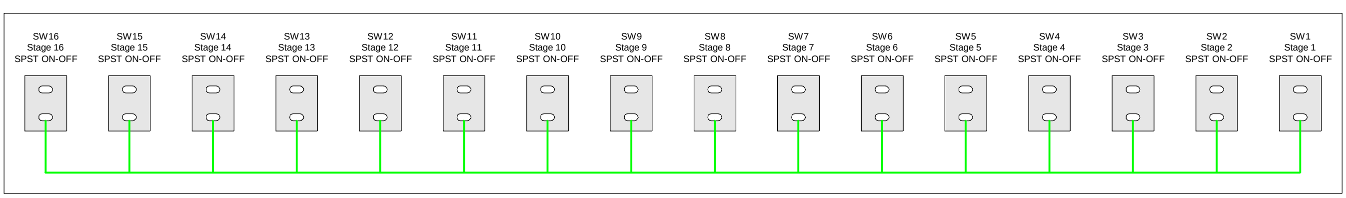


Figure 4-2: Strap Wiring Digital Ground to the Pattern Switches

- **Gate Bus LEDs**

Connect the Gate Bus 1, Gate Bus 2, Gate Bus 3 and Master Gate Bus LED **cathodes** together. Connect the cathodes together about one quarter to a half inch from the rear of the LED. Again, make sure you don't get the LEDs too hot. Snip off any excess cathode lead length. Don't connect anything to the anodes yet. This all assumes that your gate bus LEDs are, of course, grouped together. If they're not, just make sure you have the cathode of each one connected to the nearest Digital Ground connection.

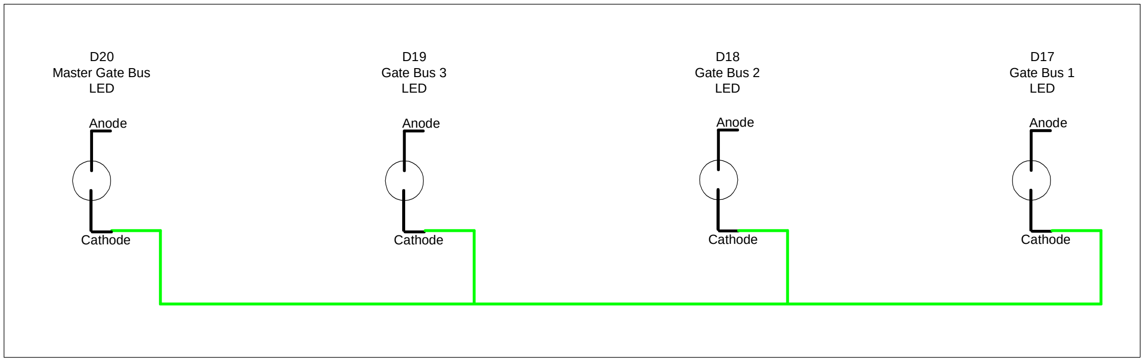


Figure 4-3: Strap Wiring Digital Ground to the Gate Bus LEDs

- **Gate Bus Jacks**

Banana jackers need not read this – there is no ground connection for a banana jack! All others, connect the Gate Bus 1, Gate Bus 2, Gate Bus 3 and Master Gate Bus gate and trigger jacks together. Make sure you know which terminal on your jack of choice is the ground terminal! As usual, this assumes your gate bus jacks are grouped together. If not, connect the ground leads of the jacks to the nearest Digital Ground connection.

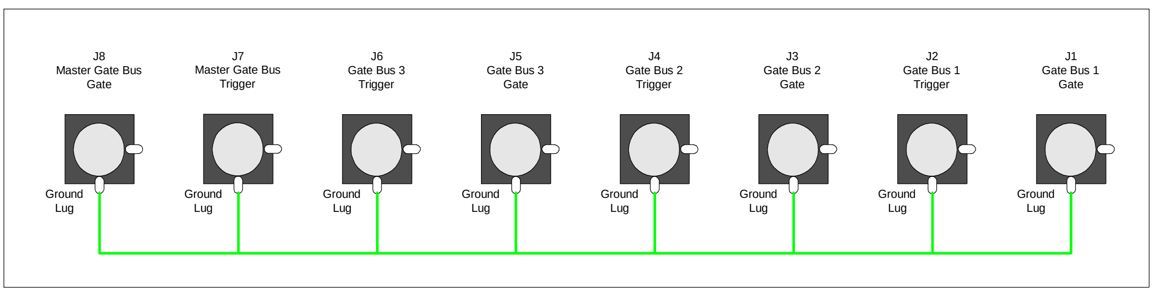


Figure 4-4: Strap Wiring Digital Ground to the Gate Bus Output Jacks

- **Clock LED**

Connect the Clock LED **cathode** to the nearest digital ground connection. Connect to the cathode one quarter to a half inch from the rear of the LED. Make sure you the LED doesn't get too hot. Snip off any excess cathode lead length. Don't connect anything to the anode yet.

- **Random Reference LED**

Connect the Random Reference LED **cathode** to the nearest digital ground connection. Connect to the cathode one quarter to a half inch from the rear of the LED. Make sure you the LED doesn't get too hot. Snip off any excess cathode lead length. Don't connect anything to the anode yet.

- **Random Reference and Random Signal Level Pots**

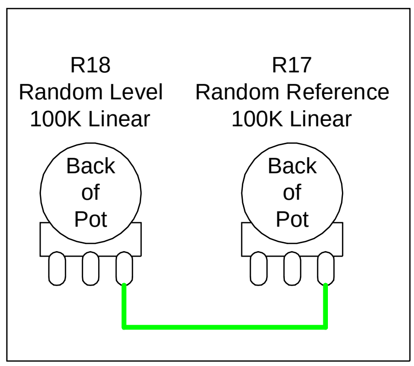


Figure 4-5: Strap Wiring Digital Ground to the Random Control Pots

Connect the ground lug of the Random Reference and Random Signal Level pots to digital ground. Remember, you're in the bizarro world of the rear panel, so the ground lug is to your right, as you're looking at the panel.

- **Clock Input Jack, External Load Jack and Random Input Jack**

Banana jackers need not apply. For all others, connect the ground lug of the Clock Input Jack, External Load Jack and Random Input Jack to each other or the nearest Digital Ground point on the panel.

- **8X2/16X1 and Random/Pattern Mode Switches**

Connect together either the upper or lower terminals on the rear of these two mode switches (remember, do not apply any strapping to the Invert B switch!). If they're not close to each other, just connect them to the nearest Digital Ground point on the panel. Being the SPST ON-OFF type, like the pattern switches, they don't really "care" which terminal you connect to, just as long as you have it oriented correctly according to the first part of this procedure. As with everything so far, the unoccupied terminal of each switch will be connected to the boards later in this document. As a reminder, don't get the switches too hot! Like a soldering iron ninja, get in there and get out.

- **Manual Step and Manual Load Switches**

  Connect together either the upper or lower terminals on the rear of these two momentary switches. If they're not close to each other, just connect them to the nearest Digital Ground point on the panel. Like the other SPST ON-OFF types, it doesn't matter which terminal you connect to. In fact, if they're the pushbutton type, you don't even have to worry about orientation! You do have to worry about getting them too hot here, but we're not going to nag you about it, you already know.

- **Gate Bus Merge 1, Merge 2 and Merge 3 Switches.**

  Connect together either the upper or lower terminals on the rear of the three merge switches. If they're not close to each other, just connect them to the nearest Digital Ground point on the panel. Again, these are the SPST ON-OFF type, so either terminal will do – just make sure you have them aligned right on the panel, as per the beginning of this screed. Leave the other terminal of each switch open for wiring to the PCBs. And, lest you forget – don't get those switches too hot!

The Final Step For Digital Ground Strapping: make sure all of the digital ground points you've wired up on the panel are all connected together. For example, you may have all the Pattern LEDs wired up to jab your eyes from the center of the panel, but the Gate Bus LEDs may be wired together over in the corner, so far unconnected from any other Digital Ground Point. Use insulated wire to solder all of the disparate wired together components together so that anywhere you attach the Digital Ground wire from the PCB, it will be connected to them all. After that, grab your DMM, connect it to one Digital Ground point on the panel, and alternately connect the other lead to all of the other Digital Ground points – make sure there is continuity to that one point from all other Digital Ground points! Coming up - your checklist:

Table 4-1: Digital Ground Strap Connection List

OK	Component
	Pattern LED 1 Cathode
	Pattern LED 2 Cathode
	Pattern LED 3 Cathode
	Pattern LED 4 Cathode
	Pattern LED 5 Cathode
	Pattern LED 6 Cathode
	Pattern LED 7 Cathode
	Pattern LED 8 Cathode
	Pattern LED 9 Cathode
	Pattern LED 10 Cathode
	Pattern LED 11 Cathode
	Pattern LED 12 Cathode
	Pattern LED 12 Cathode
	Pattern LED 13 Cathode
	Pattern LED 14 Cathode
	Pattern LED 15 Cathode
	Pattern LED 16 Cathode
	Clock LED Cathode
	Random Reference LED Cathode
	Master Gate Bus LED Cathode
	Gate Bus 1 LED Cathode
	Gate Bus 2 LED Cathode
	Gate Bus 3 LED Cathode
	Pattern Switch 1, one lug connected
	Pattern Switch 2, one lug connected
	Pattern Switch 3, one lug connected
	Pattern Switch 4, one lug connected
	Pattern Switch 5, one lug connected
	Pattern Switch 6, one lug connected
	Pattern Switch 7, one lug connected
	Pattern Switch 8, one lug connected
	Pattern Switch 9, one lug connected
	Pattern Switch 10, one lug connected
	Pattern Switch 11, one lug connected
	Pattern Switch 12, one lug connected
	Pattern Switch 13, one lug connected
	Pattern Switch 14, one lug connected
	Pattern Switch 15, one lug connected
	Pattern Switch 16, one lug connected
	Bus 1 Merge Switch, one lug connected
	Bus 2 Merge Switch, one lug connected

OK	Component
	Bus 3 Merge Switch, one lug connected
	8X2/16X1 Switch, one lug connected
	Random/Pattern Switch, one lug connected
	Manual Step Switch, one lug connected
	Manual Load Switch, one lug connected
	Random Reference Pot, Rightmost Lug (looking from back) connected
	Random Level Pot, Rightmost Lug (looking from back) connected
	Master Gate Output Jack, Ground Lug Connected (for non-banana jack)
	Master Trigger Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 1 Gate Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 1 Trigger Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 2 Gate Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 2 Trigger Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 3 Gate Output Jack, Ground Lug Connected (for non-banana jack)
	Bus 3 Trigger Output Jack, Ground Lug Connected (for non-banana jack)
	Random Signal Input Jack, Ground Lug Connected (for non-banana jack)
	Clock Signal Input Jack, Ground Lug Connected (for non-banana jack)
	External Load Input Jack, Ground Lug Connected (for non-banana jack)

Analog Ground Strap Connection Procedure

- **Programming Pots 1 through 16**

Connect the ground lugs of the sixteen programming pots together. Remember, as always, looking from the back of the pot, the ground will connect to the rightmost lug. This is assuming, of course, you are using rotary pots. If your choice of pot is a slider, identify the ground lugs of the sliders and connect those all together.

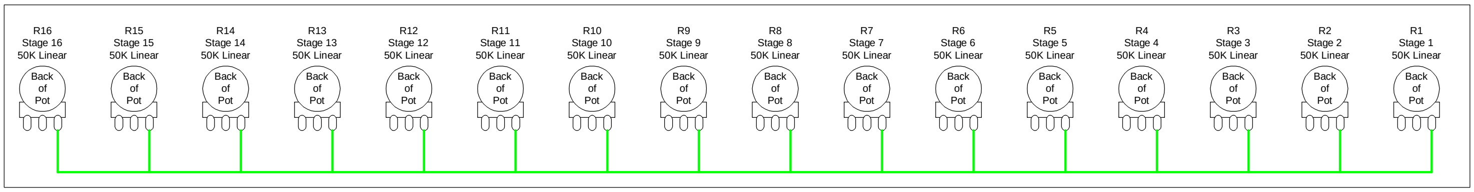


Figure 4-6: Strap Wiring Analog Ground to the Programming Pots

- **Voltage Output Jacks**

If you are not using banana jacks, you'll need to connect the ground lugs of the Voltage Output A, A+B and B jacks together. If you're also installing the Optional Voltage Output jacks, you'll also need to connect the ground lugs of those jacks to Analog Ground. Remember to be sure you know which lug is the ground lug!

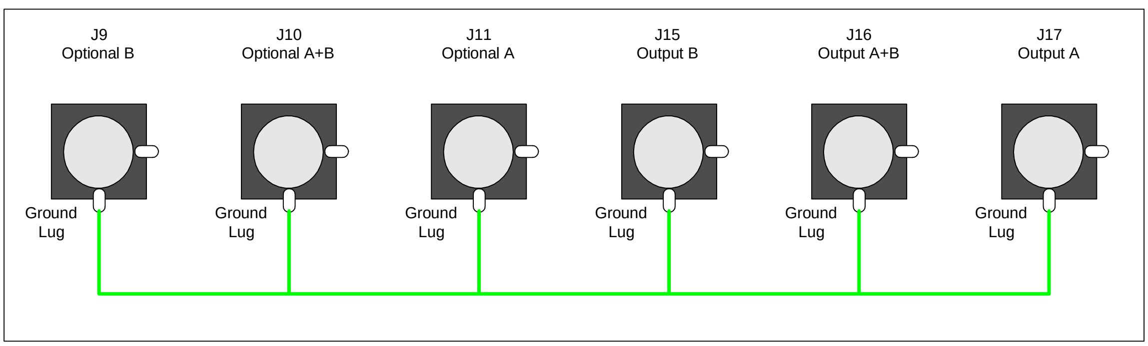


Figure 4-7: Strap Wiring Analog Ground to the Voltage Output Jacks

- **Optional Variable Range Pot**

If you choose to install the highly recommended variable range pot, its ground lug must also be connected to Analog Ground. It, too, requires that Analog Ground be attached to the same far-right lug that all of the other pots up to this time have had their ground points connected to.

- **Optional Variable External Input Jack**

If you choose to install the highly useful External Variable Range Input function, you'll need to attach Analog Ground to its ground lug as well.

Using insulated wire, connect all the scattered components that require Analog Ground connections have their Analog Ground points tied together. After you've done that, as was done with the Digital Ground strapping, it's time to ensure that all of the Analog Ground points *are* tied together on the panel. Pull out the trusty DMM, connect it to one Analog Ground point on the panel, and go through each connection with the other lead to check that all of the other Analog Ground points are connected to this point. It will be helpful to follow (and fill out in triplicate) the following checklist:

Table 4-2: Analog Ground Strap Connection List

OK	Component
	Programming Pot 1, Rightmost Lug (looking from back) connected
	Programming Pot 2, Rightmost Lug (looking from back) connected
	Programming Pot 3, Rightmost Lug (looking from back) connected
	Programming Pot 4, Rightmost Lug (looking from back) connected
	Programming Pot 5, Rightmost Lug (looking from back) connected
	Programming Pot 6, Rightmost Lug (looking from back) connected
	Programming Pot 7, Rightmost Lug (looking from back) connected
	Programming Pot 8, Rightmost Lug (looking from back) connected
	Programming Pot 9, Rightmost Lug (looking from back) connected
	Programming Pot 10, Rightmost Lug (looking from back) connected
	Programming Pot 11, Rightmost Lug (looking from back) connected
	Programming Pot 12, Rightmost Lug (looking from back) connected
	Programming Pot 13, Rightmost Lug (looking from back) connected
	Programming Pot 14, Rightmost Lug (looking from back) connected
	Programming Pot 15, Rightmost Lug (looking from back) connected
	Programming Pot 16, Rightmost Lug (looking from back) connected
	Output A Jack, Ground Lug Connected (if non-banana jack)
	Output A+B Jack, Ground Lug Connected (if non-banana jack)
	Output B Jack, Ground Lug Connected (if non-banana jack)
	Optional Output A Jack, Ground Lug Connected (if non-banana jack and used)
	Optional Output A+B Jack, Ground Lug Connected (if non-banana jack and used)
	Optional Output B Jack, Ground Lug Connected (if non-banana jack and used)
	Optional External Range Input Jack, Ground Lug Connected (non-banana, if used)
	Optional External Range Pot, Rightmost Lug (looking from back) connected

Gate Bus Strap Connection Procedure

This is where the rubber hits the road in making sure you have your orientation straight on the SPDT ON-OFF-ON switches. There are two gate bus common connections – Bus 1 is the signal that sends the gate signals to, surprisingly enough, Gate Bus 1, and Bus 3 is the signal that sends the gate signals to, well, Bus 3. Gate Bus 2, incidentally, is derived logically from connections to the middle lug of each of the gate bus switches. But, right now, we're concerned with only the two outside lugs; we're going to leave the center lugs along for the time being.

In this procedure, the illustrations assume that, when looking at the switches from the actual front of the front panel, the switch levers pointing *up* will direct the signals to Gate Bus 1 and pointing *down* will direct the signals to Gate Bus 3. That means, from the rear of the panel, looking at the switch lugs, the bottom row of lugs will be the Bus 1 line and the top row of switches will be the Bus 3 line (remember, generally up is down on the rear of a toggle switch). If your legend on the panel is reversed (you want to point down for Gate Bus 1) be sure to take this into account! Also, be sure your toggle switches work as described here. If you're not sure, re-read the beginning sections of this procedure.

- **Common Connections to the Gate Bus Switches**

Connect all of the top lugs of the switches together. After that, connect all of the bottom lugs of the switches together. As stressed before, it's stressed again – don't overheat those switches and make them go all simple on you – get in there, solder the wire on and get out!

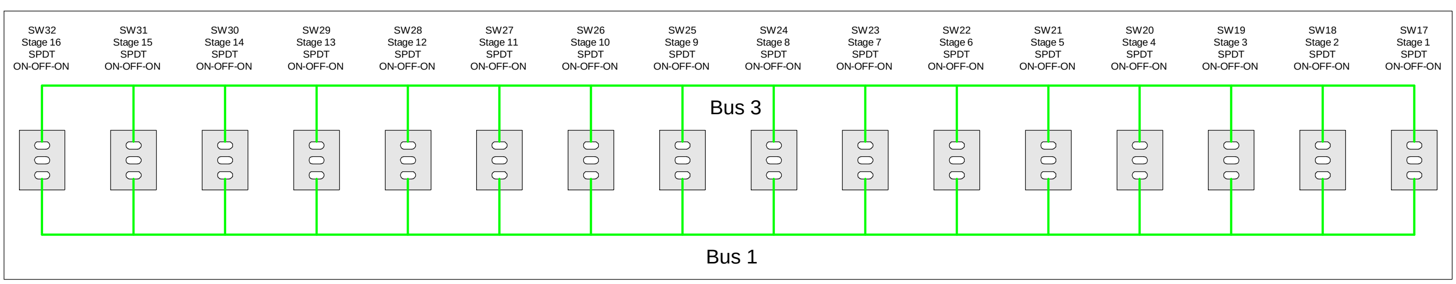


Figure 4-8: Strap Wired Gate Bus Switches – Switch Up Selects Gate Bus 1

It's a good idea to mark on the rear of the panel, which gate bus line is which. That will come in handy for later reference once you're ready to hook up to the PCBs.

- **Common Connection to Bus 1 – The Bus 1 Load Switch**

The Bus 1 load Switch is a SPST ON-OFF switch, so you don't have to worry about which lug to connect the Bus 1 signal to. Once more, you should have worked out by now that you have it oriented in the correct position to jibe with your front panel legend – with the switch closed, Gate Bus 1 Load will be on. So, solder a wire from Bus 1 to one of the lugs of this switch.

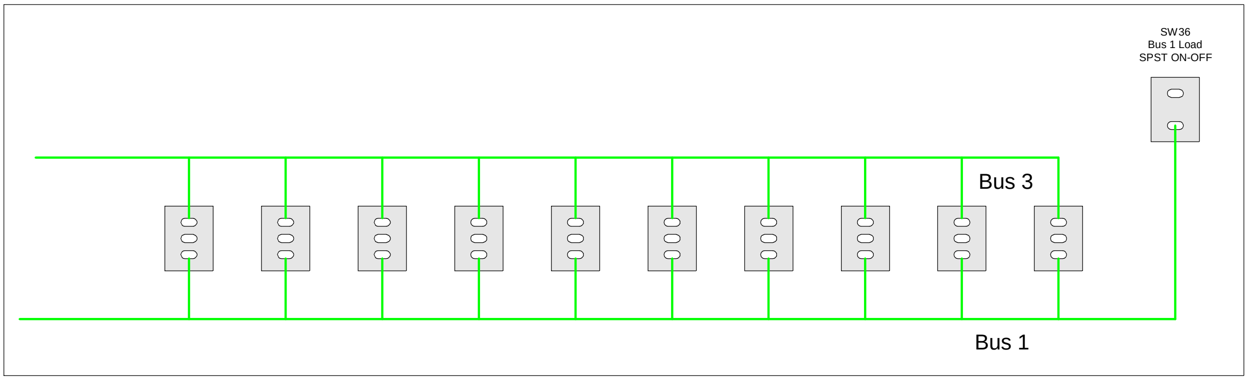


Figure 4-9: Connecting the Bus 1 Load Switch To Bus 1

After you've finished up wiring all of the Gate Bus Switches, attach a lead of your DMM to the Bus 1 common connection and ensure that the switches all have a common connection with Bus 1. Make sure to check that the Bus 1 Load Switch common connection has continuity as well.

After that, repeat the procedure with the Bus 3 Common connection.

Various and Sundry Strap Connections

You're getting very close to the end of the panel strapping process, so hang in there. The next set of connections consists of a few "single" connections – lines to connect jacks to pots and switches, mainly. Also, some of the optional Variable Range Option connections will be discussed, should you have decided to include that option.

- **Random Signal Input Jack to Random Level Pot**

  Of course, this requires that you be absolutely sure which lug of your Random Signal Input Jack is the "Tip" connection. If you use banana jacks, you are permitted to smile smugly to yourself in appreciation of the fact that, for a banana jack, this is a no-brainer – there is only one connection to a banana jack, and this the one connection you need here.

  Solder a wire between the "tip" lug (or your single banana jack connection) of the Random Signal Input Jack to the left most lug of the Random Level Pot, as viewed from the back.

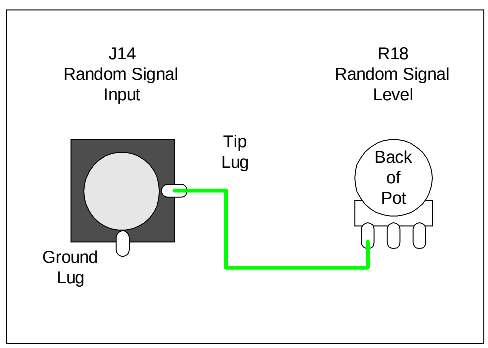


Figure 4-10: Wiring the Random Input to the Random Level Pot

- **Clock Signal Input Jack to Clock Enable Switch**

  With no comment from the banana jack gallery, ensure that you know which lug of your Clock Signal Input Jack is the "tip" connection, and solder a wire from it to one of the lugs on the back of the Clock Enable Switch. Obviously, the Clock Enable Switch is an SPST ON-OFF switch, so it doesn't matter which lug you solder to here – just (as usual) make sure you have the orientation of the switch correct to match your panel legend.

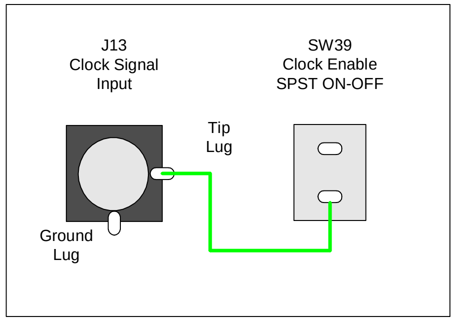


Figure 4-11: Wiring the Clock Input Jack to the Clock Enable Switch

- **Glide Pot Bits and Pieces**

The three glide pots are not strapped to anything; their inputs and outputs come from and go straight to the Analogue Board. However, there is a connection that is not utterly necessary, but is a connection that is often put on pots that are acting as variable resistors rather than voltage dividers. The connection is made between the center tap of the pot and the "maximum resistance" lug, in respect to the signal input. In this case, our signal input will be connected to the lug on the right (as viewed from the back) and the output will be taken from the center tap. The lug on the left will have the same resistance to the lug on the right as the lug on the center has to the lug on the right when the glide is cranked all the way up. So, the connection here is made from the center tap to the lug on the right.

So, why connect the center tap to the lug on the left – what does it accomplish? Not a whole lot, except that it serves as a form of "protection" should the pot suffer catastrophic failure, and, internally, the center tap disconnects from the rest of the pot. If this happens, even without the wire put in, nothing truly "destructive" would happen – there wouldn't be any magic smoke or pretty flashes of light. Instead, your CV output would just go dead (drop to 0V). With this wire in place, your CV output would still be there if the center tap somehow failed, though it the glide would be stuck at max setting, so your Klee could only moan and wail from that output, which is cool if that is your thing. In other words, it's more of a standard practice than anything terribly useful (in this instance) so you can either put the connection in or not, your choice.

If you do put it in, it's helpful to solder the jumper to the left lug, then loop the other end around the center tap, but leave it unsoldered – that tap will connect to the Analogue Board, so when that wire is attached to the center lug, it can be attached easily and both wires will be soldered at once.

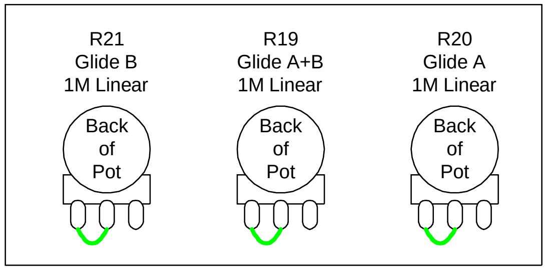


Figure 4-12: Wiring the Unused Lug to the Center Tap of the Glide Pots

From this point on, the steps listed are for optional installments only. They're optional mainly because the "standard" issue of the Klee was set in stone before the groovy functions of these options were fully appreciated. Otherwise, they would have been part of the standard package, along with the undercoating and whitewall tires.

- **External Load Signal Input Jack to Optional External Load Enable Switch**

  If you have decided to put in the optional External Load Enable Switch, connect a wire from the "tip" lug of your External Load Signal Input Jack to the External Load Enable Switch. It's an SPST ON-OFF switch, so for now, you can connect it to either terminal of the switch. If you didn't put in the optional switch, drill a hole and put one in – you'll find it's pretty handy. Or not.

  This option appears on page 6 of the front panel/interconnect schematic.

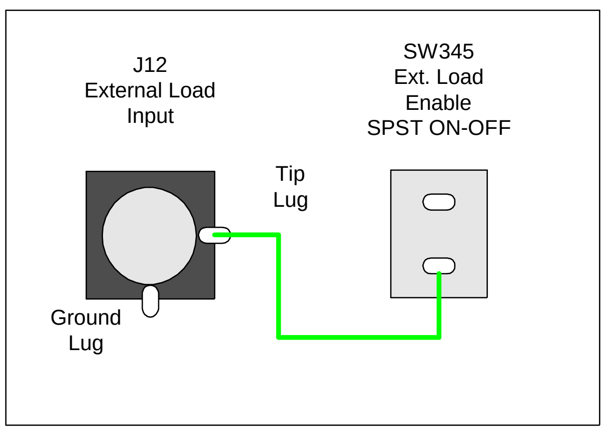


Figure 4-13: Connecting External Load Input Jack to Optional Load Enable Switch

The final optional common connections cover the ways the optional Variable Range Control can be implemented. There are actually four configurations. The first option, a single control that supplies a variable range, was covered in the Analog Ground Strap wiring section. That option does not require any additional strap wiring. The remaining three options involve injecting an external signal into the Klee, and using that signal as the maximum range of the programming pots. Remarkably enough, that is called the

External Variable Range function. All of these options are found on page 9 of the front panel/interconnect schematic. They all require the addition of an External Range Input jack, which is also mentioned in the Analog Ground Strap section. One of them (Option 4) requires an extra switch, which has yet to be mentioned.

- **Variable Range Option 2: External Variable Range Only**

This option allows only an external signal to be used to set the range of the programming pots – the Variable Range Control pot does nothing if no external range signal is applied. A connection is required from "tip" lug of the External Variable Range input to the left lug of the Variable External Range Pot. For banana jackers, as always, this just requires a connection from the one lug of the banana jack to the left lug of the Variable External Range Pot.

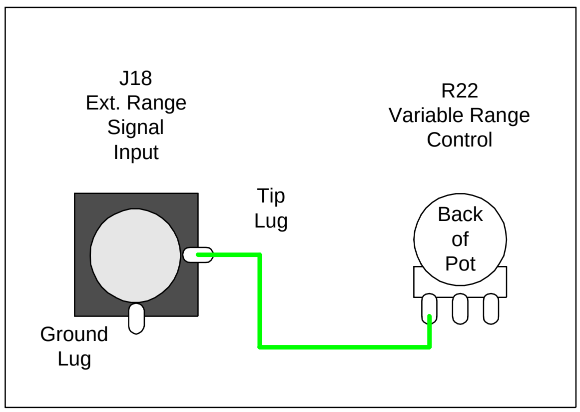


Figure 4-14: Connecting External Range Input Jack to Variable Range Pot (Opt. 2)

- **Variable Range Option 3: Auto Switched Internal/External Variable Range**

Those of you who do not use banana jacks – this is your turn to chortle. This option is not available if banana jacks are used. It uses a "normalled" connection to actuate the function. It requires either a 1/4" jack or a 3.5mm jack with a normally closed (n.c.) switch lug. It is from this switch lug that the connection is made to the right lug of the Variable Range Control pot. When a plug is not inserted into the External Range Signal Input jack, voltage supplied by the Analogue Board is applied to the Variable Range Control. When a plug is inserted into the External Range Signal Input jack, the voltage carried by that plug is applied to the Variable Range Control pot.

First of all, make absolutely sure you know which lug of your jack is the n.c. switch lug. Then **leave it unconnected** for now. You still want to connect the tip lug to the right lug of the Variable Range Control pot. The connection is essentially the same as Option 2, this is just to stress that the switched lug should not be connected now.

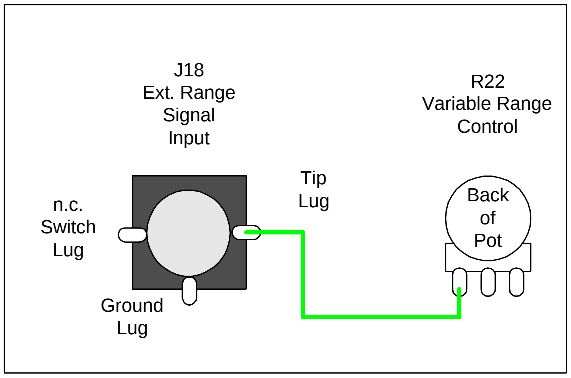


Figure 4-15: Connecting External Range Input Jack to Variable Range Pot (Opt. 3)

- **Var. Range Option 4: Manually Switched Internal/External Variable Range**

Now it's time for the banana jackers to regain the field. This option uses an extra switch (Switch 44, a SPDT ON-ON switch like the Invert B switch) to provide essentially the same functionality of Option 3 above. The extra switch, Internal/External Variable Range Select, allows either the internal and external range to be selected by flipping the switch. The disadvantage is that it requires more panel real estate. However, before you non-banana jackers giggle too much, it should be mentioned this arrangement does provide a level of convenience greater than Option 3. For example, if one is dynamically changing things during a Klee Sequence, this allows one to switch between internal and external signals without having to physically remove the plug from the External Range Input Jack.

The strap connections consist of a connection from the tip lug of the jack to the switch, and from the switch center terminal to the right lug of the pot (as viewed from the back). The connection from the switch to the pot will always be the same, but the connection from the jack to the switch will vary, depending on if you want the switch lever UP when it selects external voltage, or DOWN when it selects external voltage. Both positions are illustrated here.

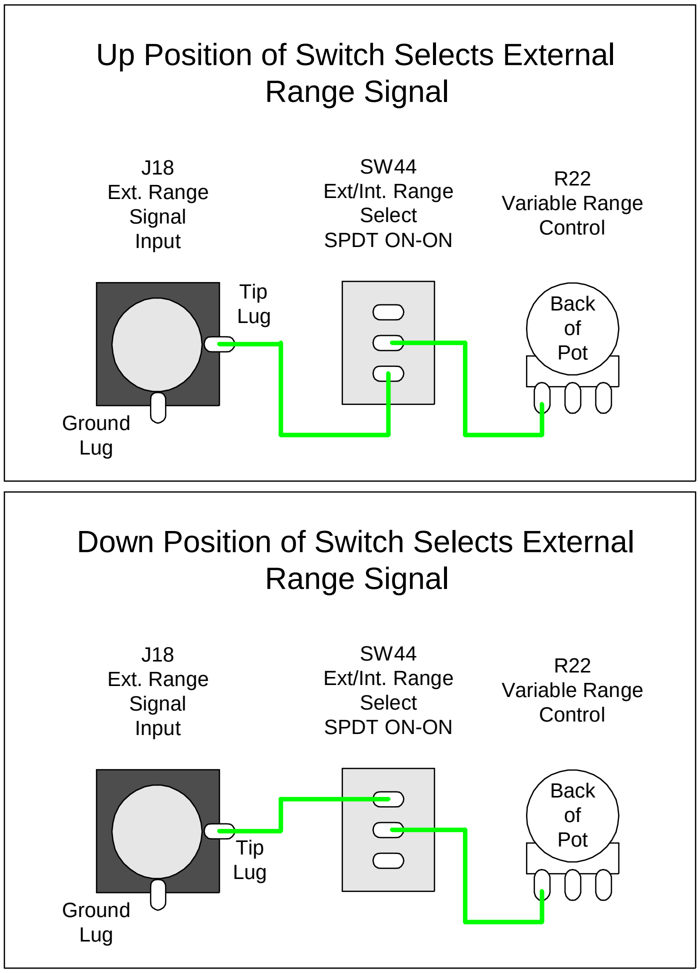


Figure 4-16: Connection of External Range Input Option 4

After all of the strap wiring is done, take the opportunity to test, once again, all of the switches – make sure they still switch OK after the soldering. If any switch decides it doesn't like hot solder applied to its lugs, this is a good time to find out – it's still comparatively easy to change it out at this point.

This wraps up all of the notes about putting in the strap connections to the front panel. Once these connections are made, a good deal of the panel work is already done. Now, the only thing left to do with the front panel is to install the wires that will connect it to the PCBs themselves. This is a good time to finish up that portion of wiring, wouldn't you think? This is true especially if you've decided to use the connectors which will just plug into your Digital and Analogue Boards. Even if you choose to hardwire it, this is still a good time to connect the wires.

The next section will deal with building the individual cables that will connect your front panel components to your boards, then, after that, soldering those cables and wires to your front panel components.

5. Building The Cables

If you've made the decision to connect your front panel to your Klee PCBs, you've come to the right page. Again, it cannot be stressed enough that using this system provides a number of advantages:

(1) Final Assembly of the Klee Sequencer is made much easier. If one is to hardwire the connections, the wires must be soldered to both the front panel and the PCB assemblies. This involves point-to-point wiring which involves a considerable amount of effort over building the cables and wiring them to the front panel.

(2) Servicing/trouble-shooting the Klee Sequencer is made easier – the panel can be easily disconnected and re-connected to and from the PCBs.

(3) It's easier to organize the wiring in a methodical manner, which leads to a neater, rats-nestless build.

This is not to say that building the cables cannot introduce problems – the cables must be built with care so they do not themselves create problems with intermittent connections, sayeth the Voice Of Experience.

Parts Used In the Cables

Each cable is comprised of three elements:

- The housing, which is a shell that the cables are "plugged into and which connects to the proper header on the PCBs. There are different types of headers used in the *electro-music* Klee Sequencer – they differ by the number of wires they will accommodate. The Klee uses 8 pin, 6 pin, 4 pin, 3 pin and 2 pin headers.
- The crimp terminals, which are crimped or soldered **or** crimped **and** soldered to the ends of the wires, depending on your chosen technique.
- The wires themselves. Generally 22 gauge or 24 gauge braided wire is required. Do not use solid core wire.

Housings and Crimp Terminals

First of all, one must be aware that the housings will plug into the PCB headers in only one direction – this ensures the wire that is to attach to pin 1 of the PCB connector is the correct wire. So, you must become aware which "hole" in your housing will mate with pin 1. On the back of each PCB, you will notice that each header has a square pad to designate pin 1 of the connector. The connector is keyed so that the housing can only be plugged in with one orientation. In other words, the header is keyed so that the housing, which has a mating "key" will plug into it. On the housing, the key is a ridge running along the edge of the "bottom" of the housing.

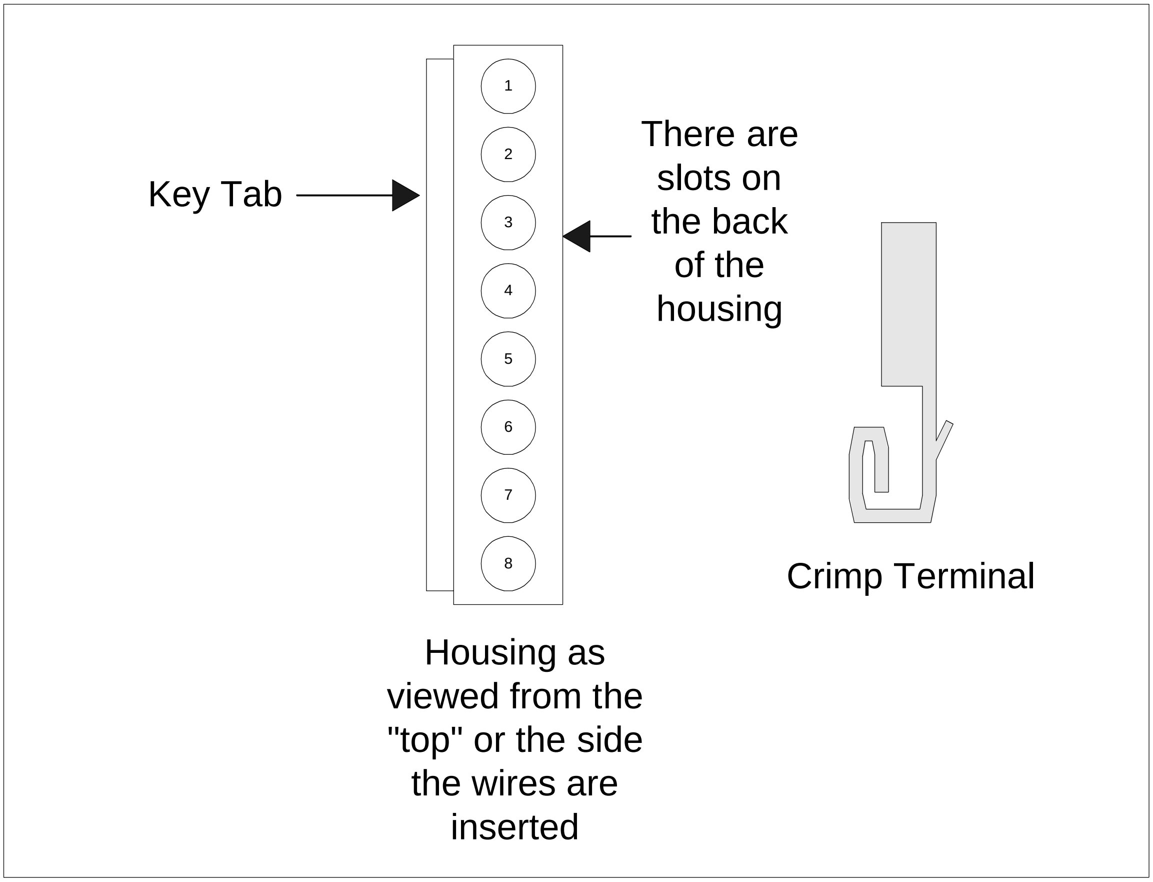


Figure 5-1: Housing and Crimp Terminal – A Graphic Anatomy

On the opposite side of the housing is a slot for each "hole" or terminal in the housing. These slots run along the bottom. The crimp terminals, which attach to the ends of the wire, have a small tab that protrudes from the "back" of the terminal. This small tab acts as sort of a fish hook and will "catch" in this slot when it is inserted into the housing.

Attaching the Crimp Terminals to the Wires

The crimp terminals attach to the ends of the wires, and are then inserted into the housing. The terminals have a couple of tabs at the top that are intended to be crimped, or folded over the insulation of the wire. The end of the wire is stripped **and tinned**, about ¼" from the end of the wire. This stripped and tinned part is to extend down so the "loop" of the crimp terminal compresses down onto the bare wire when the wire and crimp terminal are inserted into the housing.

Crimping tools can be expensive, though fairly inexpensive types that resemble a pair of wire cutters are available. In lieu of a crimping tool, many people will fold the tabs over the bare wire and put a *small* amount of solder there to hold it in place (a large "blob" of solder may prevent the crimp terminal from fitting into the housing). Generally, during the Klee proto build process, it was found that the small amount of solder made a much more reliable connection.

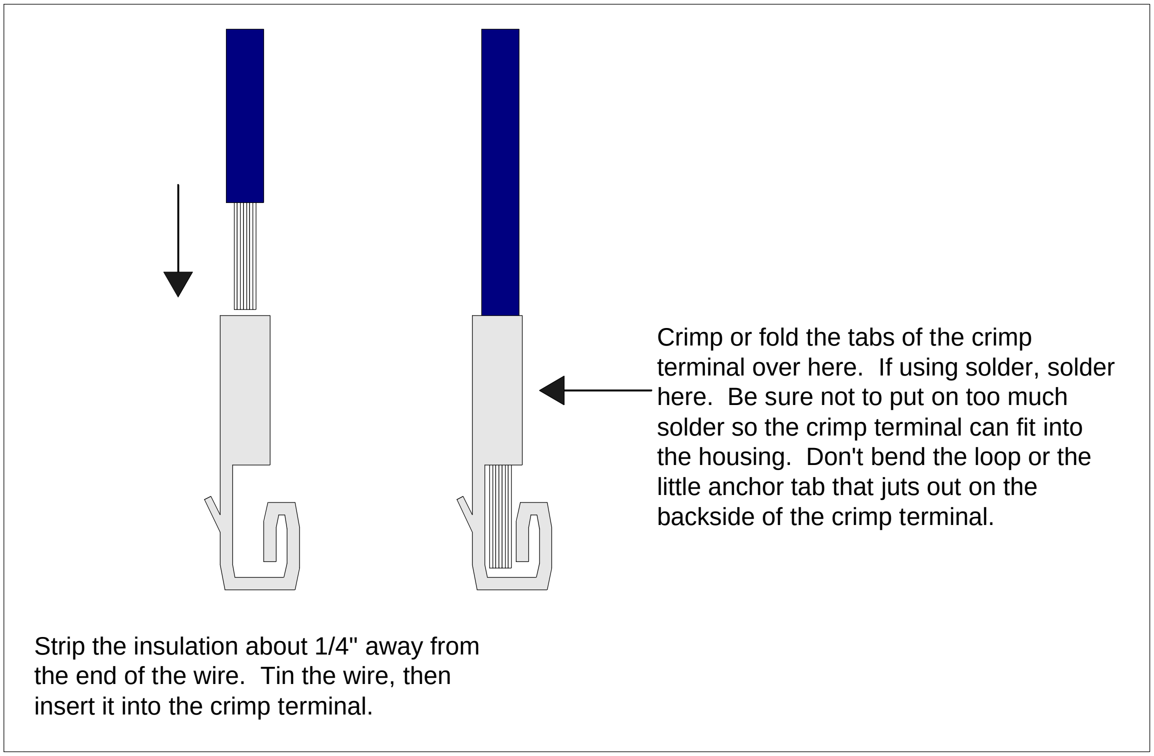


Figure 5-2: Putting the Crimp Terminals on Wires

It's a very good idea, if at all possible, to use a number of different colors of wire when building the cables. This helps you to determine very quickly which wire is pin 1, which wire is pin 2, etc. Otherwise, it's very easy to become confused which wire is which, and this can lead to errors when soldering the free ends of the cables to the front panel.

Also, make sure you provide plenty of length for the wires. By now, you've probably figured out how you're going to mount the PCBs in your Klee chassis. Making the wires longer than what you think may be needed allows you to measure them out by physically stretching them to where your boards will be and ensuring they will indeed reach before you actually do solder them to the front panel.

You can break the job down into separate tasks. For example, you can go through task of stripping all of the wires needed and attaching the crimp terminals. Then you can task yourself with inserting the wire/terminal into the housings, then you can task yourself with creating a neat looking cable by either wire-tying the cable wires together, or twisting the wires around each other to create a twisted-pair type thing. However, this last task may need to wait until after you've soldered the cables to the front panel – for now, it may be best to put a nice little twist-tie "collar" onto the cables just above the housing once the cable is assembled.

When you strip the wires, it's not a bad idea to strip just a tiny bit of the wire off the end that will connect to the panel. You can then use this exposed bit to attach a DMM or continuity checker to it and make sure your wire has continuity from the terminal to the end of the wire. A little care at these early stages can save a lot of headache at the final assembly and test stage of building the Klee Sequencer.

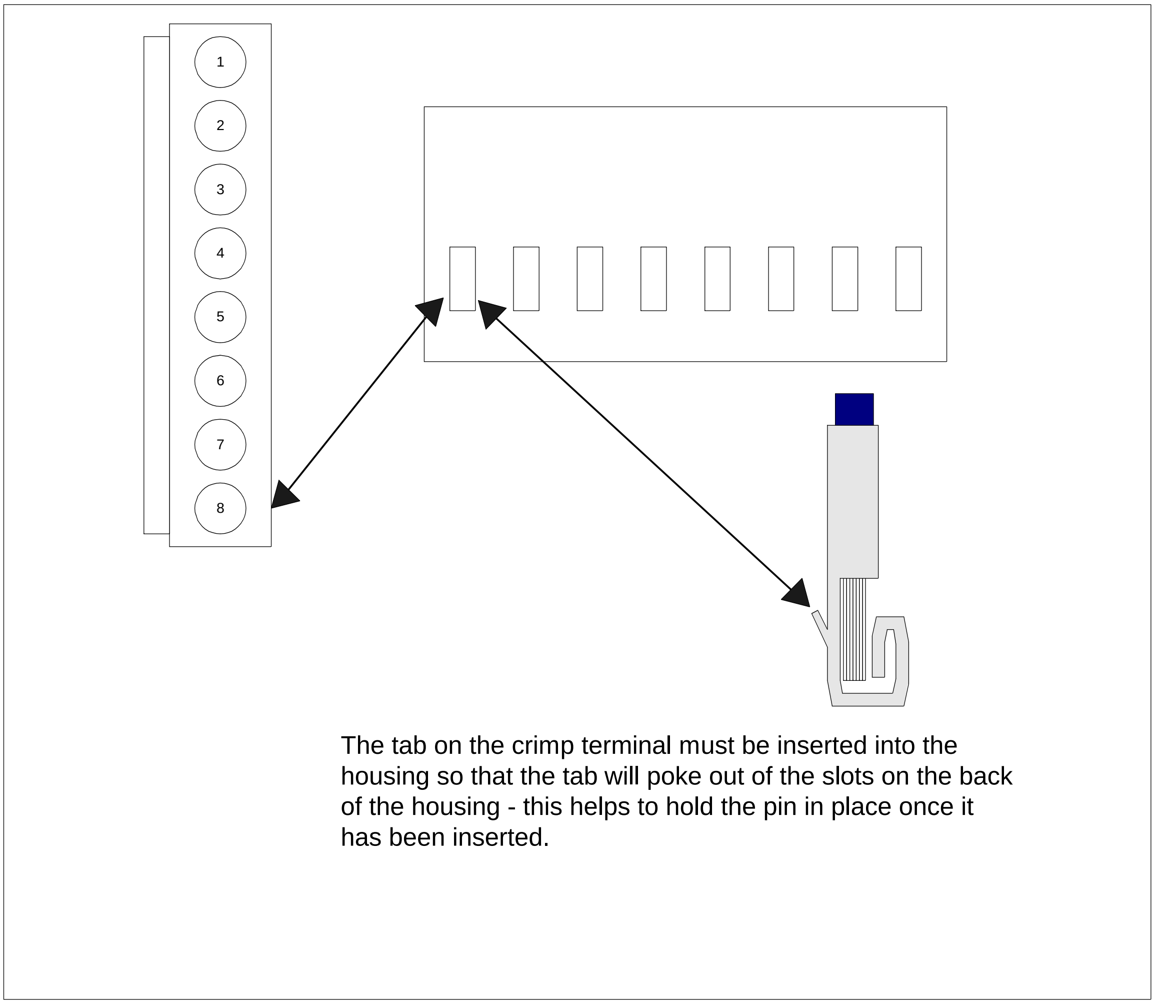


Figure 5-3: Crimp Terminal Orientation Before Insertion Into the Housing

Once you've got the terminal pins attached to your wires, you can insert them into the housings. When you insert the terminals into the housing, make sure that little barb on the back of the terminal is oriented towards the side of the housing that has the small "window" in it – the barb is designed to "catch" in that window like a hook in the mouth of a fish, and make it harder for Gorilla-Fist to yank it out at a later date. When the terminals are inserted into the housings, there should be the sensation of a soft "click" – this is a good sign that you've done a good job getting the terminals on the ends of the wires.

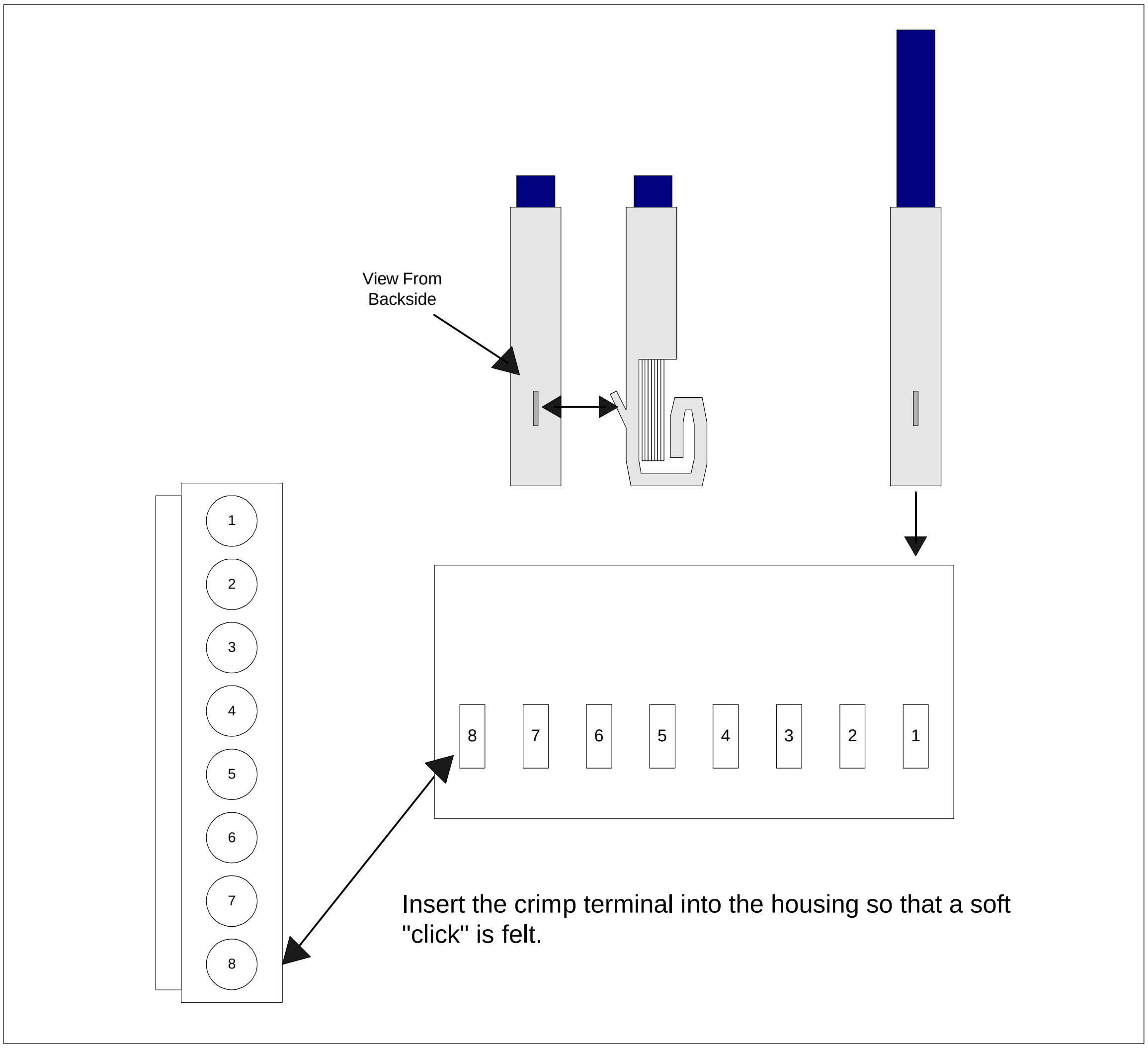


Figure 5-4: Inserting Crimp Terminals Into the Housing

Remember that "loop" on the terminal must not be crushed or misshapen – it is intended to compress down over the wire, making a good connection, and also provides a certain amount of tension that helps hold the terminal in the housing. And, again, too much solder (if you put solder on) or solder in the wrong place can inhibit the actual installation of the terminal into the housing.

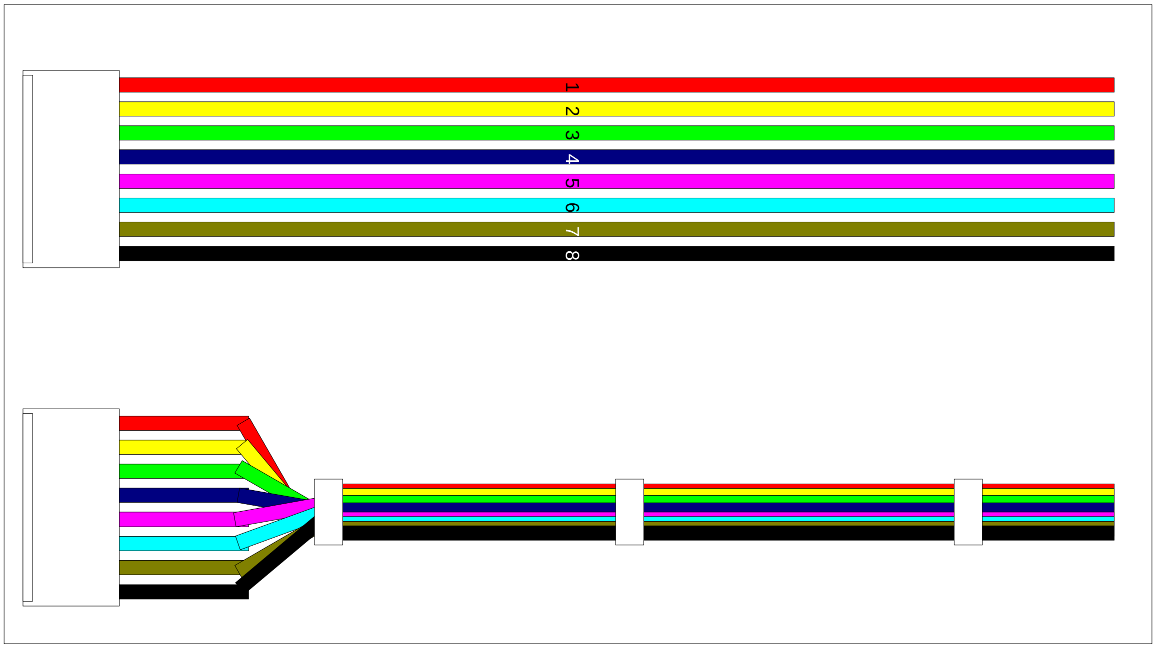


Figure 5-5: Assembled Cables

Once you've got all the wires into the housing, you can put a small collar onto the wires just above the housing. You may not want to add more at this time, because your wires will need to "fan out" in order to connect the all the disparate points they will connect to.

Once you've built your cables, you will find that soldering them to your strap-wired panel is a real cinch – very easy, and all the real work will be behind you.

Sooo……what cables need to be built and how many of them?

Following are a set of cable-tables (how cool is that?). The tables describe how many 8 wire cables need to be built, how many 6 wire cables, and so on. The tables also provide information as to which pin must be connected to what on the panel. The cables are named by the number the housing is assigned to – a "P" followed by a designation. The "P" means "plug", and the designation does have some useful information built into it as well.

The designation numbers come in two flavors – they either start with a 1 (such as P103) or they start with a 2 (such as P204).

Those designators that start with a 1 are "100 Series" designators. All of the 100 series designators will plug into the Digital Board. The number that follows the series designator is actually the board's designator as to which connector the plug will connect to. For example, P103 will plug into J3 of the Digital Board. P107 will plug into J7 of the Digital Board.

The 200 series designators will all plug into the Analogue Board. P204 will plug into J4 of the Analogue Board; P212 will plug into J12 of the Analogue Board and so on.

Table 5-1: Eight Wire Panel Cables

Plug/Cable Number	Pin Number/Panel Connections
P102	**Pin1 - External Load Jack (J312)*** Pin2 - Clock Enable Switch (SW339) Pin3 - Manual Load Switch (SW338) Pin4 - Random Reference LED (D322) Anode Pin5 - Center Tap Reference Level Pot (R317) Pin6 - Center Tap Random Input Level Pot (R318) Pin7 - 8X2/16X1 Switch (SW340) Pin8 - Random/Pattern Switch (SW341) ***If External Load Enable Option is installed:** **Pin 1 - External Load Enable Switch (SW345)**
P103	Pin1 - Bus 3 Common Connection Pin2 - Merge 2 Switch (SW334) Pin3 - Merge 1 Switch (SW333) Pin4 - Merge 3 Switch (SW335) Pin5 - Bus 1 Common Connection Pin6 - Clock LED (D321) Anode Pin7 - Bus 1 Load Switch (SW336) Pin8 - Manual Step Switch (SW337)
P104	Pin1 - Pattern Switch 8 (SW308) Pin2 - Pattern Switch 7 (SW307) Pin3 - Pattern Switch 6 (SW306) Pin4 - Pattern Switch 5 (SW305) Pin5 - Pattern Switch 4 (SW304) Pin6 - Pattern Switch 3 (SW303) Pin7 - Pattern Switch 2 (SW302) Pin8 - Pattern Switch 1 (SW301)
P105	Pin1 - Pattern Switch 16 (SW316) Pin2 - Pattern Switch 15 (SW315) Pin3 - Pattern Switch 14 (SW314) Pin4 - Pattern Switch 13 (SW313) Pin5 - Pattern Switch 12 (SW312) Pin6 - Pattern Switch 11 (SW311) Pin7 - Pattern Switch 10 (SW310) Pin8 - Pattern Switch 9 (SW309)
P108	Pin1 - Pattern LED 8 (D308) Anode Pin2 - Pattern LED 7 (D307) Anode Pin3 - Pattern LED 6 (D306) Anode Pin4 - Pattern LED 5 (D305) Anode Pin5 - Pattern LED 4 (D304) Anode Pin6 - Pattern LED 3 (D303) Anode Pin7 - Pattern LED 2 (D302) Anode Pin8 - Pattern LED 1 (D301) Anode

Plug/Cable Number	Pin Number/Panel Connections
P109	Pin1 - Pattern LED 16 (D316) Anode Pin2 - Pattern LED 15 (D315) Anode Pin3 - Pattern LED 14 (D314) Anode Pin4 - Pattern LED 13 (D313) Anode Pin5 - Pattern LED 12 (D312) Anode Pin6 - Pattern LED 11 (D311) Anode Pin7 - Pattern LED 10 (D310) Anode Pin8 - Pattern LED 9 (D309) Anode
P201	Pin1 - Gate Bus Switch 8 (SW324) Center Lug Pin2 - Gate Bus Switch 7 (SW323) Center Lug Pin3 - Gate Bus Switch 6 (SW322) Center Lug Pin4 - Gate Bus Switch 5 (SW321) Center Lug Pin5 - Gate Bus Switch 4 (SW320) Center Lug Pin6 - Gate Bus Switch 3 (SW319) Center Lug Pin7 - Gate Bus Switch 2 (SW318) Center Lug Pin8 - Gate Bus Switch 1 (SW317) Center Lug
P203	Pin1 - Gate Bus Switch 16 (SW332) Center Lug Pin2 - Gate Bus Switch 15 (SW331) Center Lug Pin3 - Gate Bus Switch 14 (SW330) Center Lug Pin4 - Gate Bus Switch 13 (SW329) Center Lug Pin5 - Gate Bus Switch 12 (SW328) Center Lug Pin6 - Gate Bus Switch 11 (SW327) Center Lug Pin7 - Gate Bus Switch 10 (SW326) Center Lug Pin8 - Gate Bus Switch 9 (SW325) Center Lug
P205	Pin1 - Programming Pot 8 (R308) Top Pin2 - Programming Pot 7 (R307) Top Pin3 - Programming Pot 6 (R306) Top Pin4 - Programming Pot 5 (R305) Top Pin5 - Programming Pot 4 (R304) Top Pin6 - Programming Pot 3 (R303) Top Pin7 - Programming Pot 2 (R302) Top Pin8 - Programming Pot 1 (R301) Top
P206	Pin1 - Programming Pot 16 (R316) Top Pin2 - Programming Pot 15 (R315) Top Pin3 - Programming Pot 14 (R314) Top Pin4 - Programming Pot 13 (R313) Top Pin5 - Programming Pot 12 (R312) Top Pin6 - Programming Pot 11 (R311) Top Pin7 - Programming Pot 10 (R310) Top Pin8 - Programming Pot 9 (R309) Top

Plug/Cable Number	Pin Number/Panel Connections
P207	Pin1 - Programming Pot 8 (R308) Center Pin2 - Programming Pot 7 (R307) Center Pin3 - Programming Pot 6 (R306) Center Pin4 - Programming Pot 5 (R305) Center Pin5 - Programming Pot 4 (R304) Center Pin6 - Programming Pot 3 (R303) Center Pin7 - Programming Pot 2 (R302) Center Pin8 - Programming Pot 1 (R301) Center
P208	Pin1 - Programming Pot 16 (R316) Center Pin2 - Programming Pot 15 (R315) Center Pin3 - Programming Pot 14 (R314) Center Pin4 - Programming Pot 13 (R313) Center Pin5 - Programming Pot 12 (R312) Center Pin6 - Programming Pot 11 (R311) Center Pin7 - Programming Pot 10 (R310) Center Pin8 - Programming Pot 9 (R309) Center
P209	Pin1 - Range Switch “Pole” Lug (SW343) Pin2 - Range Switch “Throw 2” Lug (SW343) Pin3 - Range Switch “Throw 3” Lug (SW343) Pin4 - Range Switch “Throw 4” Lug (SW343) Pin5 - Range Switch “Throw 5” Lug (SW343) Pin6 - Range Switch “Throw 6” Lug (SW343) Pin7 - Range Switch “Throw 7” Lug (SW343) Pin8 - Range Switch “Throw 8” Lug (SW343)

Table 5-2: Six Wire Panel Cables

Plug/Cable Number	Pin Number/Panel Connections
P110	Pin1 - Gate Bus 2 Trigger Jack (J301) Tip Lug Pin2 - Gate Bus 2 LED (D318) Anode Pin3 - Gate Bus 2 Gate Jack (J303) Tip Lug Pin4 - Gate Bus 1 Trigger Jack (J302) Tip Lug Pin5 - Gate Bus 1 LED (D317) Anode Pin6 - Gate Bus 1 Gate Jack (J301) Tip Lug
P111	Pin1 - Master Gate Bus Gate Jack (J308) Tip Lug Pin2 - Master Bus LED (D320) Anode Pin3 - Master Gate Bus Trigger Jack (J307) Tip Lug Pin4 - Gate Bus 3 Trigger Jack (J306) Tip Lug Pin5 - Gate Bus 3 LED (D319) Anode Pin6 - Gate Bus 3 Gate Jack (J305) Tip Lug
P212	Pin1 - Glide B Pot (R321) Center Tap Pin2 - Glide B Pot (R321) Top Pin3 - Glide A Pot (R320) Center Tap Pin4 - Glide A Pot (R320) Top Pin5 - Glide A+B Pot (R319) Center Tap Pin6 - Glide A+B Pot (R319) Top
P213	Pin1 - Optional Output A Jack (J311) Tip Lug Pin2 - Output A Jack (J317) Tip Lug Pin3 - Optional Output A+B Jack (J310) Tip Lug Pin4 - Output A+B Jack (J316) Tip Lug Pin5 - Optional Output B Jack (J309) Tip Lug Pin6 – Output B Jack (J315) Tip Lug

Table 5-3: Three Wire Panel Cable

Plug/Cable Number	Pin Number/Panel Connections
P112	Pin1 - Invert B Switch (SW342) Center Lug (Pole) Pin2 - Invert B Switch (SW342) Outside Lug Pin3 - Invert B Switch (SW342) Outside Lug

Table 5-4: Two Wire Panel Cables

Plug/Cable Number	Pin Number/Panel Connections
P113	Pin1 - Reference Level Pot (R317) Top Pin2 - Digital Ground Common Connection
P215	Pin1 - No Connection Pin2 - Analog Ground Connection
P216 (Optional)	**Internal Variable Range Option (Opt 1):** Pin1 - Variable Range Pot (R322) Top Pin2 - Variable Range Pot (R322) Center Tap **External Variable Range Option (Opt 2):** Pin1 - No Connection Pin2 - Variable Range Pot (R322) Center Tap **Internal/External Variable Range Option (Opt 3):** Pin1 - External Range Input Jack (J318) Switch Lug Pin2 - Variable Range Pot (R322) Center Tap **Internal/External Variable Range Option (Opt 4):** Pin1 - Int/Ext Var Range Switch (SW344) Outside Lug Pin2 - Variable Range Pot (R322) Center Tap

Power Supply and Board Interconnect Cables
While you're at it, this is the perfect opportunity to build the remaining cables – the cables used to connect the *electro-music* Klee PCBs together and the cable required to connect to the power supply itself.

The power supply cable is similar to the front panel connect cables – it has a housing on one end and (at this point) for wires hanging off of that.

Table 5-5: Four Wire Power Supply Cable

Plug/Cable Number	Pin Number/Panel Connections
P210	Pin1 - +V Pin2 - Analog Ground Pin3 - Digital Ground Pin4 - -V

The three board interconnect cables, however, have a housing on each end of the connector – they are the only three cables that have a housing on each end. These cables pass shift register data and power supply voltages between the two boards.

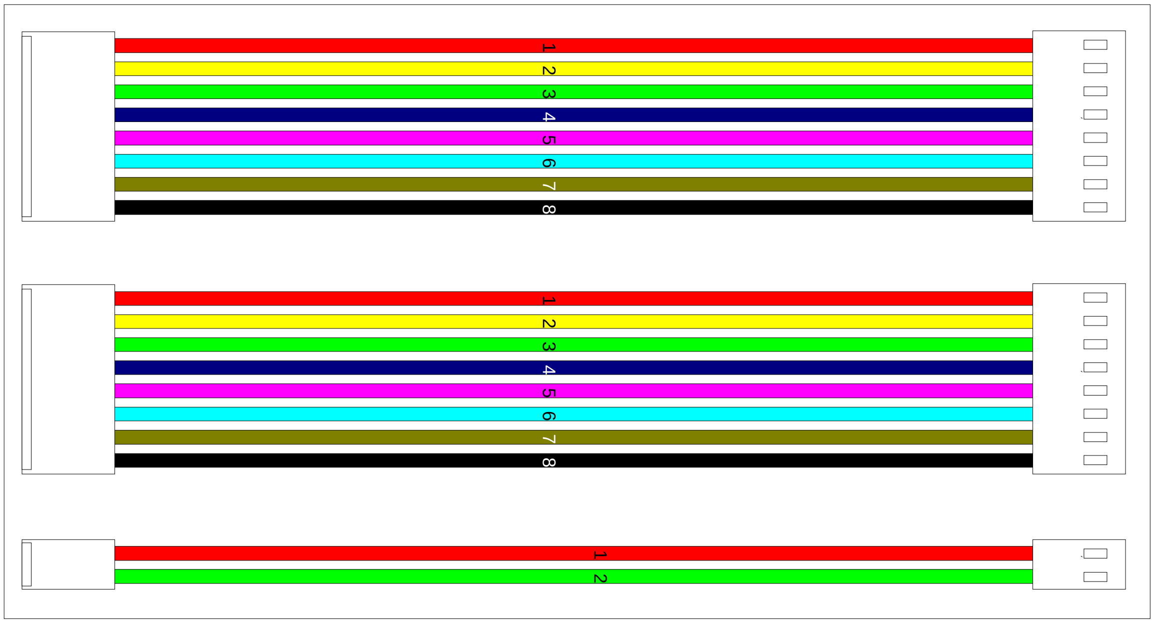


Figure 5-5: Board Interconnect Cable Assemblies

A bit of care should be taken when applying the housings to the PCB interconnect assemblies – make sure you don't get caught up in putting the housings on backwards or anything like that. Not that it's ever happened, you understand. But it could. It really could.

Remember that pin 1 of one housing must connect to pin 1 of the housing on the other side of the wire. The connectors on the PCBs all point in one direction (just as with all of the ICs). This makes things easy to identify which pin is pin 1 on the PCBs. It also means that, from the vantage point of the housings that plug into them, it requires you to remember that, when the "front side" of a housing is pointing to you on one end of the wire, the backside, with the slots, will be facing you when the cables are laid out straight in front of you.

Table 5-6: Eight Wire Board Interconnect Cables

Plug/Cable Number	Pin Number/Panel Connections
P106-P202	Pin1 - Register A Bit 8 Pin2 - Register A Bit 7 Pin3 - Register A Bit 6 Pin4 - Register A Bit 5 Pin5 - Register A Bit 4 Pin6 - Register A Bit 3 Pin7 - Register A Bit 2 Pin8 - Register A Bit 1

Plug/Cable Number	Pin Number/Panel Connections
P107-P204	Pin1 - Register B Bit 8 Pin2 - Register B Bit 7 Pin3 - Register B Bit 6 Pin4 - Register B Bit 5 Pin5 - Register B Bit 4 Pin6 - Register B Bit 3 Pin7 - Register B Bit 2 Pin8 - Register B Bit 1

Table 5-7: Two Wire Board Interconnect Cables

Plug/Cable Number	Pin Number/Panel Connections
P101-P211	Pin1 - Reference Level Pot (R317) Top Pin2 - Digital Ground Common Connection

Once all of the cables are put together, you'll notice you have a nice pile of cables. In that pile you will have:

13 eight wire cables with a single housing.
4 six wire cables with a single housing.
1 four wire cable with a single housing.
1 three wire cable with a single housing.
2 two wire cables with a single housing or 3 of them if you are installing any of the variable range options.
2 eight wire cables with housings at both ends (board interconnect).
1 two wire cable with housings at both ends (board interconnect).

Now comes the final step in building your panel – wiring these cables to the panel components.

6. Installing the Panel/PCB Connection Wiring

The Final Panel Assembly Step

This chapter of the *electro-music* Klee Sequencer Build Instruction finishes up all of the major panel work, which, as mentioned before, is where the real work in building the Klee Sequencer truly is.

For Those Not Using the Plugs and Headers
If you have decided to wire up the panel with point-to-point wiring, eschewing the use of headers, etc, this chapter will serve as your guide where to solder the wires to the Klee PCBs. As it's covered in the cable assembly chapter, which you probably didn't read because you don't intend to build cables, the plug numbers (P numbers) will tell you where on which board to solder the wires. However, this information has been added to the wiring diagrams – below the plug number is the connector number (J) and the board on which the connector is located. Remember, on the boards, pin 1 for each connector is a square pad, and the pin numbers count sequentially from there.

Wiring Diagrams
The wiring diagrams assume that the panel has already been strap wired. Some connections may not jibe directly as illustrated with what you have already strap wired – for example, you may have strap wired to the top rear terminal of an SPST ON-OFF switch as opposed to the bottom – don't worry about those differences. As described earlier in the panel mounting section, which terminal is connected on those switches doesn't matter, as long as the switch is oriented in the right direction in relation to the panel legend.

The illustrations cover each plug separately – you can follow through with each illustration and wire them up accordingly. Pay very close attention to the plug pin numbering as opposed to what you're wiring up – things aren't all that sequential, so don't get caught up in assuming they are!

It is a <u>very good idea</u> to label your plug/ housings once the cable is wired to the panel. You will thank yourself profusely later if you do that now. There are so many of them, when the time comes to plug everything into the boards, you will find yourself having to trace through the connections to see which plug is which. Use a sharpie or some other method to mark the plugs "P208", "P105", etc. In fact, mark both sides of them so they can be identified from any angle.

At this point, all of your cables will be housings that have an amount of wire attached to them. Hopefully you left enough length in the wires to “reach” from between the panel to where the boards will be situated. Before you solder each cable onto the panel, stretch the wires between the board locations and the panel components they will solder to. Leave enough “slack” on the wires so that there is no strain pulling on the connectors. When you’re sure that each wire has ample length to reach the boards (and the connectors on the boards!), cut them to size.

After you have cut each wire on the cable, strip and <u>tin</u> the ends of the wires that will connect to the panel components. Strip them about 1/4” from the end of the wire (that’s around 6.5 mm).

Again, take care that you don’t overheat the panel components as you solder. Pay particular attention to soldering the switches and LEDs.

All connections to the LEDs will be to the anode of the LED. Strap wiring should by now have taken care of all of the cathode connections. Solder onto the anode about 1/4” to 1/2” (6.5 mm to 13 mm) from the body of the LED and snip off the excess length of the anode.

One final thing – all connections are illustrated as you would be looking at them on the rear panel – that shadowy nether world of nearly-everything-is reverse.

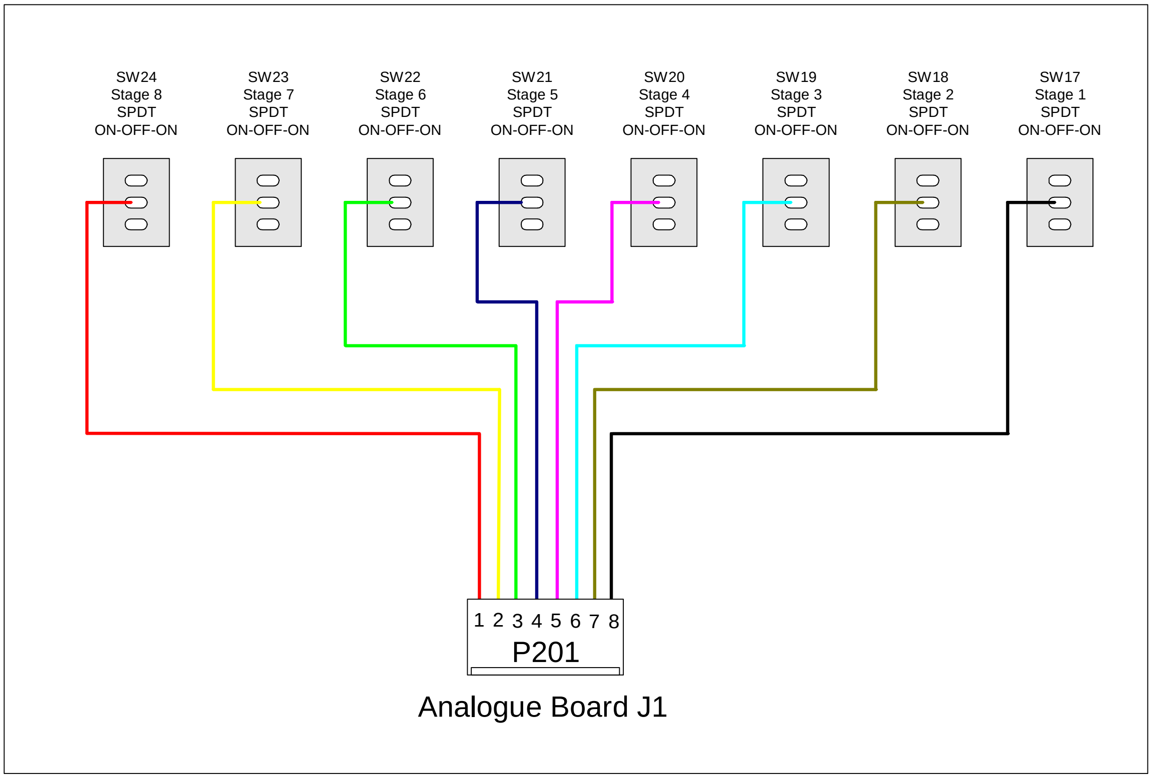


Figure 6-1: P201 Gate Bus Switch Connections

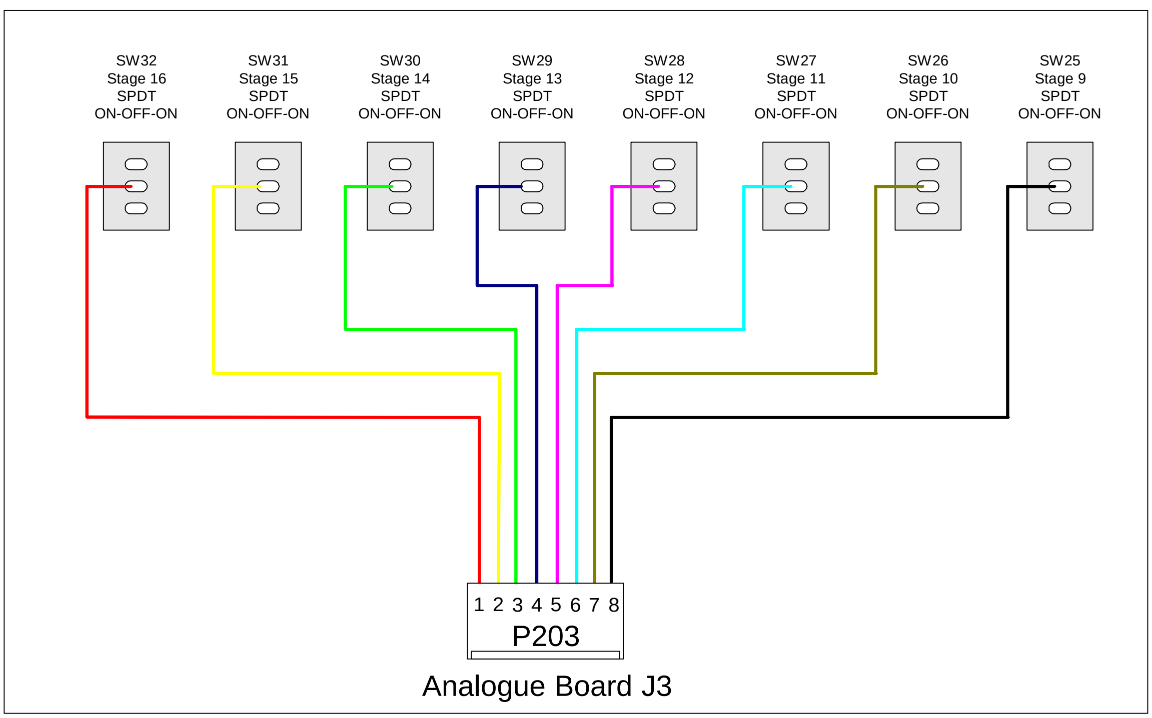


Figure 6-2: P203 Gate Bus Switch Connections

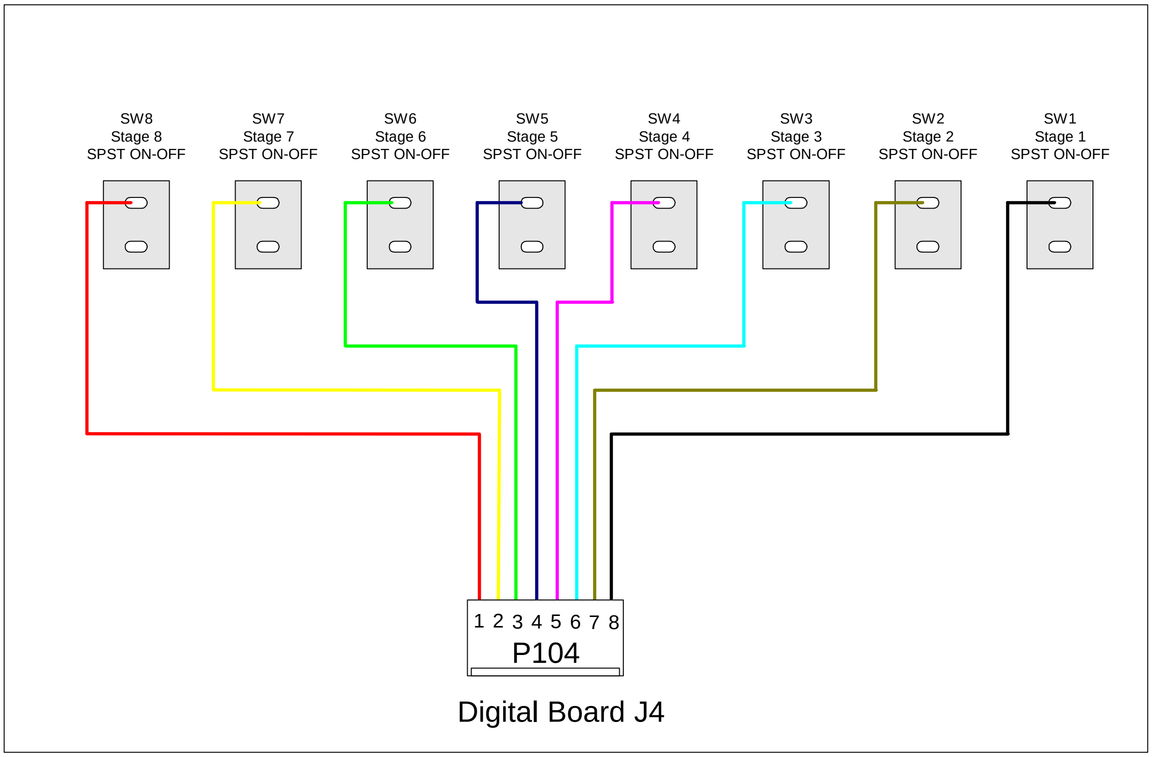


Figure 6-3: P104 Pattern Switch Connections

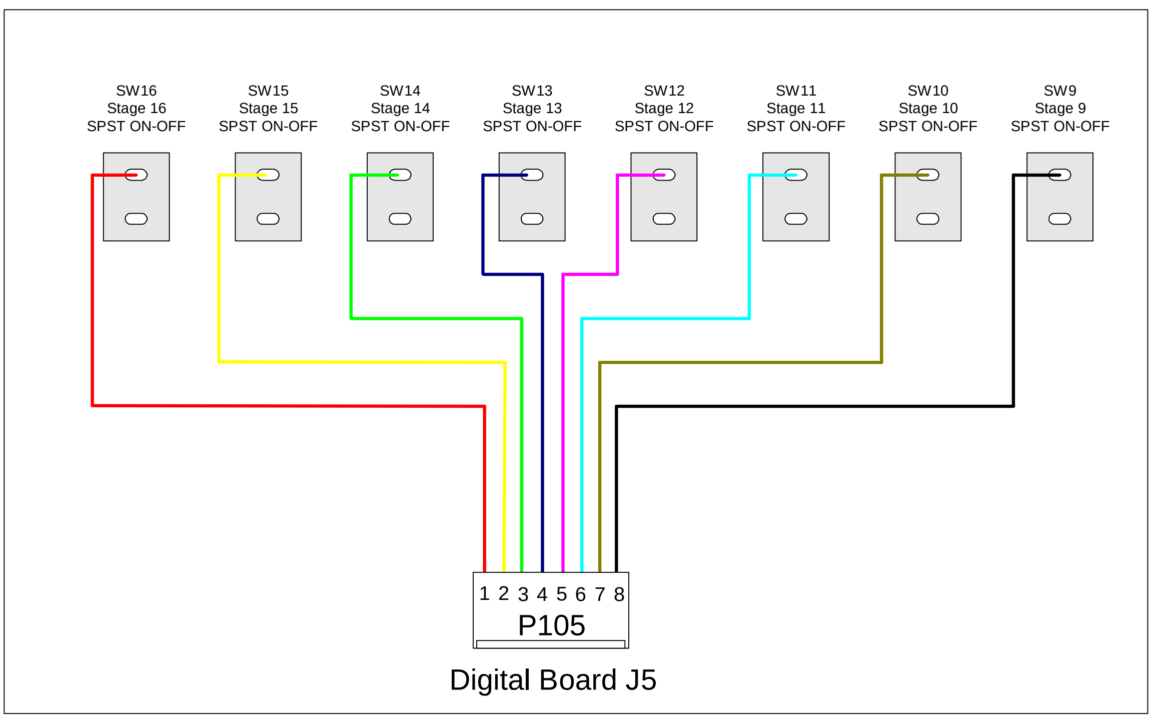


Figure 6-4: P105 Pattern Switch Connections

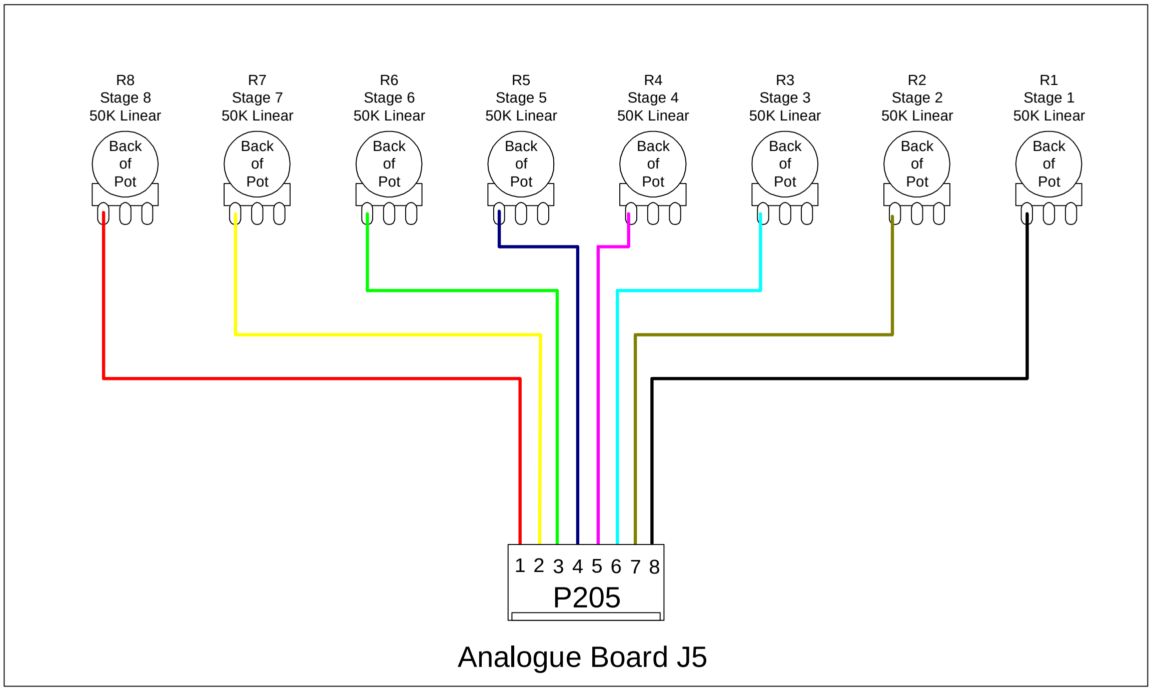


Figure 6-5: P205 Programming Pot Connections

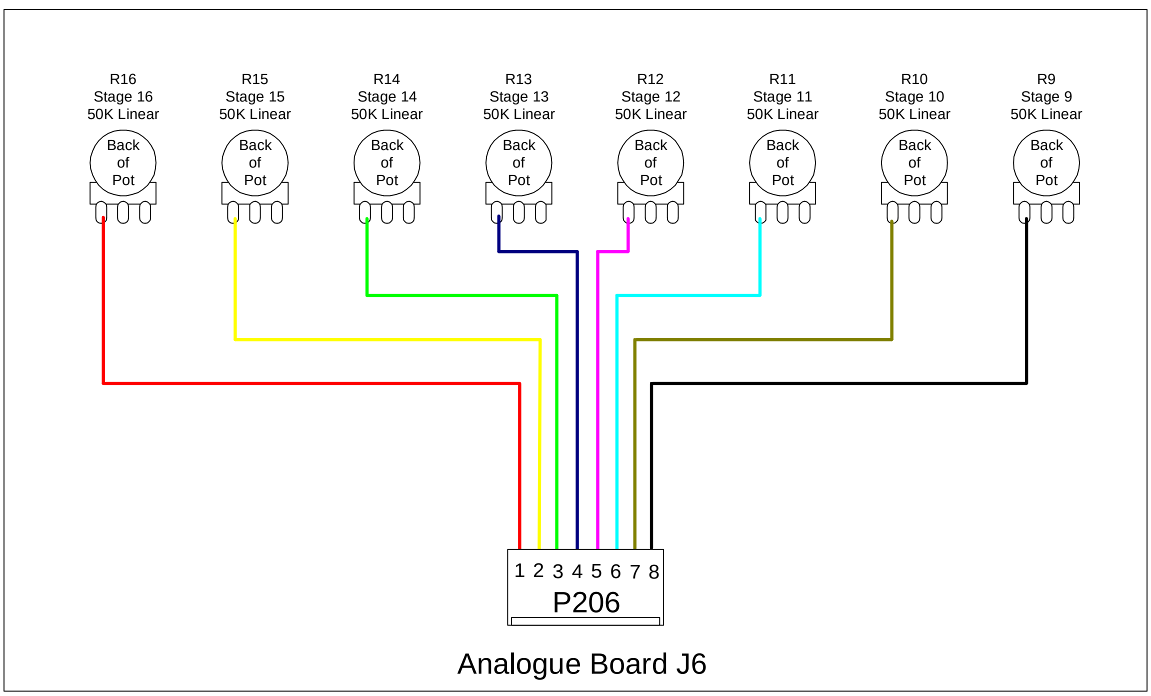


Figure 6-6: P206 Programming Pot Connections

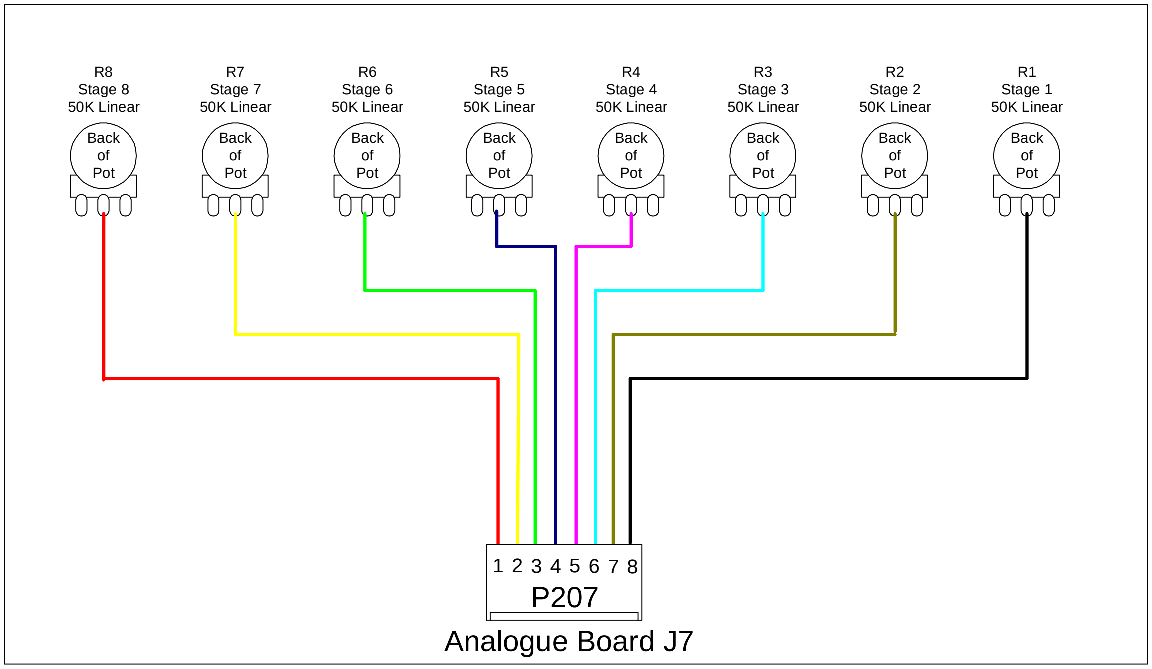


Figure 6-7: P207 Programming Pot Connections

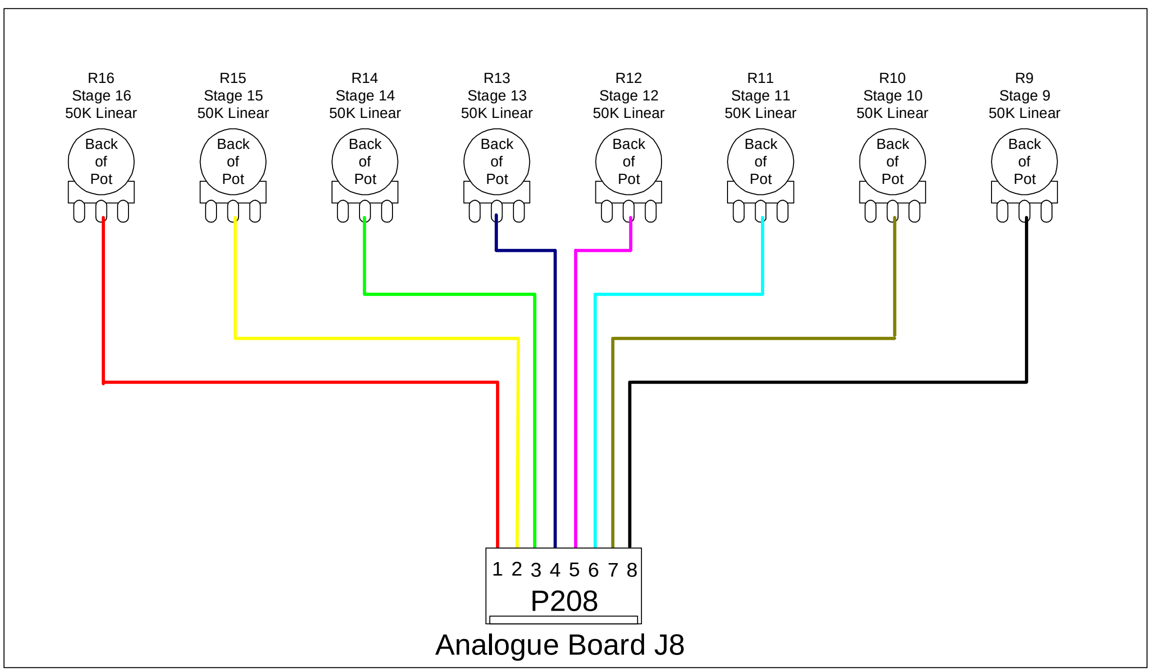


Figure 6-8: P208 Programming Pot Connections

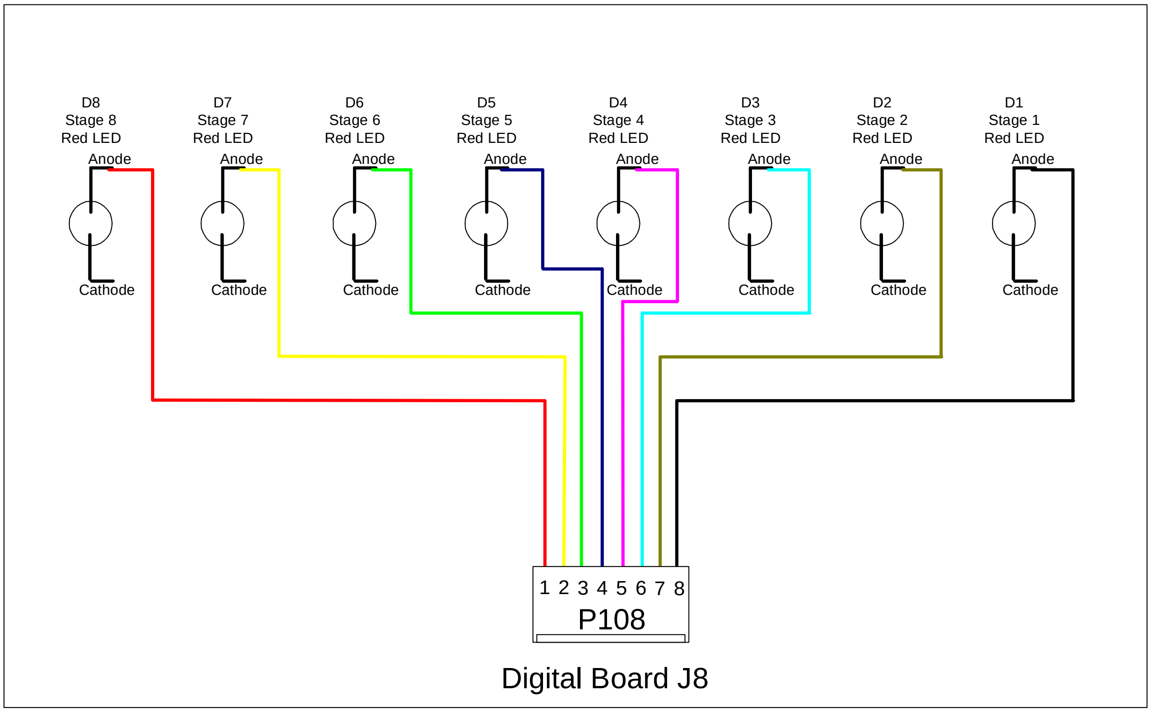


Figure 6-9: P108 Pattern LED Connections

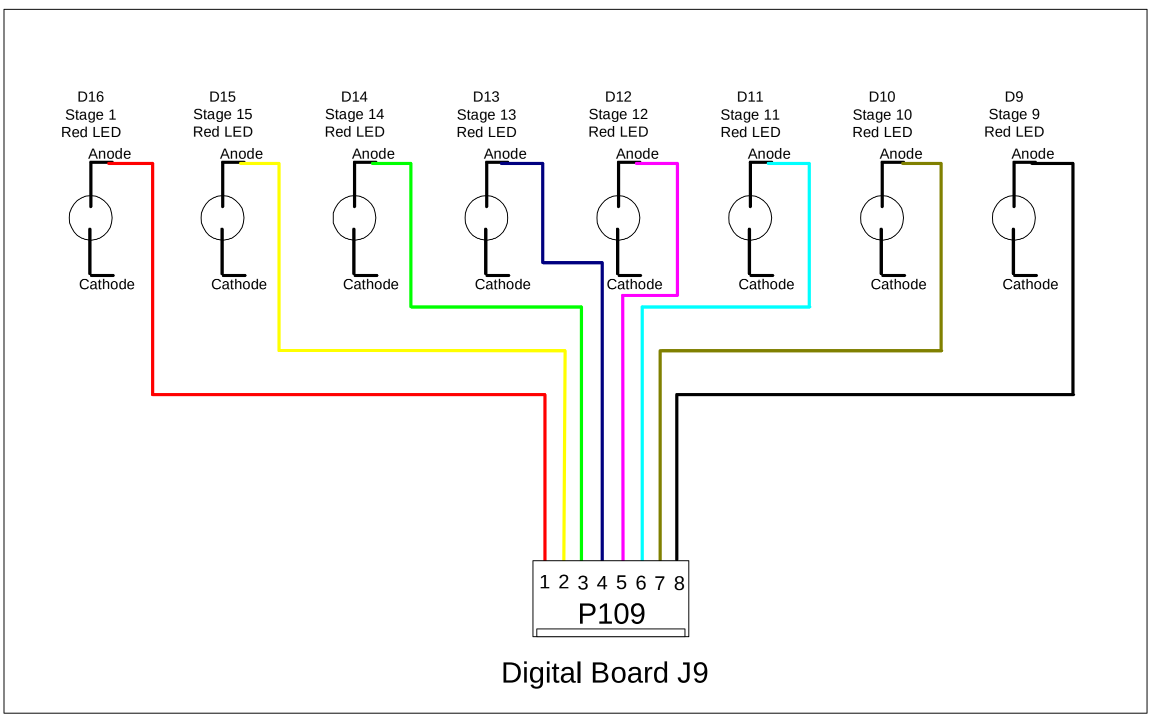


Figure 6-10: P109 Pattern LED Connections

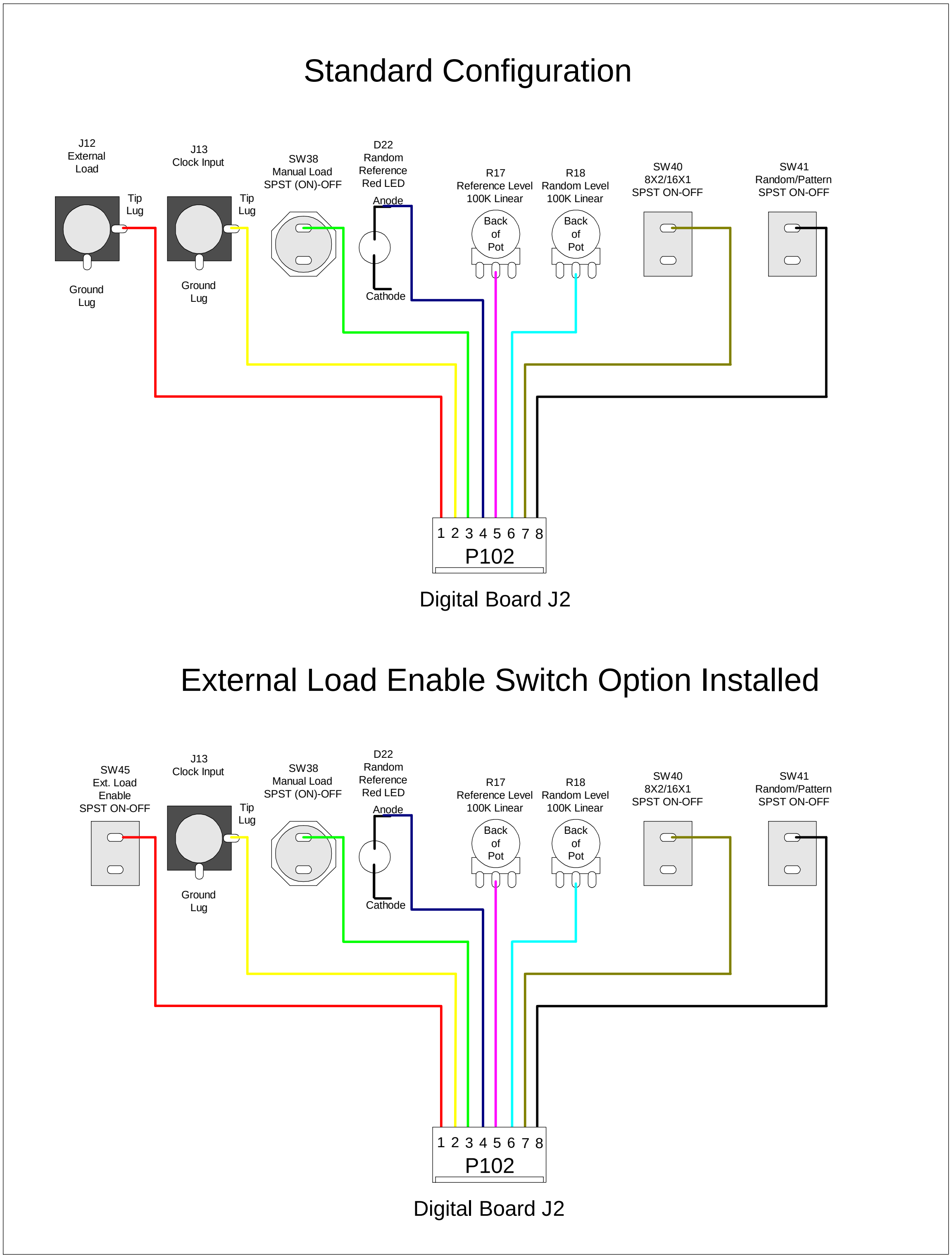


Figure 6-11: P102 Connections

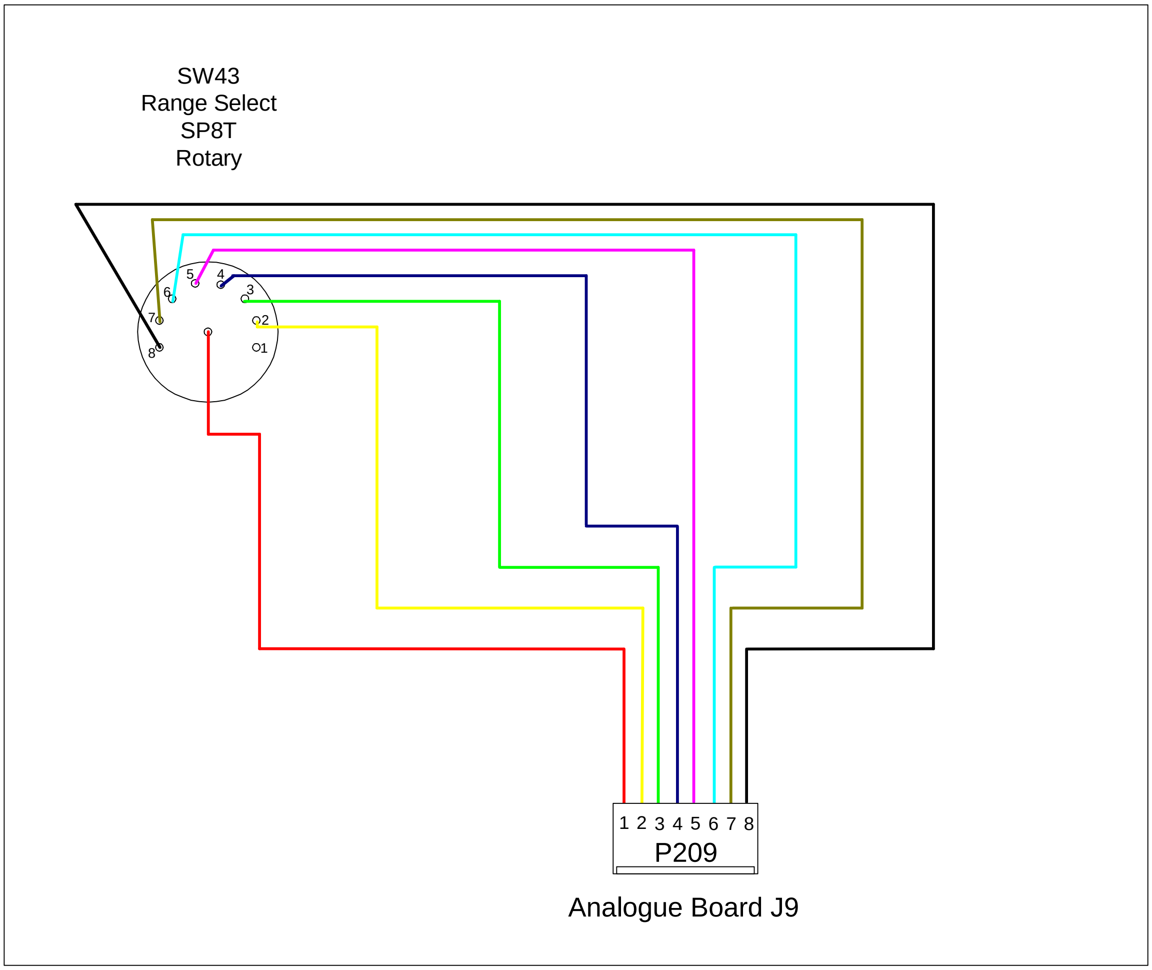


Figure 6-12: P209 Rotary Switch Connections

Rotary Switch Notes
The rotary Range Select Switch wiring diagram most likely does not reflect the choice you have made for your rotary switch. Generally, if you're like the rest of most of the known universe, you purchased a twelve position rotary switch and had to configure it so that it would turn through only eight positions. So, on the back of your switch, there are probably twelve pins around the outside of the switch, and one pin in the middle, instead of the eight pins around the outside of the switch shown here.

That is, of course, fine. Just remember, like everything else in Bizarro Rear Panel World, the pin assignments will work backwards. Make sure you verify which pins are selected (shorted to the center "pole" pin) with each position.

As a reminder - nothing is connected to the pin that is selected in position 1 of the rotary switch. A good way to remember it is pin 1 of the plug connects to the center pole connection, and pins 2 through 8 connect to switch pins of the same number.

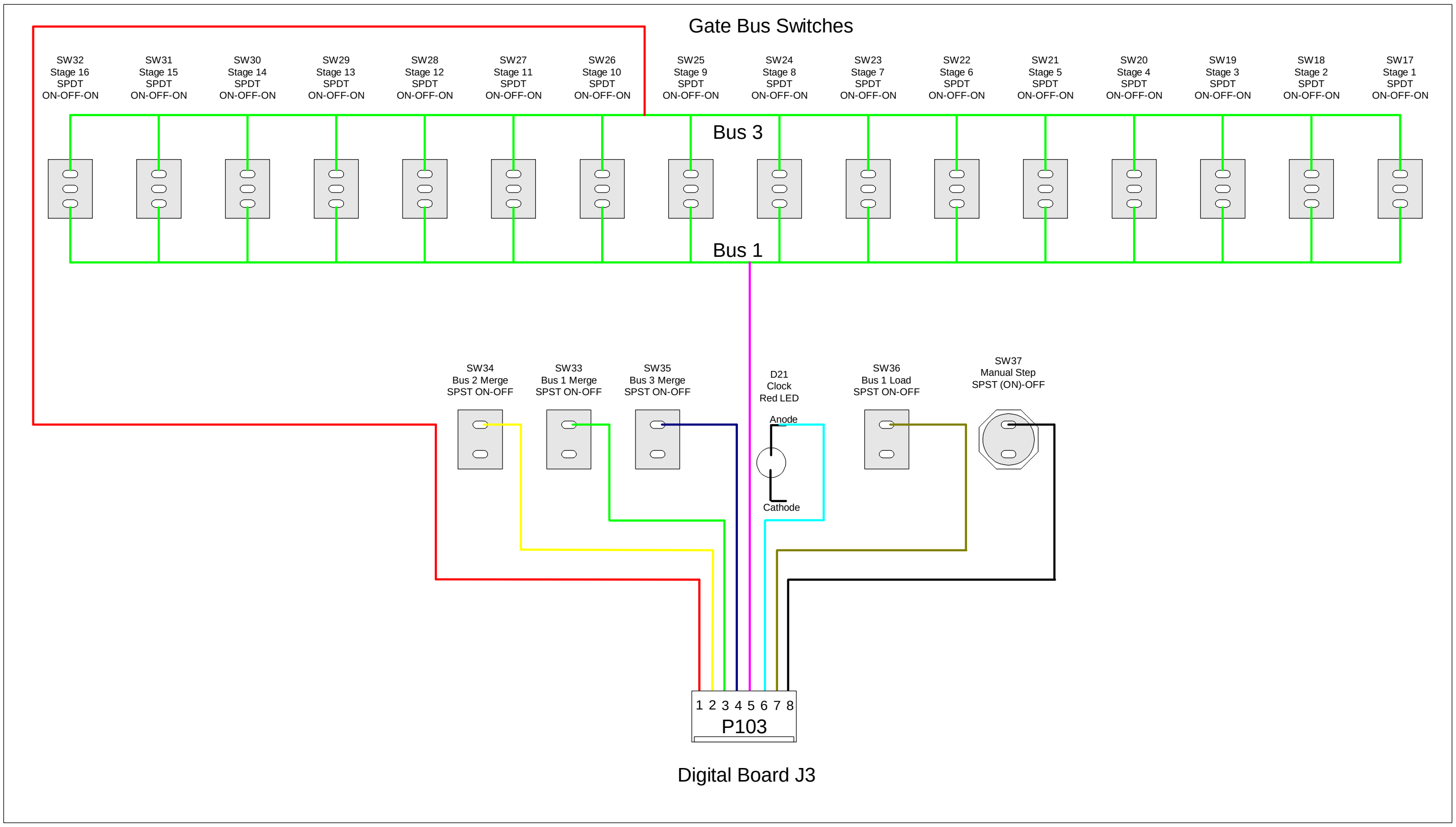


Figure 6-13: P103 Connections

A Note About P103 (Digital Board J3) Connections

You'll notice that pin 1 of P103 connects to the common connection of Bus 3, which should have been wired up when the panel strap connections were installed. The same is true of pin 5, which connects to the common connection of Bus 1. This diagram illustrates the connection if your gate bus switches choose Gate Bus 1 when the switch lever is pointed up, and Gate Bus 3 when the switch lever is pointed down.

If, for some reason, your panel legend is reversed (lever up is Gate Bus 3 and lever down is Gate Bus 1) simply reverse those connections to match.

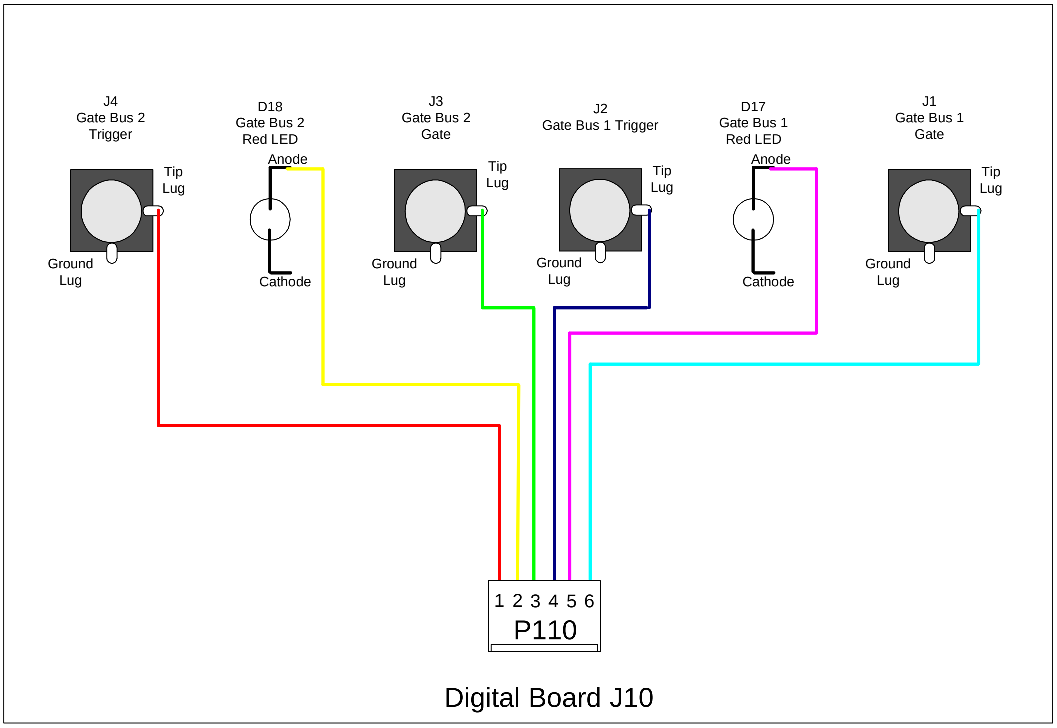


Figure 6-14: P110 Connections

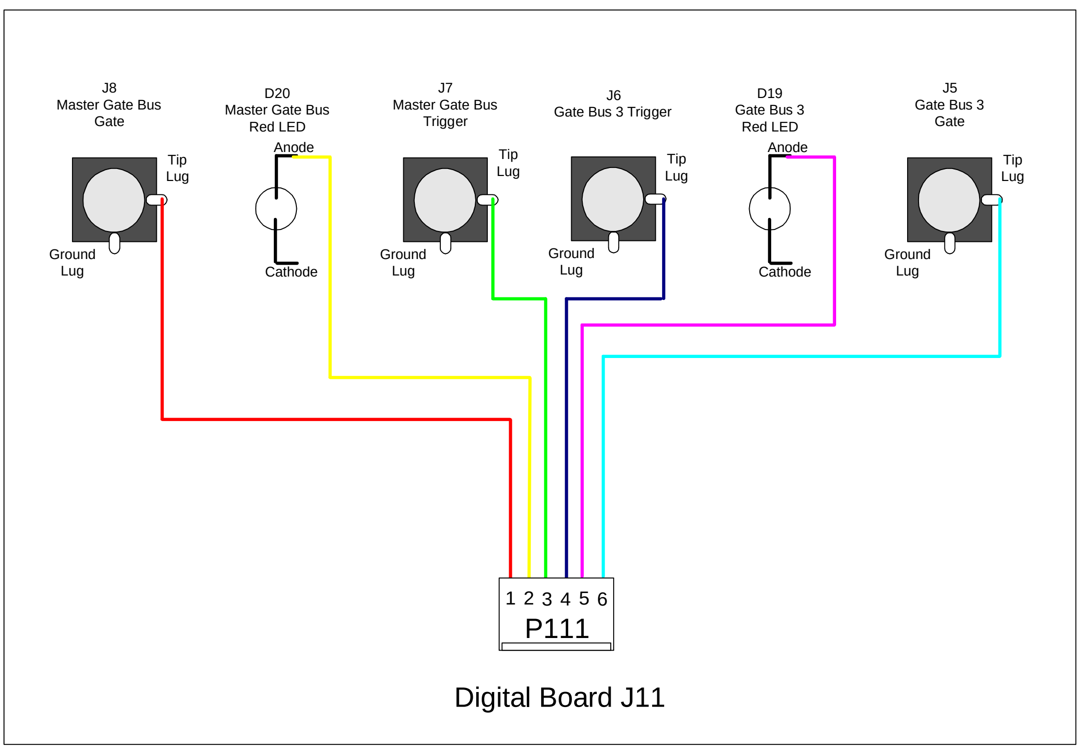


Figure 6-15: P111 Connections

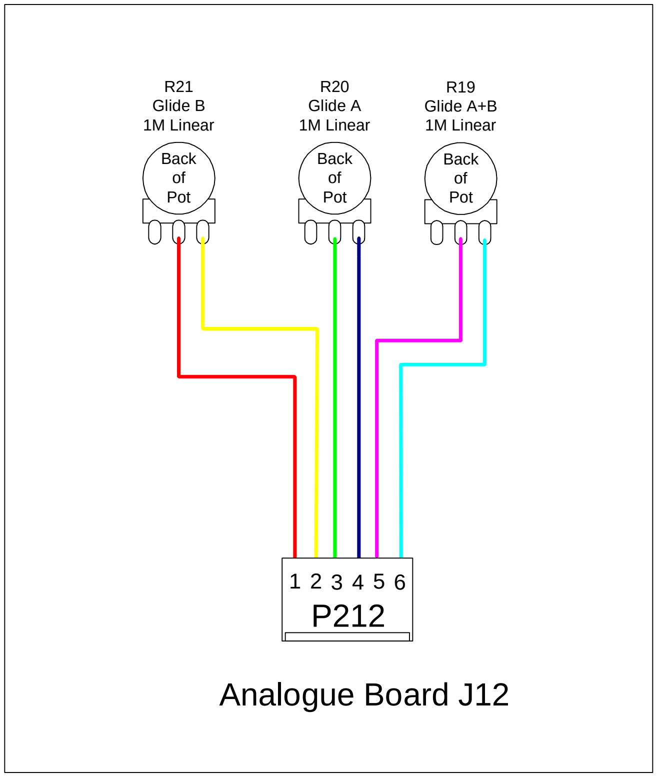


Figure 6-16: P212 Connections

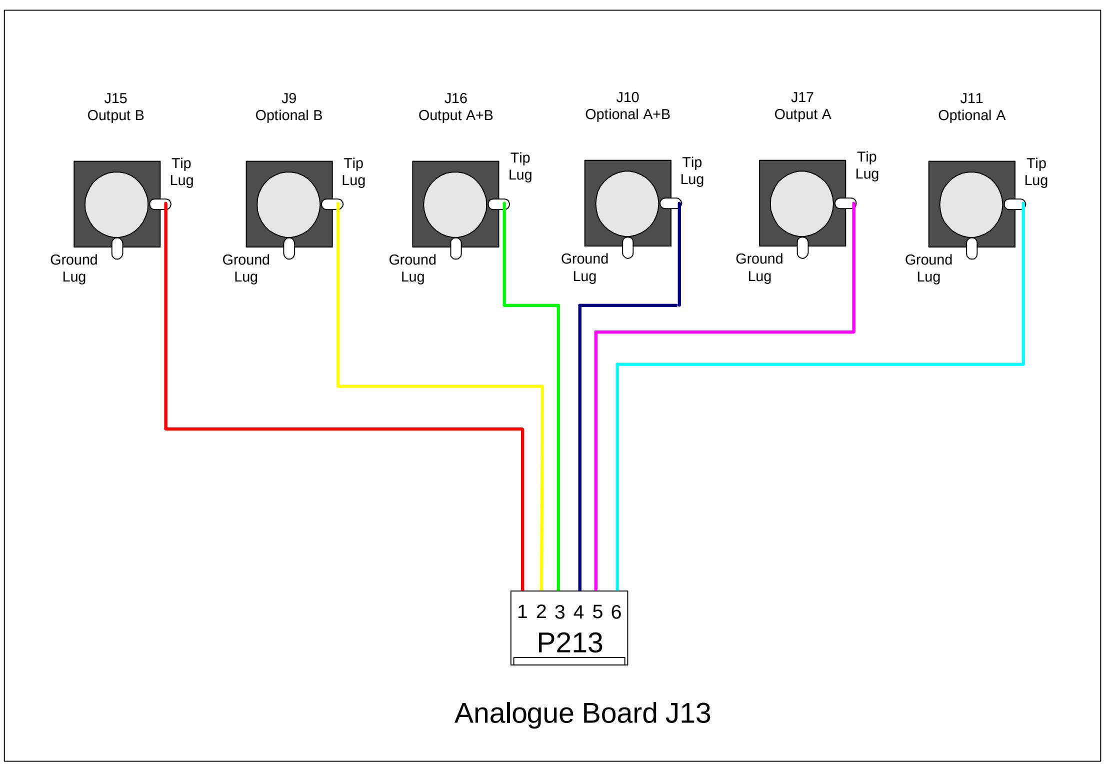


Figure 6-17: P213 Connections

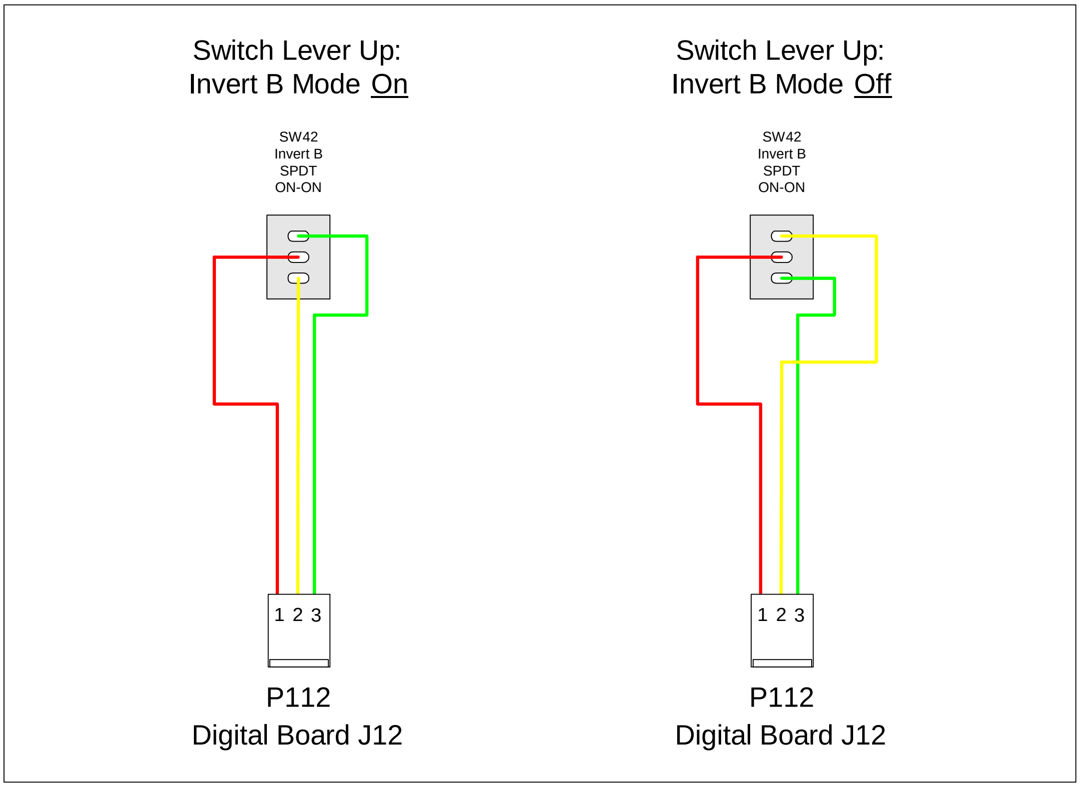


Figure 6-18: P112 Connections

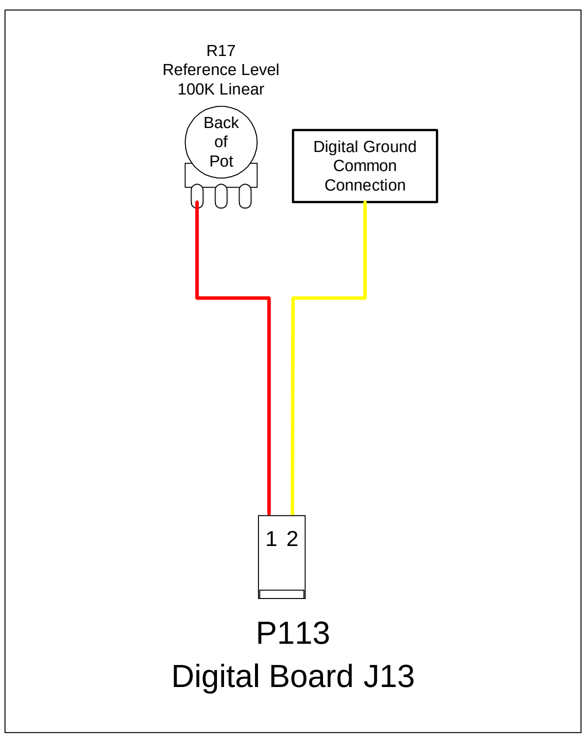


Figure 6-19: P113 Connections

The Digital Ground connection from P113 should connect to a single point on the Digital Ground system installed during the front panel strap wiring process. Ideally, a central point of connection would be a good place to connect the wire. For example, perhaps on the Digital Ground line connecting the pattern switches or pattern LEDs together.

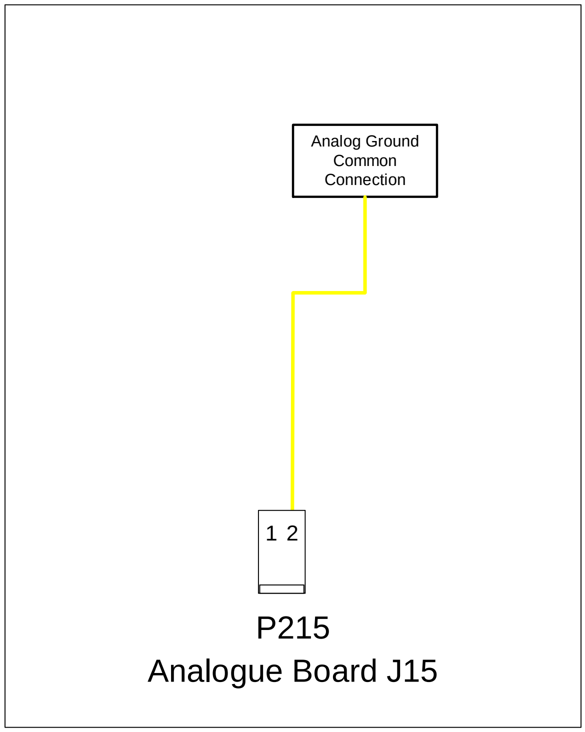


Figure 6-20: P215 Connections

The Analog Ground of P215 (which is the only signal carried by P215) should connect to a single point on the strap-wired analog ground system of the front panel. Again, a good place would be centrally located – perhaps on the analogue ground of the programming pots.

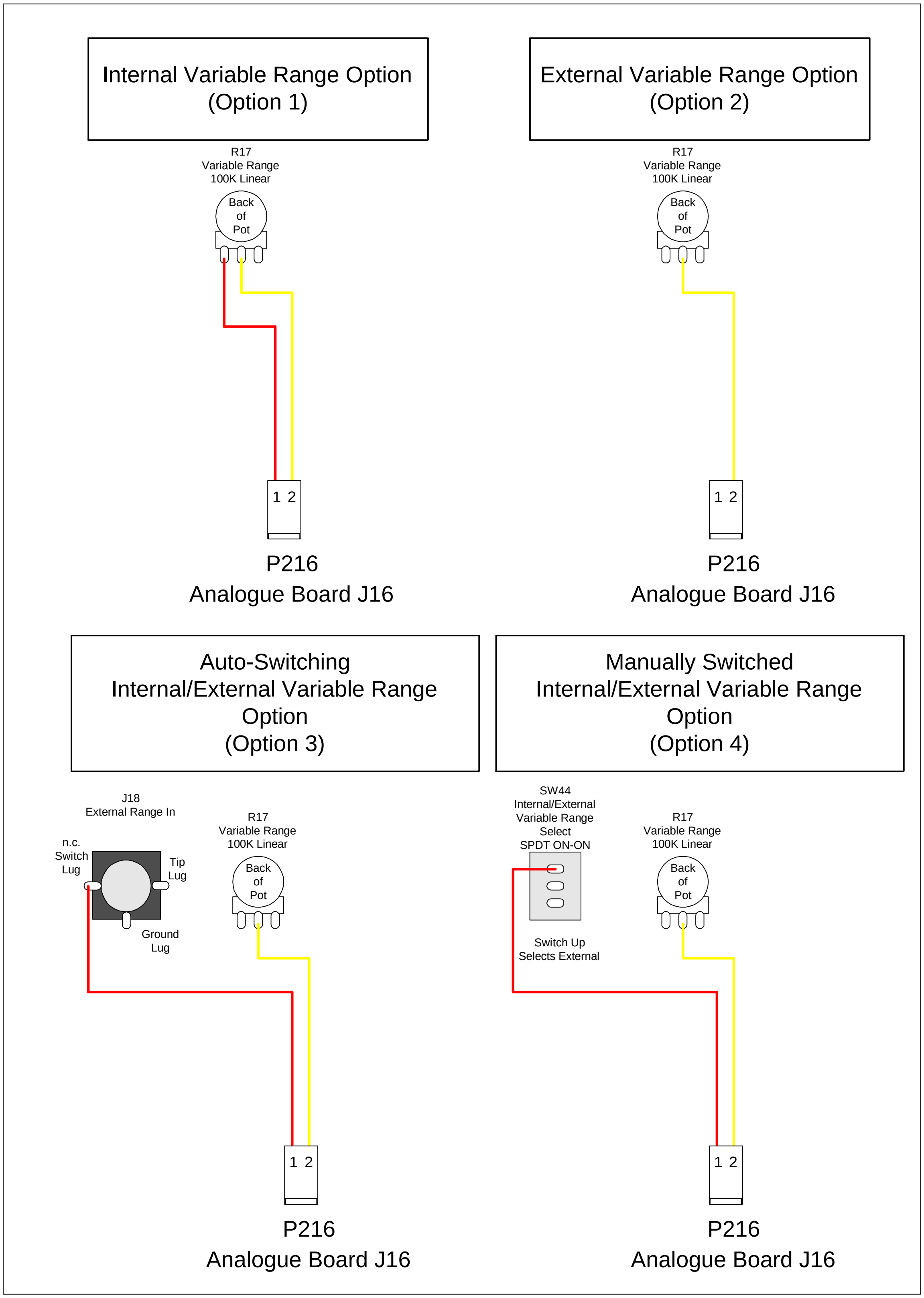


Figure 6-21: P216 Connections (Optional)

P216, of course, is only used if one of the Variable Range options is installed. The connections shown here assume the strap wiring is finished for the option already. For example, Option 3 assumes the tip lug of J18 is already connected to the top of R17. Option 4 assumes the center lug (pole) of SW44 is connected to the top of R17, etc. These connections are illustrated in figures 4-15 and 4-16 in Chapter 4. Of course, the Analogue Ground connections with these options are also assumed in the diagrams.

Option 4 is shown as External Range being selected with the switch in the up position (and Internal Range is selected in the down position). For External Range to be selected in the down position and Internal Range in the up position, simply wire the connection from Pin 1 to the opposite terminal (refer to Figure 4-16).

Once the cables are installed, take the time to neaten them up – twist them up into single cables, or tie wrap them together. Are the plugs labeled? If not, go through and label them. Snip any LED leads that may be too long. Maybe go through and check your switches.

Congratulations. The most work-intensive phase of the project is over. If you are using the housings and headers, this is especially true. Once the PCBs are stuffed and you have a power supply ready to go, all you will need to do is plug these cables into the boards, plug the boards together, plug the power supply in and you'll be ready to verify everything works, calibrate, then Klee away to your heart's content.

Put your panel away, roll up your shirtsleeves, fire up the soldering iron and get ready for stuffing the PCBs. You're close to completion.

7. Building The Boards

The *electro-music* Klee Sequencer PCB Set

The PCB set consists of two boards, as the word "set" would seem to indicate. One board, with the bulk of the analog functions is labeled the "Analogue Board". The other board, which contains the bulk of the digital functions, is called the "Digital Board".

The two boards interconnect between each other, the power supply, and the front panel to form the *electro-music* Klee Sequencer. Before you start slapping parts on them and jamming solder onto the leads, you should first read at least this first section so that you know which parts you want to slap onto the boards and jam solder onto the leads. Remember – there are a couple of options that will determine what goes in and what stays out.

Digital Board Parts Considerations
The Digital Board is fairly straightforward as to which parts are installed onto it. The only section that makes a difference would be the gate bus resistors. These resistors determine the output level of the gate and trigger signals the Klee will produce. You, the builder and owner of the Klee may have a preference as to these levels. The Klee will produce either 5V range gate and trigger signals or 10V range gate and trigger signals. The values used for these resistors will determine what gate/trigger voltages you end up with. There are no jumper wires that need be installed on the Digital Board.

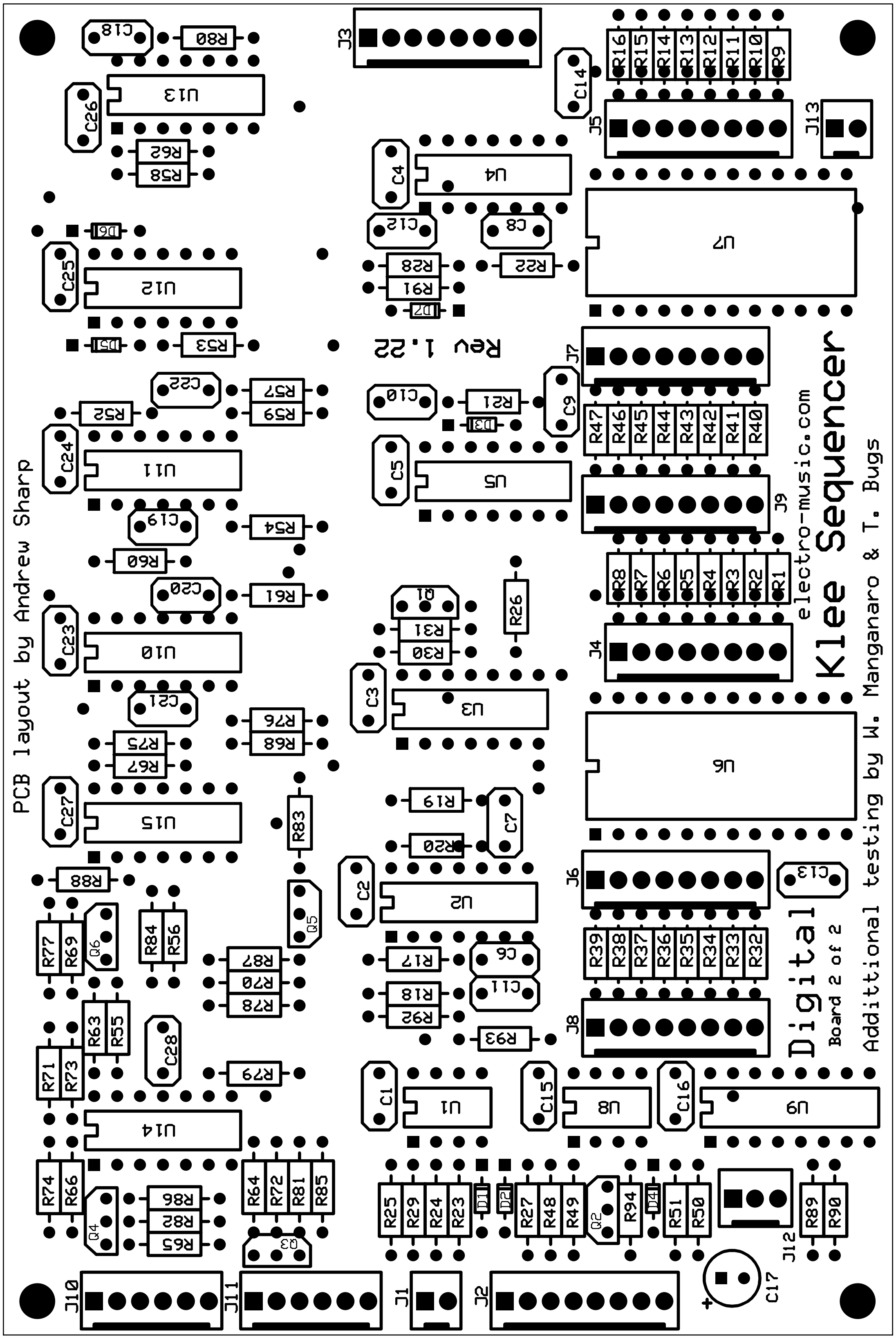
Analogue Board Parts Considerations
The Analogue Board is the board involved with the Variable Range options discussed throughout this text. If you have decided not to include any of the variable range options in your Klee, then you will need to install all of the trim pots and a jumper. There is a connector that need not be installed, as well as a diode.

If you have decided to include any of the Variable Range options, there is a jumper that is *not* installed, a trim pot that is *not* installed, and a connector and diode that *are* installed.

In addition to the Variable Range Option consideration, another jumper is installed or not, depending on if your power supply has one or two ground connections available.

That's it for the planning stages – let's get to putting those boards together!

Figure 7-1: The *electro-music* Klee Sequencer Digital Board



Steps to Soldering Parts to the Digital PCB

Grab the Digital PCB and get ready to begin soldering. You can tell which PCB is the Digital PCB, because it has "Digital" silk-screened upon it. How 'bout that?

Headers

The best place to begin is by soldering the header connectors to the boards (if you plan to use the connectors that is – if you don't plan to use the connectors and are going to hardwire the interconnections <u>**don't**</u> install the connectors – this is where your wires will be soldered). The connectors are, of course, the parts with the "J" reference designator.

Putting in the connectors first will ensure they fit and are seated flatly. There are a lot of components on this board, and if you should install other parts first, they may come close enough to where the connectors are installed, they may prevent the connectors from seating flatly on the board.

Make sure, when you solder in the connectors, they do indeed sit flatly on the board, not jutting at some obscene angle like a badly rooted incisor. A handy, if somewhat potentially painful method of doing this, is to put a dab of solder on the tip of your iron, place the jumper into position, and, while holding it, anchor one pin down with your dab of solder. The painful part is, if you're touching that pin you're dabbing the solder to, it will become hot and trigger a curse response from deep within your oral cavity. After the connector is held in place by this modest bit of solder, solder the other pins in, then make sure this original pin has enough solder as well. Bandage your finger (if required) and move on.

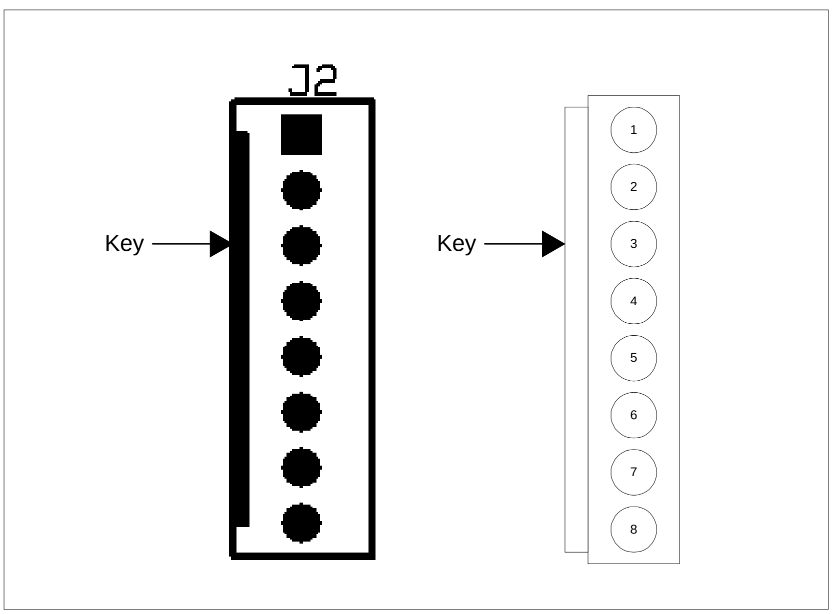


Figure 7-2: Orientation of PCB Header Connectors

When you seat the headers, make sure they are oriented in the right direction!! There is a pin 1 to each header, and that is indicated by a square pad. The silkscreen also displays which side the header's key should be aligned on.

8 Pin Headers		
Quantity	**Designators**	**Done**
8	J2-J9	

6 Pin Headers		
Quantity	**Designators**	**Done**
2	J10-J11	

3 Pin Headers		
Quantity	**Designators**	**Done**
1	J12	

2 Pin Headers		
Quantity	**Designators**	**Done**
2	J1, J13	

IC Sockets
Once all of the header connectors are installed, go ahead and put in the IC sockets. Again, make sure they sit flat and level on the surface of the PCB. The same trick can be used to "tack" the IC sockets down before soldering the rest of the pins. In this case, solder two pins in opposite corners of the socket. Though it's a bit more difficult to do, you still have the opportunity to burn the finger that is holding the socket flat, so be sure to do that. Van Gogh suffered the pain of removing an ear in the name of love or art, so what's a burned finger in the grand scheme of things?

Again, your IC sockets will probably be keyed to go in a certain direction, telling you which way to install the IC (when the time comes). Be sure to install them pointing in the right direction. As a point of interest, you'll notice the intrepid board designer designed the Klee PCBs with all of the ICs and connectors in the same direction, where pin 1 is pointed to the "top" of the board. That makes this task, and later assembly, much less complicated than it could have been, had the designer possessed the slightest of truly mean streaks.

Though they don't appear on the schematics and prints, the IC socket reference designators begin with "X". X6 is the socket U6 plugs into, X4 is the socket U4 plugs into, and so forth. Note that all of the sockets, with the exception of X6 and X7, are the standard "narrow" sockets. X6 and X7 accommodate the fat, cockroach sized CD4034s.

24 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
2	X6, X7	0.6”	

16 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
1	X9	0.3”	

14 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
10	X2-X5, X10-X15	0.3”	

8 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
2	X1, X8	0.3”	

Resistors

Now is the time to install the resistors. Before we even “go there”, we should first consider what level the gate bus gate and trigger signals will be. And then, we’ll install those resistors first and have all of that sordid business behind us.

There are sixteen resistors that determine this now much ballyhooed level. Eight of them should be of a single value, and the other eight should be of a different single value. The resistors, grouped by eight, are R63 through R70 and R71 through R78.

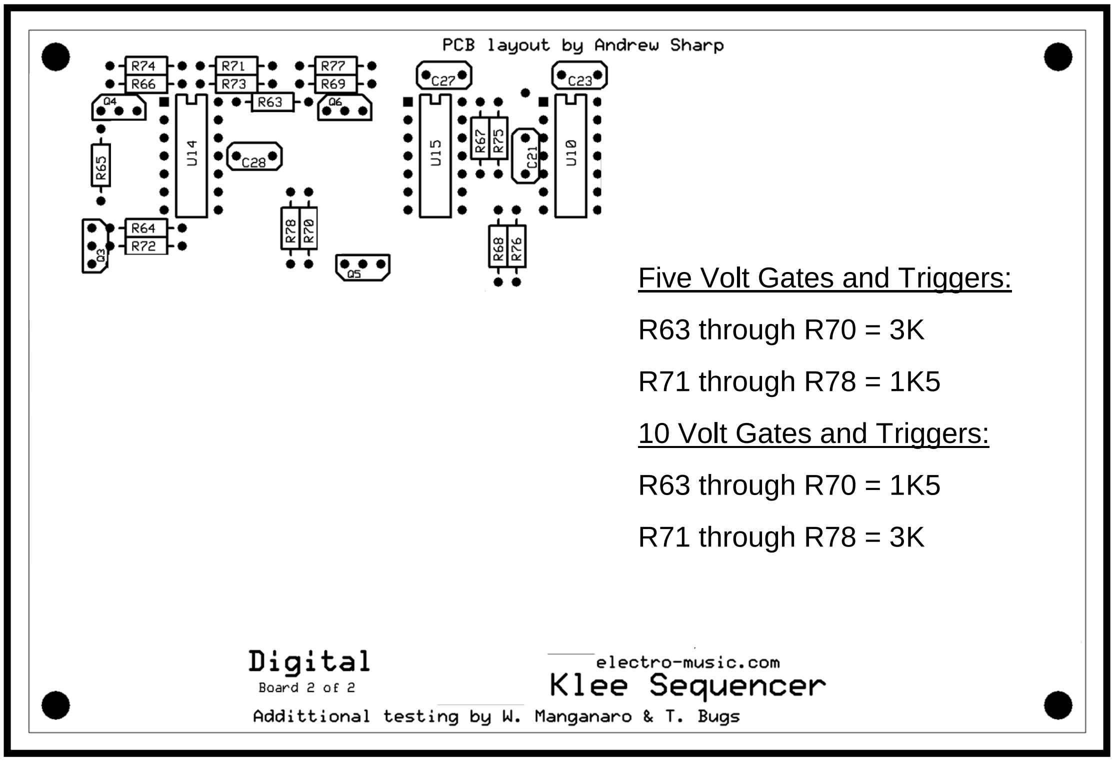


Figure 7-3: Standard Gate Bus Resistor Locations and Values

The Gate Bus Resistors are shown in 7-3, along with a few landmark transistors, ICs and capacitors. They're located in the upper left corner of Digital PCB. As the illustration states, for 5V range gates and triggers, R63 – R70 should be 3K, and R71 through R78 should be 1K5.

For 10V range gates and triggers, R63 – R70 should be 1K5 and R71 – R78 should be 3K. Note that this is for **15V operation only**. For 12V operation, the values will have to be different yet.

These values provide a 1K output impedance. Note that the terms "5V range" and "10V range" are used here. The actual voltages these resistor combinations will produce are 4.5V and 9V respectively. During prototype testing, these values were found to be compatible with all the equipment the Klee was interfaced to.

If this is still a concern to you, the values of 2K6 for R63 – R70 and 1K5 for R71 – R78 will produce voltages within 10 mV of 5V. They will have an output impedance of 951 Ohms, within 5% of 1K.

Values of 1K3 for R63 – R70 and 3K6 for R71 – R78 will produce voltages within 10 mV of 10V. They will provide an output impedance of 955 Ohms, which is within 5% of 1K.

If you are operating from 12V supply rails, then a value of 2K for R63 – R70 and 2K for R71 – R78 will produce 5V levels. This will provide a 1K output impedance.

For 12V operation, a value of 1K for R63 – R70 and eliminating (not installing) R71 – R78 will produce 10V level signals with an output impedance of 1K.

But, again, we found that the standard interchangeable values of 1K5 and 3K provided the adequate level of gates and triggers to interface with our other equipment.

Now, after all that, go ahead and install your gate bus resistors. Install all eight of the resistors R63 – R70, then install all eight of the resistors R71 – R78.

After installing the gate bus resistors, install the rest of the resistors. Perhaps the best method is to gather all of the 100K resistors and install those, then the 22K resistors, and so forth. Remember, if you've got 100K 0.1% resistors for your Analogue Board, don't install them on this board!   This board ain't so picky, and it would be an entire waste to do so.

Gate Bus Resistors (Group 1) Selected Value			
Quantity	**Designators**	**Tol**	**Done**
8	R63 – R70	5%, 1/4W	

Gate Bus Resistors (Group 2) Selected Value			
Quantity	**Designators**	**Tol**	**Done**
8	R71 – R78	5%, 1/4W	

22K Resistors			
Quantity	**Designators**	**Tol**	**Done**
25	R1 – R22, R50 – R51, R80	5%, 1/4W	

15K Resistors			
Quantity	**Designators**	**Tol**	**Done**
2	R29, R79	1%, 1/4W	

100K Resistors			
Quantity	**Designators**	**Tol**	**Done**
24	R23 – R26, R30, R49, R52 – R62, R81 – R84, R89, R90, R94	1%, 1/4W	

1M5 Resistors			
Quantity	**Designators**	**Tol**	**Done**
2	R92, R93	5%, 1/4W	

220K Resistors			
Quantity	**Designators**	**Tol**	**Done**
2	R27 – R28	5%, 1/4W	

270K Resistors			
Quantity	**Designators**	**Tol**	**Done**
1	R91	5%, 1/4W	

4K7 Resistors			
Quantity	**Designators**	**Tol**	**Done**
6	R31, R48, R85 – R88	5%, 1/4W	

6K8 Resistors			
Quantity	**Designators**	**Tol**	**Done**
16	R23 – R26, R30, R49, R52 – R62, R81 – R84, R89, R90	5%, 1/4W	

Diodes

After the resistors are installed, move on to the diodes. There are only six diodes on the Digital Board, and they're all of the same type (1N4148), so it's not a terribly large job. If you don't have 1N4148s, 1N914s will work fine. Make sure you install them in the right direction! The silkscreen will show where the cathode goes.

1N4148 Diodes			
Quantity	**Designators**	**Type**	**Done**
7	D1-D7	Diode, Si	

Capacitors

There are a number of capacitors of various values. Most of them are non-polarized. There is only one polarized capacitor on the Digital Board – C17. When you install it, be sure to do it in the right direction. The positive lead of the cap will go into the square pad, which is also marked with a "+".

1 nF (.001 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
6	C6 – C10, C18	Metal Poly	

10 nF (0.01 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
4	C19 – C22	Metal Poly	

100 nF (0.1 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
15	C1-C5, C13 – C16, C23 – C28	Ceramic	

47 nF (0.047 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
2	C11, C12	Metal Poly	

<u>Polarized</u> 47 uF Capacitor			
Quantity	**Designators**	**Type**	**Done**
1	C17	Electrolytic, 25V	

Transistors
Only one type of transistor is used throughout the Klee Sequencer – the 2N3904 NPN transistor, and they're all located on the Digital Board. These transistors are used to drive the clock, reference and gate bus LEDs. There are six of these transistors. The silk screening serves as the guide to correct orientation of the transistors.

2N3904 NPN Transistors			
Quantity	**Designators**	**Type**	**Done**
6	Q1-Q6	NPN	

This covers all of the components that are soldered into the Digital PCB. At this point, go ahead and clean off the flux (using your preferred method/chemical).

Installing the ICs
After the board is cleaned, it's time to install the ICs into the sockets. Remember – follow ESD (Electro Static Discharge) precautions while doing this. We're dealing with CMOS parts here, so be sure you're nice and grounded when handling these ICs. Find the correct sockets and insert the following components:

Digital Board Integrated Circuits			
Quantity	**Designators**	**Type**	**Done**
2	U1, U8	**LM358** Dual Op Amp	
3	U2, U10 – U11	**CD40106** Hex Schmitt Trigger	
1	U3	**CD4071** Quad 2 Input OR Gate	
3	U4, U12 – U13	**CD4093** Quad 2 Input NAND Schmitt Trigger	
1	U5	**CD4013** Dual D Flip Flop	
2	U6 – U7	**CD4034** 8 Bit Shift Register with Parallel Load	
1	U9	**CD4053** Quad 1 of 2 Switch	
2	U14, U15	**LM324** Quad Op Amp	

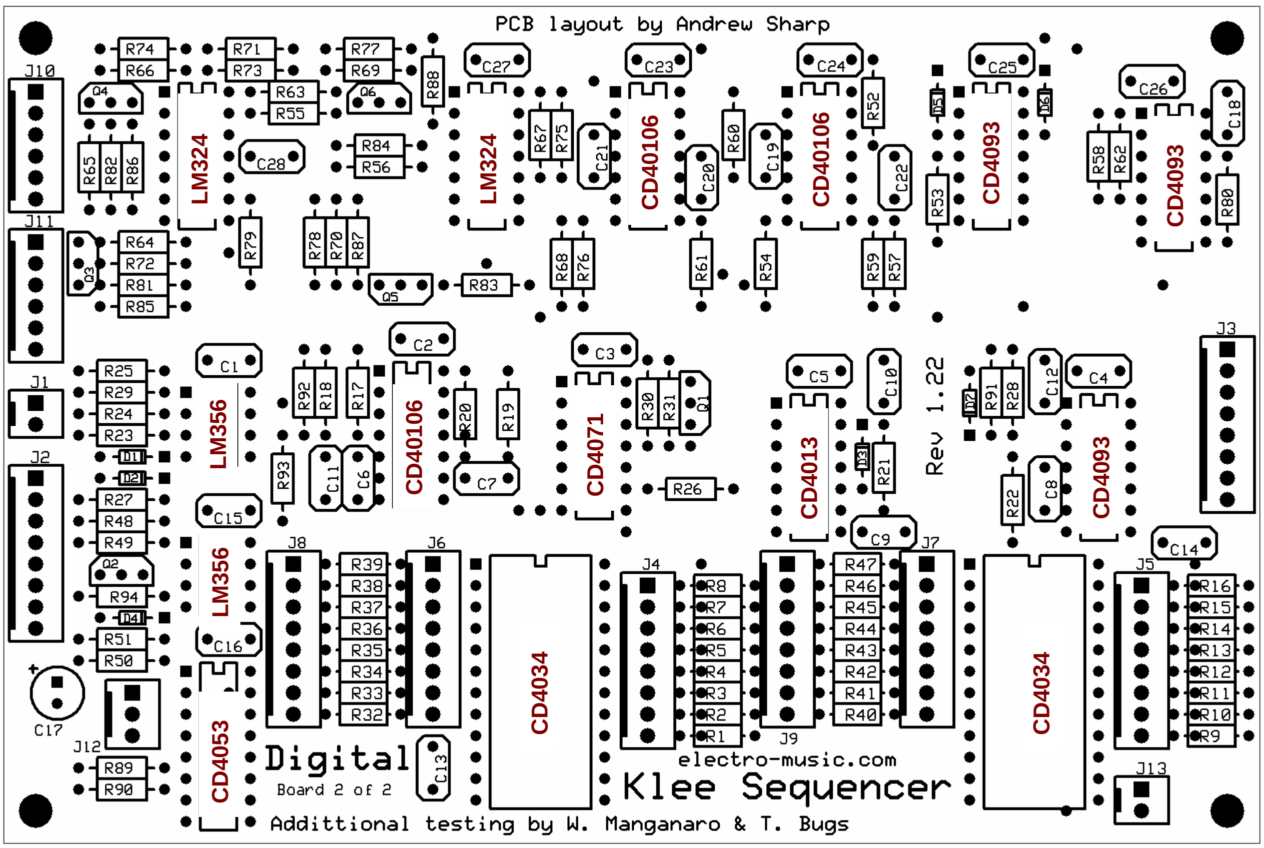
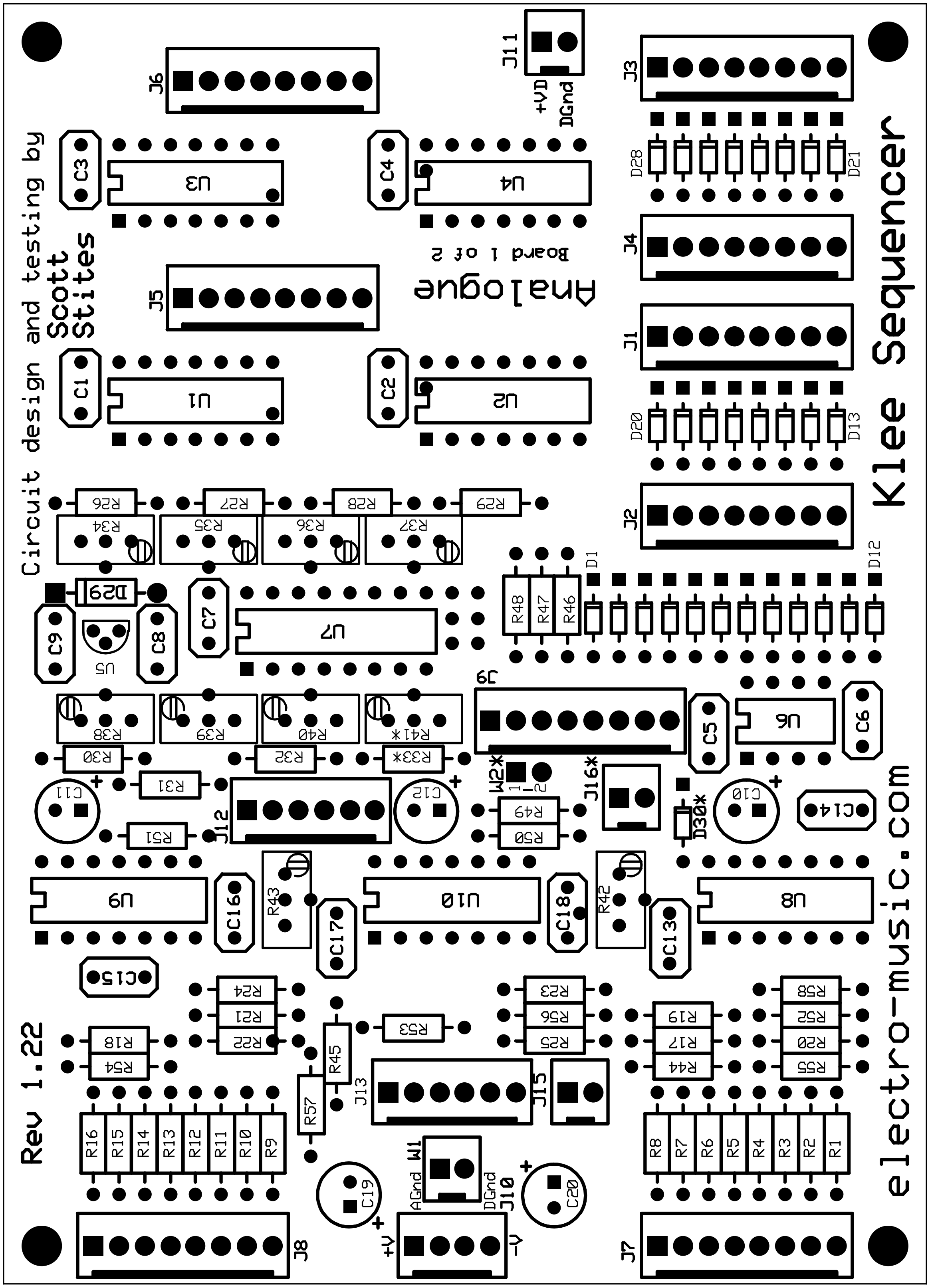


Figure 7-4: Digital Board IC Placement Guide

Figure 7-5: The *electro-music* Klee Sequencer Analogue Board



Steps to Soldering Parts to the Analogue PCB

Of course, the *electro-music* Klee Sequencer Analogue PCB is the one marked "Analogue" in the silkscreen. Before you start soldering parts to it, there are a few things to go over. Please read through this section before beginning.

Jumpers and Options

The Analogue board is the source of the signals required for the Variable Range control options. It is also the board that directly interfaces to the power supply, and the board that involves all of the calibration of the Klee.

There are two jumpers on the Analogue Board. W1 should only be installed if the power supply, for some reason, has only one ground connection. In other words, if you have a power supply with only one ground lead, install W1. This ties the analog and digital grounds together at this one point.

The only other jumper, W2, is only installed if any of the variable range options are **not** installed. If you intend position 8 of the range to access only a fixed range, and there is no other control to vary that range, as described in the Options section of Chapter 1, then install the jumper. If you do intend to install one of the variable range options, then do **not** install W2. There are other considerations to installing/not installing the variable range option such as whether a trim pot is installed or not, a connector is installed or not, and whether a diode is required or not.

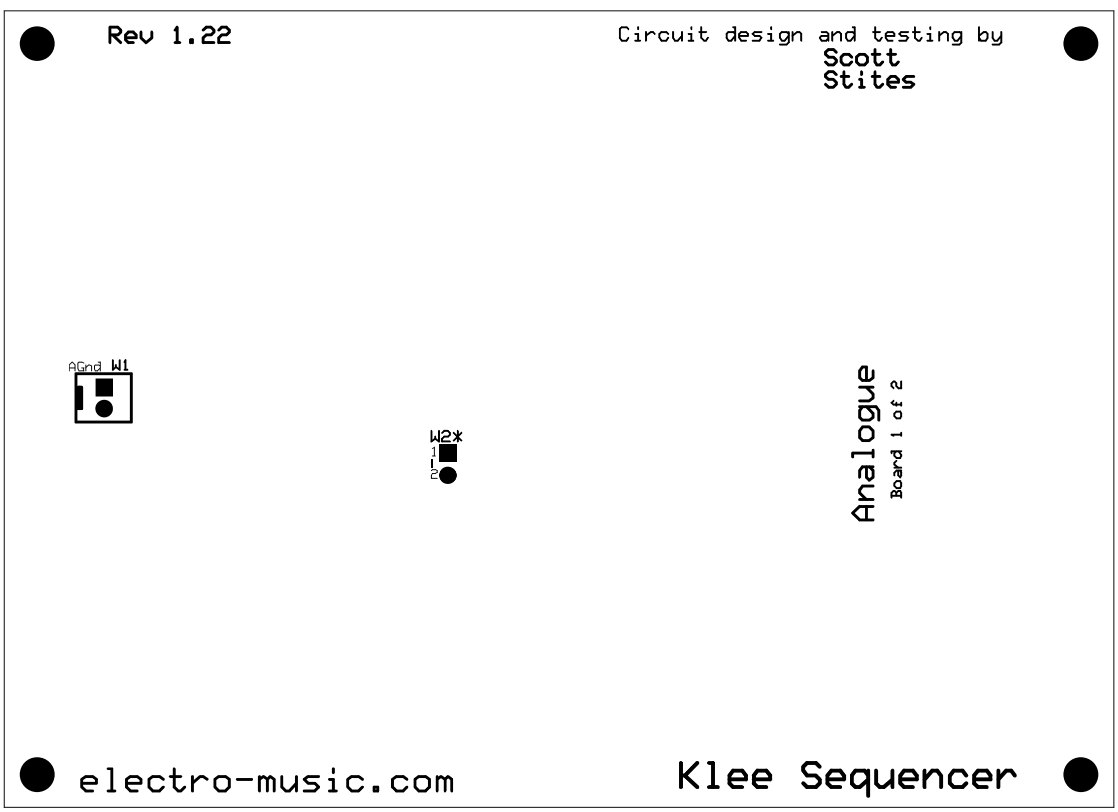


Figure 7-6: Jumper Locations on the Analogue Board

If you do not intend to install any of the Variable Range options, then you will want to follow the notes of Figure 7-7. Note that trim pot R41 is installed (it is not installed if a variable range option is to be installed). W2 is installed, but J16 is not required. Though it is not shown, D30 is not required either. If J16 and D30 are installed, this will not affect the operation of the unit, they just will serve no purpose.

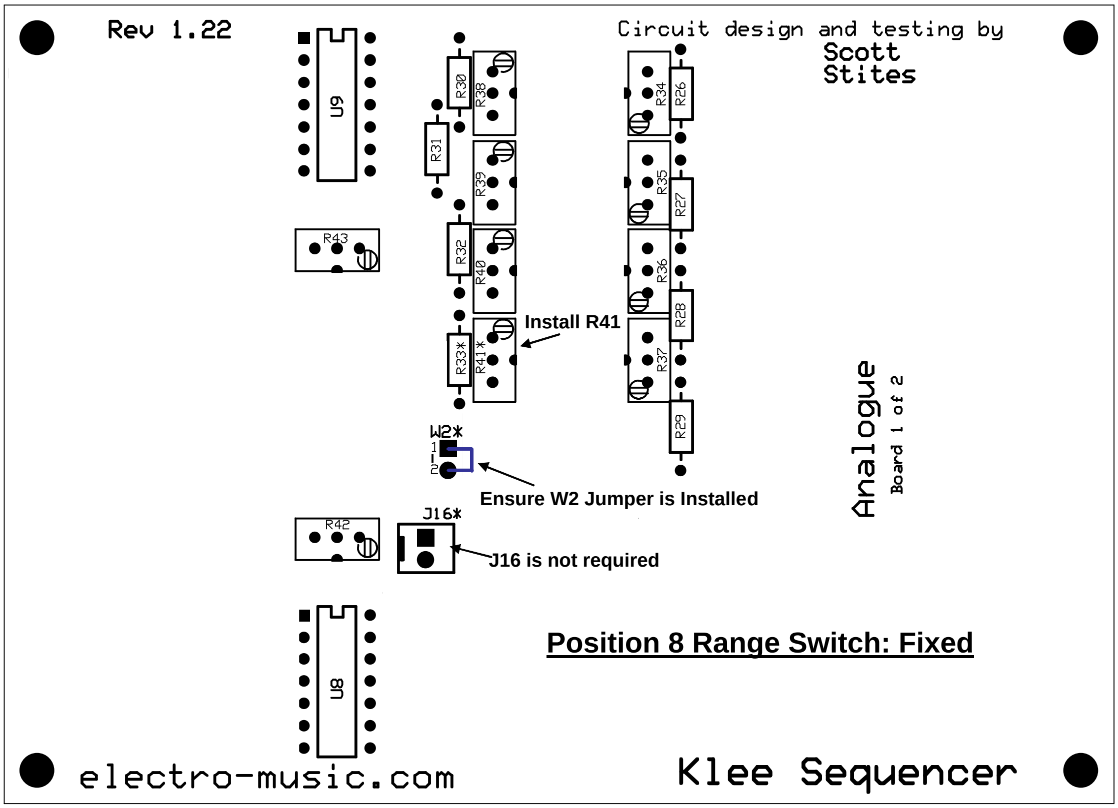


Figure 7-7: Range Switch Position 8 Fixed Range Considerations

If any of the variable range options are installed, then you should refrain from installing R41. The front panel Variable Range Control will take over the function performed by that trim pot.

J16 must be installed (unless, of course, you are hardwiring the Klee together). J16 provides the signal(s) to the front panel Variable Range control(s).

If any of the external range options are to be installed, D30 also **<u>must</u>** be installed. D30 provides protection from any negative voltages that may be applied to the External Variable Range jack. This jack directly feeds the input of U7, which is a CD4051. The CD4051 cannot accept a voltage lower than 0.5V below its supply rail. D30 is a BAT85 Schottky diode that will prevent voltages 0.4V below ground from being applied to U7.

The maximum range of the Variable Range Control is determined by R33. In other words, with the Variable Range Control maxed out at full clockwise, R33 will determine what that maximum voltage will be. So, consideration must be given to what value will be used for R33.

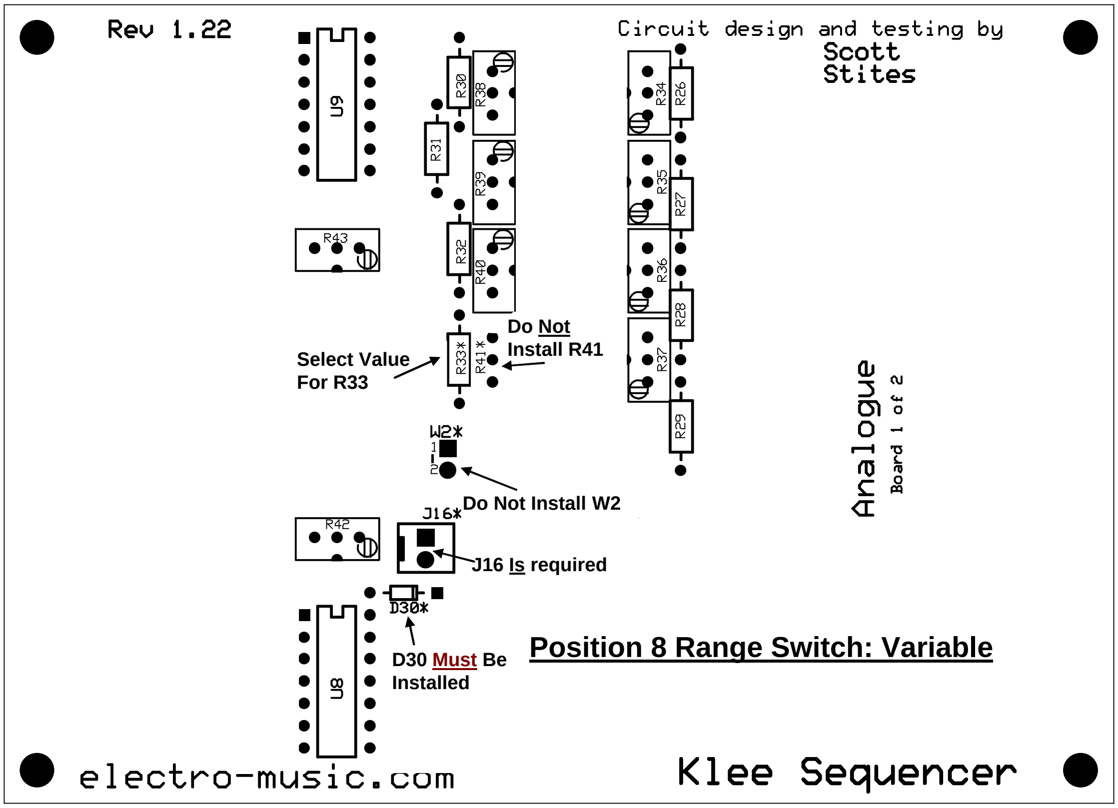


Figure 7-8: Range Switch Position 8 Variable Range Considerations

Resistors

The default value for R33 is 1K – it is used if the standard 8V fixed range is selected as the function of position 8 of the rotary Range Switch.

If you decide to install any of the internal variable range options, R33 is going to determine the maximum voltage that can be “dialed in” with the Variable Range Control.

Before that is discussed, let’s review what the “standard” range values are. Table 7-1 illustrates the default range switch functions.

Range Switch Position	Maximum Pot Range Voltage/Interval (V/Oct)
1	0.333V, Major 3rd Interval
2	0.4167V, Perfect 4th Interval
3	0.583V, Perfect 5th Interval
4	0.666V, Minor 6th Interval
5	1V, One Octave
6	2V, Two Octaves
7	4V, Four Octaves
8	8V, Eight Octaves

Table 7-1: Standard Range Switch Settings

The configuration of Table 7-1 depicts the "default" operation the chosen values provide for the Range Switch operation. Positions 1 through 4 were determined during development to be generally the most "musically" useful intervals for the programming pots. This, at best is a subjective arrangement – you, as the owner and operator of your Klee Sequencer, are the final arbiter of what could be considered "musically useful". However, before you have a chance to try the intervals, the Klee must be at first built, so trying to determine what is useful to you is much like putting the cart before the horse.

Fortunately, these values are adjustable using the trim pots. With the standard values, ranges 1 through 3 are adjustable from 0V through 0.625V. Range 4 is adjustable through 1.28V with the standard values. Ranges 5 through seven are adjustable through 5V with the standard values, and Range 8 is adjustable through 8.1V. If one changes any of the divider resistor values for these ranges (R26 through R33), it is possible to exceed these ranges. The equation is as follows:

$$\frac{10V}{R_{divider} + 10K} \times 10K = \text{Maximum Range}$$

Figure 7-9: Equation for Voltage Ranges Beyond Standard Values

This will take a bit of examination of the Analogue Board Schematic, page 2. For example, if you want range 2 to exceed 0.625, a lower value for R27 would be required. If you select 100K as the value for R27, then range 2 could be calibrated to a voltage between 0V and 0.9V, for example.

Generally, we feel you'll find the standard values fit quite well here, and you will likely not have an interest in altering these values.

What may be a bit more prevalent, however, is the desire to alter the higher ranges, particularly when using position 8 as a variable value rather than a fixed value. In fact, most may find that 8V is more voltage than required there. In the case of the fixed 8V value, that can be trimmed "down" to some other value. If you're using position 8 as a variable value, you may wish to have some other range as a higher value to compensate.

This is due to the fact that you may wish to have a very low value or a “mid” value as your maximum variable range. If your aim is to program intervals at precise values, it helps to have this range kept low, say from 2V to 4V. This lower voltage enables precise intervals to be easily dialed in.

So, back to R33 – remember R33 will determine the maximum voltage on your variable range control. Because the front panel Variable Range Control is a 100K linear potentiometer, the equation that determines this value would be:

$$\frac{10V}{R33 + 100K} \times 100K = \text{Maximum Range}$$

Figure 7-10: Equation for Maximum Variable Range Voltage

Table 7-2 lists a general range of values for R33, and the resulting maximum variable range voltage each provides.

R33	Maximum Range
910K	0.99V
400K	2V
300K	2.5V
200K	3.33V
150K	4V
100K	5V
56K	6.4V
39K	7.2V

Table 7-2: Example R33 Values and Resulting Maximum Variable Range Voltage

If one settles for a lower variable range voltage, the highest default range left is position seven, which is 4V. In that case, it may be desirable to increase that voltage to provide a range with a high enough voltage to remain effective for single bit sequencing (IE, “standard” sequencing) and Klee Sequencing. An acceptable option may be to “max out” range at around 5V, which will give five octaves of range in a V/Oct system. Table 7-3 depicts a suggested range selection when an internal variable range option is installed.

Range Switch Position	Maximum Pot Range Voltage/Interval (V/Oct)
1	0.333V, Major 3rd Interval
2	0.4167V, Perfect 4th Interval
3	0.583V, Perfect 5th Interval
4	0.666V, Minor 6th Interval
5	1V, One Octave
6	2V, Two Octaves
7	5V, Five Octaves
8	4V, Four Octaves, Variable

Table 7-3: A Suggested Range Selection Using the Internal Variable Range Option

This arrangement provides a wide range for position 8, yet provides enough resolution that fairly precise intervals can be set using the Variable Range Control pot.

100K 0.1% Resistors

One other consideration should be given to the selection of the 100K resistor values. All of the 100K resistors used on the Analogue Board are involved with mixing the voltages as programmed on the programming pots. The Range Switch is set to certain intervals so that the pots can be used more or less as switches, switching a specific interval into place or not by turning the pot either full clockwise or anti-clockwise. The tolerance of the mixing resistors will play a role in how accurately this is accomplished – this is why 0.1% resistors are specified.

0.1% resistors can be quite expensive. If you have them or can afford/acquire them, this will make things much more cut and dried. If not, it is possible to match a set of resistors to within 0.1%.

1% metal film resistors can be purchased quite inexpensively these days. Because of that, it is possible to buy a large quantity of them for a relatively low price. If you purchase a large quantity, you will more than likely find enough of them to be within 0.1% of their value as to be usable in this application.

So, if you don't have the 0.1% 100K resistors, but have a big bag of 100K 1% resistors, here's what you do: pull out your DMM, and measure each and every resistor. Make yourself a little pile of *exactly* each value. For example, you may have a pile of 99.6K resistors, a pile of 99.7K resistors, etc. What you need are 25 resistors of the *same* value, or, if you DMM has enough resolution, 25 resistors that are within 0.1% of the same value. 0.1% of 100K is 100 Ohms, so that gives you an idea of how close to your central value you need to be. Note, the value of your 25 resistors does not have to be 100K – it can be 25 resistors within 99.7K or 100.4K or whatever. **The important thing is that all 25 resistors be within 0.1% of each other.**

So, let's begin our assembly, starting with the jumpers.

Jumpers
The jumpers can be installed using bus wire, or even excess resistor lead. Remember to only install the jumpers if needed!

Jumpers		
Quantity	**Designators**	**Done**
2	W1 – Install if power supply has only one ground lead. W2 – Install if fixed range is to be used for Range Switch Position 8	

Connectors
When installing the header connectors, use the same techniques used on the Digital Board – make sure they're pointed in the right direction, and sitting flush to the board, etc.

In case you astutely determine that no J14 is listed, rest assured it does not exist. That reference designator was removed during development of the PCB.

8 Pin Headers		
Quantity	**Designators**	**Done**
9	J1-J9	

6 Pin Headers		
Quantity	**Designators**	**Done**
2	J12-J13	

4 Pin Headers		
Quantity	**Designators**	**Done**
1	J10	

2 Pin Headers		
Quantity	**Designators**	**Done**
2 (3*)	J11, J15 (*J16 for Optional Variable Range)	

IC Sockets
Next, install the sockets. Note that one IC is not socketed – U5, a 78L10 is actually a three pin device in a TO-92 package, which resembles the 2N3904 transistors that are used on the Digital Board. U5 is soldered directly to the Digital Board.

16 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
1	X7	0.3"	

14 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
7	X1 – X4, X8 – X10	0.3”	

8 Pin IC Sockets			
Quantity	**Designators**	**Width**	**Done**
1	X6	0.3”	

Resistors
This checklist will list the original values of all resistors. Bear in mind that you may or may not wish to use the same values for R26 through R33. If you are wondering why, you should go back and reread the beginning of this section again. Come on, it’s not *that* bad.

100R Resistors			
Quantity	**Designators**	**Tol**	**Done**
9	R49 – R57	5%, 1/4W	

1K Resistors			
Quantity	**Designators**	**Tol**	**Done**
1	R33 (See notes at beginning of this section),	5%, 1/4W	

10K Resistors			
Quantity	**Designators**	**Tol**	**Done**
3	R30 – R32	1%, 1/4W	

100K Resistors			
Quantity	**Designators**	**Tol**	**Done**
25	R1 – R25	0.1%	

150K Resistors			
Quantity	**Designators**	**Tol**	**Done**
3	R26 – R28 (See notes at beginning of this section)	1%, 1/4W	

2K2 Resistors			
Quantity	**Designators**	**Tol**	**Done**
1	R58	1%, 1/4W	

22K Resistors			
Quantity	**Designators**	**Tol**	**Done**
3	R46 – R48	5%, 1/4W	

4M7 Resistors			
Quantity	**Designators**	**Tol**	**Done**
2	R44 – R45	5%, 1/4W	

Diodes
There are three varieties of diodes to deal with on the Analogue Board. The 1N4148 diodes could be substituted with 1N914 diodes. The 1N4001 could be substituted by any other high power rectifier diode (such as 1N4002, etc). The BAT85 could be substituted by any low voltage Schottky diode (such as a BAT42), but be very careful that it does not exceed 400 mV at 10 mA. And do <u>not</u> substitute it with a 1N4148 or 1N914! Install them in the right direction (cathode is marked on the silkscreen).

1N4148 Diodes			
Quantity	**Designators**	**Type**	**Done**
28	D1 - D28	Diode, Si	

1N4001 Diodes			
Quantity	**Designators**	**Type**	**Done**
1	D29	Diode, Si	

BAT85 Diodes			
Quantity	**Designators**	**Type**	**Done**
1	D30	Schottky Diode, Si	

Capacitors
There are five capacitors on the Analogue Board that are polarized. All of these are the electrolytic capacitors. Be sure to put those in with the correct orientation – positive lead goes to the square pad, and the positive lead is also marked with "+" on the silkscreen.

100 nF (0.1 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
14	C1-C8, C13 – C18	Ceramic	

330 nF (0.33 uF) Capacitors			
Quantity	**Designators**	**Type**	**Done**
1	C9	Ceramic	

<u>Polarized</u> 10 uF Capacitor			
Quantity	**Designators**	**Type**	**Done**
2	C19 – C20	Electrolytic, 25V	

<u>Polarized</u> 4.7 uF Capacitor			
Quantity	**Designators**	**Type**	**Done**
3	C10 - C12	Electrolytic, 25V	

Multi-Turn Trim Pots
There are six 10K trim pots that are used for calibration of the Range Switch voltages. **<u>Remember, if you are installing any of the variable range options, do not install R41.</u>** There are two 100K trim pots that are installed regardless of configuration.

10K Multi-Turn Trim Pots			
Quantity	**Designators**	**Type**	**Done**
6 (5*)	R34 – R41 (do not install R41 if variable range option is installed).	25 Turn, Top Adjust	

100K Multi-Turn Trim Pots			
Quantity	**Designators**	**Type**	**Done**
2	R42-R43	25 Turn, Top Adjust	

Installing the ICS
All of the ICs are socketed, save for one – U5, the 78L10 Voltage Regulator. Locate its position on the silk screening, and install it in the orientation depicted on the silkscreen of the board.

78L10			
Quantity	**Designators**	**Type**	**Done**
1	U5	10V Linear Voltage Regulator	

After installing U5, all of the solder work is now done. Clean the board, then install the rest of the ICs in their sockets. As a reminder, when handling the ICs, make sure you are properly grounded to avoid damaging the ICs through electro-static discharge.

Analogue Board Socketed Integrated Circuits			
Quantity	**Designators**	**Type**	**Done**
4	U1-U4	**CD4066** Quad Analog Bi-Lateral Switch	
1	U6	**TL072** Dual Op Amp	
1	U7	**CD4051** 1 of 8 Analog Mux	
3	U8 – U10	**TL074** Quad Op Amp	

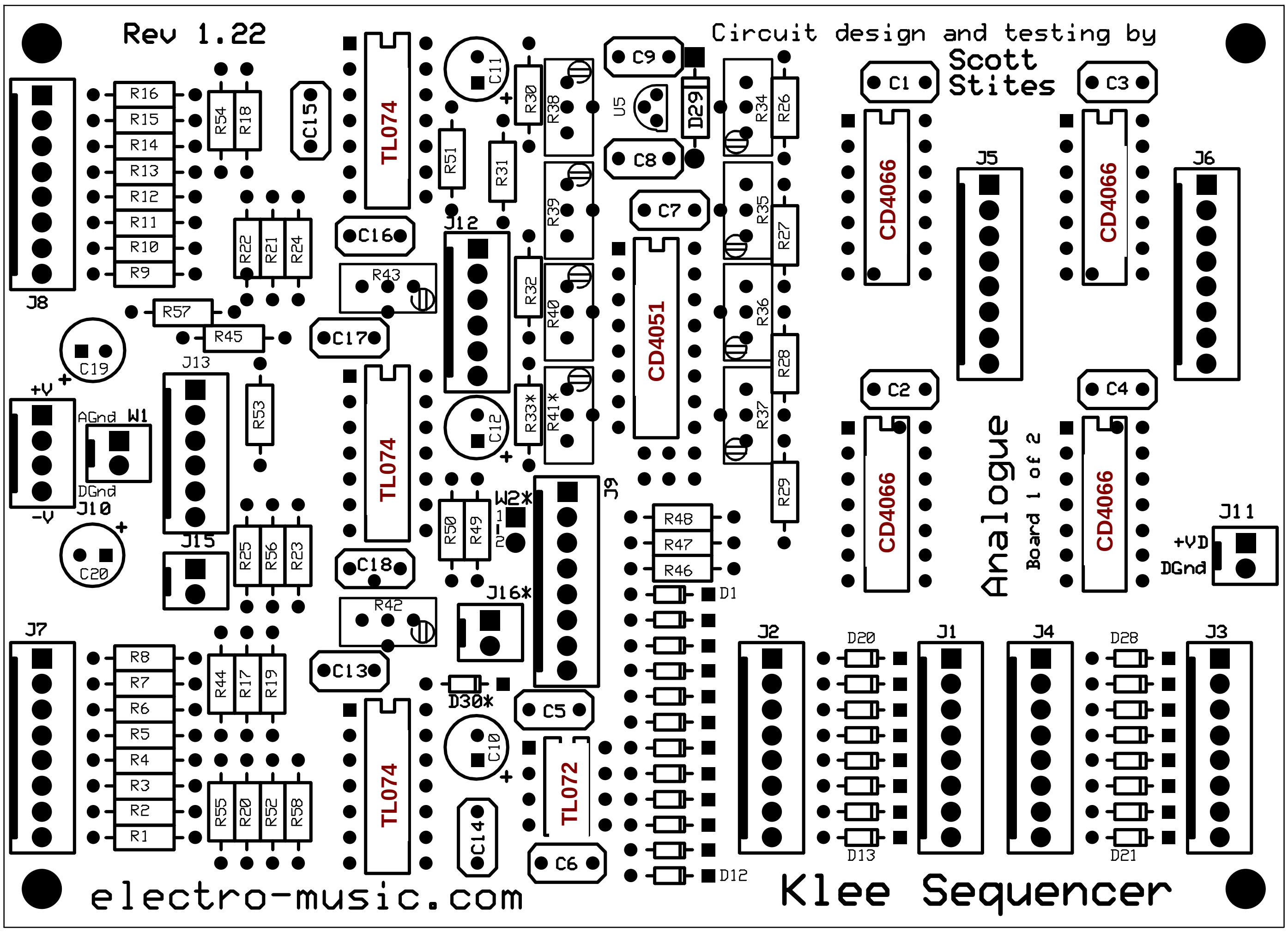


Figure 7-11: Analogue Board IC Placement Guide

8. Final Assembly of the *electro-music* Klee Sequencer

Putting It All Together

You've completed your front panel and the PCBs are all soldered up. Hopefully your power supply is all ready to go, and you've either got the chassis or at least a good test set-up going on there. It's nearly time to put things together and put the juice to your latest contraption.

But first…(there's always a "but first", have you noticed?)…..there are a few checks to make. We need to make sure everything is as hunky-dory as possible before letting those electrons run rampant through your well laid components, wires and circuit boards. You should make sure they go where they should and don't go where they shouldn't. That means a few simple checks are in order.

Inspecting the Digital Board
Before connecting the Digital Board to anything, a few simple checks will help to ensure there are no "fatal" solder shorts. We're really just looking to see that the power rails aren't shorted either to ground or to each other and they're connected, at least nominally, to the ICs at the right places. It's not a total check, but it sure may head some problems off at the pass. Checking the connections before the board is connected to anything else will immediately tell you if a problem exists on the board *now*, before everything else gets involved causing a problem to be much more difficult to trace.

Visual Inspection
Grab a magnifying glass and give the back of your board at least a cursory check – keep an eye open for any solder bridges, connections lacking solder or having an inadequate amount of solder, or relatively "dull" looking solder joints that may be cold solder joints. If you spot any problems, take care of them now.

Flip the board over. Inspect your socketed ICs. Are the socketed fully? They're not sitting at some arcane angle above the socket are they? How about the pins – are all of the pins in the socket? There aren't any folded underneath or sticking out like a buck tooth on the side of the socket, are there?

How about your transistors – do they line up with the silk screen legend? Is that electrolytic cap's positive lead really soldered to the positive pad? Are the diodes all pointed in the right direction? Failure to spot defects of any of these types will certainly cause you to tear screaming into the night (it's always the night) when you power up the Klee and begin bring-up and calibration.

Check for Power Supply Shorts
The two pin header, J1, is the power entry point for the Digital Board. This is a good place to latch on with your DMM and ensure that +V is not somehow shorted to ground. Place the positive lead of your ohmmeter to pin 1 of J1 and the negative lead of your ohmmeter to pin 2 of J1. Check to see if you have greater than at least a few hundred ohms. If you don't, and have, say, 0 or 1 or 2 Ohms showing up on your meter, this is obviously a **bad** thing. Stop what you're doing and trace down where the short is occurring, using your years of trouble-shooting Klee Sequencer Digital Board experience.

If, however, you do not have the power rail shorted to ground, this is a good thing. Your power supply won't explode or blow a fuse when it is ultimately connected to your Digital Board. You can move on with this interminable, suspenseful procedure.

Check the IC Positive Power Pins
The Digital Board is an easy, easy board to check to see if the ICs are connected up to the rails, mainly because there is only +V and ground on the Digital Board. A beeping continuity checker is great for this job.

Leave the positive lead of the DMM connected to pin 1 of J1 and begin checking the supply pins of each and every one of the integrated circuits parked on your Digital Board with the negative lead. You should read zero ohms on your DMM for each pin, or damn close to it.

Here's a handy table to assist you in finding the power pins for each and every one of the integrated circuits on your Digital Board.

Ref Des	Device	Positive Supply Pin
U1	LM358	Pin 8
U2	CD40106	Pin 14
U3	CD4071	Pin 14
U4	CD4093	Pin 14
U5	CD4013	Pin 14
U6	CD4034	Pin 24
U7	CD4034	Pin 24
U8	LM358	Pin 8
U9	CD4053	Pin 16
U10	CD40106	Pin 14
U11	CD40106	Pin 14
U12	CD4093	Pin 14
U13	CD4093	Pin 14
U14	LM324	Pin 14
U15	LM324	Pin 14

Table 8-1: Digital Board IC Positive Supply Pins

Check the IC Ground Pins
Connect the negative lead of the DMM connected to pin 2 of J1 and begin checking the ground pins of each IC with the positive lead. You should read zero ohms on your DMM for each pin, or very, very close to it.

Ref Des	Device	Ground Pin
U1	LM358	Pin 4
U2	CD40106	Pin 7
U3	CD4071	Pin 7
U4	CD4093	Pin 7
U5	CD4013	Pin 7
U6	CD4034	Pin 12
U7	CD4034	Pin 12
U8	LM358	Pin 4
U9	CD4053	Pin 8
U10	CD40106	Pin 7
U11	CD40106	Pin 7
U12	CD4093	Pin 7
U13	CD4093	Pin 7
U14	LM324	Pin 7
U15	LM324	Pin 7

Table 8-2: Digital Board IC Ground Pins

That concludes the cursory Digital Board checks. If there are any undiscovered build problems, you'll know soon enough…..

Inspecting the Digital Board
Next up for scrutiny is the Analogue Board. It's the same drill:

- Visually inspect the solder joints.
- Visually inspect the socketed ICs.
- Visually inspect the orientation of polarized parts (transistors, all those polarized caps, all of those diodes.

Check for Power Supply Shorts
The Analogue Board not only has two power rails to check, but also two ground systems as well. On top of that, it's probably a good idea to make sure that it is going to toss the power signals the Digital Board so craves.

The four pin header J10 is the power entry connector of the Analogue Board. Connect the positive pin of your ohmmeter to pin 1. Connect the negative lead of the DMM to pin 2 of J10 (Analog Ground). It should read much greater than 0 Ohms. Give it at least a couple hundred Ohms before you feel good about it.

Now connect the negative lead of the ohmmeter to pin 3 of J10 (Digital Ground). Again, you should read at least a couple of hundred ohms at minimum.

Connect the negative lead of the ohmmeter to pin 4 of J10 (-V). This should also read at minimum of a few hundred ohms. If it doesn't read 0 Ohms, then your power supply rails are not shorted together. If you get a reading of 0 or 1 or 2 Ohms in any of these checks – STOP! Fix the problem; then move on.

Now, check to see that +V and ground will make it to the Digital Board. Connect the positive lead of the ohmmeter to pin 1 of J10 and connect the negative lead to pin 1 of J11. There should be zero Ohms or really, really close to it. If so, your positive rail will make it to the Digital Board, taking for granted your cable is well constructed. There's always something to worry about.

Connect the positive lead of the Ohmmeter to pin 3 of J10 and the negative lead to pin 2 of J11. If it reads zero ohms or something tantamount to zero ohms, your Digital Ground signal should make the trip between boards.

For those who have installed W1 on the Analog Board, connect the positive lead to pin 2 of J10 and the negative lead to Pin 2 of J11. If you get zero ohms or something ludicrously close to it, your W1 jumper is well soldered and good to go analog ground and digital ground are connected together at this point.

Check the IC Positive Power Pins

Next up, it's another drill you just performed with the Digital Board. It's time to check the positive supply pins of all the ICs. Connect the positive ohmmeter lead to pin 1 of J10 and check the pins in Table 8-3.

Ref Des	Device	Positive Supply Pin
U1	CD4066	Pin 14
U2	CD4066	Pin 14
U3	CD4066	Pin 14
U4	CD4066	Pin 14
U5	78L10	Pin 1
U6	TL072	Pin 8
U7	CD4051	Pin 16
U8	TL074	Pin 4
U9	TL074	Pin 4
U10	TL074	Pin 4

Table 8-3: Analogue Board IC Positive Supply Pins

Check the IC Negative Power Pins
Here's something you didn't have to do with the Digital Board – check the IC negative supply pins. Not all of the ICs require negative supplies, but Table 8-4 contains a list of all that do. Connect the positive ohmmeter lead to pin 4 of J10 and check the pins in Table 8-4.

Ref Des	Device	Positive Supply Pin
U6	TL072	Pin 4
U8	TL074	Pin 11
U9	TL074	Pin 11
U10	TL074	Pin 11

Table 8-4: Analogue Board IC Negative Supply Pins

Check the IC Ground Pins
Not all of the ICs will have ground connections – the op amps operate between the positive and negative rails, so they do not have a direct power feed to the ground system. Connect the positive ohmmeter lead to pin 2 of J10 and check the pins in Table 8-5.

Ref Des	Device	Positive Supply Pin
U1	CD4066	Pin 7
U2	CD4066	Pin 7
U3	CD4066	Pin 7
U4	CD4066	Pin 7
U5	78L10	Pin 2
U7	CD4051	Pin 8

Table 8-5: Analogue Board IC Ground Pins

Check the Power Supply
Before connecting everything up, double-check the power supply connection. The P210 cable should be connected to the power supply terminals. Power on the supply with it connected to nothing. Ensure that there is +15V on pin 1, ground on pins 2 and 3 (if there are two ground connections) and -15V is on pin 4 of P210. Once you're sure everything is correct there, **turn off or remove power to the power supply** – we don't want to hot plug the Klee boards in the next step!

Connect the Boards Together
If you've got everything mounted and ready to go, it's time to connect the boards together. If you are using the connectors and cables, you should have three interconnect cables ready to go – two 8 wire cables and one 2 wire cable.

- Connect the P101/P211 cable between Digital Board J1 and Analogue Board J11
- Connect the P106/P202 cable between Digital Board J6 and Analogue Board J2
- Connect the P107/P204 cable between Digital Board J7 and Analogue Board J4

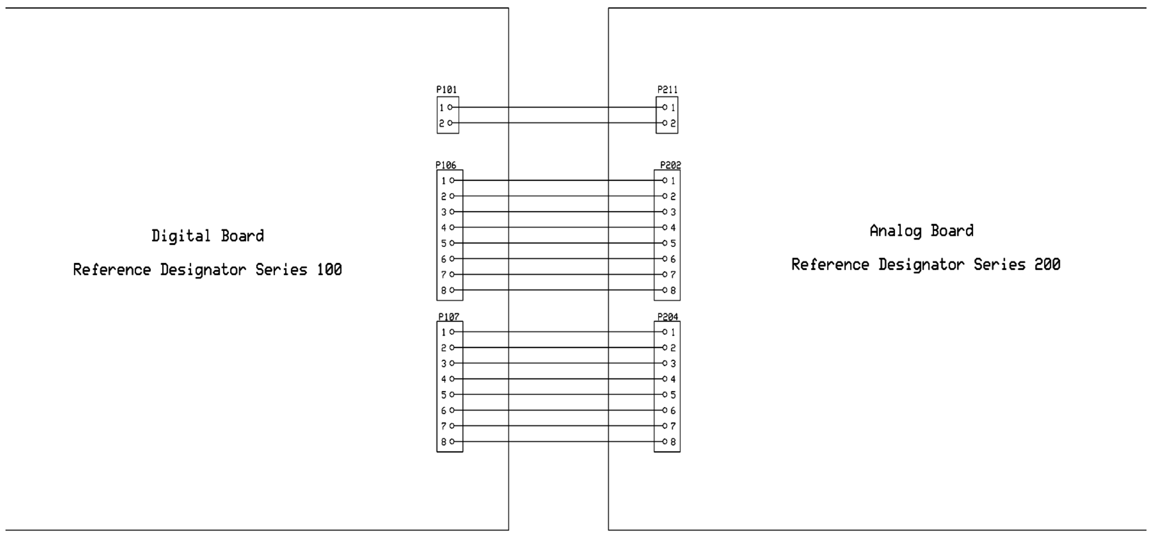


Figure 8-1: Board Interconnection

Connect the Front Panel to the Boards
This is the step where you thank yourself profusely for labeling the connectors attached to the front panel – now you need to connect them to the boards. If you didn't label them, well, you've got your work cut out for you. You'll have to trace back through and see which cable is which – Chapter 5 should give you enough direction to figure out which is which. If you're hardwiring, you can go back to Chapter 5 and start soldering.

Connect all the P2XX cables to their respective connector on the Analogue Board. Connect all the P1XX cables to the Digital Board. In case you've forgotten, J205 connects to J5, Analogue Board; J103 connects to J3 Digital Board, and so on.

After those connections are made, with the Power Supply Off, connect it to J10 of the Analogue Board.

The moment of truth has now arrived.

9. *electro-music* Klee Sequencer Bring-Up Procedure

Goals of the Bring-Up Procedure

The bring up procedure is used to determine if your Klee Sequencer does not produce any smoke it's not intended to produce, does not produce any lights it's not intended to produce, and all the controls, indicators and jacks function as they are intended to function.

Required Items for the Bring-Up procedure
It would be handy to have the following items for this procedure:

- A DMM
- Something that can be triggered, such as an EG or Drum Voice
- Something that can be gated, such as an EG or VCA
- An LFO capable of generating a signal above +2.5V, with a variety of waveforms, including square/pulse, triangle and/or sine
- Another LFO of the same type as above
- A VCO
- An oscilloscope, if at all possible

Begin the Bring-Up procedure by having nothing, other than power, connected to the Klee.

Powering Up the *electro-music* Klee Sequencer
This is the initial moment of truth – apply power to the Klee by powering on the power supply. Keep an eye peeled for wisps of smoke/flashes of light. If there are neither coming from the boards or power supply, this is a good thing.

Note: You may or may not get an illuminated LED indicator at this time. When the Klee Sequencer is powered up, it will need to be initialized by pressing the Manual Load switch. This may not be true of all Klees – it depends on the make of CD4013 Used for U5 of the Digital Board – some may offer a "random" pattern on power-up. The Gate Bus 1 Load Switch should be in the Off position.

Testing the Pattern Switches, Pattern LEDs and Manual Load Function

- Make sure the Gate Bus 1 Load Switch is set to OFF.
- Set any number of pattern switches to the **ON** or "1" position.
- Press the Manual Load switch.

➢ LEDs associated with the pattern switches that are set to "**1**" or "**ON**" should illuminate. LEDs associated with the pattern switches that are set to **OFF** or "**0**" should <u>not</u> illuminate. Try this with various combinations of pattern switch settings.

- Set all of the pattern switches to **ON** or "**1**".
- Press the Manual Load Switch.

➢ All pattern LEDs should illuminate.

- Set all of the pattern switches to **OFF** or "**0**".
- Press the Manual Load Switch.

➢ All pattern LEDs should be off.

Testing the Clock and Shift Register Circuits – 16X1 Mode
Set the following controls:

- 8X2/16X1 Switch: **16X1** position
- Random/Pattern Switch: **Pattern** Position
- Invert B Switch: **OFF**
- Clock Enable: **ON**
- Pattern Switch 1: **ON**
- Pattern Switches 2 through 16: **OFF**
- Gate Bus 1 Load Switch: **OFF**
- Press the Manual Load Switch.

➢ The Stage 1 Pattern LED should illuminate, all other Pattern LEDs should remain off.

- Connect an LFO signal to the Clock Input Jack.

➢ The Clock LED should begin flashing. If it stays on constantly, adjust the frequency of the LFO down until it begins flashing discretely. The Pattern LEDs should be lighting up sequentially from Stage 1 through Stage 16.

- Set the Clock Enable Switch to **OFF**.

➢ The Clock LED should stop flashing and the Pattern LEDs should "freeze" with only one pattern LED illuminated.

Testing the Clock and Shift Register Circuits – 8X2 Mode
Continuing from the previous procedure:

- Press the Manual Load Switch.

➢ The Stage 1 Pattern LED should illuminate, and all other pattern LEDs should remain off.

- Set the 8X2/16X1 Switch to **8X2**.
- Set the Clock Enable Switch to **ON**.

➢ The pattern LEDs for stages 1 through 8 should repeatedly cycle, and the pattern LEDs 9 through 16 should remain off.

- Set Clock Enable to **OFF**.

➢ The pattern LED's should freeze with only one illuminated LED.

- Set the Stage 1 Pattern Switch to **OFF** or "**0**".
- Set the Stage 9 Pattern Switch to **ON** or "**1**".
- Press the Manual Load Switch.

➢ Pattern LED 9 should illuminate and all other pattern LEDs should be off.

- Set Clock Enable to **ON**.

➢ The pattern LEDs for stages 9 through 16 should repeatedly cycle, and the pattern LEDs 1 through 8 should remain off.

Testing the Invert B Function
Continuing from the previous procedure:

- Set Clock Enable to **OFF**

➢ The pattern LEDs should freeze with only one illuminated LED.

- Press the Manual Load Switch.

➢ Stage 9 Pattern LED should illuminate, with all others off.

- Set Invert B to **ON**.
- Set Clock Enable to **ON**.

➢ Stages 9 through 16 should now alternately light up as all on or all off as they sequentially illuminate.

Testing the Manual Step Function
Continuing from the previous procedure:

- Set Clock Enable to **OFF**.

➢ The LEDs should "freeze".

- Set Invert B to **OFF**.
- Set Pattern Switch 1 to **ON** or "**1**".
- Set Pattern Switch 9 to **OFF** or "**0**".
- Press the Manual Load Switch.

➢ Pattern LED 1 should illuminate, all other pattern LEDs should be off.

- Set the 8X2/16X1 Switch to **16X1**.
- Press the Manual Step LED.
- Pattern LED 2 should illuminate and all other pattern LEDs should be off.
- Keep pressing the Manual Step Switch.

➢ The illuminated LEDs should step up smoothly, without skipping any stages, each time the Manual Step Switch is pressed. In this mode the illuminated LEDs should cycle from Stage 1 through Stage 16, advancing one step each time the Manual Step Switch is pressed.

Testing the Gate Bus Switches, Merge Switches and LEDs
Continuing from the previous procedure:

- Set all of the Gate Bus Switches to **Gate Bus 2** (middle position).
- Set all merge switches to the **OFF** position.
- Press the Manual Load switch.

➢ Pattern LED 1 should illuminate, all others should be off.

- Set Clock Enable to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse. The Gate Bus 2 LED should flash with each clock pulse. The Gate Bus 1 LED and the Gate Bus 3 LED should both remain off.

- Set the Merge 2 Switch to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse and the Gate Bus 2 LED should stay constantly illuminated with no flashing. The Gate Bus 1 and Gate Bus 3 LEDs should both remain off.

- Set the Merge 2 Switch to **OFF**.
- Set Clock Enable to **OFF**.
- Set all of the Gate Bus Switches to **Gate Bus 1**.
- Set Clock Enable to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse. The Gate Bus 1 LED should flash with each clock pulse. The Gate Bus 2 LED and the Gate Bus 3 LED should both remain off.

- Set the Merge 1 Switch to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse and the Gate Bus 1 LED should stay constantly illuminated with no flashing. The Gate Bus 2 and Gate Bus 3 LEDs should both remain off.

- Set the Merge 1 Switch to **OFF**.
- Set Clock Enable to **OFF**.
- Set all of the Gate Bus Switches to **Gate Bus 3**.
- Set Clock Enable to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse. The Gate Bus 3 LED should flash with each clock pulse. The Gate Bus 1 LED and the Gate Bus 2 LED should both remain off.

- Set the Merge 3 Switch to **ON**.

➢ The Master Gate Bus LED should flash with each clock pulse and the Gate Bus 3 LED should stay constantly illuminated with no flashing. The Gate Bus 1 and Gate Bus 2 LEDs should both remain off.

- Set the Merge 1 Switch to **OFF**.

Testing the Bus 1 Load Switch
Continuing from the previous procedure:

- Set the Stage 5 Gate Bus Switch to Bus 1.
- Set the rest of the Gate Bus Switches to **Gate Bus 2** or **Gate Bus 3**.
- Set the Bus 1 Load Switch to **ON**.

➢ The pattern LEDs should cycle from Stage 1 through Stage 4 only – pattern LEDs 5 through 16 should remain off.

- Set the Bus 1 Load Switch to **OFF**.

Testing the External Load function
Continuing from the previous procedure:

- Connect a second LFO to the External Load Input Jack.
- If installed, set the External Load Enable Switch to **ON**.
- Set the LFO connected to the External Load Input Jack to a fairly low frequency.

➢ Observe the LEDs – the LEDs should cycle from 1 through 16, but get reset to step 1 with each cycle of the LFO attached to the External Load Input Jack.

- If installed, set the External Load Enable Switch to OFF.

➢ The LEDs should now cycle smoothly from Stage 1 through Stage 16 without interruption.

- Disconnect the LFO connected to the External Load Input Jack.

Testing the Random Function
Continuing from the previous procedure:

- Set the Random Reference Level Control to full anti-clockwise.

➢ Observe the Random Reference LED – it should remain illuminated.

➢ Slowly turn the Random Reference Level clockwise – the Random Reference LED should turn off.

- Set the Random/Pattern Switch to **RANDOM**.

➢ Observe the pattern LEDs. The illuminated Pattern LED will not recycle once it has stepped past Stage 16. After that, the LEDs will remain off.

- Turn the Random Level Control fully Clockwise.
- Set the Random Signal Level Control slightly Clockwise so that the Random Reference LED remains off.
- Connect the second LFO to the Random Signal Input Jack.

➢ The Random Reference LED should begin flashing in time with the LFO rate. The Pattern LEDs will randomly “acquire” one or more bits and pass that sequentially from Stage 1 through Stage 16. Vary the clock frequency to ensure bits are acquired if none appear on the LEDs.

- Slowly turn the Random Reference Level Control clockwise.

➢ At some point, the Random LED should stop flashing and no more bits are “acquired” by the LEDs.

- Turn the Random Reference Level Control anti-clockwise until the Random Reference LED just begins to flash.
- Slowly turn the Random Signal Level anti-clockwise.

➢ At some point, the Random Reference LED should stop flashing.

- Set the Random/Pattern Switch to **PATTERN**.
- Press the Manual Load Switch so that only one LED is on at a time as the pattern cycles.

Testing the Gate Bus Signals
Master Gate Bus
Continuing from the previous procedure:

- If an oscilloscope is available, connect the oscilloscope to the Master Gate Bus Trigger Output.

➢ A 1 ms wide signal at the selected gate bus voltage (5V range or 10V range) should appear with every flash of the Master Gate Bus LED.

- If an oscilloscope is not available, connect a trigger-able device such as a drum voice or an envelope generator to the Master Gate Bus Trigger Output.

➢ The device should trigger with each flash of the Master Gate Bus LED.

- If an oscilloscope is available, connect the oscilloscope to the Master Gate Bus Gate Output.

➢ A pulse signal should be high at the selected gate bus voltage for as long as the Master Gate Bus LED remains on (for as long as the clock LFO is high).

- If an oscilloscope is not available, connect a gate-able device to the Master Gate Bus Gate Output. This device could be an envelope generator or a VCA passing a signal.

➢ Ensure the device stays gated as long as the Master Gate Bus LED is on.

Gate Bus 1
Continuing from the previous procedure:

- Set a number of Gate Bus Switches to Gate Bus 1, so that the Gate Bus 1 LED flashes frequently.
- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 1 Trigger Output.

➢ A 1 ms wide signal at the selected gate bus voltage (5V range or 10V range) should appear with every flash of the Gate Bus 1 LED.

- If an oscilloscope is not available, connect a trigger-able device such as a drum voice or an envelope generator to the Gate Bus 1 Trigger Output.

➢ The device should trigger with each flash of the Gate Bus 1 LED.

- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 1 Gate Output.

➢ A pulse signal should be high at the selected gate bus voltage for as long as the Gate Bus 1 LED remains on (for as long as the clock LFO is high).

- If an oscilloscope is not available, connect a gate-able device to the Gate Bus 1 Gate Output. This device could be an envelope generator or a VCA passing a signal.

➢ Ensure the device stays gated as long as the Gate Bus 1 LED is on.

Gate Bus 2
Continuing from the previous procedure:

- Set a number of Gate Bus Switches to Gate Bus 2, so that the Gate Bus 2 LED flashes frequently.
- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 2 Trigger Output.

➢ A 1 ms wide signal at the selected gate bus voltage (5V range or 10V range) should appear with every flash of the Gate Bus 2 LED.

- If an oscilloscope is not available, connect a trigger-able device such as a drum voice or an envelope generator to the Gate Bus 2 Trigger Output.

➢ The device should trigger with each flash of the Gate Bus 2 LED.

- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 2 Gate Output.

- ➢ A pulse signal should be high at the selected gate bus voltage for as long as the Gate Bus 2 LED remains on (for as long as the clock LFO is high).

- If an oscilloscope is not available, connect a gate-able device to the Gate Bus 2 Gate Output. This device could be an envelope generator or a VCA passing a signal.

- ➢ Ensure the device stays gated as long as the Gate Bus 2 LED is on.

Gate Bus 3
Continuing from the previous procedure:

- Set a number of Gate Bus Switches to Gate Bus 3, so that the Gate Bus 3 LED flashes frequently.

- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 3 Trigger Output.

- ➢ A 1 ms wide signal at the selected gate bus voltage (5V range or 10V range) should appear with every flash of the Gate Bus 3 LED.

- If an oscilloscope is not available, connect a trigger-able device such as a drum voice or an envelope generator to the Gate Bus 3 Trigger Output.

- ➢ The device should trigger with each flash of the Gate Bus 3 LED.

- If an oscilloscope is available, connect the oscilloscope to the Gate Bus 3 Gate Output.

- ➢ A pulse signal should be high at the selected gate bus voltage for as long as the Gate Bus 3 LED remains on (for as long as the clock LFO is high).

- If an oscilloscope is not available, connect a gate-able device to the Gate Bus 3 Gate Output. This device could be an envelope generator or a VCA passing a signal.

- ➢ Ensure the device stays gated as long as the Gate Bus 3 LED is on.

Testing the Voltage Outputs
A+B Output, Glide A+B Control
Though the Klee is not calibrated yet, it should still provide a high enough voltage in order to check the functionality of the voltage generation and mixing circuitry. Continuing from the previous procedure:

- Set the Range Control to Position 7.
- Set all Glide controls maximum anti-clockwise.
- Set all programming pots to full anti-clockwise.
- Connect the V/Oct control input of a VCO to the Output A+B Jack.
- Tune the VCO for a low frequency.

➢ As the single bit steps from Stage 1 through Stage 16, there should be no change in the pitch of the VCO.

- Set programming pots 1 through 8 maximum clockwise.

➢ The VCO should shift to a solid high pitch while the LED steps through stages 1 through 8 and will shift to a solid low pitch as the LED steps through stages 9 through 16.

- Turn the Glide A+B control from full anti-clockwise to clockwise.

➢ Listen to the transitions from low to high and high to low – the change between pitches should now not be abrupt, but “glide” from one to the other. The more clockwise the Glide A+B control is, the longer the glide time between the two pitches should be.

- If the optional voltage output jacks are installed, disconnect the VCO control from Output A+B and plug it into the Optional A+B Output.

➢ The change in pitch should be abrupt and unaffected by the setting of the Glide A+B Control.

- Set Glide A+B to full anti-clockwise.
- Reconnect the VCO control to the A+B Output.
- Set programming pots 9 through 16 to maximum clockwise (all pots will now be set maximum clockwise).

➢ The VCO should now emit a solid high pitch as the single bit steps from stage 1 through stage 16.

A Output, Glide A Control
Continuing from the previous procedure:

- Disconnect the VCO from the A+B Output Jack and connect it to the A Output Jack.

➢ As the LEDs step the single bit through stages 1 through 8, the pitch of the VCO should stay a constant high. As the LEDs step through stages 9 through 16, the VCO should remain at a constant low tone.

- Turn the Glide A control from full anti-clockwise to clockwise.

➢ Listen to the transitions from low to high and high to low – the change between pitches should now not be abrupt, but "glide" from one to the other. The more clockwise the Glide A control is, the longer the glide time between the two pitches should be.

- If the optional voltage output jacks are installed, disconnect the VCO control from Output A and plug it into the Optional A Output.

➢ The change in pitch should be abrupt and unaffected by the setting of the Glide A Control.

- Set Glide A to full anti-clockwise.

B Output, Glide B Control
Continuing from the previous procedure:

- Connect the VCO control to the B Output.

➢ As the LEDs step the single bit through stages 1 through 8, the pitch of the VCO should stay a constant low. As the LEDs step through stages 9 through 16, the VCO should remain at a constant high tone.

- Turn the Glide B control from full anti-clockwise to clockwise.

➢ Listen to the transitions from low to high and high to low – the change between pitches should now not be abrupt, but "glide" from one to the other. The more clockwise the Glide B control is, the longer the glide time between the two pitches should be.

- If the optional output jacks are installed, disconnect the VCO control from Output B and plug it into the Optional B Output.

➢ The change in pitch should be abrupt and unaffected by the setting of the Glide B Control.

Testing the Optional Internal Variable Range Control
Obviously, if you have not installed the Optional Internal Variable Range Option, you don't have to worry about this procedure.

Continuing from the previous procedure:

- Set the programming pots so that each produces a pitch variation – or rather, just don't have them sitting full anti-clockwise.
- Connect the VCO V/Oct control input to the A+B Output.
- Set the Variable Range Control to full anti-clockwise.
- Set the Range Switch to position 8.
- The pitch of the VCO should now drop to a single low tone.
- If you have the Internal/External Variable Range Select Switch installed, set it to **INTERNAL**.
- Gradually rotate the Variable Range Control clockwise.

➢ As you rotate the Variable Range Control, the pitch of the VCO should begin stepping in increasing intervals as the Variable Range Control is rotated clockwise.

Testing the Optional External Variable Range Control
Again, if you have not installed the Optional External Variable Range Option, you can sit out this procedure.

- If you haven't done so, set the programming pots so that each produces a pitch variation – or rather, just don't have them sitting full anti-clockwise.
- Connect the VCO V/Oct control input to the A+B Output.
- Set the Variable Range Control to full anti-clockwise.
- Set the Range Switch to position 8.
- The pitch of the VCO should now drop to a single low tone.
- If you have the Internal/External Variable Range Select Switch installed, set it to **EXTERNAL**.
- Connect the output of the second LFO to the External Range Input Jack.
- Gradually rotate the Variable Range Control clockwise.

➢ As you rotate the control, the pitch of the VCO should begin modulating in increasing intervals in time with the LFO as the Variable Range Control is rotated clockwise. Note the Klee will only react to the LFO when the waveform is positive.

If everything works out fine here, congratulations – the only function not thoroughly tested would be the Range Switch, and that will get a nice workout in the final step of your long Klee-build journey – the calibration procedure.

10. Calibrating the *electro-music* Klee Sequencer

Calibration Notes

You've now had plenty of opportunity to scrutinize the Analogue Board and become intimidated by the fact that it seems to bristle with trim pots. Really, there's nothing to fear here, and we're not saying this in the voice your doctor reserves for something you really *do* have to fear.

There are ten trim pots (nine if you've installed one of the variable range options). Two of the trim pots are used to zero the offset of the op amps that sum the Register A voltages (stages 1 through 8) and the Register B voltages (stages 9 through 16).

The remaining trim pots are used to "dial in" the maximum range voltages of the programming pots. There is a trim pot for each position of the Range Switch, hence the intimidating number of trim pots.

This procedure will address the "standard" voltage arrangement reflected in the schematic. If you decide you would like different voltages for the various positions of the Range Switch, check out the Analogue Board section of Chapter 7.

Required Tools
A digital volt meter (DVM) is the only piece of test equipment required for the calibration. Of course you'll need a trim pot adjustment tool (tweaker) as well.

The Offset Zero Calibration
The zero calibration helps to eliminate excessive DC offset on the voltage outputs of the *electro-music* Klee Sequencer. It does not totally eliminate offsets – there will be some minimal offset on each of these outputs even after this calibration, due to the mixing stages after this section, so don't let that worry you as to whether you've calibrated this section correctly.

Another reason the zero calibration was put in here is that, once the offsets are zeroed, it's easier to calibrate the range voltages.

Calibration Set Up

- Set the Clock Enable Switch to OFF (IE, don't clock the Klee during the calibration).
- Set all programming pots to full anti-clockwise.
- Set the Range Switch to position 1.
- Clip the negative (ground) lead of the DVM to analog ground. A good place to connect it would be somewhere on the analog ground system of the panel – say the ground lug of one of the programming pots.

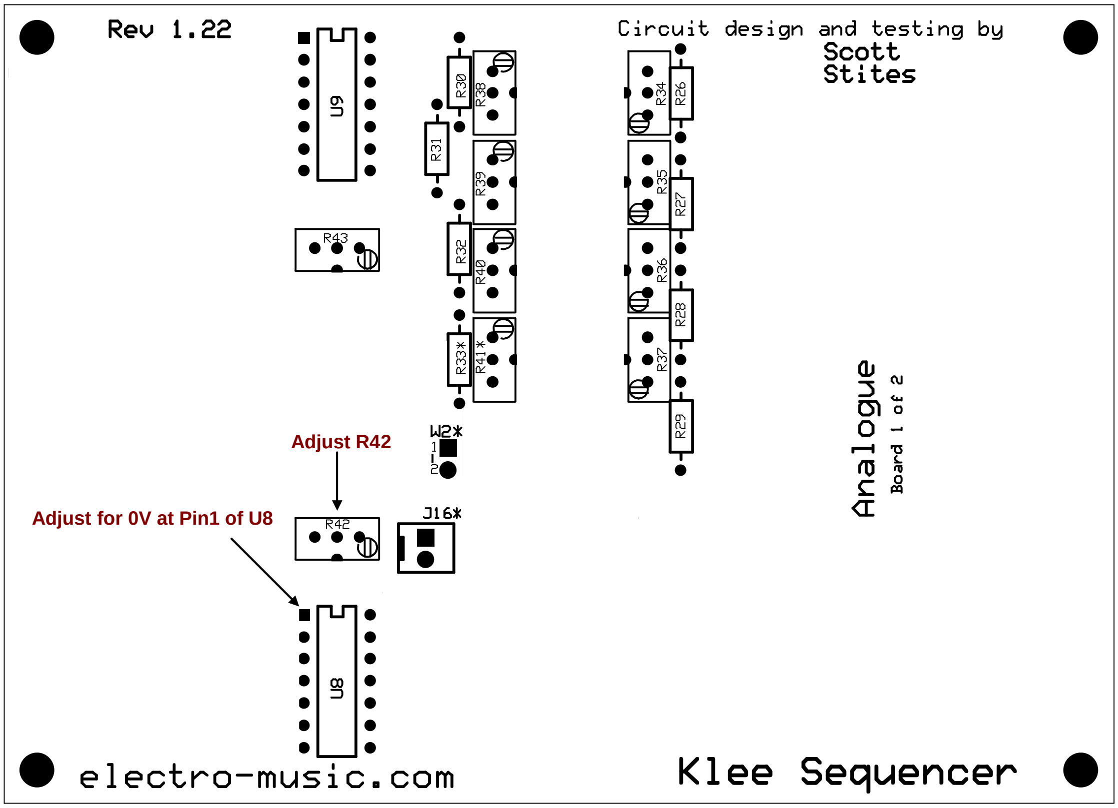


Figure 10-1: Register A Offset Zero Calibration

Register A Voltage Offset Zero Trim

- Touch the tip of the positive DVM lead to pin 1 of U8.
- While observing the DVM, adjust R42 for 0V on the DVM. Get as close to absolutely zero volts as possible.

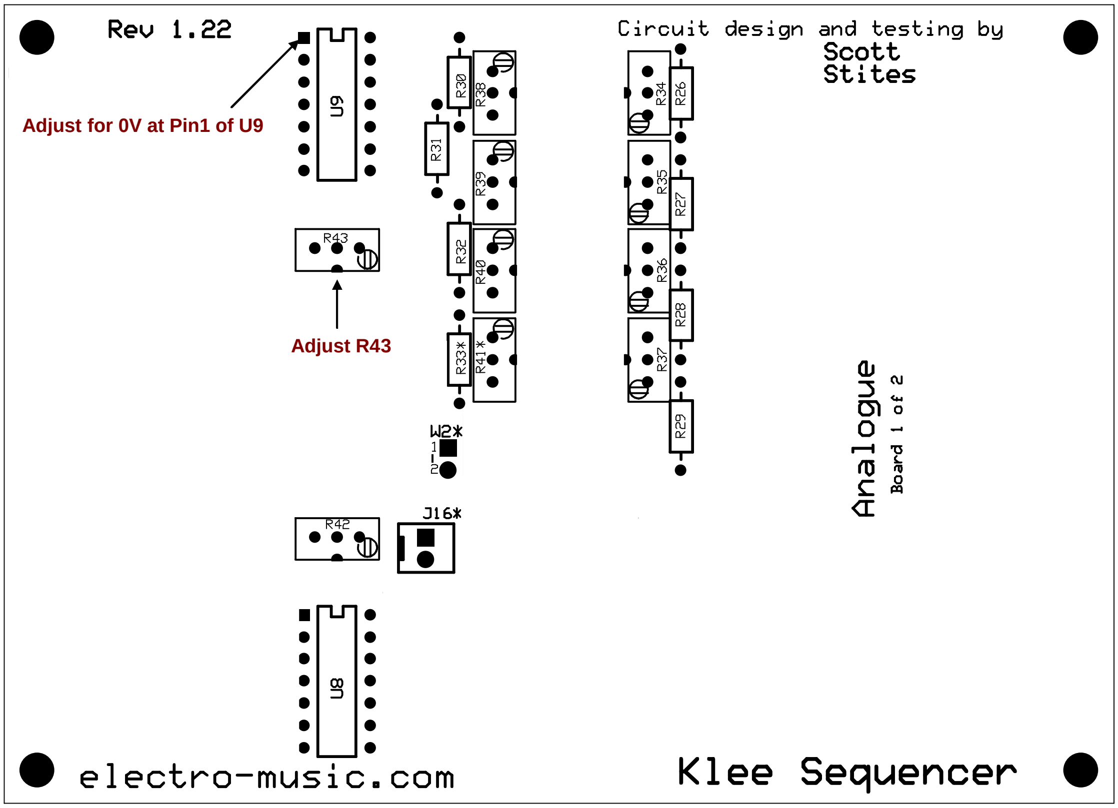


Figure 10-2: Register A Offset Zero Calibration

Register B Voltage Offset Zero Trim

- Touch the tip of the positive DVM lead to pin 1 of U9.
- While observing the DVM, adjust R43 for 0V on the DVM. Get as close to absolutely zero volts as possible.

Range Switch Voltage Calibration

The procedure is very similar to the offset zero calibrations, and is performed only after the offset zero calibrations have been completed. All measurements are taken from pin 1 of U8. It uses the same setup as the offset zero, with a couple of extra settings.

The goal of the calibration is to adjust the output voltage of one stage for each position of the rotary Range Switch. The calibration begins with Range Switch position 1 (full anti-clockwise position) and ends with Range Switch position 8 (full clockwise position). Of course, if the variable range option is installed, Range Switch Position 8 is not calibrated.

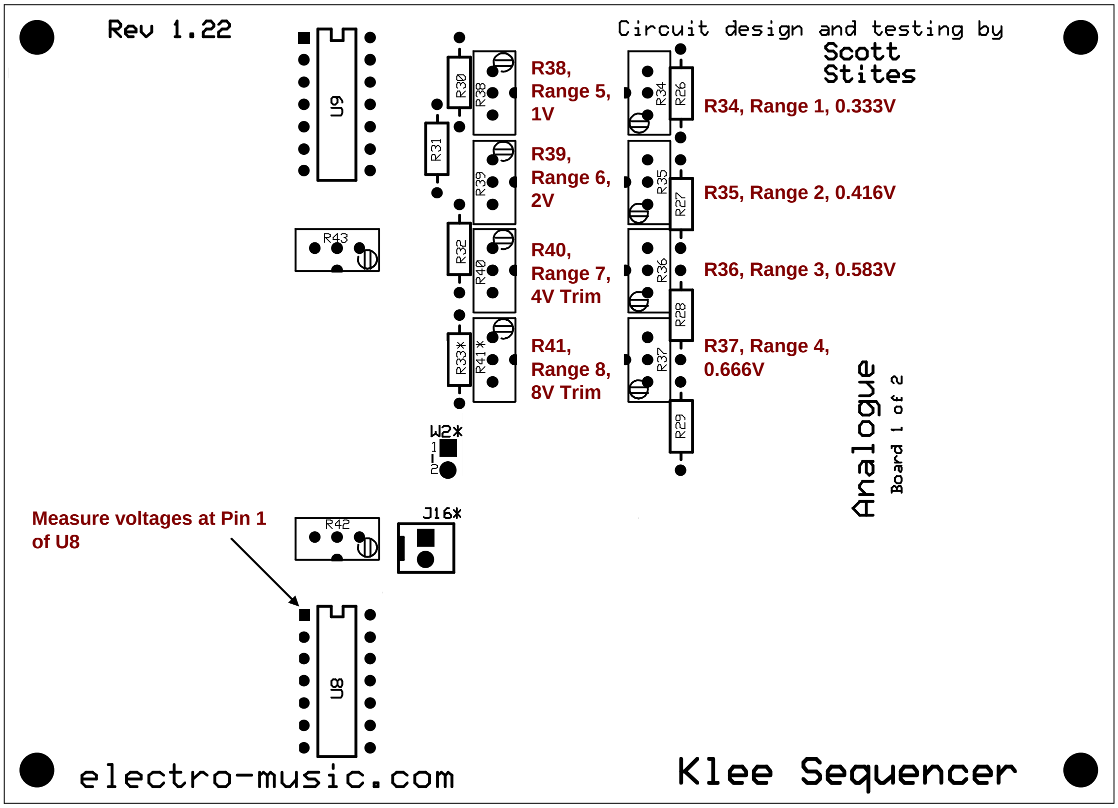


Figure 10-3: Range Switch Voltage Calibration Points

- Set pattern switch 1 to "**ON**" or "**1**".
- Set pattern switches 2 through 16 to "**OFF**" or "**0**".
- Press the Manual Load Switch so that only the Stage 1 LED is illuminated.
- Rotate the Stage 1 Programming Pot to full CW.
- Ensure Programming Pots 2 through 16 are all set full anti-clockwise.
- Refer to Table 10-1 and adjust trim pots so that the voltage at pin 1 of U8 to the *exact* voltage listed for each position of the Range Switch.

Range Switch Position	Trim Pot	U8 Pin 1 Voltage
1	R34	0.333V
2	R35	0.416V
3	R36	0.583V
4	R37	0.666V
5	R38	1V
6	R39	2V
7	R40	4V
8	R41	8V

Table 10-1: Range Switch Calibration Table

Appendix A: Analogue Board Bill of Material

Resistors

Value	Quantity	Designators	Tolerance
100R	9	R49 – R57	5%, 1/4W
1K	1	R33	5%, 1/4W
10K	3	R30 – R32	1%, 1/4W
100K	25	R1 – R25	0.1%, 1/8W
150K	3	R26 – R28	1%, 1/4W
2K2	1	R58	1%, 1/4W
22K	3	R46 – R48	5%, 1/4W
4M7	2	R44 – R45	5%, 1/4W

Capacitors

Value	Quantity	Designators	Type
100 nF (0.1 uF)	14	C1-C8, C13 – C18	Ceramic
330 nF (0.33 uF)	1	C9	Ceramic
10 uF	2	C19 – C20	Electrolytic, 25V
4.7 uF	3	C10 - C12	Electrolytic, 25V

Trim Pots

Value	Quantity	Designators	Type
10K	8	R34 – R41	25 Turn, Top Adjust
100K	2	R42-R43	25 Turn, Top Adjust

Diodes

Value	Quantity	Designators	Description
1N4148	28	D1-D28	Diode, Si
1N4001	1	D29	Diode, Si
BAT85	1	D30	Schottky, Si

Integrated Circuits

Device	Quantity	Designators	Description
78L10	1	U5	10V Linear Voltage Regulator
CD4051	1	U7	1 of 8 Analog Mux
CD4066	4	U1-U4	Quad Analog Bi-Lateral Switch
TL072	1	U6	Dual Op Amp
TL074	3	U8 – U10	Quad Op Amp

IC Sockets

Type	Quantity	Designators	Width
16 Pin DIP	1	X7	0.3”
14 Pin DIP	7	X1 – X4, X8 – X10	0.3”
8 Pin DIP	1	X6	0.3”

Header Connectors

Number of Pins	Quantity	Designators	Description
8	9	J1-J9	Sip Header, 0.1” Center
6	2	J12-J13	Sip Header, 0.1” Center
4	1	J10	Sip Header, 0.1” Center
2	2 (3*)	J11, J15,*J16 (*J16 for Optional Variable Range)	Sip Header, 0.1” Center

PCB

electro-music Klee Sequencer Analogue PCB

Appendix B: Digital Board Bill of Material

Resistors

Value	Quantity	Designators	Tolerance
100K	24	R23 – R26, R30, R49, R52 – R62, R81 – R84, R89, R90, R94	1%, 1/4W
15K	2	R29, R79	1%, 1/4W
1K5	8	R71 – R78	5%, 1/4W
1M5	2	R92, R93	5%, 1/4W
22K	25	R1 – R22, R50 – R51, R80	5%, 1/4W
220K	2	R27 – R28	5%, 1/4W
270K	1	R91	5%, 1/4W
3K	8	R63 – R70	5%, 1/4W
4K7	6	R31, R48, R85 – R88	5%, 1/4W
6K8	16	R23 – R26, R30, R49, R52 – R62, R81 – R84, R89, R90	5%, 1/4W

Capacitors

Value	Quantity	Designators	Type
1 nF (.001 uF)	6	C6 – C10, C18	Metal Poly
10 nF	4	C19 – C22	Metal Poly
100 nF (0.1 uF)	15	C1-C5, C13 – C16, C23 – C28	Ceramic
47 nF (.047 uF)	2	C11, C12	Metal Poly
47 uF	1	C17	Electrolytic, 25V

Diodes

Value	Quantity	Designators	Description
1N4148	7	D1-D7	Diode, Si

Transistors

Value	Quantity	Designators	Description
2N3904	6	Q1-Q6	NPN

Integrated Circuits

Device	Quantity	Designators	Description
CD40106	3	U2, U10 – U11	Hex Schmitt Trigger
CD4013	1	U5	Dual D Flip Flop
CD4034	2	U6 – U7	8 Bit Shift Register with Parallel Load
CD4053	1	U9	Quad 1 of 2 Switch
CD4071	1	U3	Quad 2 Input OR Gate
CD4093	3	U4, U12 – U13	Quad 2 Input NAND Schmitt Trigger
LM324	2	U14, U15	Quad Op Amp
LM358	2	U1, U8	Dual Op Amp

IC Sockets

Type	Quantity	Designators	Width
24 Pin DIP	2	X6, X7	0.6”
16 Pin DIP	1	X9	0.3”
14 Pin DIP	10	X2-X5, X10-X15	0.3”
8 Pin DIP	2	X1, X8	0.3”

Header Connectors

Number of Pins	Quantity	Designators	Description
8	8	J2-J9	Sip Header, 0.1” Center
6	2	J10-J11	Sip Header, 0.1” Center
3	1	J12	Sip Header, 0.1” Center
2	2	J1, J13	Sip Header, 0.1” Center

PCB

electro-music Klee Sequencer Digital PCB

Appendix C: Front Panel and Wiring Bill of Material

Switches

Type	Quantity	Designators	Description
Toggle	24	SW1-SW16, SW33-SW36, SW39 – SW41, SW45*	SPST ON-OFF
Toggle	16	SW17 – SW32	SPDT ON-OFF-ON
Toggle	2	SW43, SW44*	SPDT ON-ON
Pushbutton	2	SW37 – SW38	SPST (ON)-OFF
Rotary	1	SW43	SP8T

***Optional Parts**

Potentiometers

Type	Quantity	Designators	Description
Rotary/Slide	16	R1 – R16	50K Linear, Panel Mount
Rotary	3	R17-R18, R22*	100K Linear, Panel Mount
Rotary	3	R19 – R21	1M Linear, Panel Mount

***Optional Parts**

LEDs

Type	Quantity	Designators	Description
Red	20	D1-D20	High Efficiency

Jacks

Type	Quantity	Designators	Description
Tip Connection	17	J1-J16, J17*	1/4”, 3.5mm, Banana
N.C. Switch	1	J17*	1/4”, 3.5mm

***Optional Parts**

Connector Housings

Type	Quantity	Designators	Description
8 Pin	17	P102-P106, P107-P109, P201-P202, P203 -P209	Connector Housing 8 Pos
6 Pin	4	P110-P111, P212-P213	Connector Housing 6 Pos
4 Pin	1	P210	Connector Housing 4 Pos
3 Pin	1	P112	Connector Housing 3 Pos
2 Pin	5	P101, P113, P211, P215, P216***,**	Connector Housing 2 Pos

***Optional Parts**

Crimp Terminals

Type	Quantity	Designators	Description
Female Crimp Terminal	177	N/A	Connector Term Female 22-30 AWG

Additional Items:

Front Panel
Stranded Wire, 22 – 24 AWG