Milton

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INTRODUCTION/FUNCTION OVERVIEW

I've made two sequencers. The first, a 2 x 8, is completed and installed into the Eclectic Music box . It was originally designed as a two bank for simultaneous control of the attack and decay phases of my VC envelope generators. Apart from the standard pulse in/hold/rest functions, it also allows up/down, pendulum and pseudo-random counting, enabled by by either an external pulse or by a faceplate switch. It has an bank A output, a bank B output, and a combined A/B bank output (16 steps), as well as separate pulse outs for each of the 8 stages.

This was good enough for me for some time. The problem is was having was in the pseudo random operation. To definition they aren't truly random and repeating ghost patterns manifest continually. While this effect wasn't necessarily displeasing, it wasn't exactly what I wanted.

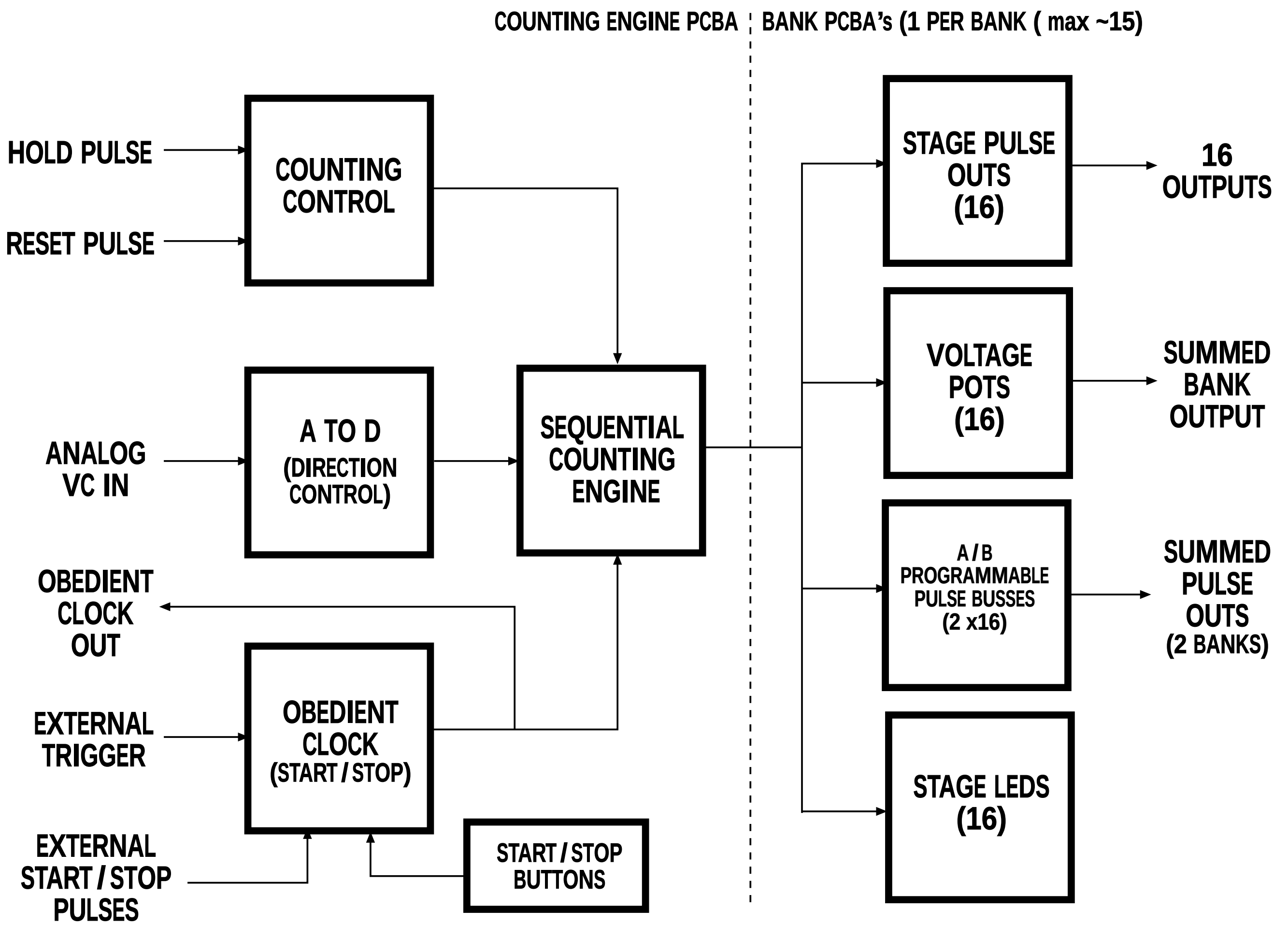

Diagram 1 - Milton functional model

I began work on another sequencer to remedy this. A much larger one, a voltage controllable one which would not only give me 4 banks of 16 steps, but full VC control of direction, using the Buchla 200's sequencer as a functional model.

The sequencer requires an external pulse for operation, which is routed through a flip-flop allowing for both manual and external (pulse activated) start/stop control of the incoming clock. An obedient clock. There is also an output for this obedient clock for syncing to external devices. There are the normal reset and hold functions, separate trigger outs for each stage and some things that aren't so normal:

Milton is fully voltage controllable. There is an external input for a positive analog voltage which is converted to four bit digital which is used to load the preset inputs of the 4516 counter which does all of the counting within the machine. The operation is simple - the input is quantized via an A to D into 16 levels (digital 0000 thru 1111). Depending on the level of the incoming voltage, the sequencer will be instantly sent to the corresponding stage. This control runs through a latch which is gated by the same clock which drives the machine, so these changes are timed to the same current sequencer speed. This may not be immediately apparent,. Depending on the speed of the changes and activity at the VC input, stage advancement may appear to be slower when in actuality, the voltage is forcing the sequencer to remain at the same stage for more than 1 beat.

Operation is straight forward from then on. You want random? Insert a S+H sampling noise. Backward operation? Insert a ramp. Pendulum? Insert a triangle wave. This plus a billion different patterns your incoming voltage may afford you.

The VC input has two modes of operation. In one, the VC cuts off if the voltage present is less than .2 volts (below the stage 2 threshold) With this arrangement, the input sitting there that will have no effect on the counting sequence until that voltage rises to a level above the .2 volts. So, if the input was an envelope generator, the sequencer would be going on it's merry sequential way until you fired the envelope, then all hell would break loose.

The second mode of ops for the VC inhibits this .2 volt limit, so if the same envelope generator was connected, the sequencer would sit at stage one while the E.G. was inactive until its output told Milton otherwise. Sounds wacky? Not really - this input is scaled to 1v/oct. If you connect a keyboard into the input, you now have a 16 stage programmer which advances one step with each key of the keyboard and will sit at that stage until another key is depressed (operationally similar to the Buchla Touch Plates and Serge Programmer). Obviously, this also makes tuning a sequence much easier.

There is no internal clock on Milton. It (he) depends on an external trigger. That trigger is routed through a flip-flop, allowing both full manual (buttons) and VC (trigger inputs) control of start and stop modes, with leds indicating the state. There is also a separate output for that obedient trigger to the outside world.

There are also two programmable pulse busses. Each stage has a three position switch which allows the operator to throw a pulse when that stage is active into one of two separate pulse busses, each have it's own summed output. You cannot send a pulse into both busses on the same step. It could easily be modified to do this however with an addition switch installed on the faceplate. There is as well a master disable (button and voltage input) to turn off the pulses at these busses at any time you wish. The pulses at these busses are shaped so two consecutive enabled stages will in fact give you two pulses - it won't glop them together as one legato event. The individual stage trigger outputs are also shaped in this manner.

I arranged this sequencer so that all of the main counting, clock control and VC functions are handled on a main engine board, and each of the banks with all of their associated controls (voltage pots, stage trigger outs, programmable pulse banks, summed voltage and pulse outputs and stage LEDs) on each of those bank boards. The Counting engine is terminated by 4050 line drivers with enough muscle to drive up to 15 banks simultaneously under full load.

Obviously, some of these bank boards require a different level of assembly. Some will have only the voltage pots and summers. In my arrangement, the top bank will also have the stage led drivers and stage trigger output componentry installed, while the bottom bank will also have the programmable pulse busses installed.

A QUICK COMPARISON BETWEEN RANDOM AND PSEUDO-RANDOM CONTROL:

Anyone who has used a Serge TBK will notice that their 'random' function creates undeniable patterns during its use. These 'sidebands' are unavoidable in the Serge method of generating random due to intervocalic ratios which present themselves from the constant (metric) operation of the high speed clock driving the pseudo-random engine vs that of the (comparatively low speed) main counting engine it controls.

In brief, 'random' is created in the Serge by using a secondary counter which is running at an comparatively high speed (high kHz, well above audio range) to that of the main counter, in the case of the Serge, a 4516. This high speed counter runs at a constant metric pace and is counting sequentially (L. to R., step 0 to 15), over and over again, very quickly. The outputs of this secondary clock are fed through a latch which gates (samples) the its current count and feeds it into the presets of the main counter at the exact moment the main counter receives an incoming clock - much like a digital sample and hold. This four bit preset information overrides the counting order of the 4516 main counter's sequence, and forces the unit to the preset number generated by the secondary clock. In that it's running so much faster, chances are this is going to send the main counter to something other than a adjacent step in the direction the unit was travelling before this control is applied. But because both the external secondary counter IS and the main counter MAY be running metrically (constant pace), patterns will appear.

This is the exact method incorporated in the first sequencer I built.

The Modcan unit runs under the same principle. It's also based around the 4516 as the main counter. In that Bruce has random SELECTION vs. voltage control, I think he used the same process as the Serge and my first sequencer: I use a 4516 in Milton as well, but have incorporated an A to D that attacks the preset inputs of that chip, thus enabling direct external generation of the preset loading, as opposed to external ENABLING of internally generated four bit binary data.

MILTON OPERATION:

If you've used an analog sequencer before, Milton is pretty cut and dried, with a few exceptions. For the purpose of this text, I will assume you have assembled a standard Milton - that being per the assembly drawing and having four banks of 16 steps , one set each of stage LEDS and Gates outputs, and one Programmable Pulse bank. Depending on how you've actually assembled it, your mileage may vary.

On power up, it will default to step 1 and will be halted (STOP led on). To get it running, insert a clock source into the input jack and press the 'RUN' button. See Milton go, go Milton, go...left to right which each incoming clock.

What? It isn't going? Make sure the VC select switch is set to the 'Std' position and not 1V/ oct setting. When in this mode, the VC input completely overrides the incoming clock and unless there's a voltage connected to that input, it will sit at step one awaiting one. Flipping the input select switch to the other position will get it going and it is in that setting you could call 'normal' operation.

Once you've done this and it's now flying along, there are a few things you should play with immediately. The sequencer can be halted at any time by a few methods: By pressing the STOP button, by inserting a positive going signal into the STOP jack, by flipping the VC SELECT SWITCH to the 1V/OCT mode, or by putting a high signal into the HOLD jack. All will effect the sequencing similarly - it will simply stop running on the stage where that signal was introduced. Getting it going though depend on the method used to halt it of course. While the HOLD jack and VC INPUT SELECT disabling is obvious, the use of the Start/Stop Buttons may not be.

Both the Start/Stop buttons and their corresponding input jacks control the front end of a flip flip which in turn enables the incoming clock through an AND gate. Once one of them is depressed, depressing it again, or changing the state of the corresponding input jack will do nothing. If it's stopped, pressing the STOP BUTTON, or putting a high into that STOP jack will have no effect. If you've pressed the STOP button, you'll need to press the START button next to get it going again. Similarly, instead of pressing the START BUTTON, you may elect to put a high into the START jack, which will have the same effect. The inverse holds true as well. If running, you may stop it by either depressing the STOP BUTTON or inserting a high into the STOP input jack.

The START/STOP jacks allows you to start and stop Milton by two external signals. You will find this feature great fun. You can set Milton up for 'one time' sequencing by putting the STAGE GATE OUTPUT of the LAST stage you wish to run in your one time sequence into the STOP jack. Then you can insert an external pulse into the START and RESET jacks. A good one to try out is the gate output from a keyboard. Each time you depress a key on the keyboard, Milton will perform one sequence, up to the stage you've determine as the last by virtue of it's gate out going into the STOP JACK.

This is just one example of the use of the external START/STOP function. You will find a million more in the months to come.

So now let's assume its humming along, advancing left to right which each clock pulse received. Each bank you've installed has an output jack which will give you the sequential playback of the settings of the 16 pots in the corresponding bank. The voltage range of these pots will go from zero, to a high level which is determined by a couple of things: The power supply limit you are using Milton with (either 12 or 15 volts) and the value of the final feedback resistor or the bank's output summer. I will get to that in the ASSEMBLY SECTION.

Each stage has a GATE OUTPUT which will stay active (high) as long as that stage is engaged. These outputs can be used to turn on external devices at predetermined times, or routed back into Milton for an automatic step feature. If you use multiple stage gate signals to trigger the same external device - know that this will give you legato operation: If you use two adjacent stage outs you will in effect blend to two together into one single gate.

A word of caution when doing this: Depending on how you've wired the gate/LEDS outputs (options A, B or C) YOU MUST MULT THESE GATES THOUGH A MIXER. If you simply use a mult, or if equipped with banana jacks just simply stack multiple gate outs, you are going to be not only sending these gates out to where you want them, but also back into each stage of the sequencer itself, turning an internal transistor inherent to the gate outs into a zener diode, permanently. If you've used option B, then it should be no problem - these stage is protected by the stage LED. Using the other options, I highly recommend you not do this - you should instead mult these outputs through a mixer.

But you WANT to do that? No problem - but for this type of multi-triggering it's best to use the PROGRAMMABLE PULSE BANKS as those triggers are run through internal summers, therefore protecting the stage triggers from one another.

The Programmable pulse bank is a set of 16 switches (one per step) which allow you to route a TRIGGER (not a gate) through either the A or B bank output, depending on how you have the switch thrown. If in the center position, the trigger is not routed to either output - so that stage trigger is skipped. If thrown in the A position, a trigger will fire out of the A output when the sequencer goes to that stage. If set to the B position, the trigger is routed out the B output. Each time a trigger is sent to either of the banks, the banks' LED will turn on, indicating a trigger has fired. The Programmable Pulse banks take the trigger signal coming from the obedient clock. They will have a 15 MS on-time. If this ends up not being long enough for you, you can change that (this is covered in the ASSEMBLY section of this manual).

There are also conditions of use of the Programmable Pulse banks. If you set a switch pattern up in one of the banks, start the sequencer and notice there's nothing coming out of the bank out and there is no activity at that banks' LEDs, then more than likely you've got the GATED PULSE SWITCH set to the external mode. Flip this switch and see what happens - you'll now see that pattern manifest itself out the bank output. This switch was added so that you can manually turn the patterns on and off at will. This may also be done automatically through the use of an external enable (high signal). When the GATED PULSE SWITCH is not in the manual mode (pattern off), you can turn it on externally by giving the EXTERNAL PULSE ENABLE jack a high signal. If the switch is in the manual mode, this external jack has no effect.

Milton has also been fitted with an OBEDIENT CLOCK OUTPUT. This is the same signal going to the pulse banks outputs routed thorough the internal flip -flops. This clock will be present only when th sequencer's START/STOP switches are in the START mode. The purpose of this output was to allow you to sync external devices (such as envelop generators) along with Milton. When it stops, the envelopes stop. When it goes, the envelopes startup again.

Other than that, Milton is also equipped with the normal controls found in most sequencers. There is a RESET jack, which will reset the counting to stage one on a high signal and a HOLD jack, which will hold the counting to the active stage when that signal goes high. Once that signal goes low, the counting will resume from the stage where it was temporarily halted.

So there is an overview of the 'standard' operation of the Milton sequencer. Fortunately, there are things about this device which aren't standard and that involves the use of the VC INPUT, setting Milton in a category along with the fabled Buchla 248 and Wiard Sequantizer as the only production analog sequencers ever made which are truly voltage controllable.

There are two controls (actually three - but one is inside the unit) that control Milton's sequencing. The VC INPUT allows a portal to the outside world so that an external analog voltage level can by used to override the stage selection by the internal counter and assign which stage will be active. Once this voltage is received, it's routed through an four bit A to D converter. This information is then fed into the preset inputs of the main counter, and the level of that external voltage, not the counter, will determine which stage is active. There is a also SENSITIVITY SWITCH which will allow you to change the way this eternal voltage is processed. In the 'standard' setting, the external voltage will only effect the sequencer when that voltage is above .2 volts. In that way, you can leave something connected to the VC jack and it won't effect the counting until that signal rises about that threshold. A good example of this is using an envelope generator. If connected, it will do nothing until that envelope is fired.

Once this happens, Milton will respond immediately to that incoming voltage level. High voltage will send the sequencer to stage 16, ground sends it back into internal counting. Anything in between will send the sequencer to any one of the 16 stages. You'll have to play around with these to get the feel of it.

By throwing the SENSITIVITY SWITCH into the other position (let's call it 1V/OCT), the VC input signal is routed through a voltage doubler, which has an internal trim pot allowing you to adjust the accuracy of that doubling 10% (thus being the third control effecting the VC input). When in this setting, your incoming voltage will have a x2 effect of the same voltage present while in the other setting of this switch. Test this. Put a constant (non fluctuating) voltage into the VC input while the switch is set to 'standard'. Adjust this voltage so the sequencer now sits at stage 5. Flip the switch and you will see that sequencer jump to stage 10. This will happen no matter which stage you are on: 1 to 2, 2 to 4, 3 to 6, 4 to 8, 5 to 10, 6 to 12, 7 to 14, 8 to 16 and 9 to 18. Just kidding - there are only 16 steps available -but it there were 18, you know where Milton would be.

Another feature of the 1V/OCT switch setting is the .2 volt activation threshold limit is bypassed, so a level of ground will rest the sequencer to stage 1. I did this so that if a keyboard was connected, each key will effect the active stage and at no time would the sequencer start advancing by itself. I find both modes quite useful.

Operation of the VC input is straight forward from then on. You want random? Insert a S+H sampling noise or just noise for that matter. Backward operation? Insert a ramp. Pendulum? Insert a triangle wave. This plus a billion different patterns your incoming voltage may afford you.

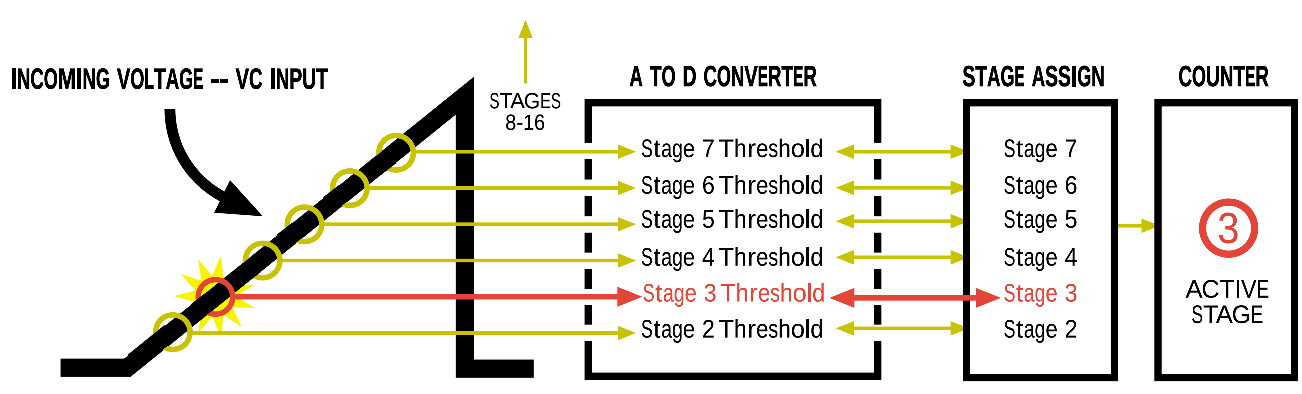

Diagram 2 - VC response

Be aware that both of these modes are SYNCHRONOUS to the incoming clock. Changes will not occur until the next incoming clock is received. I did this so that the current running speed of the sequencer would not be effected when an incoming voltage was received at its VC input. There is an assembly option which will allow you to switch between SYNCHRONOUS and ASYNCHRONOUS control - please see the assembly sections for details. If you elect to install this option (another switch will be required on the faceplate), then the voltage will effect a stage change regardless of the incoming clock. At that point the incoming clock is pretty much disconnected.

Also be aware that the VC input only responds to POSITIVE voltages. Anything lower than that will not damage the unit, it will just have no effect. So AC signals will be half rectified - only their + voltage travel will effect the unit. If you hate this, if you don't have one I highly recommend a voltage processor which will allow you to offset an AC waveform fully to the positive rail. Once you've done this, there will be no stop in the action so to speak of the effect of an AC waveform.

The VC input, regardless of options incorporated or switch settings, is in application a digital sample and hold. An incoming analog voltage is received, converted to binary numbers and send to the main counter when an internal latch tells it to. Be aware of this as it does effect the response. If you want to send the sequencer backwards, you'll have to set up the rate of change of that incoming signal with the speed of the clock going to Milton in order not to get duplicate steps where the sequencer doesn't respond. Also be aware that most envelope generators have log outputs, the curves are not linear, which will also effect the rate of travel when used to control Milton. Having envelopes generators with linear outputs will be helpful if this becomes problematic. A fine example is the Blacet EG. You can set internally for log or linear operation. There are many other features of this envelope generator which make it one of the best out there.

Once the voltage at the VC input has been released, or falls below the .2 volt threshold, Milton will resume counting L to R by itself immediately from the last stage active when the VC was controlling things.

INTERCONNECTION:

Once the boards are assembled, the first thing you'll need to know is how to slap it all together. You will notice on the Engine Board a 16 pin DIP labeled J3. This is the main signal output of the engine board and passes the buffered outputs of the CD4516 main counter to the outside world. On each Bank Board there are two simular DIP patterns, labeled J1 and J2.

You will also find on the Engine Board a five position in line Molex connector terminal labeled J2. This requires a key'd five pin in-line Molex connector and will serve as the power buss to the Bank Boards -and- the Gated pulse signal for the programmable buss as follows:

Pin 1: Gated Pulse
Pin 2: -V (12 - 15)
Pin 3: Ground
Pin 4: Ground
Pin 5: +V (12 - 15)

(Pin 2 and Pin 5:) Must be equal in voltage, with an acceptable operating range of +/-12 thru +/-15.

Interconnections between the Engine Board and the Banks Boards is done by daisy-chaining 16 pin DIP header cables as follows:

Notice that J2 and J4 of the last Bank Board (4) are intentionally Not terminated. This allows for future expansion (additional banks). The signal on the data buss (the 16 pin DIP header cable) is buffered from a CD4050, which should allow for up to about from between 12 to a maximum of 15 banks to be connected without further current amplification. So if you ever care to add more, J2 of the last bank board on the string is where they should be connected.

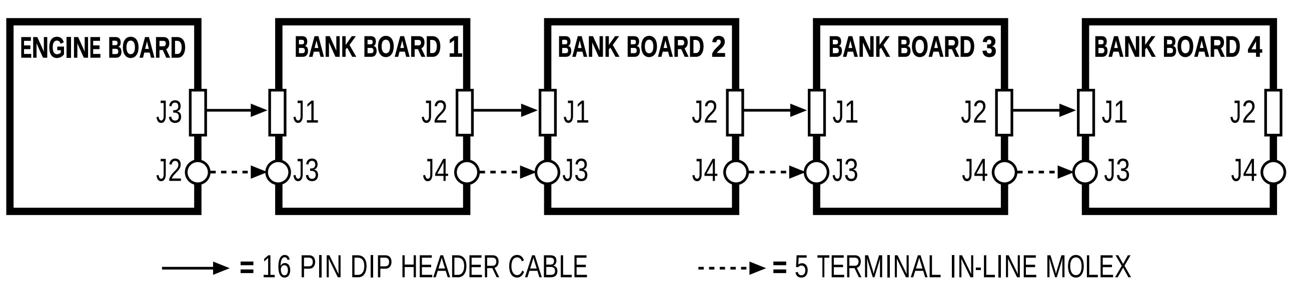

Diagram 2 - Milton PCBA Interconnect Diagram

Outside of the interconnects listed above, there are between 12 and 15 wires which will need to be routed from the Engine board to the faceplate (depends on what option you use) and either 1, 21 or 33 wires from the banks boards to the faceplate. Only 1 each is required for banks 2 and 3, which only require the summed voltage to be routed out. 21 will be required on bank boards fitted with the programmable pulse banks and between 17 to 33 will be required with bank boards fitted with the stage gate outs and stage LEDs, depending on what configuration you choose to drive those signals. More detail can be found in the assembly section.

For easy serviceability, I recommend you use connector for the signals going from the Engine Board to the faceplate.

Care should be taken when installing the power buss connectors (5 pin in-line Molex). Although these are fitted with locking mechanisms, thus forcing the correct polarity, with enough elbow grease anything is possible and you WILL be able to force them in backwards. When you do, unless your power supply is equipped to foldback on dead shorts, expect to have to replace most of the CMOS and all of the op amps on all boards.

ASSEMBLY:

GENERAL CONSIDERATIONS

Some guidelines:

Solid white lines between holes designate jumpers to must be installed at that location. Look closely, some are hard to find.

The nature of these boards (non plated thorough holes) require an iron that's not too hot. Too much heat (especially when removing components which have already been soldered) could result in lifting pads. If you are removing components after they have been soldered, take care to assure all of the solder has been removed and that the leads of the component move freely (fully disengaged from their pad) or the pad will surely lift when trying to force the component out.

Metal can 2N2222s work best in this boards, as the polarity indicators (tabs) are clearly marked in the silkscreen legend. While plastic bodied equivalents will not induce an electronic incompatibility, please verify proper insertion via the graphics, which clearly indicate the base, emitter and collector.

You will notice that some of the designators for the discrete passive components list a value of XX along with its designator number. This was intentional, as these specific components are either not required for all applications or have values which will vary to match your specific electronic environment (signal level compatibility).

There is an abundance of bypass capacitors on these boards. This was intentional due to noise problems associated with digital counters. There are specific locations however where they are optional and should be installed only if you are having count problems. Those instances are outlined in these assembly instructions.

The location of double arrows >> on the schematic indicate input/output pads, leading to either jacks, switches, LEDS or other types of faceplate controls. In most cases, they point in the direction of signal flow, just as an indicator. I may have made some errors in this, but it is not detrimental to the assembly process.

This assembly is littered with CMOS components which are sensitive to damage due to static discharge! Inmost cases, the damage is not catastrophic (the part ill still function), but it's life will more than likely be seriously compromised. Two smart safeguards is to use IC sockets for all locations and install the CMOS last, and secondly once they are installed, USE PROPER ESD HANDLING SAFEGUARDS!!

ENGINE BOARD

The Engine Board is just that - it contains the circuitry to convert an external clock into a paced sequence which will advance either linearity (left to right), or non-linearity when an external VC is also applied. There are also options for control of this external pulse (such as start and stop) and signal conditioning for the pulse which will be used in the Programmable Pulse Busses. Although there are others (obedient clock out and gated pulse out), the main signal output of this board is J3, a 16 pin DIP header socket which sends the sequence information out the the bank boards.

First, I need to call to your attention a missing designator of the Engine Board. If you holding the PCB so that "Copyright 2003 by Peter Grenades" is visible in the upper lefthand corner, you will see a diode in the lower lefthand corner without a screened designator for it's type. Install a 1N914 into that location. If you notice that it is indeed marked, then you have a rev 3 board, in which this was the only correction.

You will notice an unplated hole next to most of the pads which require wires to be run to the faceplate. These were added to provide a stress relief for the wire if you care to do so. TO use these, insert the tinned wire through the non-plated hole form the back side of the PCB and then wrap bend the tinned wire into the 'live' plated hole so it may be soldered. These will probably not be needed, but I through them in just in case.

As with the bank boards, solid white lines between holes on the Engine Board designate jumpers. Install of the the parts on the Engine Board, with the following omitted/left as optional:

JM1 should have a jumper installed (between both leads of JM1).

JM2 requires either a switch or a jumper depending on if you wish to have selectable sync or async operation for the VC. If you only wish for sync operation, install a jumper into that location. If you only want async VC (not recommended), then Omit the jumper at JM2. If you wold like to switch between sync and async operation, install a DPST switch at JM2 leading to the faceplate. When th switch is closed, you will be in synchronous VC operation. With it open ,it will be async. For a description of what sync and async VC behaves, see the OPERATION section of this manual.

JM3 are four test points (one for each output of the 4516 counter) as serve no purpose unless you are planning of internally linking two Miltons together. I was included more than anything for possible future expansion and o leave the architecture open at this critical point. In the meanwhile, nothing goes in these locations.

The Programmable Pulse Disable LED indicator is totally optional. If you do not wish to include this feature, both the 2N2222 transistor directly above the top 9 x 33k resistor network (just above center of the PCB) and the 1K resistor above that transistor can be omitted.

Input clock length adjustment: Looking at the schematic, you'll see that an R/C has been added to the base of the 2N222 transistor that supplies the external clock to the Milton counters. This signal conditioning is critical to assure proper operation without conflicts from multiple input pulse stimuli, such as resets and start/stop commands coming from the outside world. You will also notice however that the same waveshaped clock provided the signal for the Obedient Clock Output and routed through as the output pulse for the Programmable Pulse busses. In the event this pulse is too short in length for you external modules to recognize (currently 30ms), changing the values of the 100k resistor and/or .01 cap in series with the base of that transistor will change that on-time. Be careful though - there is a point where this pulse will be too long, which will lead to counting problems.

I have included pads and routing for both sides of all faceplate switches and indicators. This means separate +V and ground returns for all switches and LEDS. As an option to running wires back to the board for these busses, you may elect to daisy chain them from one supply line leading to the board. The benefit of this be less wires going from the PCB to the faceplate and back again. It is fairly simple to figure out how to do this, so I will not go into that detail here.

It is highly recommended that you use IC sockets for all IC locations.

J3 is a 16 DIP socket which serves as the main output of the counter to the bank boards. To assure contact integrity, a 'high rel' turret type (not spring contact) socket must be used at this location.

Please reference the schematic to locate two capacitors which should only be installed in the event you are having noise problems. They are the .01 coming off of pin 9 of U1, the .01 after the 1k in the output side of the Obedient Clock Output, and the .1 hung off of pin 10 of U9.

A mylar cap should be used for C1, the .022 cap in the U14 sync oscillator circuit used in the digital to analog converter. This circuit especially hates ceramic disk caps - don't even think about it. In the event your D to A isn't working, this is probably the culprit. If you can't locate a mylar, use test leads to experiment with different types until you are seeing a clean square wave at U14, pin 11.

BANK BOARDS:

The Milton Bank Boards provide the necessary hardware to derive all of the stage voltage presets and operator interface functions for a given bank and have been designed so that they may be configured in a number of different ways:

They can be assembled so that they only provide the hardware for the stage voltage pots and the summer for those pots (CONFIG A below).

They may be configured to provide both that and the Programmable Pulse Bank hardware (CONFIG B below).

They may be configured so that that contain the voltage pot hardware and the stage LEDs and stage gate outputs (CONFIG C below),

...or they may be configured so that one bank board has all of those features (CONFIG D below).

How these boards are configured is determined on which components are installed or omitted on a given bank board.

Configuration A - Bank preset voltage pots and summers ONLY:

Note: Unless you wish to configure your sequencer under special circumstances, all bank configurations (A, B, C, D above) will require these components as they are required to drive the voltage pots that make an analog sequencer function.

For location purposes, please hold the bank board so that the pots are on the bottom. The required components for configuration A are:

All 16 Pots, the 16 1 meg resistors directly below them and the jumpers next to those 16 1 megs.

The jumper to the left of Q1 on the far left of the PCB.

All of the discrete components associated with the summing circuit in the first and second op amps in U1. These are the parts which are located directly BELOW U1 (3 430k resistors, a .0022 cap and R1 and R2).

J3 and J4 in-line Molex connectors

The 16 .01 bypass caps located the right of Q1-Q16 (the Q16 bypass is located above the transistor).

J1 and J2 16 pin DIP sockets. High reliability (gold turret type) sockets are required here - do NOT use the spring loaded low cost type in these locations.

Variables:

The values of R1 and R2 voltage divider at U1 dictates the maximum output level of the bank voltage summer. Ohms law will dictate these values based on the signal levels you are integrating Milton to.

Use the following values if a 0-8 volt range is acceptable (although this will vary based on either a +12 or +15 voltage supply level):

R1 = 330 ohm

R2 = 1k ohm

In the event R1 is not be required for your specific application, a jumper will need to be installed at this location

You may also want to adjust the feedback resistor values (the 430K ohms) if you cannot reach your desired range through combinations of R1 and R2 alone .

Configuration B - Additional components required for the Programmable Pulse busses:

This is easy. For this configuration, along with the components listed for configuration A above, you will be required to install EVERYTHING located above the row of 16 .01 caps found at the vertical center of the board (everything above the unicorn graphic 0 including the jumpers), with two exceptions:

1) You will also need to install the two 1k's to the left of Q1 (they are slightly below the unicorn).

2) R22 is optional and should be omitted unless you are seeing lazy pulses out of the Programmable Pulse banks. It serves as a means to provide a pulldown to guard against false triggering of the two 2n2222's. Unless the 16 pin DIP headers are very long, this resistor should not be required.

Variables:

The values of R3 and R5 should be the same as the value used for R1

The values of R4 and R6 should be the same as the value used for R2.

While not directly associated with the Bank Board, please notice on the schematic 16 SPDT (ON-OFF-ON) faceplate mounted switches. **Please note that these switches need to be equipped with a center off position in order to be fully operational.**

Configuration C - Additional components required for the stage LEDs and stage Gate outputs:

Also easy. For this configuration, along with the components listed for configuration A above, you will need to install the everything BELOW the unicorn graphic.

Variations:

Please reference the Bank Board schematic. Notice there are two methods of providing the stage gate outs and stage LED out. Depending on which you need, this will dictate how your assemble C configured Bank Boards. In most cases, Detail A will be your best bet. Detail B was included for Modcan users to prevent damage by overdriving trigger inputs. I think the schematic is pretty clear for both of these options, so I don't feel additional information need to provided here.

Configuration D Know all, do all Bank Boards:

While using the greatest amount of parts, this configuration is the easiest to assemble:

Install everything.

Follow the divider guidelines for R1-R6 shown above.

APPENDIX I: FUNCTIONAL COMPARISON:

The following is a matrix which compares the functionality of Milton to the balance of other 16 step analog sequencers - namely the Serge TBK, Buchla 246 and Doepfer MAQ 16.3. Each episode is broken down into two categories:

A) Things that specific sequencer does that Milton can't

B) Things Milton can do that specific sequencer can't

AS COMPARED TO THE SERGE TBK

WHAT THE SERGE DOES THAT MILTON CAN'T	MILTON'S EQUIVALENT (IF ANY)
Pulse enabled directional presets (for/back/random)	Full voltage control of direction
Touchplates for manual assignment of stage/trigger	1 v/oct CV input processing for keyboard control of stage
Vertical sequencing (compounded banks)	None
WHAT MILTON DOES THAT THE SERGE CAN'T	TBK's EQUIVALENT (IF ANY)
1 v/oct control inputs (keyboard controls active stage)	None
True random stage advancement	Pseudo-random
2 programmable pulse busses	None
Start/Stop control of external trigger	None

AS COMPARED TO THE BUCHLA 246

WHAT THE BUCHLA DOES THAT MILTON CAN'T	MILTON'S EQUIVALENT (IF ANY)
Start of sequencer stage selection	Accessible through offset CV, but more difficult
WHAT MILTON DOES THAT THE BUCHLA CAN'T	BUCHLA'S EQUIVALENT (IF ANY)
2 programmable pulse busses	None
Audio processing (attenuation of non-harmonic partial)	None

AS COMPARED TO THE DOEPFER MAQ 16/3

WHAT THE MAQ DOES THAT MILTON CAN'T	MILTON'S EQUIVALENT (IF ANY)
Midi output	None
Midi CC output	None
Totally Independent bank operation	None
Memory recall of sequences	None
Quantized outputs (only)	None
5 directional presets/bank	Full voltage control of direction
Midi controllable	None

WHAT MILTON DOES THAT THE MAQ CAN'T	MAQ'S EQUIVALENT (IF ANY)
Linear (non quantized) analog outputs	None
Analog control of incoming clock	None
Receives external clock	Runs off of internal clock only
Voltage control of direction	5 directional presets/bank
Individual stage pulse outs	None
2 programmable pulse busses	None
4 banks of 16 steps	3 banks of 16 steps

APPENDIX 1I - SAMPLE PATCHES:

The following patches are a few examples of a few ways to do a few things. They are by no means the ONLY way to get these things done, nor are they showing all Mitlon is capable of. They do however give you some ideas. Enjoy.

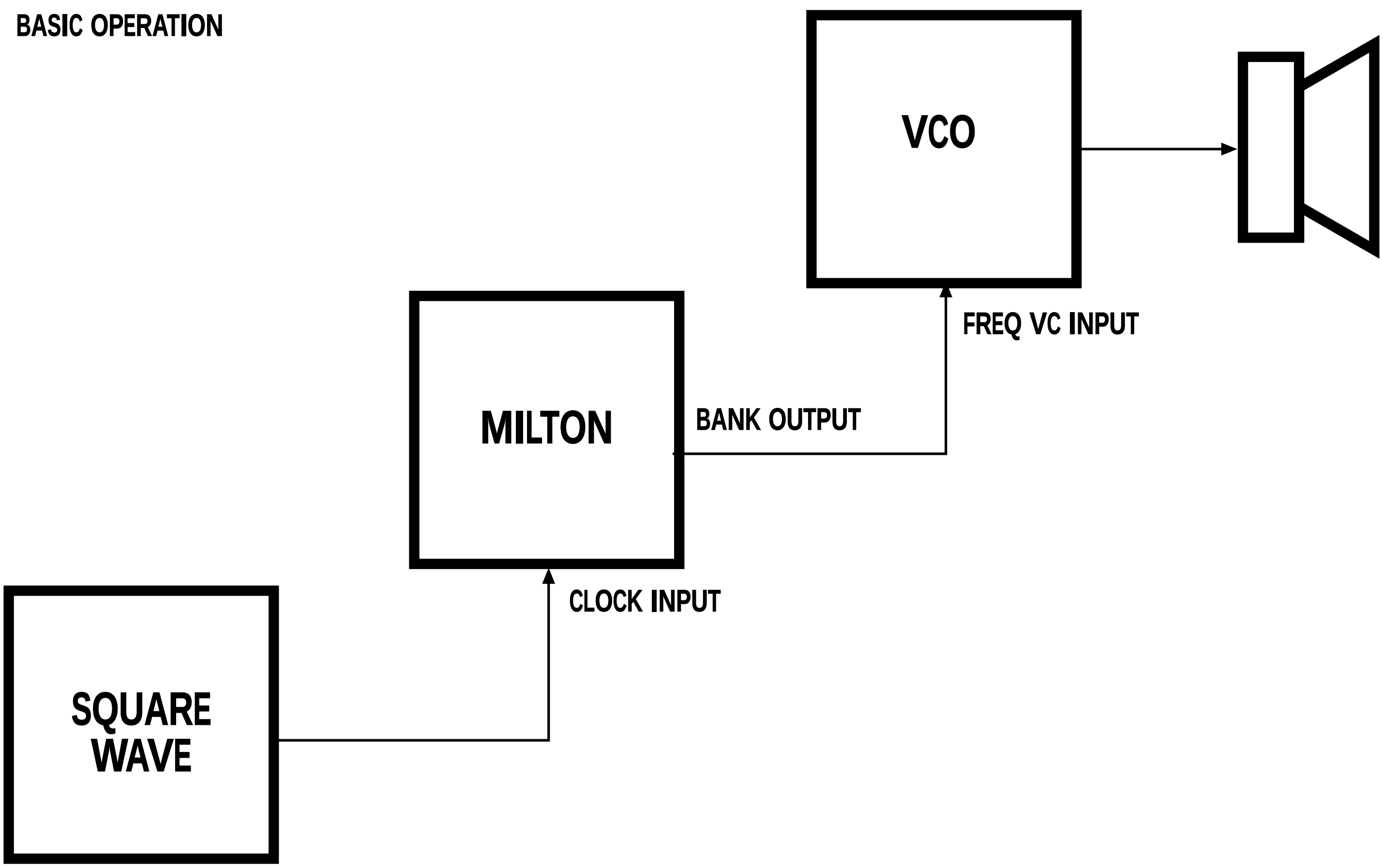

Diagram 3 - Basic Operation

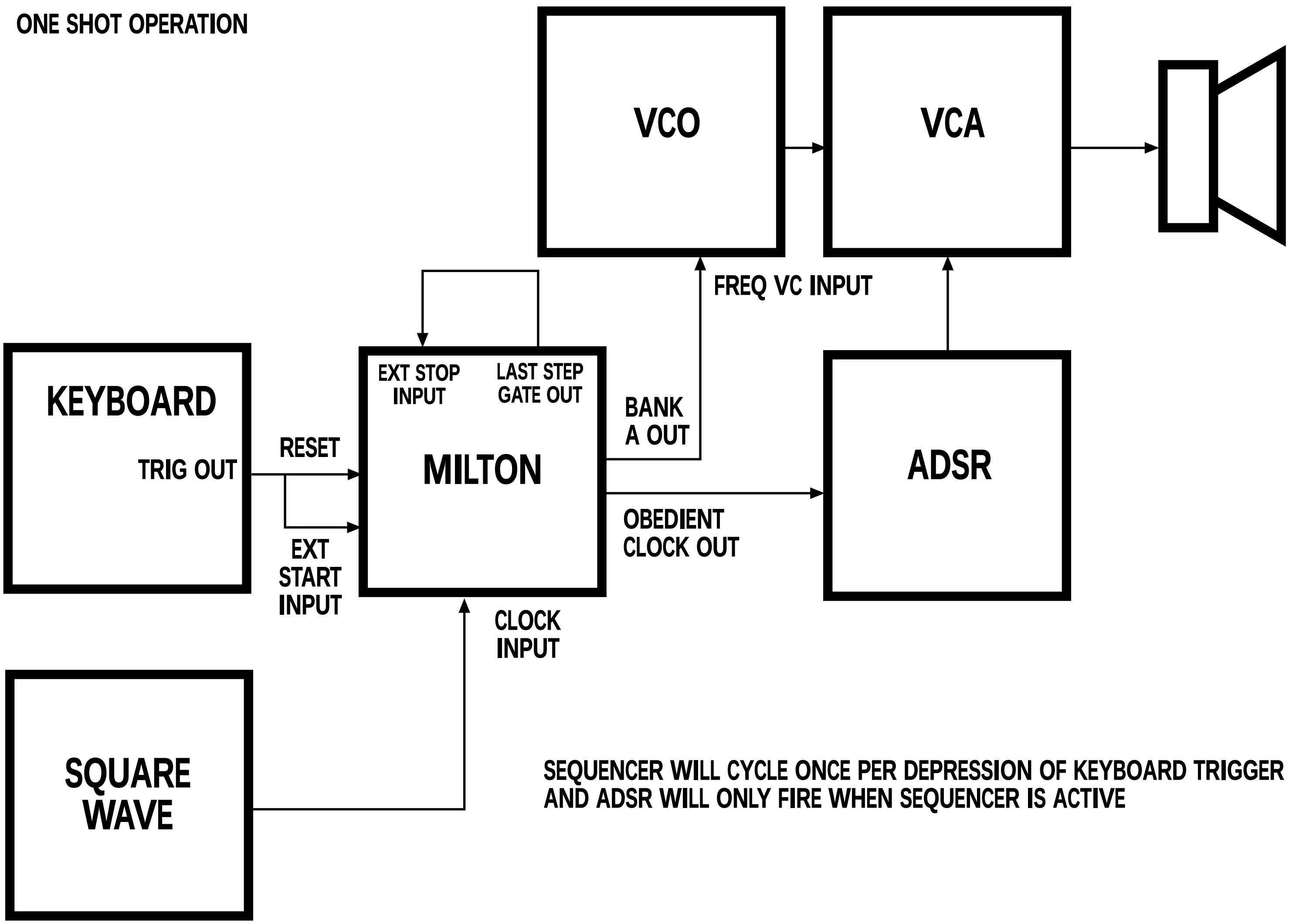

Diagram 4 - One shot Operation

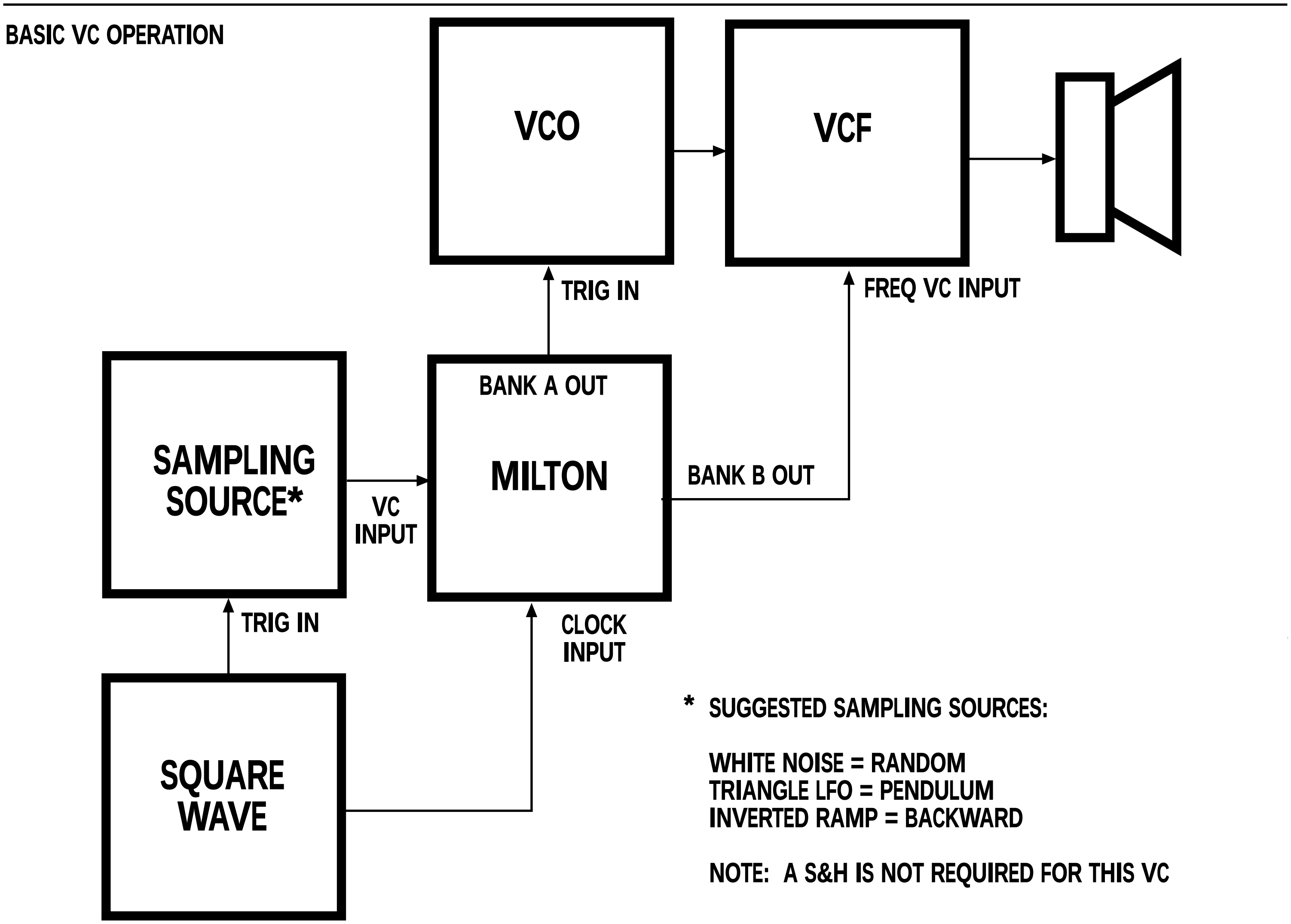

Diagram 5 - VC Operation

APPENDIX III - THEORY OF OPERATION:

he following is a quick overview of what happens and why, broken down by functional block. Please refer to the schematic for details.

ENGINE BOARD

The Engine Board consists of two main functional systems, as follows:

1) Sequential Counting Engine

The components that make up the counting functions are the heart of any analog sequencer. They take a serial trigger and fan it out sequentially to any number of decoded outputs - in this instance a maximum of 16 with patterns shorter than that determined by a reset pulse.

U1, 3, 4, 6, 7, and 8 make up the three primary counters used on Milton.

The 4516 (U1) is the main counter who's primary function is to convert serial pulses to four bit binary data. It can also respond however to external 4 bit data present at its preset inputs. When these presets are enabled (pin 1 high in this instance), they override the current count being decoded from the external clock. In this way and through careful arrangement of preset information, an external VC of direction has been devised.

Once either a serial clock or four bit preset word has been output from the 4516, it is immediately fed into two 4051 (U3 and U4) mutliplexers, which take this four bit binary data and fans it out of 16 parallel discrete outputs, thus creating the main sequential drive current for the stage dividers (pots) to dissect into fixed, yet variable voltage levels. The 4051 is actually a sequentially enabled analog switch. It will pass any signal preset at pin 3 to it's multiplexed outputs sequentially . In this instance, I have supplied it with V+. In that these outputs are floating open when not active, 33K pulldown resistors are required on all outputs to return them to logic state 0 (ground) when not selected, thus turning the inactive sequence stages off and allowing only one stage to be active per bank for any given input pulse.

The counting engine is terminated with three 4050 buffers, which amplify the current output of the 4051's that allow for multiple banks, Programmable Pulse busses, LEDs and Gate outs all to be active simultaneously without causing loading problems. In theory, up to 13 banks should be OK without hick-up.

2) Direction Control Engine (D to A Converter)

The second most important part of Milton operation is what makes it unique - the VC control circuitry. This consists of four ICs (U2, U11, U12 and U14) which for the most part, run off of a regulated 5 volt supply inherent on the Engine Board itself (78L05). The direction control circuit requires four simultaneous conditions in order to operate: an external positive DC voltage present at the VC input; an enable signal provided by the VC select switch setting; a high signal form U14 which is configured as a 40kHz clock which serves at the sampling rate for the A to D to do it's conversion; and in synchronous mode, an incoming clock - the same clock which drives the sequencer through its paces.

The heart of the direction control engine is the U11, the ADC 0804 8 bit Analog to Digital Converter. It receives a discrete analog voltage (regulated to a 5 volt maximum through a 1n5249 zener at the buffering stage), and converts it to 8 bit binary data, although only the first four are used in the final application here. Once this 0-5 volt, high true data is generated, it is run through a series of conditioning transistors (2n2222) to return them to the 0-12 volt range necessary for the CMOS circuitry (remember, in order for CMOS to respond to a high logic condition, that signal must be at a minimum 3/4 that of the ICs supply voltage - its Vcc).

Once this data has been converted back to a 12 volt range, it is fed through U2, a 4042 four bit latch which serves as a digital sample and hold. The 4042 takes the amplified output of the A to D converter and holds it until its told to pass it on into the preset inputs of the main 4516 counter described earlier. If the sequencer is set for synchronous operation, this means that the stored data will be held in the 4042 until an incoming clock is received. If set for asynchronous mode, the 4042 is in effect bypassed, so the main 4516 will respond to state changes at the A to D output the moment they happen, regardless of the state f the incoming clock.

Along with the counting and direction control engines, the Engine Board also conditions all the incoming signals required for these two systems to operate as as well manages several digital switching functions such as the manual/external start/stop functions, reset and hold.

BANK BOARD

The operation of the Bank Board is pretty much cut and dried: it receives the 16 outputs of the main counter from the Engine board and sends it through 1 6 pots, one per stage, which act as voltage divers to attenuate the logical 1 (high) signal coming form the active stage (about 8 or so volts when Vcc = 12). the outputs of these 16 pots is then sent through an active summer which does the final conditioning and set the maximum output levels before passing this information out to the outside world.

The Bank Board also routes the outputs of the counters into a series of emitter-followers which is used to create the stage gate outputs and turn on the stage LEDs. These transistors in the emitter-followers (2N3904) are diode protected to keep multiple gate outputs from backing up and turning the transistors into zeners.

Another function of the Bank Board which is unique to Milton is the Programmable Pulse Bus. This circuit takes the gated clock signal (which is the same as the obedient clock signal, yet passed through an enabling AND gate on the Engine Board), buffers it through a transistor pair and sends it through 16 AND gates, which are in turn enabled by the current active (high) stage of the sequence. The outputs f these AND gates are then fed to the faceplate to SPDT ON-OFF-ON switches which route the outputs into three possible conditions: Into the BANK A output buffer, into the BANK B output biffer, or into neither (switch set into the center 'off' position). In this way, an operator can choose which Pulse bank a given stage's output pulse ir routed, or if it disabled, therefore passing the pulse nowhere at that stage

APPENDIX IV - FACEPLATE CONSIDERATIONS

The following page shows a sample faceplate utilizing all of Miltons controls accept the asynchronous/synchronous VC operation. It is the artwork used for the MIlton prototype and is quite functional. If you do not wish to use this , you can reference it as a guideline when designing your own graphics. You are free to do what you wish.

One convention you must adhere to however are the **.8 inch centers for the pots, as this is how they are spaced in the bank boards.** Each bank will be fine at about an inch from one another - but the pots on your faceplate will need to be .8 inch center to center form one another. OK, I've made that clear!

APPENDIX V - SAMPLE FACEPLATE

The following page shows a scaled down version of the sample artwork. A full scaled one at high res can be downlaoded at:

http://www.buzzclick-music.com/faceplate.jpg

This faceplate was designed for easy mounting into a single rack space, 4 RU high.

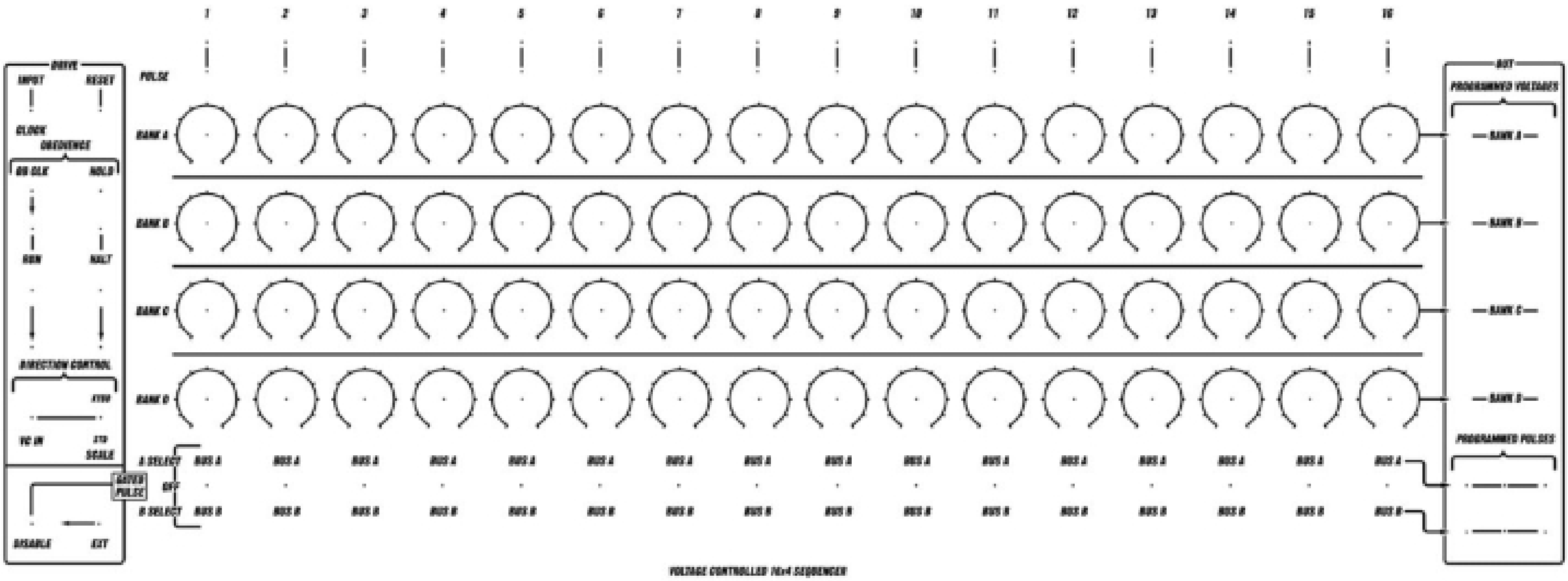

Diagram 6 - Sample Milton faceplate