REFERENCE MANUAL

for

tomoberheim

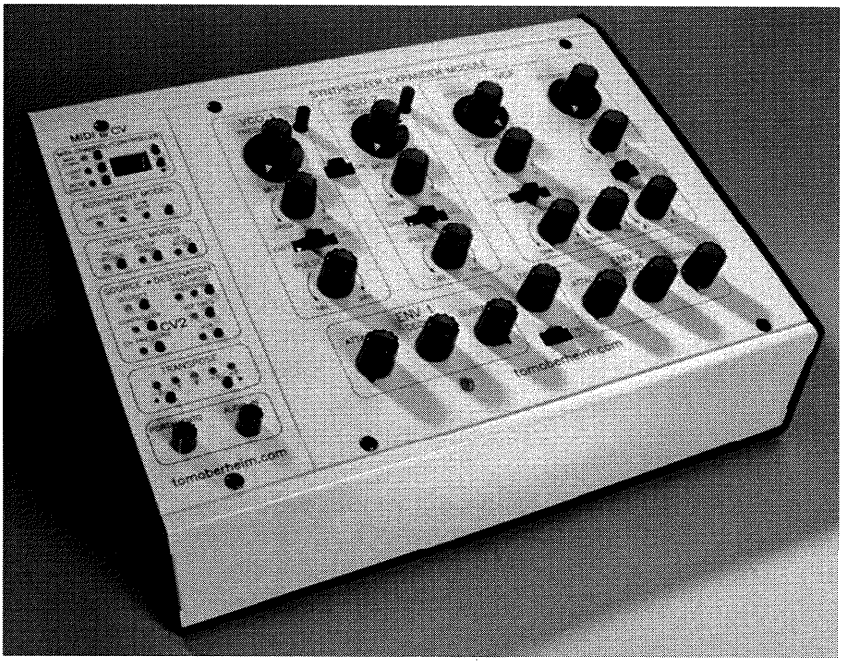
SYNTHESIZER EXPANDER MODULE

"MIDI to CV" version

Marion Systems Corporation

1480 Moraga Road
Suite i-394
Moraga, CA 94556
(925) 631-9095

www.tomoberheim.com


MIDI to CV
CV2
tomaberheim.com
tomaberheim.com

Reference Manual

tom oberheim

SYNTHESIZER EXPANDER MODULE

"MIDI to CV" Version

Table of Contents

Text by Mitchell Sigman & Tom Oberheim

First Edition
March 2010

MARION SYSTEMS CORPORATION
1480 Moraga Road Suite i-394
Moraga, CA 94556
(925) 631-9095
www.tomoberheim.com

1. QUICK START

This section will get you started making music quickly. We encourage you to read this guide in its entirety to get the most from the Tom Oberheim SEM.

First we'll power up the unit. The power switch is located on the back panel. The "zero" position is off, "one" is on. Please note that the LED on the front of the unit is **not** a power light, thus it won't illuminate when the power is turned on.

Do not use any other power adaptor other than the one that comes with the SEM! *The SEM power adaptor supplies a unique voltage and using a different adapter most likely will not work, and may harm the SEM. If you lose the adapter, please contact Tom Oberheim for a replacement.*

• Plug a standard MIDI cable from the output of a MIDI controller keyboard or the MIDI out jack of a computer MIDI interface.
• Plug the SEM's rear panel 1/4" output into an appropriate amp or mixer, and make sure the volume is at a moderate level.
• Make sure the MIDI keyboard or computer transmitting MIDI to the SEM is outputting on MIDI channel 1. This is the default receive channel on power-up of the SEM. You can easily change the SEM's MIDI reception channel in the MIDI to CV panel section by pressing the *MIDI CHAN* button, then pressing the up/down arrows next to the LED numeric display. The large LED on the front panel beneath the ENV 1 section will flash to display note reception.

• Make sure the VCA On/Ext slide switch is in the left position. The LED to the left should illuminate when keys are depressed.

• Set sustain in the ENV 1 and ENV 2 sections all the way up.

• In the VCF section, make sure the frequency knob is at a setting greater than zero, then rotate the VCO1 and VCO2 knobs to the left or right to set the volume of saw or pulse waves. You may want to make sure the resonance knob is turned down in order to avoid a potential squelching fury. You should be able to hear notes played from a standard MIDI controller.

2. OVERVIEW

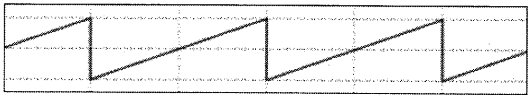
The Tom Oberheim Synthesizer Expander module (SEM) is a classic all-analog two-oscillator monophonic synthesizer. Its circuitry is almost identical to the original coveted SEM modules of the seventies, originally packaged as a standalone and within the thunderous Oberheim Two-, Four-, and Eight-Voice polyphonic synthesizers.

The synth voice consists of two oscillators, the classic Oberheim 12db/per octave multi-mode filter, two ADS envelope generators, one voltage-controlled amplifier and a sine-wave low-frequency oscillator.Compared with the vintage SEM, the original unit's dual-concentric oscillator tuning/fine-tuning knobs have been replaced by a large coarse tuning knob along with a compact "shaft"-style fine tuning pot. This simplifies setting and maintaining accurate tuning. This version of the new SEM features a full-function MIDI to CV converter for use with contemporary MIDI keyboard and computer setups.

The new SEM is packaged in a rugged metal case and is self-powered. Oscillator stability is unsurpassed. Due to the unique "piggy-back" printed circuit board construction technique used, the unit is virtually wire-free which enhances reliability and serviceability.

3. OSCILLATORS

The SEM features two oscillators, both capable of generating sawtooth or variable-duty cycle pulse waveforms. Controls are almost identical for each oscillator.

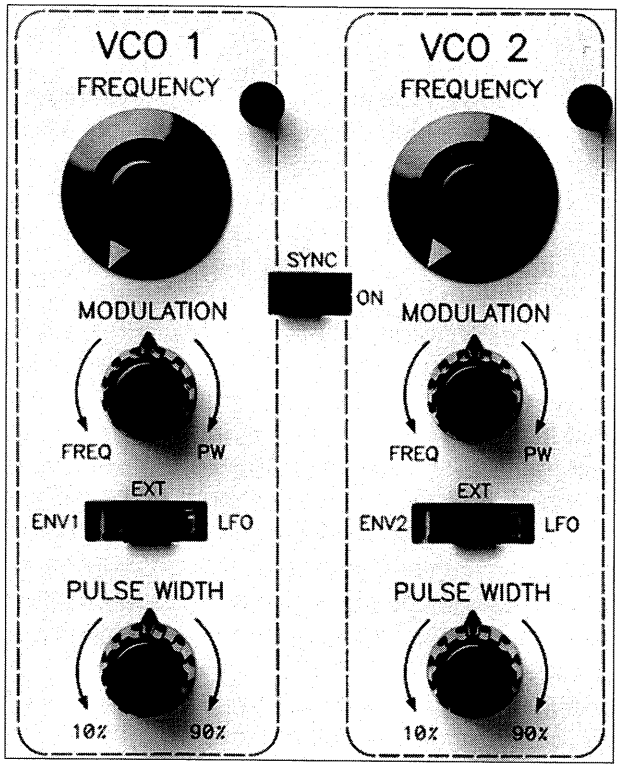


Sawtooth wave as displayed on an oscilloscope.

Sawtooth waves are named for their resemblance to the teeth of a saw blade. They contain both even and odd harmonics of the fundamental frequency. Because of its harmonic richness, it's well-suited to rich sounds such as brass, solo strings, bright synth bass. Sawtooth waves work well in a classic subtractive-synthesis setting because there's a lot of harmonic content to filter out using a voltage-controlled filter.

Square wave as displayed on an oscilloscope.

Pulse and square waves contain squared-off edges when viewed on an oscilloscope. A square wave is symmetrical in shape and contains mostly odd harmonics, giving it a thick but hollow tonality similar to a flute or clarinet. The "duty-cycle" or pulse-width can be adjusted resulting in a thinner, buzzier sound. If the width is made too narrow, the sound output will disappear altogether. Varying the width of a pulse wave in real time either manually or via voltage-controlled modulation creates a desirable timbral animation.



FREQUENCY: This sets the initial pitch of the oscillator. Use the large pointer knob to set the coarse tuning; this knob has about a four-octave range. The small shaft to the right is a fine-tuning knob with range of about a major third for precise tuning. The SEM MIDI/CV Version features a “hidden” A-440 tuning reference for accurate tuning (see Section 8, “MIDI to CV Converter” for details). You'll find the SEM's tuning very solid over a wide range, with minimal or no "warmup" period necessary.

MODULATION: This bi-directional pot adjusts the amount and destination of modulation sources. In its center position, modulation level is zero. Rotating the knob counterclockwise will modulate oscillator pitch. Rotating the knob clockwise will modulate the width of the oscillator's pulse wave. Pulse-width modulation has no audible effect on sawtooth waves.

MODULATION DESTINATION SWITCH: This switch selects the input source that is routed to the modulation amount pot. Envelope modulation is useful for pitch sweeps (try this with the *SYNC* switch engaged) or pulse-width mod sweeps. LFO will create vibrato when modulating frequency, and timbral animation when modulating pulse width. Note that oscillator 1 makes use of envelope 1 for modulation, whereas oscillator 2 uses envelope 2 for modulation. The EXT position works in conjunction with the auxiliary control voltage/MIDI controller as set in the *SOURCE TO DESTINATION* section of the MIDI to CV converter.

PULSE WIDTH: This sets the initial setting of the pulse wave's width. For a square wave (50% pulse width), set this to control to its middle position. Pay close attention to the position of the pulse width knob when applying additional pulse-width modulation; this will help fine-tune the range.

SYNC: When oscillator hard sync is engaged, oscillator 2's cycle is forced to reset each time oscillator 1's cycle repeats. This creates unique and rich harmonics and sounds especially good when oscillator 2's frequency is swept with an envelope or LFO. When swept with an envelope, this creates the "swept sync" sound made famous by The Cars and Kraftwerk.

MODULATION: This bi-directional pot adjusts the amount of modulation sources. Like the mod amount knobs in the oscillator section, at center position, modulation level is zero. Rotating the knob counterclockwise will add negative modulation, i.e. modulation sources will effectively reduce the cutoff frequency when applied. Rotating the knob clockwise adds positive modulation, i.e. modulation sources will increase the cutoff frequency when applied.

MODULATION DESTINATION SWITCH: This works exactly like the modulation destination switch in the oscillator 2 section - it selects the input source that is routed to the modulation amount pot. Filter cutoff modulation from ENV2 is very useful for recreating any type of sound that starts bright and becomes duller as its volume diminishes. All plucked or hammered acoustic string instruments behave this way, so filter envelopes are effective for emulating bass or electric guitars (make sure to use positive modulation and decrease the initial cutoff setting so you'll be able to hear the modulation's effect). The LFO position is useful for creating repeating "wah wah" effects. As in the oscillator section, EXT position works in conjunction with the auxiliary control voltage/MIDI controller as set in the *SOURCE TO DESTINATION* section of the MIDI to CV converter.

NOTCH: The notch knob selects whether the SEM filter functions as a lowpass or highpass filter or anywhere in between! In the in-between positions, you're essentially hearing lowpass and highpass filtering simultaneously. With settings away from the "LP" or "HP" extremes, the effect is to reduce a narrow band of frequencies from passing through the filter.

BP: Engaging this switch puts the filter in bandpass mode. This disables the the *NOTCH* knob.

VCO1/VCO2 Controls: This is the SEM's oscillator mixer section. In the middle position, oscillators are off. Rotate counterclockwise to increase sawtooth wave volume; rotate clockwise to increase the volume of the pulse wave.

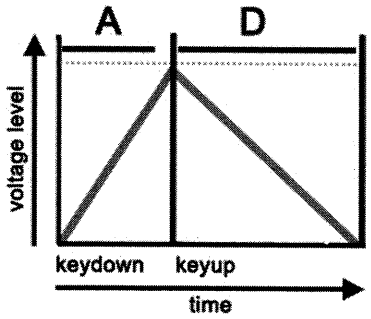
EXT #1/#2 Controls: This sets the input volume of external audio sources plugged into *AUDIO IN #1* and *AUDIO IN #2* on the rear panel. *AUDIO IN #1* features a preamp circuit with adjustable gain level via the *AUDIO IN* knob at the bottom of the MIDI to CV section. The gain level is appropriate for use with low-level inputs such as electric guitars, basses, and microphones. *AUDIO IN #2* is intended for line-level sources. See BACK PANEL section for more on the audio inputs.

Since the SEM has no master volume control, the mixer section acts as the only point where volume may be set. For optimum performance, we recommend setting oscillator (or external) volumes close to full, then using external equipment to set appropriate listening levels.

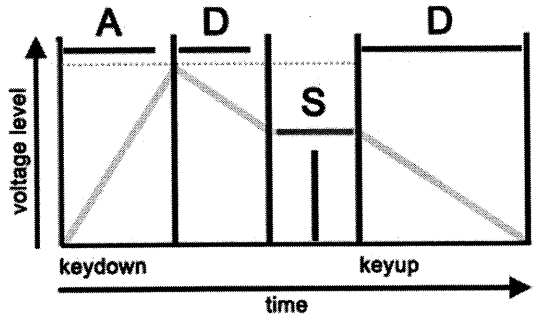
5. ENVELOPE GENERATORS

Envelope generators are used to "shape" the sound via a rising and falling voltage, and are most commonly used to control amplitude and filter settings. When a key is depressed, a gate voltage is generated which is a +5 volt voltage is sent to the envelope generators for as long as the key is held down, thereby triggering the envelope generators.

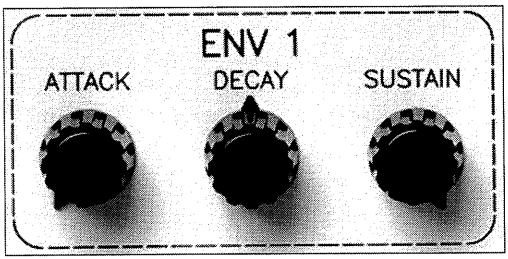
The envelope generators output a changing voltage; the rate of change is defined by the knob settings. The ATTACK knob sets how quickly the voltage rises from zero to maximum. Once the maximum voltage is reached, the voltage falls at the rate defined by the DECAY. If the key is released before the end of the decay stage is reached, the voltage will continue to fall until it returns to zero volts. If the key is held down, the voltage will fall until it reaches the voltage level set by the SUSTAIN knob. The SUSTAIN knob does not affect time; it simply sets a "hold" level. Once the key is released, the voltage will continue to fall at the rate set by the DECAY knob until it returns to zero.



Envelope contour when key is released before sustain segment is reached.

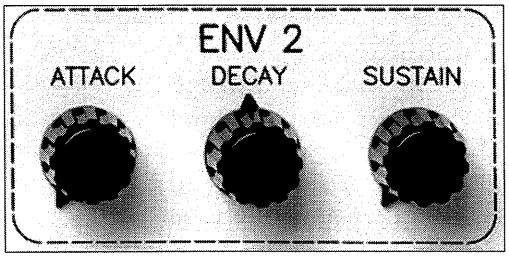


Envelope contour when key is held through attack and decay segments. Voltage level remains at sustain level until key is released.



ENV 1

This is hardwired to the voltage-controlled amplifier for controlling volume contours. Additionally, envelope one may be routed to modulate oscillator 1's pitch or pulse-width via the switches in the oscillator one section. ATTACK, DECAY, and SUSTAIN controls affect amplitude as detailed above.

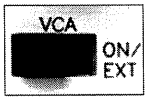


ENV 2

This is hardwired to the voltage-controlled filter for real-time timbre modulation. Additionally, envelope 2 may be routed to modulate oscillator 2's pitch or pulse-width via the switches in the oscillator 2 section. ATTACK, DECAY, and SUSTAIN controls affect filter cutoff frequency as detailed above. The aforementioned MODULATION knob in the filter section sets the intensity of envelope 2's modulation of the filter cutoff frequency.

6. AMPLIFIER

The SEM contains a single voltage-controlled amplifier. For all intents and purposes, a voltage-controlled amplifier functions as a volume knob regulated via a control voltage from an envelope or LFO modulation source.



In normal use, the *ON/EXT* switch should remain in the left position; this routes envelope 1 to the VCA for amplitude contour control via envelope 1's controls. When the *ON/EXT* switch is moved to the right position, envelope 1's controls are bypassed, and the VCA remains "on" unless overriden by a Source signal from the MIDI to CV section(with VCA selected as a Destination). This is useful for continuous synth drones, or when using the the filters for processing external audio - you won't need to hold down a key for a continuous audio source to pass through to the SEM's outputs.

7. LOW-FREQUENCY OSCILLATOR

A low-frequency oscillator (aka LFO) is included for modulation purposes. Though technically similar to a standard voltage-controlled oscillator, unlike a VCO, an LFO is not intended to create sound. Instead, its output is used as a control signal for modulation of pitch, pulse-width, or filter cutoff. The SEM's LFO generates a sine wave only.

The knob controls LFO rate, variable from from about 0.1 Hz to 55 Hz. LFO destination amount is set in the oscillator and filter sections (see OSCILLATORS and FILTER section).

8. MIDI TO CV CONVERTER

The SEM MIDI/CV Version includes a full-featured MIDI to CV converter, enabling full compatibility with standard MIDI keyboard controllers and sequencers. Though housed in a common enclosure, the MIDI to CV converter has been designed as a completely independent subsystem from the SEM module. This allows the SEM's 100% analog audio path to remain original and uncompromised.

The MIDI to CV converter has been designed for tremendous flexibility, yet is very easy to use, featuring dedicated buttons for all functions. It recognizes the following types of MIDI data:

• **note on/off**: notes played on a controller keyboard generate a note-on message when depressed and a note-off message upon release. This tells an instrument which note is played and whether to start or stop.

• **note velocity**: most MIDI controllers transmit velocity data as part of the note on message representing how hard a note has been struck.

• **channel pressure**: also known as "aftertouch". Some MIDI controllers transmit controller data when a key is pressed harder while notes are held down. This controller is sent continuously as a sustained note is pressed softer and harder. Most controller keyboards send "mono aftertouch", that is, aftertouch is not sent separately for each key, but is instead averaged amongst all currently held keys. This is a non-issue for the SEM in that it can only generate one note at any given time.

• **MIDI controller numbers**: the MIDI/CV converter can respond to MIDI control messages in the range of 0 to 99. The most common MIDI control message is "1' which represents data from a standard keyboard modulatioin wheel.

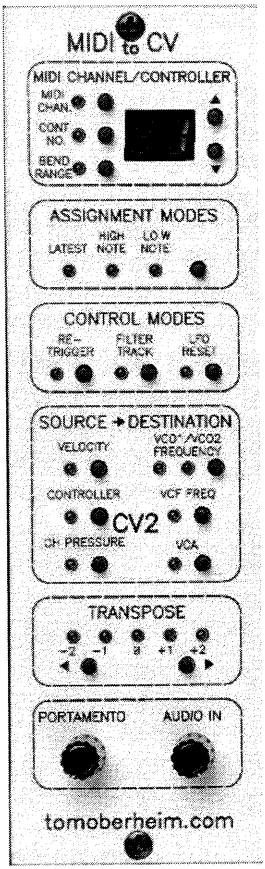
The SEM MIDI to CV converter also features some valuable extras:

• **dual audio inputs:** these allow the SEM's filter and amp sections to process external audio signals.

• **portamento:** also known as "glide", portamento allows melodies to slide smoothly from pitch to pitch.

• **A-440 reference tone:** this can be used not only for tuning the SEM's oscillators, but as a tuning reference for other instruments.

MIDI to CV CONVERTER CONTROLS



Here we'll explain the functions of all controls in the MIDI to CV section.

MIDI CHANNEL/CONTROLLER

MIDI Channel: Pressing this button puts the LED numeric display and the up/down buttons in MIDI channel number selection mode; the LED next to *MIDI CHAN* will light. Use the up/down buttons to specify which MIDI channel (1-16) that the SEM will receive MIDI data on. The SEM will ignore MIDI data on all other MIDI channels.

Note: If MIDI reception doesn't seem to work, check that the MIDI controller transmit channel and SEM receive channel match.

Controller Number: The SEM can receive MIDI continuous controller data from controller numbers between 0 and 99. Set the MIDI continuous controller number to be received by pressing the *CONT NO.* button, then use the up/down buttons to select a controller number as shown on the LED numeric display. Holding down the up or down button will cause the numbers to scroll more rapidly.

Bend Range: This setting defines the range of bend when pitch bend messages are received from a controller. Press the *BEND RANGE* button, then use the up/down buttons to select a value from 0-12, with 0 being no bend at all and 12 being a full octave up or down.

ASSIGNMENT MODES

Since the SEM is a monophonic synthesizer (that is, only one note can sound at any given time), note assignment prioritizes which note will sound in the event multiple keys are struck simultaneously.

The SEM lets you choose from the following three note assignment modes:

LATEST: in the event multiple keys are played, the most recently played note sounds.

HIGH NOTE: in the event multiple keys are played, the highest note held on the keyboard sounds.

LOW NOTE: in the event multiple keys are played, the lowest note held on the keyboard sounds.

CONTROL MODES

RETRIGGER: With retrigger mode engaged (LED on), ENV1 and ENV2 are triggered with every note struck. When retrigger

mode is off, the envelopes only retrigger once all keys have been released. This is known as "legato mode", and is useful for emulating the sound of real instruments such as guitars, wind instruments, etc.

Note: Retrigger mode only functions in the "LATEST' assignment mode.

FILTER TRACK: Engaging the *FILTER TRACK* button routes the keyboard control voltage to the filter's cutoff frequency. The filter cutoff frequency follows (or "tracks") the notes played, causing a more consistent tone as higher pitches are played on the keyboard.

LFO RESET: This causes the phase of the SEM's low-frequency oscillator to reset to the top of the sinewave arc with new key depressions.

SOURCE TO DESTINATION

The SEM MIDI to CV converter features an auxiliary control voltage (aka CV2) that can add modulation to either or both oscillators, the filter, or the amplifier sections. The SOURCE TO DESTINATION section defines which performance characteristic sets this voltage level (source), and what parameter the voltage will be applied to (destination).

SOURCES

• *VELOCITY*: CV2 is derived from the force with which notes are struck; soft playing generates a low voltage, harder playing generates a higher voltage.

• *CONTROLLER*: CV2 is derived from the value of the MIDI continuous controller number defined previously in the MIDI CHANNEL/CONTROLLER section.

• *CH PRESSURE*: CV2 is derived from aftertouch controller data, sent continuously as a sustained note is pressed softer and harder.

DESTINATIONS

• *VCO1/VCO2 FREQUENCY*: with repeated presses of the *VCO1/VCO2 FREQUENCY* button, either or both oscillators may be chosen to receive CV2. External pitch modulation of VCO2 is useful with the oscillator *SYNC* switch on, as this gives expressive timbre control when using a mod wheel or velocity as a mod source. The VCO's will only respond to auxiliary control voltage when their mod switches are set to *EXT* mode. If they don't seem to be responding to MIDI controller input, make sure the mod switch is properly set to *EXT.*

• *VCF FREQ*: CV2 is routed to the cutoff frequency of the filter for expressive real-time control of timbre. The VCF will only respond to auxiliary control voltage when its mod switches are set to *EXT* mode.

• *VCA:* CV2 is routed to the to the amplifier section allowing real-time control of volume. The VCA will only respond to auxiliary control voltage when its mod switches are set to EXT mode. It's important to remember that by placing the VCA in EXT mode, you'll be bypassing the amplitude envelope- external control and amp envelope are not combined (this would have entailed changes to the basic SEM design). Thus, MIDI aux voltage control may have limited usefulness. Perhaps the best use is for applying an external controller such as a mod wheel (MIDI controller #1) for real time control of volume of a droning synth sound or external audio input.

IMPORTANT: The SEM supports only **one** auxiliary control voltage source. The SOURCE setting can be just one of the three at any time: VELOCITY, CONTROLLER, or CH PRESSURE. Selecting a SOURCE automatically disables the other two. However, the SEM **can** route the selected mod source to any combination of destinations.

TRANSPOSE

The transpose button is used to shift incoming MIDI note data up or down one or two octaves. At a setting of zero, it has no effect at all.

PORTAMENTO

The portamento knob causes notes to smoothly slide from pitch to pitch, like a trombone. Portamento is off with the knob at its minimum setting, and the amount of time to glide from note to note increases as the knob is turned clockwise.

AUDIO IN

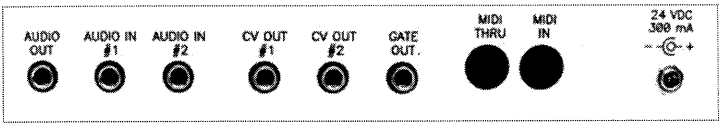
The SEM MIDI/CV Version features rear panel jacks for routing two independent mono audio sources through the filter and amplifier sections. AUDIO IN #1 features a preamp circuit with adjustable gain level via the AUDIO IN knob. The gain level is appropriate for use with low-level inputs such as electric guitars, basses, and microphones. See BACK PANEL section for more on the audio inputs.

STORING MIDI to CV SECTION SETTINGS

All MIDI to CV section settings except Portamento and Audio In are stored in a non-volatile flash memory. That is, they're unaffected by turning the SEM's power off. To save the current button settings to memory, hold down the button in the ASSIGMENT MODES section for over two seconds; you'll see the current version of the MIDI to CV section software briefly displayed in the LED numeric display indicating that the front panel settings have been stored.

Note that the onboard memory only stores settings for the MIDI to CV converter; it doesn't store knob or switch settings from any other section of the SEM.

9. REAR PANEL



Audio Out: Standard line-level signal output, compatible with most mixers and instruments amps.

Audio Input #1: Use this jack to route external signals through the SEM's filter and amp sections. The initial input trim level is adjustable from instrument to line-level via the front panel *AUDIO IN* knob located at the bottom of the *MIDI to CV* section. Au*dio Input #1* is compatible with low-level signals such as electric guitars, basses, and microphones.

The best procedure for setting external input level is to turn the *EXT* knob in the *VCF* section fully counterclockwise to *#1*, then use the *AUDIO IN* control to set a level roughly equivalent to the SEM's internal oscillator volumes (as set with the adjacent *VCO1* and *VCO2* knobs). The center position of this knob will turn *Audio Input #1* off completely.

Audio Input #2: This works similarly to *Audio Input #1*, but the preamp gain level is fixed, thus it is **not** affected by the front panel *AUDIO IN* knob setting. *Audio Input #2* is optimized for line-level signal and is intended for use with other synths and standard audio gear. *Audio Input #2* level is set by turning the *EXT* knob in the *VCF* section clockwise toward *#2.* The center position of this knob will turn *Audio Input #2* off completely.

A-440 Reference Pitch Generator: The SEM contains a "hidden" A-440 pitch generator, allowing easy tuning of the SEM or other instruments. With nothing plugged into *Audio Input #2*, the A-440 pitch generator will be routed to the *EXT #2* level knob in the *VCF* section. Simply turn the the *EXT #2* level knob clockwise from center position and play a controller keyboard to hear it, or set the VCA *ON/EXT* to the right position to hear the A-440 pitch constantly. If you're using it to tune other instruments, you'll want to set the adjacent *VCO1* and *VCO2* knobs to center position to

minimize oscillator volume. Note that the A-440 reference pitch is overridden by plugging a jack into *Audio Input #2.*

CV OUT #1: This duplicates the SEM's internal oscillator pitch control voltage and may be used to control the oscillators of any standard 1V/octave analog synthesizer. There are a few vintage synths that don't conform to this standard; these are listed in APPENDIX C.

CV OUT #2: This duplicates the SEM's internal CV2 auxiliary control voltage as detailed in the *MIDI CHANNEL ./ CONTROLLER* and *SOURCE to DESTINATION* sections, and may be used with any analog synthesizer. It will retain the *SOURCE to DESTINATION* section's *SOURCE* settings, but the *DESTINATION* setting will be irrelevant, i.e. CV2 will be present at the *CV OUT #2* jack regardless of the *DESTINATION* setting.

GATE OUT: This duplicates the SEM's internal gate voltage. When a MIDI note is played, the SEM generates a constant +5 voltage. When notes are released, the voltage goes to 0 volts. This gate voltage output is typically used to trigger envelopes on most standard analog synthesizers. It's not compatible with Moog "S-trigger" or shorting triggers, but if you're handy with electronics, it's easy to construct a circuit to convert trigger types (search "S-trigger" on the web; Tom Oberheim cannot be held liable if you solder your nose to your finger).

Note that by using the SEM's external CV/gate outs, the SEM may be used as a standalone MIDI to CV converter.

MIDI THRU: This simply repeats all MIDI data transmitted through the input cable, and is provided to allow easy "daisy-chaining" to other MIDI instruments. If the MIDI channel of an instrument attached to the SEM's MIDI thru jack is set the same as the SEM, both instruments will play the same part; if the daisy-chained instrument is set to a different MIDI channel than the SEM, they will play only the parts assigned to their unique channels.

MIDI IN: The input is used for plugging in any standard MIDI keyboard or sequencer.

24 VDC INPUT JACK: This is the input for the included power supply. Do not attempt to use any other power supply with the SEM as it could harm it. If you lose the power supply, please contact www.tomoberheim.com for a replacement

10. HISTORY OF THE SEM

By the fall of 1971 I was set up as an ARP dealer in a store front in Santa Monica where I was building Maestro Phase Shifters. With my first ARP 2600 in hand, I set out to learn about analog synthesis. I systematically began learning every part of the 2600, and after a few weeks knew it backwards and forwards. It was one of the best times of my technical life as a completely new area of electronics was opened up to me. Things like the basic patch, a big, fat three-oscillator drone that sounded like a fleet of B-29s, filter sweeps, keyboard control voltage reversal, sample and hold tricks with noise and different oscillator mixes, on and on... The 2600 was such a great design that I still admire Alan Pearlman's handiwork to this day.

As my experience with the ARP 2600 increased, I became interested in building my own sequencer. I was familiar with the power of sequencers from seeing them in action at Paul Beaver's studio and also at the UCLA electronic music lab. Those sequencers were the classic modular Moog and Buchla totally analog types, but I started thinking about how digital circuitry could be incorporated. I was aware at the time of the growing field of semiconductor memory, so I decided to design a more practical system that combined digital logic with one of these new memory chips.

The result was the DS-2 Digital Sequencer that interfaced to either an ARP 2600 or Odyssey, or a MiniMoog, and allowed the user to load the sequence, both notes and timing, by simply playing the sequence on the synthesizer keyboard. The first version, called the DS-2, had one Intel 2102 memory chip, which contained 1024 bits (not bytes) and cost about $25! Later the cost of this chip came down to about $15 and I added a second chip which doubled the number of notes, and I changed the name to DS-2A. The first units were delivered in August of 1973. The device was in the Oberheim product line for three or four years and I think about 200 units were eventually sold.

The DS-2 sequencer was an interesting and useful device, but it created a perplexing problem. After the sequencer was loaded with a sequence and the sequence played back, the synthesizer

player was left with no synthesizer to play! (At this time, most synth players had only one synthesizer) This predicament gave me the idea to design a minimal synthesizer module that the DS-2 could play while the synthesizer musician is playing the main synthesizer. I was selling the ARP Odyssey at that time so I was very familiar with the concept of a minimal synthesizer. So in late 1973 I used my knowledge of the Odyssey and of my MiniMoog and conceived what I thought would be the absolute minimum synthesizer voice.

The design concept for the module, soon to be called the Synthesizer Expander Module (SEM-1), included:

- basic circuits for a true analog synthesizer voice
- low cost
- small size
- patchable (to some extent)
- two-pole, multi-mode filter to complement the standard four-pole filter
- simple but flexible user interface

At the time, my thoughts were that getting seriously into the synthesizer business, even in 1973/1974, was a major undertaking. But by starting out making just the SEM-1, without all the other complications that are part of making a complete keyboard synthesizer, the process was made easier. The plan was simply that the SEM-1 would be an accessory product to be used with a synthesizer made by some other company (ARP, Moog, etc.) And, to that end, I purposely built the voice around a two-pole, multi-mode filter as a complement to the standard four-pole filter.

The overall design of the SEM-1 was done by Jim Cooper (of JLCooper fame) and myself. I came up with the feature set and user interface, and Jim designed much of the circuitry. In addition, Dave Rossum of E-Mu systems helped with the VCO design and Dennis Colin of ARP designed the multimode filter. Little did I realize at the time how critical the SEM-1 would be to the later success of Oberheim when in 1975 I utilized the SEM-1 to create the Oberheim 2-Voice and 4-Voice synthesizers.

Tom Oberheim- 12/09

APPENDIX A

CALIBRATION PROCEDURES

Important: Let the SEM warm up for at least 10 minutes before attemping calibration.

Initial Settings:

- **VCO FREQUENCY** pots fully CCW - **FINETUNE** pots centered
- **SYNC** off
- **VCF FREQUENCY** pot fully CW - **RESONANCE** fully CCW
- **VCF** in **LP** mode - **BP** off
- All **MODULATION** pots in off (center detent) position
- All **MODULATION** switches in **EXT** (center) position
- Both **PULSE WIDTH** pots in center (12 o'clock) position
- All **MIXER** pots in off (center detent) position
- **LFO** pot in center (12 o'clock) position
- **ENV** - CCW, center, CW
- **ENV** - CCW, center, CCW

Pulsewidth Adjustment:

- **VCA** switch on
- **VCO1 MIXER** pot fully on - **PUL**
- Adjust T4 trimmer for minimum overtones
- **VCO2 MIXER** pot fully on - **PUL** (VCO1 MIXER pot off)
- Adjust T8 trimmer for minimum overtones
- **VCA** switch off

VCO1 Initial Frequency and Volts/Octave Adjustments:

- Apply +3.000 volt control voltage to VCO1 Volts/Octave input
- Observe VCO1 frequency and adjust T1 trimmer for 261.6 Hz
- Apply 0.000 volt control voltage and adjust T2 trimmer for 32.7 Hz
- Repeat two or three times as necessary

VCO2 Initial Frequency and Volts/Octave Adjustments:

- Apply +3.000 volt control voltage to VCO2 Volts/Octave input
- Observe VCO2 frequency and adjust T5 trimmer for 261.6 Hz
- Apply 0.000 volt control voltage and adjust T6 trimmer for 32.7 Hz
- Repeat two or three times as necessary

VCF Adjustments:

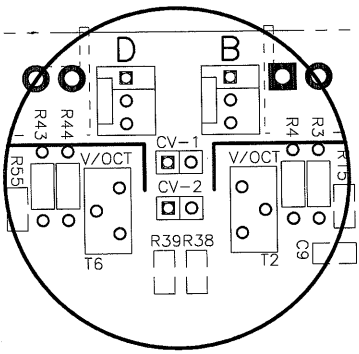
- All **MIXER** pots in off (center detent) position
- Observe connector pin Q5 and adjust T9 trimmer for zero volts
- Observe connector pin Q2 and adjust T10 trimmer for zero volts
- **VCO1 FREQUENCY** and **VCF FREQUENCY** pot fully CCW - **RESONANCE** pot fully CW
- **VCO1 SAW MIXER** pot on
- Jumper keyboard control voltage Volts/Octave to H1
- Apply +1.000 volt control voltage
- Adjust T11 to maximize the fundamental of the input sawtooth wave

VCA Adjustment:

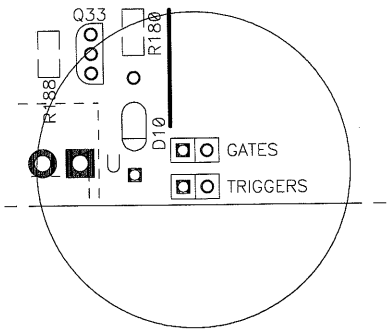
- All **MIXER** pots in off (center detent) position
- Observe output IA1
- Apply gate signal and adjust T13 for minimum offset due to gating

APPENDIX B
STRAPPING OPTIONS

There are separate Volts per Octave inputs to both VCOs but for convenience these inputs can be connected together using small shorting bars. Applying a shorting bar to the "CV-1" connector connects together the VCO 1 and VCO 2 Control Voltage #1, and applying a shorting bar to the "CV-2" connector connects together the VCO 1 and VCO 2 Control Voltage #2.



Similarly, there are separate Gate and Trigger inputs to both envelope generators but for convenience these inputs can be connected together again using small shorting bars. Applying a shorting bar to the "GATES" connector connects together the Gate signal to both envelope generators and applying a shorting bar to the "TRIGGERS" connector connects together the Trigger signal to both envelope generators.



APPENDIX C

NON 1V/OCTAVE SYNTHESIZERS

The following instruments do not make use of 1V/octave pitch scaling. You won't hurt anything by using them with the SEM, but their keyboard outputs will cause the SEM to play out of tune. In some instances this may not matter (i.e. percussion, sound effects, really bad music).

vintage Korg MS-series synths
vintage Yamaha CS-series synths

Old Korg and Yamaha synths use Hz/volt scaling- this can be accommodated and converted by some MIDI-to-CV converters.

EMS synthesizers
Buchla synthesizers

EMS and Buchla use their own unique pitch scaling curves and can be difficult to interface with other synths.