Analog Metropolis

AM3030
Voltage Controlled
Oscillator (SSM2030)

Project Notes
V1.0

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1 Module Description

This module is a VCO based around the classic SSM2030 chip that was used in the original Prophet 5's (Revision 1 and 2). In 1977 Dave Rossum designed the SSM2030 as the first non-proprietary VCO chip ever manufactured. The chip was the basis for a number of custom E-mu Systems synthesizers, as well as the original Prophet 5 and 10. This is a good VCO design, based on the E-mu Systems Modular VCO with High Frequency trimming. The relatively similar performance of each chip within a batch enabled polyphonic designs to be created in the late 1970's.

The frequency performance of the SSM2030 has been exceeded by more recent designs, both in terms of tracking and temperature stability. For example the CEM3340 in the Prophet 5 Revision 3 manages 0.05% exponential accuracy (which is one reason SCI moved to this chip). However these improvements are not dramatic in the context of a modular system, and this VCO module is entirely useable.

VCO Specifications:

Maximum Frequency Range:	0.02Hz to 200 kHz
Sawtooth Amplitude:	10V peak-peak
Pulse Amplitude:	7.5V peak-peak
Exponentially (trimmed):	0.1% (100-10kHz)
Power Supply Sensitivity:	0.5%/V
Temperature Stability:	50ppm/°C

The VCO produces three waveforms directly from the SSM2030; triangle, pulse and sawtooth, with just a bit of help on the triangle waveform. These waveforms are available individually from the VCO PCB.

The VCO has both coarse(FREQ) and fine(FINE) frequency controls, as well as initial pulse width(PULSE WIDTH), pulse width modulation(PWM) exponential frequency modulation control(EXP_FM) and linear frequency modulation control(LIN_FM). Pulse width modulation ranges from 0 to 100%.

The SSM2030 can be operated as a LFO by switching in a larger integrator capacitor and a discharge transistor. However the prototype showed that the wiring to the switch between NORMAL and LFO mode caused frequency instability through stray capacitance and the low frequency waveforms are not that accurate either. The production PCB's therefore do not have an LFO mode.

The VCO can be sync'd to other VCO's, both as Hard sync and Soft sync[1], this provides a wider palette of sounds.

[1] Soft sync enables VCO's to be phase locked to frequencies that are an exact small integer ratios of one another.

INPUTS	CV_INS1, CV_IN2, EXP_FM, LIN_FM, PWMOD, PW SOFT_SYNC, HARD_SUNC
OUTPUTS	TRIANGLE, SAW, PULSE, SYNC_OUT
POTS	FREQUENCY, FINE, EXP_FM, LIN_FM, PW, PWM

2 The AM Circuit

The Analog Metropolis circuit is a straight copy of the Prophet 5 Revision 2 design with pulse, triangle and sawtooth waveforms created from the VCO core. Refer to Appendix A for more details on the SSM2030 design.

The summer control voltages into pin 12 drive the exponential current generator transistor within the SSM2030, which charges C1 through the current mirror. The direct integration yields a sawtooth. The falling edge results from the on-shot discharging C1 when triggered by the comparator. The sawtooth is 0-10V.

IC3 (an OP177 low drift Op Amp) maintains exponential current characteristics by forcing the onboard transistor current to equal the reference current established by R12. D2 and R10 compensate for the internal buffers input bias current at the low end and the bulk-emitter resistance effect of the logging transistors at the high end, by providing extra base drive at high current to the sweep circuit. IC2 (an OP177 low drift Op Amp) sums the control voltages and the V/OCT trimmer enables the correct 1V per octave response to be set.

An external Tempco resistor PTC1 s used (1K 3600ppm) is mounted on the SSM2030 chip and R27 is mounted on the PCB. The integrator capacitor C1 is a high quality polystyrene capacitor for temperature stability and low leakage. C2 compensates the current mirror, reducing the possibility of high frequency oscillation in the control circuit.

Variable pulse width is derived by internally comparing the sawtooth to the pulse width input. Control sensitivity is 10%/V (100% at 0V, decreasing to 0% at 10V). The Pulse output is 0 - 7.5V.

The sawtooth and pseudo-triangle output pins are both emitter-followers from the internal sawtooth. IC5 (which must be a slow 741 Op Amp) produces the actual bipolar triangle by subtracting the sawtooth from the half sawtooth obtained by biasing the pseudo triangle emitter follower and amplifying x2. TTRIM adjusts the bias set equal slopes.

The frequency synchronisation options have been extended from the Prophet 5 by adding Soft Sync, which is available from the SSM2030 directly, as well as the usual Hard Sync.

The VCO PCB outputs three waveforms, triangle, square and triangle.

An optional set of 2 switch PCBs mixes the VCO outputs se into inverted and non-inverted outputs. These 2 small PCB's contain an analog mixer and a set of 4 momentary push buttons that control analog switches (DG403's) via simple CMOS flip-flops. This replicates the look of the Prophet 5 control panel and makes for more interesting ergonomics!

The REV03 board is the production board. There are two minor errors.

1) The FINE frequency control. Pins 1 and 3 should be reversed when connecting the potentiometer to the PCB location for the control.
2) IC2 power pins are incorrect. Pin 1 and 5 should be snipped off from the IC fitted here.

4 Front Panel Format

The AM3030 PCB is designed to work with the AM Low and High Density panel format, to be mounted to the front panel by using two ECO pot brackets which fit Spectrol 248 potentiometers.

AM High Density

This panel format enables a higher density of controls on each panel, and panels are usually 90mm wide. All the pots have a small spindle diameter of 3.18mm which enables the control knobs to be located closer together. Both 19mm and 13mm control knobs can be used. The "look and feel" is similar to the ARP 2500.

Panels are 4U high and 90mm wide. Panels are fitted to horizontal 12mm angled aluminium strip using 4mm diameter machine screws in each corner of the panel. The strip is mounted into a standard 19" rack unit with small wooden end strips.

AM Low Density

This panel format has a lower density of controls on each panel, and panels sometimes have to be 135mm wide to accommodate all the controls. All the pots have a spindle diameter of 6.35mm which means the Eμ Systems replica 19mm control knobs can be used. The "look and feel" is similar to the Eμ Systems Modular.

Panels are 4U high and 90mm or 135mm wide. Panels are fitted to horizontal 12mm angled aluminium strip using 4mm diameter machine screws in each corner of the panel. The strip is mounted into a standard 19" rack unit with small wooden end strips.

MOTM Panels

This established panel format has pot spacing very close in dimensions to the AM PCB's, MOTM is 41.275mm compared with 40mm of the AM format. This means you can design MOTM style front panels but with 40mm spacing and this won't look significantly different. Alternatively you maybe be able to mount the AM PCB on 41.275mm hole centres by slightly bend the pot brackets to fit.

5 PCB, Pots and Power

The PCB is held to the front panel at 90 degrees by the use of two ECO pot brackets. These brackets are centred at 40mm apart and pot brackets can be supplied for ¼" or 1/8" shaft potentiometers. The PCB can be mounted in alternative configurations without the pot brackets but using 0.1" Molex connectors or soldering the wires directly to the PCB.

The PCB is double sided with solder mask, component names are shown in the silk screen but not the component values. The size of the PCB is 80mmx100mm.

The PCB is designed to be mounted to the front panel using pot brackets and two Spectrol 248J potentiometers.
REMEMBER: The FINE potentiometer pins 1 and 3 need to be reversed, so mount the pot onto the bracket but don't solder the pot onto the PCB but connect it with 3 wires.

The module should be powered from a well regulated +15V and -15V power supply, current consumption is around 25mA. The power connector is the standard two ground MOTM/Oakley 4-pin Molex connector. One ground is for the circuit, the other is for the panel.

6 PCB Connections

The PCB has a number of connections designed for MTA 0.1" headers, so that the panel components can be connected to the PCB. I use headers and sockets to enable the board to be easily replaced, however you can solder wires straight to the PCB.

PCB Header Name	Pin #	What is it?	Where does it go?
CV_INS	Pin 1	Input CV1	Internal Keyboard CV bus
	Pin 2	Input CV2	Jack Socket CV IN
FM	Pin 1	Exponential CV	Jack Socket EXP IN
	Pin 2	Liner CV	Jack Socket LIN IN
PWMOD	Pin 1	Pulse Width	Jack socket PW
	Pin 2	Pulse Width Modulation	Jack socket PWM
WAVES	Pin 1	Triangle Out	Jack Socket Triangle
	Pin 2	Saw Out	Jack Socket Sawtooth
	Pin 3	Pulse Out	Jack Socket Pulse
FREQ	Pin 1	FREQ Pot	FREQ Pot Pin 1
	Pin 2	FREQ Pot	FREQ Pot Pin 2
	Pin 3	FREQ Pot	FREQ Pot Pin 3

PCB Header Name	Pin #	What is it?	Where does it go?
FINE	Pin 1	FINE Pot	FINE Pot Pin 3
	Pin 2	FINE Pot	FINE Pot Pin 2
	Pin 3	FINE Pot	FINE Pot Pin 1
EXP_FM	Pin 1	EXP_FM Pot	EXP_FM Pot Pin 1
	Pin 2	EXP_FM Pot	EXP_FM Pot Pin 2
	Pin 3	EXP_FM Pot	EXP_FM Pot Pin 3
LIN_FM	Pin 1	LIN_FM Pot	FINE Pot Pin 1
	Pin 2	LIN_FM Pot	FINE Pot Pin 2
	Pin 3	LIN_FM Pot	FINE Pot Pin 3
PW	Pin 1	PULSE WIDTH Pot	PULSE WIDTH Pot Pin 1
	Pin 2	PULSE WIDTH Pot	PULSE WIDTH Pot Pin 2
	Pin 3	PULSE WIDTH Pot	PULSE WIDTH Pot Pin 3
PWM	Pin 1	PW MOD Pot	PW MOD Pot Pin 1
	Pin 2	PW MOD Pot	PW MOD Pot Pin 2
	Pin 3	PW MOD Pot	PW MOD Pot Pin 3
SYNC	Pin 1	SOFT SYNC IN	Jack Socket SOFT IN
	Pin 2	HARD SYNC IN	Jack Socket HARD SYNC IN
	Pin 3	SYNC OUT	Jack Socket SYNC OUT
PAD	Pin 1	Panel Earth	Jack socket earth bus

6 Building the Module

To follow.

Check voltage rails are correct at IC1 before inserting SSM2030.

7 Trimming

This module is simple to set-up, and three trimmers need to be adjusted.

TTRIM Observe the triangle waveform on an oscilloscope and adjust the trimmer for a pure shape. Alternatively just listen to the triangle output and trim for the smoothest sound.

V/OCT This trimmer adjusts the CV input response, so that the VCO accurately tracks the keyboard. Adjust this trimmer to give 1V per octave at 200 and 400Hz.

HFT This trimmer adjusts the high frequency accuracy. Adjust this trimmer for 1V per octave at 2000 to 4000Hz once V/OCT has been set.