

## GENERAL

The Etherwave Pro consists of the following sections:

### On The Pitch Board:

- Variable Pitch Oscillator
- Fixed Pitch Oscillator with tuning circuit.
- Detection and Register Select
- Waveshaper
- Filter
- Timbre Select resistor matrix
- +12V and -12V regulators.

### On The Volume Board:

- Volume oscillator with tuning circuit
- Volume CV Detection and Processing.
- Main Output VCA
- Headphones Output VCA
- Pitch to CV Converter

The Pitch Antenna inductors are on the skinny board that goes into the pitch antenna support arm. The Volume Antenna inductor is on the small board that is soldered to the volume antenna jack.

The Pitch Board, Volume Board, and the Panel Board are connected together via a 34-conductor ribbon cable. The connectors that the cable plugs into are labeled J1 on all three boards. The signals and voltages appearing at these connectors are the following:

#### #1 - PITCH TUNING POT:

- Source: Wiper of PITCH pot (P1) on the Panel Board.
- Destination: Fixed Pitch Oscillator tuning circuit.     Range: 0 to -12V DC

#### #2 - UNFILTERED HIGH REGISTER AUDIO:

- Source: U1-3 on Pitch Board
- Destinations: The Register switch on the front panel, and the input to the Pitch-to-CV converter
- Range: 0 to +5V rectangular wave, rapid, with varying duty cycle.

#### #3 - UNFILTERED MEDIUM REGISTER AUDIO:

- Source: U1-6 on Pitch Board
- Destination: Register switch
- Range: 0 to +5V rectangular wave, rapid, with varying duty cycle.

#### #4 - UNFILTERED LOW REGISTER AUDIO:

- Source: U1-8 on Pitch Board
- Destination: Register switch

Range: 0 to +5V rectangular wave, rapid, with varying duty cycle.

#### #5 - REGISTER OUT:

Source: Wiper of Register Rotary Switch (SW1) on Panel Board

Destination: Signal Input of Waveshaping circuit

Range: Same as #2 - #4.

#### #6 - WAVEFORM POT:

Source: Wiper of WAVEFORM pot (P5) on Panel Board.

Destination: Biasing input of Waveshaping circuit.

Range: 0 to as high as +4.5V, depending on magnitude of Pitch CV.

#### #7 - BRIGHTNESS POT:

Source: Wiper of BRIGHTNESS pot (P4) on Panel Board.

Destination: Gain Control input of waveshaping circuit.

Range: 0 to +5V

#### #8 - FILTER POT:

Source Wiper of FILTER pot (P3 on Panel Board.

Destination: Control input of filter circuit.

Range: 0. to +5V

#### #9 - TUNER JACK:

Source: Filtered High Register Audio (on Volume Board)

Destination: Tuner jack.

Range: 1V peak-to-peak

#### #10, #18, #26, #28, #32, #34 - GROUND:

System ground.

#### #11, #12, #13 - TIMBRE SELECT BITS:

Source: TIMBRE SELECT rotary switch (SW2) on panel board.

Destination: Control inputs of U11, U12, and U13 on Pitch Board.

Range: Either +5V (through 100K resistors) or ground.

#### #14 PITCH ANTENNA RESPONSE:

Source: Wiper of Pitch Antenna Response pot on front panel.

Destination: Gain Control input of U4-A on Panel Board (provides variable coupling between oscillators)

Range: 0 to -12V DC

#### #15 TOP OF WAVE POT:

Source: Emitter of Q14 on Pitch Board

Destinations: Top of Waveform Pot; R50, 51, 52, 54, and 55 on Pitch

Board

Range about  $-2.8\text{ V}$  to  $+4.5\text{ V}$ , depending on magnitude of Pitch CV

#16 - VOLUME TUNING POT:

Source: Wiper of VOLUME pot (P2) on Panel Board

Destination: Volume Oscillator tuning circuit

Range: 0 to  $-12\text{ V DC}$

#17 - VOLUME ANTENNA RESPONSE:

Source: Wiper of Volume Antenna Response pot on front panel.

Destination: Volume CV Processor.

Range: 0 to  $+5\text{ V}$

#19 - HEADPHONES OUT:

Source: U6-12 (Headphones VCA) on Volume Board

Destination: Inputs of U1 on Panel Board

Range:  $10\text{ V P-P}$  Audio

#20 - HEADPHONES CV:

Source: Wiper of Headphone Volume pot on front panel

Destination: R25 on Volume Board

Range: 0 to  $-12\text{ V DC}$

#21 - VOLUME CV:

Source: U1-7 (Output of Volume CV Processor)

Destinations: Gain Control input of Audio Out VCA; Gain Control Input of Headphone Out CV; VOLUME CV jack; control input of filter.

Range:  $-0.3$  to  $+5.5$ ;  $0\text{ V}$  = silence;  $+5.0\text{ V}$  = maximum volume

#22 - PITCH CV:

Source: Output of Pitch-to-CV converter

Destinations: PITCH CV jack; control input of filter; R58 on Pitch Board.

Range:  $-3\text{ V}$  to  $+4\text{ V}$ ; one volt per octave;  $0\text{ V}$  =  $256\text{ Hz}$  (middle C)

#23 - AUDIO TO VCA's:

Source U9-9 on Pitch Board (Output of Filter)

Destination: Audio inputs of Main Audio VCA and Headphone VCA

Range:  $4\text{ V}$  Peak to Peak audio.

#24 - AUDIO OUT GND:

Source: Junction of R63 and R66 on Volume Board

Destination: Ring Terminal of Audio Out jack.

Range: close to  $0\text{ V}$

#25 - AUDIO OUT:

Source: U6-5 on Volume Board (output of main audio VCA)

Destination: Tip terminal of Audio Out jack.

Range: 2.8V Peak to peak (+2 dBm)

#27 - -15V

Source: Power Module

Destinations: Entire system.

Range: 15V +/- 0.3V

#29 - +15V

Source: Power Module

Destinations: Entire System.

Range: 15V +/- 0.3V

#30 - +12V

Source: U2 on Pitch Board

Destinations: Entire System

Range 12V +/- 0.3V

#31 - -12V

Source: U5 on Pitch Board

Destinations: Entire System

Range 12V +/- 0.3V

#33 - +5V

Source: Power Module

Destinations: Entire System

Range 5V +/- 0.02V (Adjustment on the Power Module)

## VARIABLE PITCH OSCILLATOR (VPO)

The Variable Pitch Oscillator (VPO) is the oscillator to which the Pitch Antenna circuit is attached (at J2). It includes Q2, Q3, Q4, and Q5 and the associated components. It is a somewhat more advanced version of the Etherwave VPO.

The resonant circuit that determines the frequency of the VPO is the inductor L1 and the combined capacitance of C15, C7, and C14, as well as whichever of C10, C13, and C16 are selected during calibration. L1 is a 100 microhenry high Q phenolic core inductor. C15 is a high stability 2.7 nanofarad film capacitor. When calibrated properly and with nothing connected to J2, the oscillator produces a frequency of 276 kHz. The sine waveform at the collector of Q4 is about 44 volts peak-to-peak, from about -10 volts to greater than +30 volts.

C14 and C3 form a capacitive voltage divider. The signal at the base of Q5 is about 1.5 volts peak to peak. R9 (1K) in series with R35 (100 ohms) provides the necessary DC path to -12V. Q5 serves as an emitter follower. It supplies positive feedback to the emitter of Q4. This is the positive feedback that sustains the oscillation.

Q3 and Q2 form a current mirror that determines how much current flows through Q4 when it is on, or through Q5 when Q4 is not on. The current is set by R25 and R26 to slightly less than 6 milliamperes. The magnitude of this current is important. If it is too much, the waveform at the collector of Q4 will clip hard at -12V. If it is too little, then the waveform will be significantly less than 44 volts peak-to-peak.

### CALIBRATING THE VPO

1. Set C7 so that the plates are about half meshed (You can determine this by looking closely at C7.) Do not connect anything to J2, and don't put any shunts on SF1 at this time.
  2. Measure the DC voltages at the collector and base of Q4. The collector DC voltage should be +12V, and the base voltage should be -12V. If you do not observe these voltages, check the board thoroughly, especially regulators U2 and U5.
  3. Check the waveform at the collector of Q4. It should be a sine wave, and should go from about -10V to about +32 volts. Do NOT proceed unless you see this waveform.
  4. Connect a frequency counter from the base of Q5 to ground. (Use minihooks or microhooks to connect to the base of Q5 (or C3, or R9. Be CAREFUL that you don't short out the circuit elements when the power is on.) The frequency should be higher than 276 kHz. Find a combination of shunts that, when placed on SF1 (thereby connecting a combination of C10, C13, and C16), the frequency is close to 276 kHz. Then adjust C7 so that the frequency is 276 kHz +/- 100 or 200 Hz.
- This completed the calibration of the VPO.

## FIXED PITCH OSCILLATOR (FPO)

The basic Fixed Pitch Oscillator is virtually identical to the VPO.

Q9 and associated circuitry form an electronic tuning circuit. As the current through Q9 increases, the frequency of the FPO is lowered. The current through Q9 is determined by the current mirror Q11, Q13, and associated circuitry. As the pitch tuning voltage (J1-1) goes from -12V to 0V, the FPO frequency is lowered about 4 kHz. This is how the pitch oscillators are "tuned" during performance.

NOTE: U8, U4B, and associated circuitry are not used. (R27 is omitted, so U4B is shut off completely.) So don't worry about them.

### CALIBRATING THE FPO

1. Set C12 so that the plates are about half meshed.

2. Check the waveform at the collector of Q6. It should be a sine wave, and should go from about -10V to about +32 volts. Do NOT proceed unless you see this waveform.

3. Connect a frequency counter from the base of Q7 to ground. (Use minihooks or microhooks to connect to the base of Q7 (or C26, or R36. Be CAREFUL that you don't short out the circuit elements when the power is on.) Turn the PITCH TUNING pot on the Panel Board through its entire range. You should see the frequency change about 4 kHz. Set the pot so that the frequency is right in the middle of its range, and then leave the pot alone for the remainder of the calibration. (NOTE: Geoff, the Panel Board that's floating around on my bench is one of the original boards. The PITCH and VOLUME pots are switched around, to the PITCH pot is on the

left.) The frequency should be higher than 282 kHz. Find a combination of shunts that, when placed on SF2 (thereby connecting a combination of C18, C20, and C22), the frequency is close to 282 kHz. Then adjust C12 so that the frequency is 282 kHz +/- 100 or 200 Hz.

This completes the calibration of the FPO. There is nothing further to calibrate on the Pitch Board. Keep in mind that you have set the frequency difference between the VPO and the FPO to be about 6 kHz.

## OSCILLATOR COUPLING CIRCUIT

U4-A is a VCA that feeds some of the VPO signal into the FPO. The higher the Pitch Response voltage (J1-14), the more signal is fed through the VCA, and the tighter the VPO and FPO couple. NOTE: The Rev B schematic and board have U4-A going in the opposite direction from the way it needs to go. The cobs of moving R9 and R36 to the back of the board, and clipping U4-5 and connecting it instead to the base of Q7, are done to get U4-A working in the right direction. I hope all this is clear. If it isn't, I'll try to draw an explanatory diagram and FAX it to you, if you like. Just let me know.

Right now I don't have an easy way to check the Oscillator Coupling Circuit while the board is on the bench. We'll work something out later. For now, just inspect the cobs as closely as you can.

## REGISTER SELECT

The signals at the bases of Q5 (VPO) and Q26 (FPO) are applied to the dual comparator U6. The outputs of U6 (U6-1 AND U6-7) are square waves. Each is fed to a divider (U7). The outputs of the dividers go to Exclusive-OR circuits (U1). One of the outputs of the Exclusive-OR circuits is selected by the REGISTER switch on the Panel Board, and then fed to the waveshaping and filter circuits (J1-5). If you look at the waveform at the junction of R13 and C5, you will see that it is a 6 kHz triangular wave of several volts peak-to-peak. This is the audio signal prior to waveshaping and filtering.

## WAVESHAPING AND FILTERING

The waveshaping circuit is U3 and associated components. The filter is a two-pole voltage-controlled lowpass filter, consisting of U9 and associated circuitry. The waveshaping circuit is roughly similar to that of the Etherwave, while the entire Waveshaping and Filtering section is nearly identical to that of the Ethervox.

To check this circuit, connect an oscilloscope to U9-9 (top end of R80), which is the output of the filter. Turn up the FILTER control on the panel board. (Remember that it is on the left on the board on my bench!). Also turn up the BRIGHTNESS control. You should see a 6 kHz quasi-rectangular waveform. Turning the WAVEFORM control back and forth should change the width of the waveform. Turning the BRIGHTNESS control down should cause the rectangular waveform to round off. Turning the FILTER control counterclockwise should smooth the waveform out to a sine wave and reduce its amplitude. If you see all these things, then the entire Waveshaping and Filtering section is working properly.

## GENERAL DESCRIPTION OF THE VOLUME BOARD

This description refers to the schematic labeled VOLUME BOARD BRD-10-011 510 REV C, and to the Preliminary BOM dated Sept 12.

The Volume Board contains the following four sections:

Volume Oscillator - produces 455 kHz - 465 kHz signal that is fed to the volume antenna resonant circuit;

Volume CV Processor - converts the volume antenna signal to DC and performs level-shifting functions;

Main Audio Out and Headphone Out VCAs;

Frequency-to-Pitch CV converter.

## POWERING THE VOLUME BOARD FOR TESTING AND CALIBRATION

1. Connect a long 34-conductor test cable from a panel board to the Volume Board under test.
2. Connect the other end of the test cable to the little prototype board that contains the +/- 12V regulators. These regulators are the same as those on the Pitch Board. They need to be connected to the Volume Board in order to supply +/- 12V.
3. Apply +/- 15V and +5V power to the panel board.

## VOLUME OSCILLATOR

The Volume Oscillator is nearly identical to the Fixed Pitch Oscillator on the Pitch Board. The main differences are that the frequency of the Volume Oscillator lies within the range 455-465 kHz and the waveform at the collector of Q6 goes from 0V to about 24 volts. The volume oscillator is tuned by Q11 and the associated circuitry. The wiper of the VOLUME tuning pot (J1-16) varies from 0V to -12V. It varies the current through Q13, which changes the operating point of Q11 and therefore the frequency of the oscillator.

The output of the oscillator (collector of Q6) is sent to the volume antenna (J2) through R21. As the impedance of the volume antenna circuit changes, the magnitude of the signal at J2 also changes.

## CHECKING AND CALIBRATING THE VOLUME OSCILLATOR

1. Verify that the signal at the collector of Q6 goes from 0V to about +24V.
2. Verify that the frequency of the oscillator is slightly higher than 465 kHz. Do this by connecting a frequency meter to the base of Q5.
3. Verify that the frequency of the oscillator decreases several kilohertz as VOLUME TUNING control on the panel board is turned clockwise through its range.
4. Set the frequency of the oscillator by adding shunts to SF1 and adjusting C7. The frequency should be set between 455 and 465 kHz.



## VOLUME CV PROCESSOR

The signal at J2 is applied to emitter follower Q2. Without anything connected to J2, the waveform at the emitter of Q2 should go from -1V to +10V, and should be somewhat clipped at the bottom. This signal is rectified by D6. The voltage at U1-1 should be about +10V DC.

The circuit U1-B, Q1, Q3, and Q4, and associated components inverts and shifts the level of the voltage at U1-1. The shape of the level shifting is determined by the voltage from the wiper of the VOLUME RESPONSE pot on the front panel (J1-17). The voltage at U1-7 should vary from +5V to 0V as the voltage at U1-1 varies from +5V to +8.5 volts. The voltage at J1-21 is the Volume CV signal. It is applied to the VOLUME CV jack, and to the output VCAs.

## CHECKING THE VOLUME CV PROCESSOR CIRCUIT

A quick check of this circuit is the following: Connect a voltmeter from either end of R10, to ground. With nothing connected to J2, the voltmeter should read a few tenths of a volt below 0V. With a 1 nF capacitor connected from J2 to ground, the voltmeter should read about +5.5V.

A more thorough check of the circuit is the following: Connect a voltmeter from either end of R10, to ground. Connect the volume antenna circuit (which must be mounted in a test cabinet) to J2. Tune the volume antenna circuit so that the voltmeter reads +5V when your hand is away from the antenna, but begins to decrease when your hand comes within 10 inches or so of the volume antenna. Then, as you bring your hand nearer to the antenna, the voltmeter should decrease. The voltmeter should read slightly less than 0V when your hand is less than 2-3 inches from the antenna.

## OUTPUT VCAs

The Volume CV signal (labeled “F”) is applied to U10-B and associated components. This circuit converts the Volume CV voltage to currents that control the gains of VCAs U6-A and U6-B. When “F” is +5V, the VCA gains are maximum; when “F” is 0V, the VCAs are off.

The control current to the Main VCA comes from the collector of Q12. It is fed directly to U6-1 through R41.

The control current to the Headphone VCA is divided down by Q7 and Q8. The division ratio is determined by the voltage across R30, which in turn is determined by the voltage at the wiper of the HEADPHONE VOLUME pot (J1-20).

The output of the main VCA (U6-5) is connected directly to the AUDIO OUT jack (J1-25 and J1-24). The output of the headphone VCA (U6-12) is fed through J1-19 to the input of the headphone driver on the Panel Board.

## CHECKING THE OUTPUT VCAs

1. Apply an audio signal of about 0.2 volts peak-to-peak from J1-23 to ground.
2. Connect a 1 nF capacitor from J2 to ground. Observe the audio waveform at the outputs of the VCAs. The audio waveform at U6-5 should be about 2 volts peak-to-peak, while the audio waveform at U6-12 should be about 10 volts peak-to-peak.
3. Disconnect the 1 nF capacitor from J2 to ground. Again observe the outputs of the VCAs. There should be no visible audio waveform at the output of either VCA.



## FREQUENCY-TO-PITCH CV CONVERTER (All of Sheet 2)

The high register unfiltered audio signal (J1-2, from the Pitch Board) is applied to U3-3. U3-1 is the amplified audio; the waveform at this point goes from 0V to +12V.

U2-A squares off the audio waveform. U2-2 is a square wave that goes from 0V to +12V. U2-4 is a similar waveform. The rising edges of the two waveforms advance counter U4. When there is an audio signal, the waveforms D00 - D04 are 25% duty cycle rectangular waves.

The waveform at U8-1 consists of four segments. The first two segments rise linearly from 0V. The third segment is level, and the fourth segment decays rapidly to zero.

The voltage at U8-7 is equal to the voltage of the level portion of the U8-1 waveform. This voltage is proportional to the period of the audio waveform. It is about one volt when the period is 4 milliseconds (about middle C). This voltage is call “the period voltage”.

U9-A, U9-B, U7-B, U11, and the associated circuitry constitute an analog logarithm-taking circuit. The voltage at U9-1 is proportional to the logarithm of the period voltage. This voltage increases by 1 volt when the period voltage is divided by two (or the frequency is multiplied by two). In slightly different words, the relationship between the frequency of the incoming audio the voltage at U9-1 is one volt per octave. Alternately, the voltage at U9-1 increases by 3.32 volts when the incoming frequency is multiplied by 10.

U7-A is a unity-gain buffer. Its output is the PITCH CV. It goes through J1-22 to the PITCH CV jack and to the filter and waveshaping circuits on the Pitch Board.

U3-B and associated circuitry are a temperature regulating circuit. It compares the voltage at the emitter of U11-A (which changes with chip temperature) with the voltage at the wiper of P1. U11-C is used as a heater to keep the U11 transistors at a constant elevated temperature.

## CHECKING AND CALIBRATING THE FREQUENCY-TO-PITCH-CV CIRCUIT

1. Connect the voltmeter between the wiper of P1 (U3-5) and ground. Set P1 carefully to 400 +/- 5 millivolts.
2. Set up the function generator to supply 262 Hz triangular wave, positively offsetted so the waveform goes from 0V to +5V. Apply this signal to J1-2 (the yellow wire on the little prototype board that supplies +/- 12V).
3. Connect the voltmeter from either point on R35, to ground.
4. Check the waveforms described in the previous section.
5. Set P3 (RANGE) so the output is very close to 0V.
6. Switch the input frequency down by a factor of 10 (26.2 Hz). Set P4 (SCALE) so the output is very close to -3.322V.
7. Switch the input frequency up by a factor of 10 (2620 Hz). Set P2 (OFFSET) so the output is very close to +3.322 volts.
8. Repeat steps 5, 6, and 7 two or three times, until the values converge.

This completed the description of the Volume Board.