ALTURA
User Manual

THEREMIN MIDI CONTROLLER

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Quick Start Guide and Reference Manual

QUICK START GUIDE

Look for the companion demo video at http://zeppelindesignlabs.com/product/altura/ or on our YouTube channel.
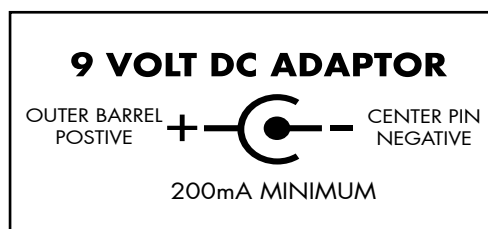
The ALTURA is a MIDI controller that emulates the classic theremin. The right sensor transmits note data to set the pitch. The left sensor transmits a variety of MIDI controller data to influence the sound in many ways. In X-Y mode, the right sensor mimics the left: both sensors transmit control data of your choosing.

The ALTURA's memory is volatile: most of your setup will vanish when you turn off the power.

1. **POWER UP** Use a 9V DC power supply or a battery.

   • 9V DC power supply ("wall wart"): Must be rated for 200 mA minimum, with center-negative polarity, such as a typical guitar pedal supply. Look for this graphic on the power supply. (Your controller won't work with a center-positive power supply.) Plugging in the power supply disconnects the battery.

   • 9V battery: Use a high-quality alkaline battery, like Energizer. (Don't waste your money on cheap batteries!) Open your cabinet; insert the battery into its holder; snap the contacts into place; and then push down to snap the battery into the holder.

2. **CONNECT A MIDI DEVICE** Plug a standard MIDI cable into the Altura's MIDI OUT jack, and connect it to the MIDI IN of your Macchiato Mini Synth or any other device; or plug into a MIDI patch bay or other port device; or use a MIDI-to-USB cable to plug into your computer.

3. **SET THE KNOBS** to the following default positions, just for this tutorial, until you become familiar with their functions:

DATA FAR	DATA NEAR	FUNCTION	KEY	SCALE	OCTAVE NEAR	OCTAVE FAR
Right	Right	Left	Left	Left	Straiht up	Straight up

4. **TURN ON YOUR SYNTH** If you are using a Macchiato Mini Synth, set it for short attack, long release, and a deep LFO. If you are using a different synth, set its receive channel to 1 or Omni. (By default, the Altura transmits on Channel 1. You will learn how to change this shortly.)

5. **TURN ON YOUR ALTURA** Press the red power button on the back of the Altura. If you built a card stock case, be careful how you squeeze your theremin; you don't want to crush the cabinet. The display will show "[1", indicating the C Major scale. More on key and scale in a moment.

6. **WAVE YOUR RIGHT HAND** The right sensor selects the pitch to transmit to your synth. As you wave your hand, you should hear notes coming out of your synth! The sensor is sensitive: hold your hand steady and flat; move it steadily in and out from the Altura until you learn where the beam is pointing. There is much more information in the Reference Manual.

7. **WAVE YOUR LEFT HAND** The left sensor sends Control Change data to your synth to influence the sound in a variety of ways. It is presently in Function 1: Pitch Bend mode. Play a steady note with your right hand, and also wave your left hand. The display will show a cute spinny-graphic that represents Bend Up and Bend Down – try it!

8. **CHANGE THE FUNCTION** Turn the FUNCTION knob to display numbers 1 – 7, corresponding to the functions shown in the table below, and on a label on the bottom of your Altura. After the table there's a brief description of each function, with much more to learn in the Reference Manual.

| FUNCTION NUMBER | CONTROLLER | | | |
	NAME	NUMBER	DATA FAR	DATA NEAR
1	Pitch Bend	1	Adjust size of neutral zone	Max. pitch bend range (Macchiato only)
2	Modulation	2	Modulation maximum and minimum values	
3	Note-On Velocity	n/a	Velocity maximum and minimum values	
4	Channel Volume	5	Volume maximum and minimum values	
5	Portamento Time	7	Portamento Time maximum and minimum values	
6	X-Y Mode	User Defined	The DATA and OCTAVE knobs set the max and min values transmitted by left and right sensors. KEY and SCALE set the left and right CC#.	
7	Send Channel Select	n/a	DATA FAR sets the MIDI Send channel (default 1)	

- Function 1: Pitch Bend

  Wave your hand in front of the left sensor. The display shows a cute spinny-thing to represent Pitch Bend Up and Down. As you move your hand, the display spins and the pitch bends. When you lock into the fully-bent pitch, either up or down, this symbol appears: " []. " Remove your hand to snap back to the "Neutral", or "No Bend" position, indicated with "_".

  FULL BEND DOWN   "NEUTRAL" OR NO BEND   FULL BEND UP

  Turn the DATA FAR knob to display numbers 0 – 12. With a Macchiato Mini Synth, this sets the number of semitones the pitch will change at maximum bend. On other devices, this knob will have no effect or an unpredictable effect. Set to 0 to disable Pitch Bend.

  Turn the DATA NEAR knob to display numbers 0 – 127. This changes the size of the Neutral Zone in the air, separating the Bend Up and Bend Down zones. On startup, the zone was set to 127: you will find a large piece of air where the pitch remains unaffected. Change it to zero and the Neutral Zone diminishes.

- Function 2: Modulation

  Turn DATA FAR to ⌷ and DATA NEAR to ⎰⎰. The DATA knobs set the maximum and minimum MIDI value to be transmitted when your left hand is near to or far from the left sensor. Wave your left hand, and as the number rises you should hear note modulation, usually a tremolo effect. As the number falls, the effect fades away. You can reverse the effect by swapping the NEAR and FAR numbers. The controller acts like a mid-air slider: move your hand to the desired value; remove it and the value will "stick". This behavior is the same across Functions 2 – 6.

  On the Macchiato Mini Synth, Modulation controls the depth of the Low Frequency Oscillator (LFO). Touching the Depth knob on the Macchiato will override the Altura. Using the Altura will override the knob on the Macchiato.

- Function 3: Note-On Velocity

  The Note-On Velocity defaults to 127 upon startup. Use the DATA NEAR and FAR knobs to set maximum and minimum values for Velocity. (Keeping a minimum velocity around 30 will prevent you from accidentally silencing your Altura!) This affects the starting velocity of each new note. Velocity usually impacts the volume of the note, but your synth might use this to influence other effects, such as brightness.

- Function 4: Channel Volume

  The Channel Volume defaults to 127 upon startup. This function affects the overall output volume of your synth, and is useful for swells while a note sustains.

- Function 5: Portamento

  "Portamento" refers to notes gliding smoothly from one pitch to the next. This effect emulates the classic sound of a theremin. The left sensor sets the Portamento Time: small numbers mean short, fast glides; higher numbers mean long, slow glides. Set the DATA FAR knob to about 10 or 20. Set the DATA NEAR knob to around 80. Play your Altura with a Macchiato Mini Synth and you will hear that spooky theremin sound! Setting Time = 0 will turn Portamento off.

  Some synthesizers will respond to Portamento as readily as the Macchiato; others may only respond with a bit of coaxing; and many synthesizers do not support Portamento at all. Consult your synthesizer's documentation, and the Altura Reference Manual.

- Function 6: X-Y Mode

  In this mode, the right sensor behaves like the left. Each sensor sends MIDI values from 0 – 127 to a different Control Change number. Select left and right CC#'s with the KEY and SCALE knobs. Set the right sensor MIDI max and min with the OCTAVE knobs.

DATA FAR	DATA NEAR	FUNCTION	KEY	SCALE	OCTAVE NEAR	OCTAVE FAR
Left Sensor MIDI Max and Min		Function Select	Left CC# Select	Right CC# Select	Right Sensor MIDI Max and Min	

  Since this mode does not trigger notes, use it with a drone synth or a sequencer. The Altura defaults to CC#'s 85 & 86 on startup, which are undefined. Consult the CC# chart of your synthesizer to select suitable controller numbers. This function is not recommended for use with the Macchiato Mini Synth.

  Here's what the display is telling you:

  0 – 127   When just one sensor is active, this is the MIDI number being transmitted.
  – – –   Both sensors idle
  ⊢ – ⊣   Both sensors transmitting.

- Function 7: Send Channel Select

  The Altura defaults to MIDI Send Channel 1. Use DATA FAR knob to change the send channel.

9. **CHANGE THE KEY AND SCALE** Set FUNCTION to any value from 1 to 4. Now turn the KEY knob slowly to the right while playing notes with your right hand. The display will move through the twelve root notes of the Western scale, with a decimal indicating Sharp:

$$C \quad C. \quad d \quad d. \quad E \quad F \quad F. \quad G \quad G. \quad A \quad A. \quad b$$

Turn the SCALE knob slowly to the right while playing notes. The display will show 1 – 12. These numbers are keyed to the label on the bottom of your Altura. The Altura plays a wide variety of scales and modes. See the Reference Manual for more details.

Playing your scales was never so easy!

10. **TRANSPOSE THE OCTAVE** Turn the OCTAVE NEAR knob just enough to cause the display to appear. You should see 5 5 . This means near the sensor, you are playing in Octave 5 (out of a range of 1 – 8), and far from the sensor, you are still playing in Octave 5 – a range of one octave, probably descending as you move from near to far.

    a. Turn the OCTAVE FAR knob left until the display shows 5 4. Now your hand covers two octaves descending: Octave 5 near the sensor, Octave 4 far from the sensor.

    b. Turn the OCTAVE FAR knob right until the display shows 5 6. Now your hand covers two octaves ascending: Octave 5 near the sensor, Octave 6 far from the sensor.

    c. Turn the OCTAVE FAR knob left until the display shows 5 5 again. Now this one-octave range is *ascending!* Remember it used to be *descending?* Whenever you set the Altura to cover one octave, that one octave will ascend if the previous range was ascending, and descend if the previous range was descending.

11. **ARTICULATION** It is possible to adjust the minimum time between notes, somewhat similar to the Quantize function in a sequencer. This serves to strike a balance between responsiveness and stability. See the Reference Manual for details.

REFERENCE MANUAL

INTRODUCTION

The Altura Theremin MIDI Controller by Zeppelin Design Labs was inspired by the early electronic instrument invented by Russian physicist Léon Theremin. Léon's device features a pair of antennae that can sense the capacitance of a person's hands. The right antenna affects a voltage controlled oscillator (VCO) circuit. As the player moves his hand closer to this antenna, the device emits a sine wave tone that rises in pitch. The left antenna affects a voltage controlled amplifier (VCA) circuit. As the player moves his left hand farther away from this antenna, the tone becomes louder. The device is very sensitive and can make wonderful, spooky music – but it is very tricky to play. The performer has to play by ear: there are no frets in mid-air!

The Altura Theremin MIDI Controller makes many improvements on the original device. First, the Altura does

Alexandra Stepanoff playing the theremin on NBC Radio, 1930

not itself make sound; instead, it simply controls synthesizers and computer programs that employ the MIDI protocol (Musical Instrument Digital Interface). Thus any sound that your synthesizer can make the Altura can control. Further, you can determine the key and mode (scale) in which to play.

HISTORY

In 1920, as Léon Theremin (1896 - 1993) was developing radio equipment for the Soviet government, he heard strange sounds coming from some of his circuitry. He noticed that the frequency (or pitch) of this sound changed with how close his hand was to the circuit. He developed this device into a musical instrument which he initially called the Thereminvox. In 1927 he left the USSR to tour Europe in promotion of his invention, performing to large audiences and receiving mixed reactions. His tour took him to New York where he stayed for the next 10 years; in which time he opened a laboratory and studio, patented the Theremin, licensed its manufacture to RCA, performed with a theremin ensemble at Carnegie Hall, and invented an electronic cello. In 1930 he conducted the first-ever concert of an electronic orchestra. In 1938 Léon Theremin suddenly disappeared – it was said that he had been kidnapped by Soviet agents; and later he was presumed dead.

Through the late 30's, Theremin's protégé Clara Rockmore rose to prominence as the world's pre-eminent thereminist. She preformed with world-class orchestras in large concert halls. These performances established the theremin as a legitimate performance instrument and started to open the public consciousness to electronic instruments and electronic music in general.

In the late 50's, Rockmore visited Moscow and by chance made contact with her old friend Léon Theremin. After 20 years of mysterious silence, she received word to meet Léon on a subway platform, where they spoke for a few minutes.

It seems Theremin's disappearance may have had more to do with the IRS than the KGB. What is certain is that upon Theremin's return to Russia, he was arrested and sent to the labor camps. He landed in a secret Soviet laboratory where he developed spy gear for the KGB. He was released in 1947 but "volunteered" to continue with the KGB until 1966.

In 1991 Léon, now 95 years old, returned to New York where he gave concerts, received awards, and was reunited with Clara Rockmore. It is not clear that he remembered her. He died in Moscow in 1993, aged 97.

As for his namesake invention, the theremin was just too difficult to play to ever achieve wide-spread popularity. The performer needed to have a very good sense of relative pitch, if not perfect pitch. Also, the instrument takes a lot of skill to play in a controlled manner. So besides Rockmore, there haven't been many other popular thereminists. But the theremin has never completely gone away. In fact, it has consistently been at the center of a sub-culture passionate about electronic instruments and music, where people are not afraid to blur the line between technology and art. One of our personal heroes, Bob Moog, got his start back in the 1960's designing and selling theremin kits, before he revolutionized popular and electronic music with his modular synthesizers. At Zeppelin Design Labs, with our love of electronic instruments and DIY kits, we hope the Altura will continue Léon Theremin's legacy of inspiring both artists and electronics nerds.

HOW IT WORKS

Our MIDI version of Léon's device uses sonar range finders in place of antennae, and rather than producing sound directly, the Altura emits discreet packets of digital data that are interpreted by a separate synthesizer or other sound-making device. The Altura's right-hand sensor transmits Note-On messages to play specific notes, thus controlling pitch. The left sensor transmits Channel Volume data, thus controlling volume. But this is just the start! The left sensor can be set to transmit many MIDI functions, like pitch bend, modulation, note velocity, and portamento time. The Portamento function causes one note to glide smoothly to the next, emulating that spooky Theremin sound; but the device is always gliding to a specific note within a key and scale you designate. As a result, the Altura always plays in tune!

The Altura was designed as a companion to the Macchiato Mini Synth by Zeppelin Design Labs. There are a few special features that will only work well when paired with the Macchiato. Otherwise, the Altura conforms with General MIDI specifications and should easily control any device bearing this mark. Many MIDI devices do not conform to the General MIDI specification. These devices will not necessarily respond to the Altura as described herein. In these cases, you may need to fiddle a bit with your synthesizer to get it to behave. Alternatively, you can route your Altura controller through a software application that will enable you to redirect its data as needed.

The Altura comes as an easy do-it-yourself kit, or assembled and ready-to-use. You can make your own case from card stock or from a cereal box using the provided template, or you can get a shiny black acrylic case. The acrylic case also comes as a super-easy kit or assembled and ready-to-use.

Connect with your music like never before: build your own gear!

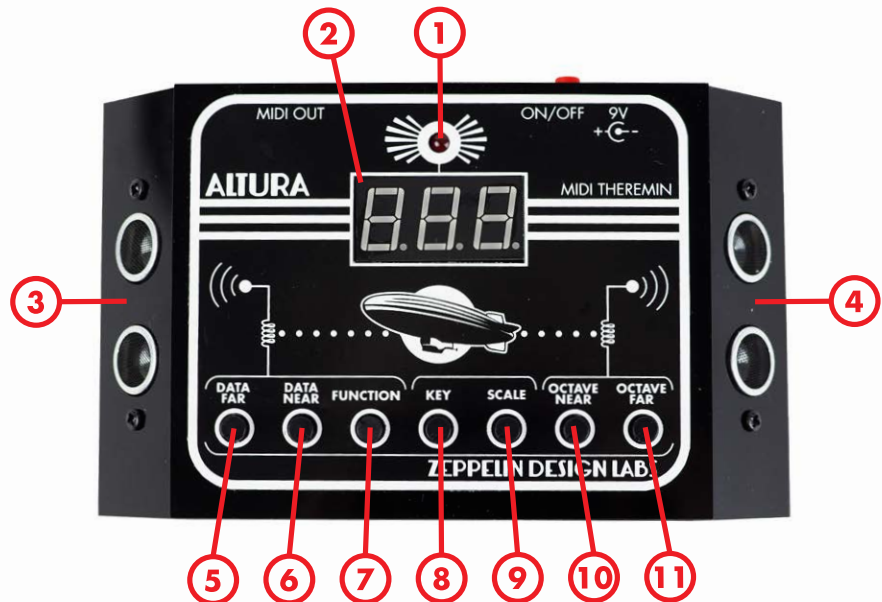## FEATURE LIST

REAR PANEL

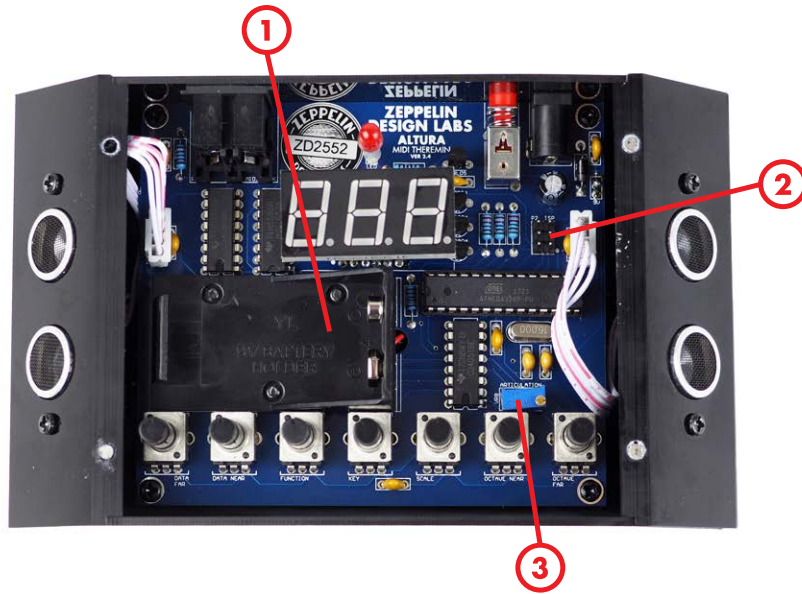1. 9V DC Power Input

2. Power On/Off
3. MIDI Out

TOP PANEL

1. Power On Indicator
2. 3-Digit Display
3. Left Distance Sensor – MIDI Control Functions
4. Right Sensor – MIDI Pitch
5. DATA FAR Adjust
6. DATA NEAR Adjust
7. FUNCTION Select
8. KEY (Root Note) Select
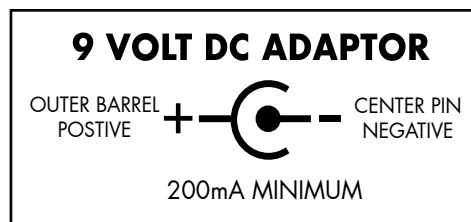9. SCALE (Mode) Select

10. OCTAVE NEAR Select
11. OCTAVE FAR Select

ON THE PCB

1. Battery Holder
2. ISP Header
3. Articulation Adjust

REAR PANEL FEATURES

1. 9V DC POWER INPUT

You can power your Altura with a 9V DC power supply ("wall wart"). It must be rated for 200 mA minimum, with center-negative polarity, such as a typical guitar pedal supply. Look for this graphic on the power supply. Your controller won't work with a center-positive power supply. Zeppelin Design Labs offers a suitable power supply as an

9 VOLT DC ADAPTOR

OUTER BARREL POSTIVE   CENTER PIN NEGATIVE

200mA MINIMUM

accessory. Simply plug the cable into the back of your Altura under the "9V" label. This disconnects the battery. It does not matter if you leave the battery inside. The only concern is if years go by and you forget the battery is there, and it leaks all over your Altura.

2. POWER ON/OFF

Push the red button to switch the Altura on. The red LED on top lights up. Push the button again to switch it off.

3. MIDI OUT

The Altura transmits data along one pin of a standard MIDI cable. We recommend you connect all your MIDI cables before turning anything on. To use the Altura, simply plug a cable from MIDI OUT to MIDI IN of any MIDI device; or use a MIDI-to-USB converter or other interface device to send the Altura's data directly into your computer. See also "Function 7: Channel Select" on page 19 below.

TOP PANEL FEATURES

1. POWER ON INDICATOR

This lights up when the power is on; off when it's off. This is a reliable indicator of whether your power supply is working or not. If you run the Altura from a battery, this light will get considerably dimmer rather suddenly when the battery is near the end of its life. Time for a new battery.

2. 3-DIGIT DISPLAY

Depending on conditions, this display shows a variety of information. It times out after 60 seconds and turns itself off, to spare your battery. To reactivate it, just turn any knob, or wave a hand in front of either sensor.

Here is a summary of what you might see on the display, and what it means. Each section in the Manual also has its own explanation of what the display is displaying.

IF YOU SEE:	FOR EXAMPLE:	IT MEANS:
A letter and a number	d 3	This is the KEY (letter) and the SCALE (number). See those sections below for details. When not in X-Y mode, the display defaults to this after 3 seconds.
Two separate numbers	5 4	These are the Octaves. The left number is the octave active NEAR the right sensor; the right number is the octave active FAR from the sensor. See OCTAVE SELECT below.
A one-, two- or three-digit number	8 67 122	While turning the DATA knobs, this is the limiting value of MIDI data the left sensor will transmit. See the various FUNCTIONS for details. While waving your hand in front of the left sensor (or the right sensor when in X-Y mode), this is the MIDI data value the Altura is transmitting.
A dynamic, spinning symbol	0.0⊐⌐⌐_ _⌐⌐⊏⊏00	Indicates amount of pitch bend, from "_" (no bend) to "0." (maximum bend). See PITCH BEND.
Dashes	– – –	X-Y mode Idle: no data transmitting from either sensor.
This thing:	⊢ – ⊣	X-Y mode Active: both sensors transmitting data.

DISTANCE SENSORS - GENERAL

The distance sensors are ultrasonic ranging devices. One of those eyeballs is a speaker, the other is a microphone. Several times a second, the speaker emits a high-frequency chirp; the microphone listens for an echo. If it fails to hear an echo before a preset timeout, the sensor returns a null value. The

Altura software attempts to distinguish between a timeout because there is truly nothing there, versus a timeout because it simply missed a chirp or two while your hand wiggled around. If the sensor hears an echo before the timeout, it returns the elapsed time in microseconds. The Altura software uses this time to calculate how far away your hand is, and decides what particular data this represents – a note number or a control change value. That data is worked into a standard MIDI message, which is then sent to the MIDI OUT cable.

The sensors monitor a cone-shaped space. They are terrific at identifying things like walls. To spot your hand, you will have to learn exactly where the sensor is looking. This takes practice, as any fretless instrument requires.

When most people play with an Altura for the first time, their instinct is to wiggle their fingers and flap their hands. This will produce chaotic results, which may be what you are after. However, for precise melodic control, you must hold your hand flat and steady, and perpendicular to the axis of the sensor. For stage drama, you might want to perform with paddles or dinner plates strapped to your hands.

We have pre-set the minimum and maximum distance over which the sensor is active, to optimize playability and reliability. It is active from about 3" – 40" (8 – 100 cm). Any object in this range can trigger the Altura: dangling cables, a passing guitar neck, a Marshall stack. Keep the play-zone clear!

Since the Altura uses sonar, and measures the speed of sound in air, its performance is somewhat subject to atmospheric conditions. The active range will vary a little if you move between extreme climates. These default range values can be changed if you hack the open-source software. See "Programming The Altura" below. The sensors actually have a maximum range of about 4 meters! You could use the Altura as a door bell, a motion-sensor alarm, or part of an interactive installation, where Alturas are triggered by participants moving about the display space.

3. LEFT DISTANCE SENSOR – MIDI CONTROL FUNCTIONS

The left sensor generally determines a MIDI data value to send to the MIDI OUT. The data it sends is determined by the FUNCTION currently selected. See "MIDI Function Select" on page 16.

When using Pitch Bend, removing your hand snaps the pitch back to No Bend, just like when you release the Pitch Bend wheel on a conventional controller. When using the other functions, however, removing your hand will fix the controller at the current value, like a slider. You set maximum and minimum values with the DATA NEAR and DATA FAR knobs. See each FUNCTION section below for details.

4. RIGHT SENSOR - MIDI PITCH

In Functions 1 - 5, the right sensor transmits Note-On messages. Whenever the Altura detects a new note to send, it first turns off the current note by transmitting a "Note On, Velocity 0"message.

The minimum and maximum distance over which the sensor is sensitive is pre-set to about 3" – 40" (8 cm - 100 cm). You can alter this by hacking the open-source software. See "Programming the Altura"

below. Holding your hand closer than the minimum distance can confuse the sensor and produce unexpected behavior.

You can control how many octaves of notes are covered in the active range, from one to eight, using the OCTAVE NEAR and OCTAVE FAR knobs. You can determine which way the notes range – from low to high or high to low. See "10, 11. Octave Near and Octave Far Select" on page 21 below. The more octaves you select, the smaller the piece of air available for any one particular note. At one octave of a pentatonic scale, each note gets about 6" (15 cm) of air, and they are quite easy to find. Six octaves of a diatonic scale leaves only about ½" (1 cm) per note! The Altura software uses some clever trickery to stabilize note selection, and minimize random fluctuations between notes. Nonetheless, you will discover some practical limitations. There are more details in the OCTAVE section below.

You can set the key and scale in which the Altura will play. This restricts the MIDI note numbers to those within the selected key signature. See the KEY and SCALE sections, below.

Another trick the Altura uses to stabilize note selection is what we call Articulation. This limits how frequently the device will update the note being played. See "Articulation Adjust" on page 22 below.

In Function 6 - X-Y Mode, the right sensor emulates the left sensor and transmits user-defined control change data. See "Function 6: X-Y Mode" on page 19 below.

5, 6. DATA FAR AND NEAR ADJUST

The DATA knobs have slightly different functions depending on the FUNCTION knob setting. These behaviors are summarized in this section, but please see the respective Function sections below for more details.

Function 1 – Pitch Bend: The DATA FAR knob controls the size of what we call the Neutral Zone, where the pitch remains unbent. The DATA NEAR knob sets the maximum semitones of bend when used with a Macchiato Mini Synth.

Functions 2 – 6: The left sensor behaves much like the Data slider found on most MIDI controllers. You use the DATA knobs to set the maximum and minimum values produced by the slider. DATA NEAR sets the limiting value the Altura will transmit when your hand is near the sensor – any value from 0 – 127. DATA FAR sets the limiting value far from the sensor, also any value from 0 – 127. By swapping values, you can make the Altura transmit values that either ascend or descend. Adjusting the DATA knobs does not cause any Controller message to be transmitted. No message is actually sent until you stick your hand in front of the sensor.

For Function 7: Channel Select, the DATA FAR knob sets the MIDI Send channel. The DATA NEAR knob has no function.

When you use the left sensor to send a MIDI control change message, that control value will "stick" even when you change functions. For example, you might wave your hand to set Modulation = 30 and then change to Function 5 to work with Portamento effects. The Modulation effect will remain active at

value 30. However, when you return to Function 2 – Modulation, the old values of Modulation Near and Far will be overwritten by the current knob positions. You will continue to hear modulation at value 30 until you use your left hand to change it, but the Near and Far limiting values may have changed! Be aware of this behavior in a live performance situation.

7. MIDI FUNCTION SELECT

The FUNCTION knob determines what type of MIDI data the left sensor will produce. The available functions are:
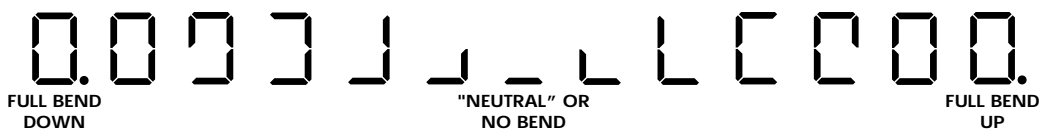
1. Pitch Bend
2. Modulation
3. Note-On Velocity
4. Channel Volume
5. Portamento Time
6. X-Y Mode
7. Channel Select

A label on the bottom of your Altura reminds you of these functions. The order of the functions can be rearranged by hacking the open-source code. See "Programming the Altura".

Following is detailed information about each MIDI function. Please also see the sections "Left Distance Sensor – MIDI Control Functions" on page 14 and "5, 6. Data Far and Near Adjust" on page 15 for general notes applicable to all functions.

FUNCTION 1: PITCH BEND

Function 1 emulates the Pitch Bend wheel on a conventional MIDI controller. The Altura sends MIDI values of -8184 to +8184 based on left sensor readings, tagged as Pitch Bend data (Controller #1) on the currently-selected Send channel. When you wave your hand in front of the left sensor in Pitch Bend mode, the display shows a cute spinny-thing to represent Pitch Bend Down and Pitch Bend Up.

FULL BEND DOWN	"NEUTRAL" OR NO BEND	FULL BEND UP

At the neutral zone, or No Bend position, the display shows "_". As you move your hand in, or Near to the sensor, the pitch bends up and the display spins clockwise. As you move your hand away, or Far from the sensor, the pitch bends down and the display spins counter clockwise. At Maximum Bend, either up or down, the display forms a complete " ⎕ ". When you lock in to the fully-bent pitch, a decimal appears: " ⎕. "

Turn the DATA FAR knob to display numbers 0 – 12. If you are using a Macchiato Mini Synth by Zeppelin Design Labs, this will set the number of semitones the pitch will change at maximum bend up and down. On other devices, this knob will have no effect or an unpredictable effect. The Altura is passing data to the Macchiato using unassigned Controller #20. If your synthesizer happens to use this controller for something, as does the Korg Monologue for instance, then something unexpected will happen. You will have to route the Altura through software to redirect this control number, or avoid touching this knob when in Pitch Bend function.

Turn the DATA NEAR knob to display numbers 0 – 127. This changes the size of the Neutral Zone that separates the Bend Up zone from the Bend Down zone. On startup, the Altura defaults to Function 1: Pitch Bend, and the neutral zone will default based on the physical position of the DATA NEAR knob. At 127, you will find a large piece of air where the pitch remains unaffected. Change it to zero and the neutral zone will essentially disappear: you will find it difficult to return a bent note to its original pitch, except by simply removing your left hand. When using the Altura in Pitch Bend mode, set the neutral zone to whatever value suits your need.

You will find the Altura lacks the resolution to use the Pitch Bend to produce precise, subtle vibrato effects characteristic of the original theremin. Use the Modulation effect for this instead.

FUNCTION 2: MODULATION

Function 2 emulates the behavior of the Mod Wheel on a conventional MIDI controller. It transmits a value from 0 – 127, as determined by the left sensor, to Control #2 on the currently selected Send channel.

Turn DATA FAR all the way left to display 0. Turn DATA NEAR all the way right to display 127. Move your hand near, the number rises, and you should hear note modulation, usually a tremolo effect. Move your hand far away, the number falls, and the effect diminishes. You can reverse the effect by swapping the numbers. The controller acts like a mid-air slider: move your hand to the desired value; remove it and the value will "stick". This behavior is the same across Functions 2 – 6. Note that changing the Data knob values will have no effect until you wave your hand in front of the left sensor. Only this will trigger transmission of a MIDI message.

On the Macchiato Mini Synth, Modulation controls the Depth of the Low Frequency Oscillator (LFO). (You won't hear any effect if the Rate knob is set to Minimum!) Touching the Depth knob on the Macchiato will override the Altura. Using the Altura will override the knob on the Macchiato.

FUNCTION 3: NOTE-ON VELOCITY

This function emulates the role of key velocity on a conventional keyboard. The Altura reads values 0 – 127 as determined by the left sensor, and combines this with pitch data from the right sensor. Whenever the Altura detects it is time to transmit a new Note On message, it combines the current Velocity value with the current Pitch value into a single Note On message transmitted

on the currently selected Send channel. The Note On Velocity defaults to 127 upon startup of the Altura. Use the DATA NEAR and FAR knobs to set a maximum and minimum value for Velocity. (Keeping a minimum velocity around 30 will prevent you from accidentally silencing your Altura!) You won't actually hear an effect until you wave your hands in front of both sensors.

Velocity usually impacts the volume of the note, but your synth might use this data to influence other effects, such as brightness or voice switching. This controller acts like a slider: Set Velocity to a particular number; remove your hand and that number will "stick". All notes will now play with that velocity value. You can now switch to another function and the velocity will continue unchanged.

FUNCTION 4: CHANNEL VOLUME

The Channel Volume emulates the Master Volume slider found on many MIDI controllers. Channel Volume defaults to 127 upon startup. Use the DATA NEAR and FAR knobs to set a maximum and minimum value for Volume. (Keeping a minimum volume of at least 30 will prevent you from accidentally silencing your Altura!) This affects the overall output volume of your synth, and is most useful for creating swells as a note sustains. This function lacks the resolution for subtle tremolo effects. It is better to use your Modulation effect for that.

FUNCTION 5: PORTAMENTO

Portamento means a smooth glide between notes. When you play a slide flute or trombone, you can portamento all the time. This glide effect is what you need to emulate that good ol' theremin sound. We designed the Altura's Portamento function to work well with the Macchiato Mini Synth. Many synthesizers do not implement Portamento at all. Some only implement it with a few voices. Some allow you to edit portamento behavior, more or less easily. We have tested the Altura on some Korgs, for instance, that responded immediately, with fantastic results; and other Korgs that did not respond at all, and could not easily be made to do so. You may need to do some fiddling with your synth or your DAW software to get results with this feature.

When the FUNCTION knob is set to 5, and Portamento Time is other than zero, the Altura sends a "Portamento ON" message (Control 65, value 127, on the currently selected Send channel). If you send a Portamento Time = 0 message, or if you send any Pitch Bend messages, the Altura will send a "Portamento OFF" message (control 65, value 0, current Send channel).

Waving your hand in front of the left sensor transmits a Portamento Time message (control 7, value 0 – 127, current Send channel). Zero represents an infinitely short glide from note to note, which is the same as no glide at all; that's why Portamento Time = 0 will switch off the effect. Portamento Time = 1 means a very fast glide between notes, almost too fast to perceive. Portamento Time = 127 produces a glide about 1 second long. Intermediate numbers produce glide times along a linear interpolation. It is an absolute time: the glide will last the same number of milliseconds whether the interval is one semitone or six octaves. For pleasant melodic playing reminiscent of 70's classic pop and progressive rock sounds, you will need Time values below about 20. The Altura sounds most like a theremin at Time values around 30. Higher numbers

give you the long, dramatic sweep you remember from REO Speedwagon's live "Riding The Storm Out" and Styx "Suite: Madame Blue". Set the DATA FAR knob to the slowest effect you want to hear, and DATA NEAR knob to the fasted. See the section "PRESETS" on page 24 for suggestions on how to achieve the most faithful emulation of a theremin, as well as some other sounds.

FUNCTION 6: X-Y MODE

This function causes the right sensor to emulate the left sensor: it no longer sends Note On messages. It sends control change messages of your choosing, just like the left sensor. You would use this mode not to create melodies, but to shape the sound already being produced by a synthesizer. A typical use would be to assign two different filter sweeps to the left and right sensors, or a filter sweep to one and resonance to the other.

With FUNCTION knob set to 6, the DATA FAR and NEAR knobs serve to set the limiting MIDI values produced by the left sensor. The OCTAVE FAR and NEAR knobs do the same for the right sensor. In this mode, key signature has no meaning, so use the KEY knob to select the Control Change Number (CC#) for the left sensor, 0 – 127, and use the SCALE knob to select the right-sensor CC#. On startup, these default to CC# 85 & 86, which are undefined. Your synth may respond immediately to many of the standard MIDI-defined controllers. See your synthesizer's documentation for a table of available CC's. By using one of the many undefined CC#'s, you can route the Altura through performance software and redirect the data any way you wish, assigning it to any function.

DATA FAR	DATA NEAR	FUNCTION	KEY	SCALE	OCTAVE NEAR	OCTAVE FAR
Left Sensor MIDI Max and Min		Function Select	Left CC# Select	Right CC# Select	Right Sensor MIDI Max and Min	

FUNCTION 7: CHANNEL SELECT

Turn the DATA FAR knob to set the channel on which the Altura sends MIDI messages. Only devices downstream set to the same channel will respond to the Altura. This lets you daisy-chain scads of devices without ever using control software. Old school!! The Altura defaults to Channel 1 on startup.

8. KEY (ROOT NOTE) SELECT

The KEY knob sets the root note of the scale you are playing. Turn the KEY knob and the display will show a letter and a number, i.e. D 4. The letter will change as you turn. It will display the twelve notes of the Western scale, with a decimal to indicate sharps:

C C. d d. E F F. G G. A A. b

This note will always play at the nearest and farthest points on the right sensor. For instance, if you set KEY to "F.", then the nearest and farthest notes your right hand can find will always be F-Sharps. Which F-Sharps depends on the OCTAVE NEAR and OCTAVE FAR settings.

9. SCALE (MODE) SELECT

The SCALE knob selects from one of a dozen pre-programmed scales, or modes. These scales are listed on a label on the bottom of your Altura for easy reference. We have selected a variety of common and not-so-common scales, including a couple of pentatonic scales popular with guitarists. We have also included the Chromatic scale, which includes all twelve notes in the Western scale.

A "scale" is defined by the intervals between adjacent notes as you make your way up an octave from one root note to the next. The following table describes the interval formulae we used in programming the Altura. You can change this easily to add your own scale by hacking the open-source software. See "Programming the Altura", below.

MODE	SEMITONES											
Ionian (Major)	2	2	1	2	2	2	1					
Dorian	2	1	2	2	2	1	2					
Phrygian	1	2	2	2	1	2	2					
Lydian	2	2	2	1	2	2	1					
Mixolydian	2	2	1	2	2	1	2					
Aeolian (Natural Minor)	2	1	2	2	1	2	2					
Locrian	1	2	2	1	2	2	2					
Harmonic Minor	2	1	2	2	1	3	1					
Major Pentatonic	2	2	3	2	3							
Minor Pentatonic	3	2	2	3	2							
Whole Tone	2	2	2	2	2	2						
Chromatic	1	1	1	1	1	1	1	1	1	1	1	1

You cannot program non-Western pitches with the Altura. Each key on the piano has its own standard MIDI number, ranging from 1 – 127. The pitches associated with each is a universal standard. To detune these frequencies to match non-Western music can only be done inside a synthesizer or sometimes with intermediate control software. It's probably easiest to change with "soft-synths": synthesizers that only exist as software in your computer.

10, 11. OCTAVE NEAR AND OCTAVE FAR SELECT

The Altura has a range of eight octaves (1 – 8), covering MIDI note numbers 12 (C0) through 119 (B8). (The original theremin had a range of about 5-1/2 octaves.) You do not have access to the lowest subsonic tones, or the few highest squealing notes. The OCTAVE NEAR knob sets which octave is active when your hand is near the right sensor. The OCTAVE FAR knob sets which octave is active when your hand is far from the right sensor, at the limits of its range. When both OCTAVE knobs are set to the same number, the Altura covers that one octave range. The nearest and farthest notes will both be the root note as selected with the KEY knob; in between will be the notes specific to the mode selected by the SCALE knob. Thus for one octave of a pentatonic scale, six notes will be accessible; for a harmonic scale, eight; and for the chromatic scale, thirteen.

The more octaves you assign to the right sensor, the smaller is the air space for each note. If you are trying to play a specific melody, two octaves is probably your practical limit. If you are jamming along with the band, just set the key and scale and as many octaves as you like, and get grooving. You can adjust octaves on the fly as you play.

If the OCTAVE FAR value is higher than OCTAVE NEAR, then naturally the scale will ascend as you move your hand farther from the sensor, and vice versa. If you set the two octaves to be equal, then the Altura covers a single octave, and its direction will match the previous selection: if it was two octaves ascending, then now it is one octave ascending. If it was two octaves descending, then now it is one octave descending. To demonstrate this to yourself, follow these steps and listen carefully:

a. Set the Altura to C Major. The display shows "C 1".
b. Set OCTAVE NEAR to 5 and OCTAVE FAR to 6. The display shows "5 6". You will hear the note C5 near to the right sensor, and C7 far from the sensor: two full octaves ascending, with the root note at both ends.
c. Set OCTAVE FAR to 5; the display shows "5 5". Now you will hear C5 near the sensor and C6 far away: one full octave, ascending.
d. Set OCTAVE FAR to 4. The display shows "5 4". Now you hear C6 near the sensor and C4 far away: two octaves descending.
e. Finally, return OCTAVE FAR to 5. The display shows "5 5" again, but lo! The near note is C6, the far note is C5 – one octave *descending*. Remember a moment ago it was *ascending?* Whenever you set the Altura to cover one octave, that one octave will ascend if the previous range was ascending, and descend if the previous range was descending.

ON THE PCB

Lift the lid off your acrylic Altura case, or open the top of your card stock case, and take a look inside.
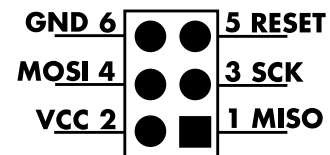
1. BATTERY HOLDER

Use a high-quality 9V DC alkaline battery, like Energizer. Do not waste your money on cheap batteries! You will regret it. Insert the battery into the holder, and push down to snap the battery into place. You may need to use a small screwdriver as a shoe horn to coax the battery into place.

As the battery drains, the ON LED will grow dimmer and the Altura may behave unpredictably. You are not likely to damage anything, but it simply won't work well. Replace the battery!

Plugging in a 9V DC power supply will disconnect the battery. It's okay to leave the battery installed while using an external power supply. The only concern is if you forget the battery is there and years go by. Eventually the battery will leak acid all over your Altura, and this could damage or destroy it.

2. ISP HEADER

On the PCB to the right of the 3-digit display there is a cluster of six little pins, three rows of two each. This is the In-System Programmer (ISP) header. This is the data port you use to communicate with the microcontroller that runs the Altura. To make use of it, you need a little device called a programmer. This is a little circuit board with a USB cable out one end to plug into your computer; and out the other end is a ribbon cable with a socket to plug into the ISP header. Pin 1 of the header is the bottom right pin; look for a tiny white dot on the PCB. (This is upside-down compared to how ISP headers are typically arranged.) The socket on your programmer will have an indicator on one corner, or a stripe on one wire, to indicate pin 1. Be sure to attach your programmer to the header correctly! When installed correctly, the Altura's LED and display will illuminate.

We used a USB-Tiny clone programmer to develop the Altura. Zeppelin Design Labs offers this programmer as an accessory. If you obtain a programmer from another source such as Sparkfun or Adafruit, be sure it is a USB-Tiny. Some users have had trouble with other types of programmers, such as Arduino boards. How to use the programmer is covered in the section "Programming the Altura".

3. ARTICULATION ADJUST

We developed the Articulation feature to improve the stability and playability of the Altura. The Altura is driven by software running on a microcontroller, an ATmega 328PA by Atmel. Microcontroller programs usually just run in loops as fast as they can, and they can run really fast. The left and right sensors will "ping" hundreds of times per second if allowed to do so. Your hand is a squashy, flappy, lumpy thing – and it is relatively small compared to the space the sensors are monitoring. As a result, the information the sensor gets back can vary considerably from one ping to the next. When we let the Altura use this data with no further processing, the result is a very unstable instrument: notes come

and go, or bounce around the scale at random. We use a number of clever data processing tricks to distinguish signal from noise and stabilize the Altura's performance. One of these tricks is to simply slow down the loop. You will never need to play hundreds of notes per second, so why collect so much data? The tiny blue trim pot just above the OCTAVE NEAR knob is the Articulation Adjust pot. This little knob slows down or speeds up the right-sensor read rate. The Articulation value represents time between polling cycles: low values mean very fast polling; high values mean very slow polling.

You access this control using the "Easter Egg" principle:

    a. Turn off the Altura.

    b. Turn all seven control knobs to the far left.

    c. Turn on the Altura. The software version displays for a few seconds, followed by a number which is a multiple of 15. This is the Articulation setting. We factory-preset Articulation to 45, which is pretty fast. This value seems best for quick response and good stability.

    d. For fast response at the expense of stability, turn the pot clockwise. The number will fall in increments of 15.

    e. For increased stability at the expense of responsiveness, turn the pot counterclockwise. The number will rise in increments of 15. At values around 60 or 75, you will be able to move your hand along the right sensor faster than the Altura can keep up. You will miss notes. When you remove your hand from the beam, the last note will linger before the Altura decides your hand is gone for good and terminates the note. This can be ideal if you play slow, languid melodies, and precise note selection is essential.

Articulation is a "set-it-forget-it" thing.

PROGRAMMING THE ALTURA THEREMIN MIDI CONTROLLER

The Altura software was developed in the Arduino integrated development environment (IDE). If you are an Arduino enthusiast, you can download the Altura open-source code from our github repository, edit it to your heart's content, and upload, or "flash", it to your Altura to make your own custom controller. Even if you know nothing about programming, and have no desire or intention to learn, the ISP header on your Altura's PCB makes it simple to obtain software updates from Zeppelin Design Labs and flash them to your Altura.

The Altura Theremin MIDI Controller is covered by the Creative Commons Share Alike / Attribution / Non-Commercial license. You are free to modify and redistribute the Altura software as long as you a) redistribute it under the same license as the original, b) give proper attribution to all previous contributors, and c) don't try to sell your work without talking to us about it first.

We host the Altura source code on Github at www.Github.com/zeppelindesignlabs. Please go to the Altura repository page now and read the README.md file for detailed, current instructions on obtaining and modifying the Altura source code.

We publish updates from time to time. You may develop your own Altura mods and contribute them to our Github page for possible inclusion in future releases.

If you get stuck, please contact us by email at info@zeppelindesignlabs.com, or consult our forum at http://zeppelindesignlabs.com/forums/.

PRESETS

Here are a few suggestions for setting up your Altura to achieve specific effects.

	Theremin	Synth Lead	Piano			
Synth Voice	Whistle or Saw Lead	Square Lead	Piano or other			
Macchiato Waveform	Sine, Saw	Square	Triangle			
Modulation Near	60	0	0			
Modulation Far	10	90	0			
Modulation Set Value	~30	~15	0			
Velocity Near	127	127	10			
Velocity Far	127	127	127			
Velocity Set Value	127	127	64			
Channel Vol Near	0	127	10			
Channel Vol Far	127	127	127			
Vol Set Value	~100	127	~80			
Portamento Near	20	20	0			
Portamento Far	80	127	0			
Port. Set Value	~40	~20	0			
Octave Near	6	4	3			
Octave Far	2	6	5			
Performance Function	Modulation or Volume	Port Time or Modulation	Velocity or Volume			