

Academy Audio Inc.

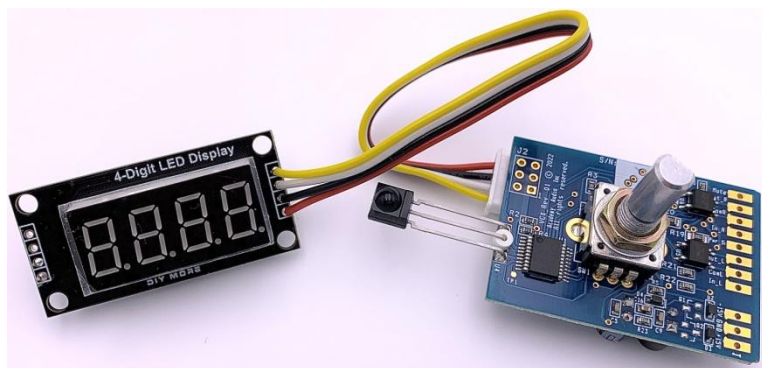
discovering the soul of music®

VCX Micro Hi-End MUSES® Electronic Volume Control

Ver. 01

User Manual

Rev. 03



MUSES® is a trademark of NJR Corporation. Other trademarks are a property of their respective owners.

1. Introduction

Thank you for purchasing the VCX, a fully integrated Hi-End MUSES® Micro Electronic Volume Control from Academy Audio Inc.

The VCX is a result of further improvement and enhancement of the VCU Hi-End MUSES® Micro Electronic Volume Control board. VCX is a complete ready to use two channel volume control unit that requires only a +/-15V power supply to operate.

The unit is built using a unique NJR MUSES®72320 volume control chip. Unlike other electronic volume control chips, this chip does not include any active circuitry, and therefore provides vanishingly low level of noise and distortions.

The VCX can be used with an outboard amplifier/buffer section or without any active amplifier/buffer. A built-in muting relay is provided to eliminate any unwanted noises from power-up/power-down processes.

The VCX Board features a rotary encoder, and a 4-character LED display for volume and mode indication, and provides a complete Volume and Balance control solution for a stereo preamp or an integrated audio amplifier. A Mute mode is also provided as a standard feature. An On/Off control signal is provided for the main power supply or auxiliary circuitry. All the functions are also controlled with a provided remote control unit. The VCX may be reconfigured to use an Apple remote or any NEC encoded remote control.

Designed and built in the United States.

2. What's Inside the Box

The VCX Board package includes the following items:

- VCX Board
- LED Display
- Deluxe Remote Control unit

3. Specifications

- | | |
|-----------------------------|---|
| • Power supply voltage | +/- 9-16Vdc |
| • Power supply current | ≤ 15mA (per rail) |
| • Volume Control Range | -120dB(Mute); -112dB to 0dB |
| • Volume Control Step Size | 0.5dB |
| • Balance Control Range | ±7.5dB |
| • Balance Control Step Size | 0.5dB |
| • Output Noise: | -118dBV (MUSES chip only) |
| • THD @1kHz , 1Vrms: | 0.0005% typ (MUSES chip only) |
| • THD @10kHz , 1Vrms: | 0.001% typ (MUSES chip only) |
| • Max. Input Voltage: | 9Vrms @+/-15Vdc power |
| • Dimensions | 1.285”H x 1.800”W x 1.450”D (including encoder) |

4. Description

Referring to Figure 1, the front of the VCX board features a rotary encoder with a push switch function located at the center, and an IR remote control sensor. There are also Audio, Control and Power connector pads connected to the ones on the back side.

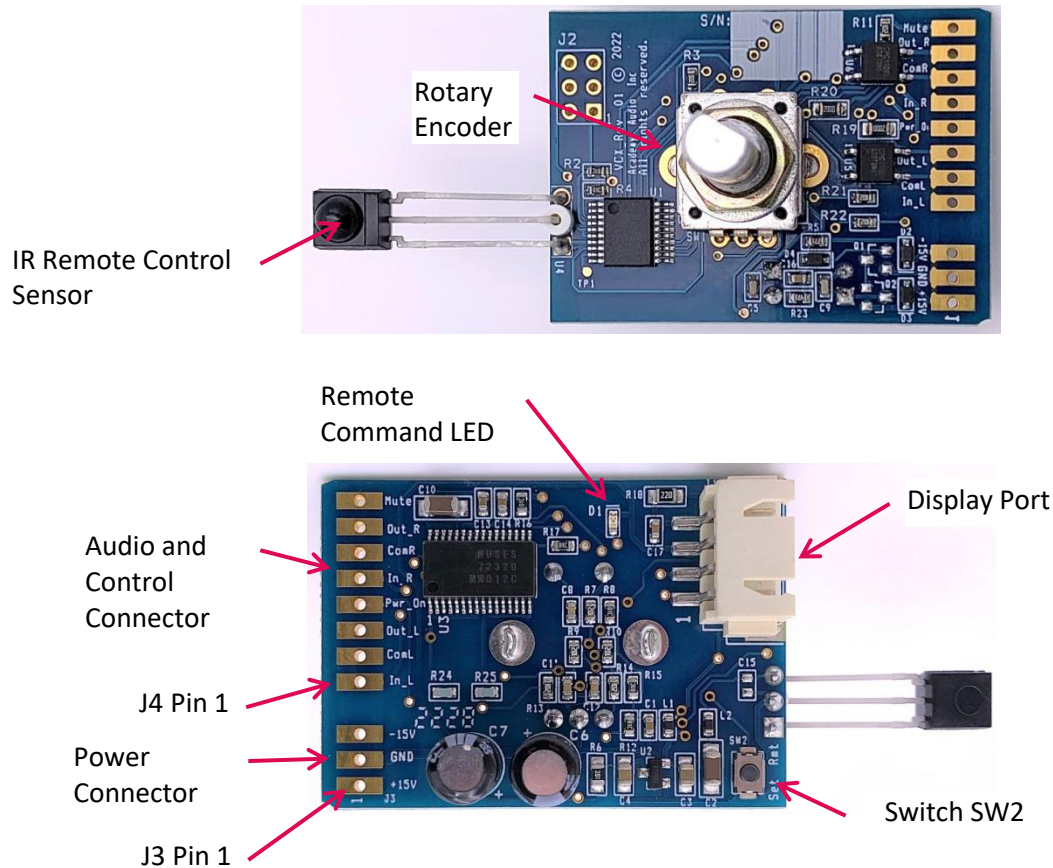


Figure 1. VCX Board Front View (top) and Rear View (bottom).

The back of the board features a Power Connector J3 and an Audio and Control Connector. An LED D1 serves as a remote command indicator when a remote control signal is received.

5. Features

The VCX is packed with useful features that make it a control center for the audio amplifier:

- 0-100 Volume control (-112dB to 0dB, 0.5dB step)
- -15 - 0- +15 Balance control (+/- 7.5dB, 0.5dB step)
- Muting control
- Soft volume roll-on/roll-off.
- Soft start-up.
- Start-up volume limiter to avoid hearing loss and speakers' damage.
- On/Standby control with a control output.
- Display dimming control.
- Dedicated IR Remote control unit.
- Ability to pair with an Apple remote control unit.
- Ability to learn any NEC coded remote control unit.
- Configurable power-up status (On or Off)

6. Mechanical LED Display Dimensions

VCX comes with a four-character LED display. The dimensions of the display are given at Figure 2.

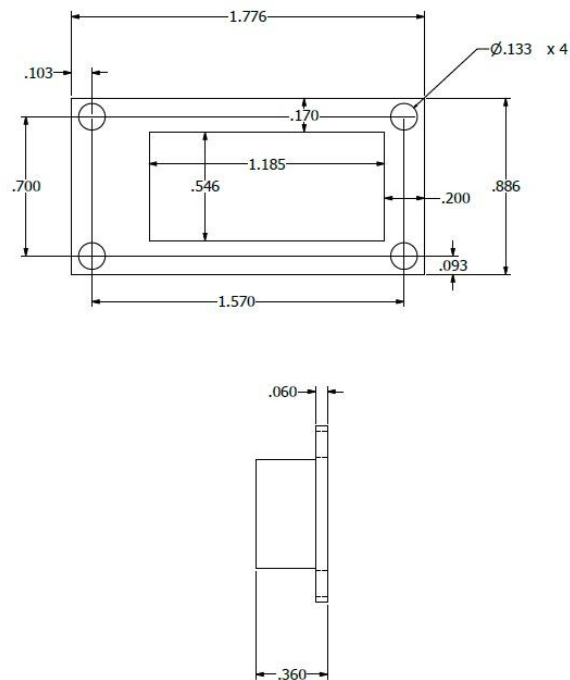


Figure 2. LED Display dimensions.

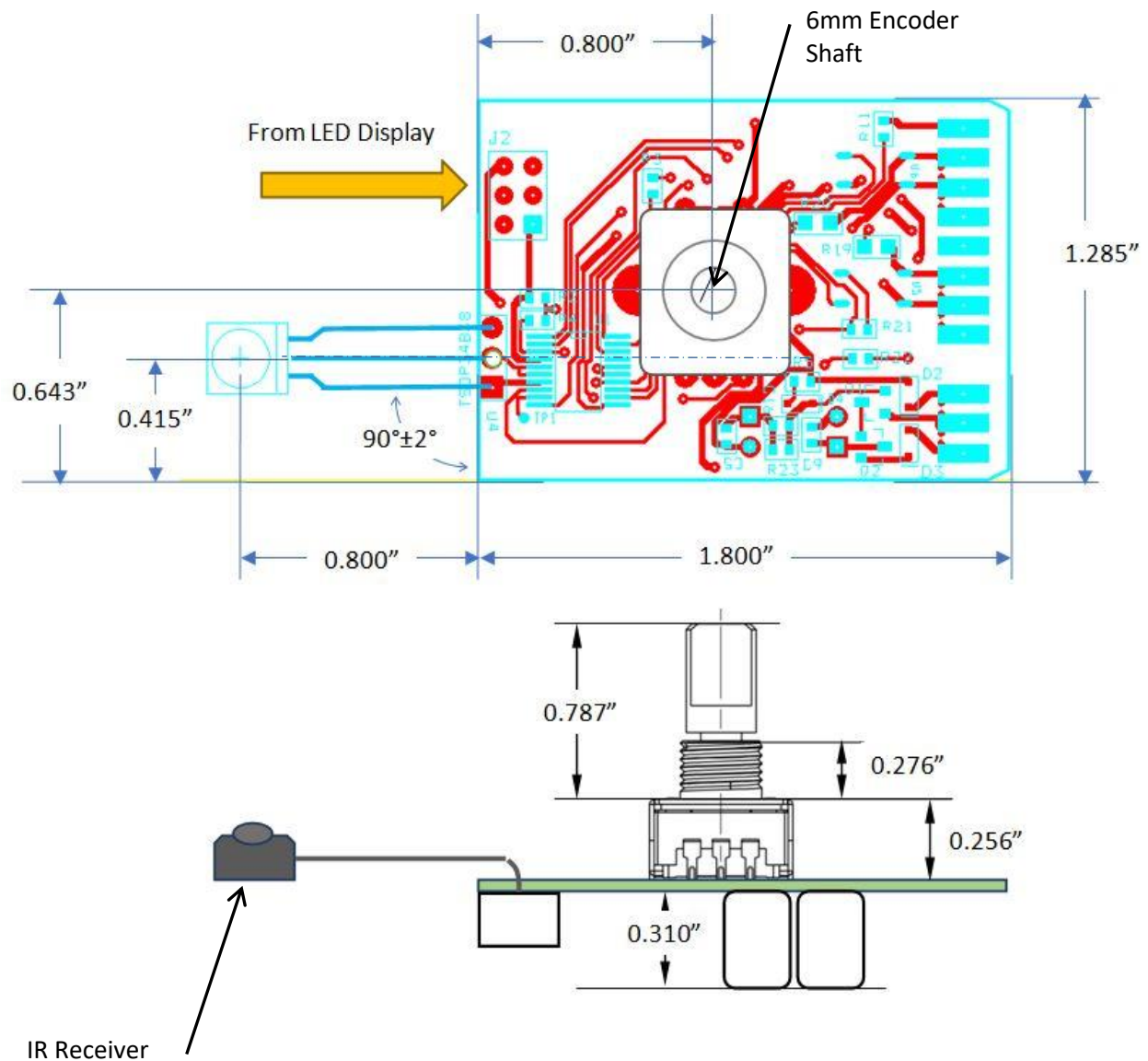


Figure 3. VCX board dimensions.

Refer to Figure 3 for mechanical dimensions and mounting holes location. The VCX board may be installed on a faceplate as a regular potentiometer into a 0.300" hole, and secured with a provided 7mm nut. Make sure the knob can be pushed in to enable Balance adjustment and Mute mode. Make sure the IR Remote control receiver is not blocked from receiving the IR commands. A piece of infra-red transparent plastic may be used as a window for the IR receiver.

7. Power Supply

The VCX board requires a clean analog bi-polar power source of $V_{cc}=+9V_{dc}$ to $+16V_{dc}$, 10mA and $V_{ee}= -9V_{dc}$ to $-16V_{dc}$, 5mA. Make sure positive and negative voltages are applied at the same time. **Applying a negative voltage only may permanently destroy the MUSES chip.**

8. Connectors Description

The VCX board features several connectors that provide all required connectivity for every application option.

A power solder pads connector J3 provides all power connection points. The connector **may not be used** as a mechanical mounting feature for the VCX board.

Table 1. J3 Pin Assignment

Pin	Ref	Description
1	+15V	+9V to +16V analog power
3	GND	Analog Ground
5	-15V	-9V to -16V analog power

A signal solder pads connector J4 is provided for all audio signal connections.

The J4 connector pin assignment is summarized in a Table 2.

Table 2. J4 Pin Assignment

Pin	Ref	Description
1	In_L	Left Channel Input
2	Com_L	Left Channel Common
3	Out_L	Left Channel Potentiometer Output
4	Pwr_On	On/Off Control Output (Active High – Power On)
5	In_R	Right Channel Input
6	Com_R	Right Channel Common
7	Out_R	Right Channel Potentiometer Output
8	On/Stby	Optional On/Stby Switch Input *

* Marked as MUTE on the board, which is an error.

9. Theory of Operation

A potentiometer based volume control, shown at Figure 4, is the most traditional volume control solution.

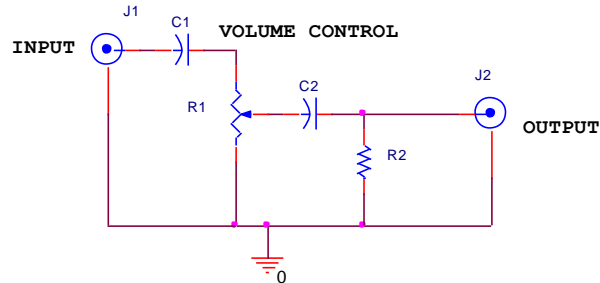


Figure 4. Potentiometer Volume Control

A capacitor C1 blocks any DC current from the input reaching the potentiometer, and capacitor C2 prevents any input DC bias currents from the downstream circuitry passing through the potentiometer. Both capacitors are needed to avoid cracking noises while adjusting the volume. Resistor R2 represents a load of the volume control. Both capacitors are in the audio signal path and may affect sound quality. They have to be of a high quality type, and properly sized to pass low frequency audio signals with minimum degradation. Capacitor C2 may be omitted if the downstream circuit has a JFET high impedance input with practically no bias current. The C1 may be removed only if the circuitry feeding the volume control has no DC output component at all times. Precision of the volume control operation is affected by the load, and is degraded when the load impedance is less than 10 times higher than the potentiometer value. Placing a high input impedance buffer or amplifier after the volume control assures perfect compliance with the regulation curve. So called “passive” volume controls use no active electronic circuitry and are heavily dependent on the input impedance of the loading audio component.

The MUSES[®]72320 volume control chip is built on the resistive elements commutated with a high quality MOSFET switches, and performs like a potentiometer based volume control. Figure 5 is an excerpt from the official JRC datasheet.

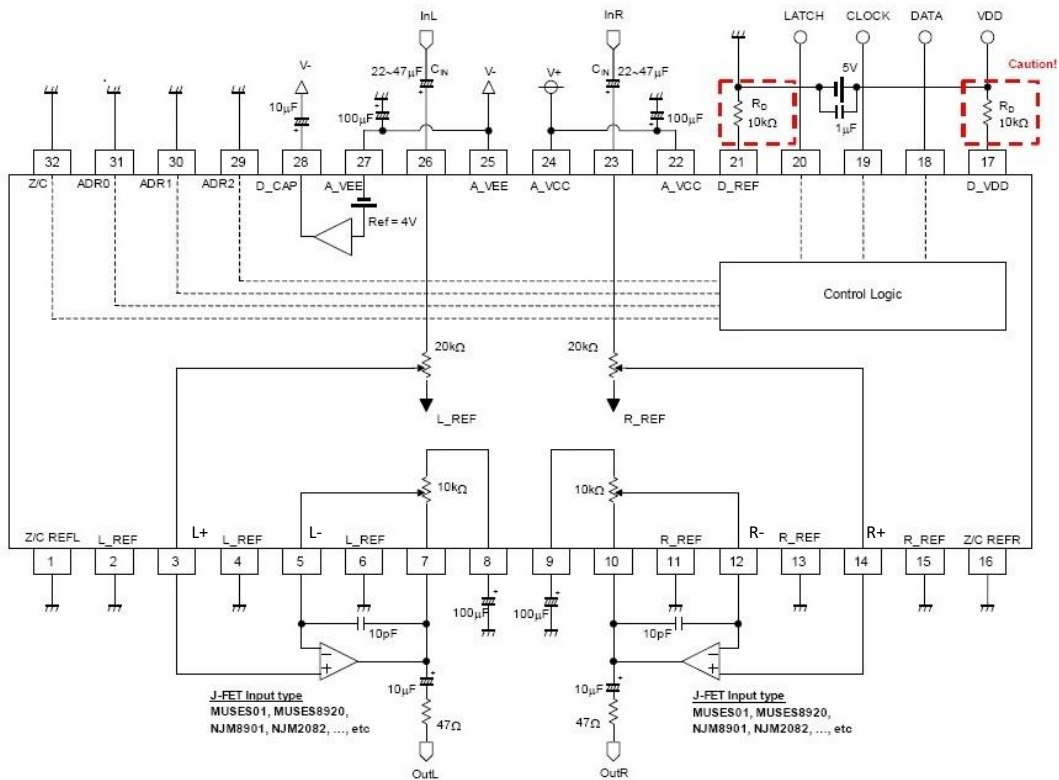


Figure 5. MUSES®72320 Volume Control Chip Recommended Application.

Capacitors C_{in} connected to input pins 23 – In_R and 26 – In_L perform the function of the capacitor C1 of Fig. 2. Capacitors equivalent to the capacitor C2 of Figure 4 are omitted due to external J-FET opamps used at the potentiometers' outputs.

Two 10kΩ internal potentiometers connected to pins 5, 7, and 8 for the Left channel, and pins 9, 10, and 12 for the Right channel allow to add up to +31.5dB gain to each channel if desired. When these pots are configured for a 0dB gain, the opamps act as buffers introducing minimum distortion and noise to the signal.

10. Application Information

10.1. Power and Audio Connections

The VCX board features separate connections for the Left (Com_L) and Right (Com_R) analog grounds. These grounds are connected on the board to minimize cross talk. It is recommended to use isolated ground audio connectors to ensure the lowest cross talk and noise pick-up. Make sure the input signals do not exceed 9Vrms at +/-15V analog power.

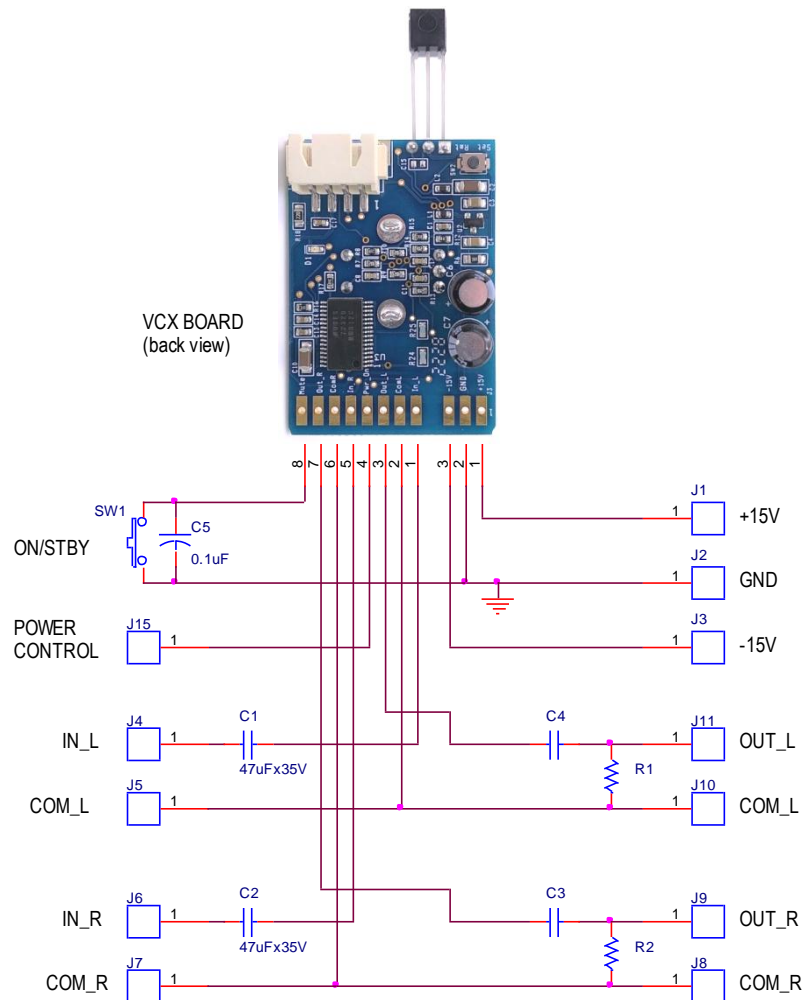


Figure 6. Potentiometer Type Single Ended Volume Control Application.

The volume regulation precision of this circuit is heavily dependent on the loading of the downstream audio circuitry. The table of Figure 7 shows an error magnitude depending on the value of the loading impedance.

R_load, kOhm	Volume Control Position	
	0dB to -32dB	-32dB to -112dB
	Error, dB	Error, dB
10	-4.08	-2.28
20	-2.28	-1.21
47	-1.04	-0.54
100	-0.51	-0.26
200	-0.26	-0.13
1000	-0.05	-0.03

Figure 7. Volume Control Error.

It is obvious that higher impedance loads provide lower volume control errors. It is recommended to use a buffer or a high input impedance amplifier at the output of the volume control. For buffers and amplifiers having a bipolar input, resistors R1 and R2 provide a current pass for their input bias currents, and capacitors C3 and C4 block DC current from reaching resistive elements of the MUSES chip. Resistor values shall be selected between 100kOhm and 470kOhm for optimal performance. Capacitors' values shall be high enough to pass low frequencies of the audio band. For JFET based buffers and amplifiers, or when the circuit is used as a passive outboard Volume control feeding a power amplifier with a DC insensitive input, the DC blocking networks C3R2 and C4R1 may be omitted.

10.2. *Balanced Volume Control Applications*

The VCX board requires a Balanced Audio Input Board (BIB) for a balanced volume control operation. See the application details in the BIB Manual.

10.3. *On/Off Switch*

An optional On/Off switch may be connected to Pin 8 of the signal connector J7 (See Figure 6). The pin is labelled MUTE, which is an error. Use the normally open momentary switch only. If the On/Off switch is not used, change the Power-Up mode to On (See Section 13.1). The VCX will then start in the On mode upon power-up. This mode is useful only when there is a separate On/Off switch that controls power for the entire system. The On/Off button of the remote control will still control the Standby mode.

10.4. *Muting Relay*

According to the MUSES®72320 volume control chip datasheet, the chip is sensitive to the audio signal applied to the inputs before the power is supplied. In this case a distorted audio may be fed through the chip to the outputs. Some power-up pops and clicks are also possible. An external muting relay may be needed to eliminate power-up pops and clicks generated by other audio circuitry (e.g. a buffer/amplifier following the VCX). The BIB (Balanced Audio Input Board) and the IOB (Single Ended Input/Output Board) come with that relay and the basic line stage.

10.5. *Capacitors Selection*

It is well known in the High End audio enthusiasts circles that the best DC blocking capacitor in the audio path is “no capacitor”. However, as discussed in Section 6 of the Manual, presence of the DC voltage

on the input or output of the MUSES® chip may adversely affect the circuit operation and create extra noise and distortions. Use direct input connection only when it is assured that no DC voltage will be applied to the inputs. Use direct output connection only when no DC voltage will be applied to the inputs AND outputs of the chip. In all other cases high quality DC blocking capacitors shall be used.

High quality polypropylene capacitors present the best choice for the output DC blocking when the control is feeding high impedance loads. They get pricy at higher than 10uF values.

High quality non-polar electrolytic capacitors of 47uf to 100uF provide good results when bypassed with 10nF to 100nF film or COG (NPO) ceramic capacitors.

The MUSES®72320 volume control chip datasheet shows polar electrolytic capacitors connected with positive terminals facing the chip inputs. Outstanding results were achieved with ELNA Silmic II polar capacitors of 100uF at the inputs and 47uF at the outputs, all caps bypassed with 10nF COG ceramic capacitors.

10.6. Application Boards

Academy Audio provides application boards for the Single Ended (SE) audio operation (IOB – SE Input Output Board) and for the Balanced Audio operation (BIB – Balanced Audio Input Board). Both boards feature high quality audio capacitors, a muting relay and a linear stage providing a complete SE or balanced audio volume control solution.






10.7. Break-in Period

High-End audio enthusiasts are familiar with the “break-in” phenomenon: the sound gets better with time. In engineering terms that refers to reduced distortions of the audio signal. This distortion reduction may be attributed to priming of the capacitors and all the contacts in the audio path. A noticeable sound improvement is expected after about 100 hours of listening.


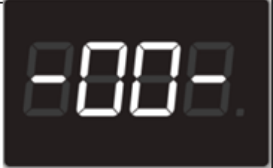

11. VCX Board Operation

Controls Functionality:

The VCX board is set up at the factory to start in a Standby mode at power up. This is a programmable option. See section 13.1 for instructions.

Function	Action	Display
Power up	Any time when power is applied to VCX or it is turning on from a Standby the LED display shows a start-up pattern.	
Standby	When VCU is in a Standby mode, the LED display shows a blank screen with just a dot dimly lit. The Standby mode provides a low power operation. The Power Control pin is set low.	
On	When VCX turns on, it restores the Volume and Balance settings stored on the non-volatile memory (NVM) and displays the power up pattern, and then the current Volume setting. The maximum volume at turn-on is limited to 60 to prevent hearing loss and possible speakers' damage. The Power Control pin is set high.	
On/Stby Operation	When VCX is in Standby, click the Encoder Knob switch to turn it on. Use an optional On/Stby switch to turn the VCX on or put it in a Standby mode. Use the On/Stby button of the remote control for the same purpose.	
Adjusting Volume	Rotate the Encoder Knob or use the Volume Up and Volume Down buttons of the remote control to set the desired Volume. The VCX provides soft roll-up/roll-down to avoid volume jumps. The volume setting is stored in NVM.	
Mute	When VCX is on, click the Encoder Knob switch or the Mute button on the remote control to enable or disable the Mute mode. While in the Mute mode, the Mute pattern is displayed. When the Mute mode is turning off, a soft volume roll-up ensures a smooth return to the previously set volume level. The restored volume level will not exceed 60.	

Continued on the next page...

Function	Action	Display
Balance Control	When VCX is on, click and hold for more than 2 sec the Encoder Knob switch to enable Balance Control. Rotate the Encoder Knob to adjust the balance to the desired position. Use Balance Left or Balance Right buttons on the remote control for the same purpose. The VCX returns to the Volume display after a timeout.	
Balance Left	The display shows a numeric value and a mnemonic symbols for the balance adjustment.	
Balance Centered	When the Balance control is at the central position, the Balance Centered pattern is displayed.	
Balance Right	The display shows a numeric value and a mnemonic symbols for the balance adjustment.	
Display Dim	Use a Dim button on the remote control to switch the display brightness between normal and dim operation.	

12. Remote Control Unit

A dedicated Deluxe style IR remote control unit is provided with each VCX Board. Due to shipping regulations, the remote control unit is shipped without the battery. **Install a fresh CR2025 lithium coin battery before operating the remote control unit.**

The remote control unit buttons functionality is illustrated at Figure 8. Unused buttons are reserved for future enhancements. The D1 LED indicator blinks GREEN when a remote command is received. Also blinks a dot on the right bottom corner of the LED display.



Figure 8. Deluxe Remote Control Unit.

13. Programming Options

13.1 Power-up Status

The VCX is shipped with the power-up with OFF option enabled. This option is useful when the optional On/Stby switch is installed in the system and connected to the VCX board. If this switch is not used, there is a way to change the power-up option to On, so the unit always starts with the On status when the power is applied. The sequence of operations to select the required power-up status is shown below.

Action	Function	Display
	To change the VCX Power-up status.	
While powering up, press and hold the SW2 or On/Stby switch. Release in 2 seconds.	The VCX goes into a Learn Mode.	
Click the SW2 or On/Stby switch.	The VCX goes into a Power-up Status Mode selection.	
Click the Encoder Knob switch.	If you click the SW2 or On/Stby switch at this moment, the VCX restarts with the On at power -up. This is useful when no On/Stby switch is used. The VCX will always start On once the power is applied.	
Click the Encoder Knob switch.	If you click the SW2 or On/Stby switch at this moment, the VCX restarts with the OFF at power -up. This is useful when the On/Stby switch is used. The VCX will always start OFF once the power is applied.	
Click the Encoder Knob switch.	The VCX returns to the Power-up Status Mode selection.	


13.2 Restore Default Remote Control Operation

The VCX is shipped with the original Deluxe remote control unit. To restore the operation with the default remote control unit, follow the steps below.

Action	Function	Display
	To enable the Default remote control unit.	
While powering up, press and hold the SW2 or On/Stby switch. Release in 2 seconds.	The VCX goes into a Learn Mode.	
Click the Encoder Knob switch.	If you click the SW2 or On/Stby switch at this moment, the VCX restarts with the Default remote control unit enabled.	

13.3 Enabling an Apple Remote Control

To enable VCX operation with an aluminum Apple remote control unit, follow the sequence of operations listed below.

Action	Function	Display	
	To enable the Apple remote control unit.		
While powering up, press and hold the SW2 or On/Stby switch. Release in 2 seconds.	The VCX goes into a Learn Mode.	0000	
Click the Encoder Knob switch.		0F00	
Click the Encoder Knob switch.		AP00	
Click the SW2 or On/Stby switch.	Ready to pair with an Apple remote.	0000	
Click the Menu button on the Apple remote.	Pairing - 1st Step	0000	
Click the Menu button on the Apple remote again.	Pairing - 2nd Step. The first two characters show the remote unit ID code, the last two characters show On/Stby command code. (The actual characters will reflect the actual remote control unit codes)	F200	
Click the SW2 or On/Stby switch.	The VCX restarts with the Apple remote control enabled. Use the Apple remote control buttons as follows: Menu - On/Stby Play/Stop - Mute Up - Volume Up Down - Volume Down Left - Balance Left Right - Balance Right Select - Dim Display		

13.4 Learning an NEC Remote Control

The VCX can learn to operate with any NEC coded remote control. The following sequence assigns any button of the available NEC coded remote control unit to a corresponding function of the VCX. Each button may be used to a single function only. If the display shows an error (Err) at any time, start the entire learning process from the beginning. Check all the assigned buttons operation when the VCX restarts. Repeat the process, if not all the assigned buttons operate.

Action	Function	Display
	To program operation with any NEC encoded remote control unit. (Beta)	
While powering up, press and hold the SW2 or On/Stby switch. Release in 2 seconds.	The VCX goes into a Learn Mode.	
Click the Encoder Knob switch.		
Click the Encoder Knob switch.		
Click the Encoder Knob switch.	Ready to learn an NEC encoded remote control.	
Click the Encoder Knob switch.	Ready to learn an On/Stby button	
Click the On/Stby button on NEC remote control	Learning the On/Stby button.	
Click the On/Stby button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the On/Stby command code. (The actual characters will reflect the actual remote control unit codes)	

Continued on the next page...

Action	Function	Display	
Click the Encoder Knob switch.	Ready to learn a Mute button		
Click the Mute button on NEC remote control	Learning the Mute button.		
Click the Mute button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Mute command code. (The actual characters will reflect the actual remote control unit codes)		
Click the Encoder Knob switch.	Ready to learn a Volume Up button		
Click the Volume Up button on NEC remote control	Learning the Volume Up button.		
Click the Volume Up button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Volume Up command code. (The actual characters will reflect the actual remote control unit codes)		
Click the Encoder Knob switch.	Ready to learn a Volume Down button		
Click the Volume Down button on NEC remote control	Learning the Volume Down button.		
Click the Volume Down button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Volume Down command code. (The actual characters will reflect the actual remote control unit codes)		

Continued on the next page...

Action	Function	Display
Click the Encoder Knob switch.	Ready to learn a Balance Left button	8888
Click the Balance Left button on NEC remote control	Learning the Balance Left button.	8888
Click the Balance Left button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Balance Left command code. (The actual characters will reflect the actual remote control unit codes)	8004
Click the Encoder Knob switch.	Ready to learn a Balance Right button	8888
Click the Balance Rightbutton on NEC remote control	Learning the Balance Left button.	8888
Click the Balance Right button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Balance Right command code. (The actual characters will reflect the actual remote control unit codes)	8005
Click the Encoder Knob switch.	Ready to learn a Balance Right button	8888
Click the Balance Rightbutton on NEC remote control	Learning the Balance Left button.	8888
Click the Balance Right button on NEC remote control again	Learning - 2nd Step. The first two characters show the remote unit ID code, the last two characters show the Balance Right command code. (The actual characters will reflect the actual remote control unit codes)	8061
Click the Encoder Knob switch.	The VCX restarts with the newly learned NEC remote control enabled.	

14. Technical Support

Academy Audio Inc continuously improves the design of their products. Please refer to the website for the latest information.

For any questions regarding operation of the VCX Volume Control board and for the latest documentation please visit us at www.academyaudio.com.

Happy listening!