

# *Academy Audio Inc.*

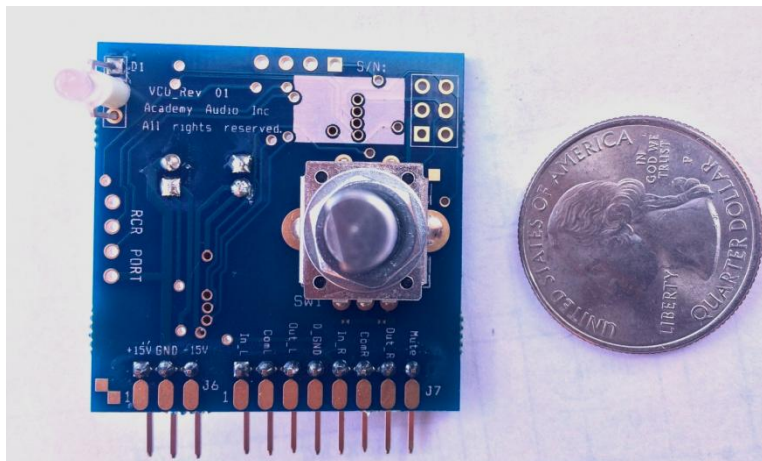
discovering the soul of music®

## **VCU Micro Hi-End MUSES® Electronic Volume Control**

**Ver. 01**

## **User Manual**

Rev. 01



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## 1. Introduction

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

The VCU is a result of integration of a famous VCM Hi-End MUSES® Mini Electronic Volume Control board and an MCU-M – a matching controller board. VCU 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 VCU can be used with an outboard amplifier/buffer section or without any active amplifier/buffer. A control signal for an external muting relay is provided to eliminate any unwanted noises from power-up/power-down processes.

The VCU Board features a rotary encoder, and a dual color LED for 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 IR Remote control option enhances control functionality.

Designed and built in the United States.

## 2. What's Inside the Box

The VCU Board package includes the following items:

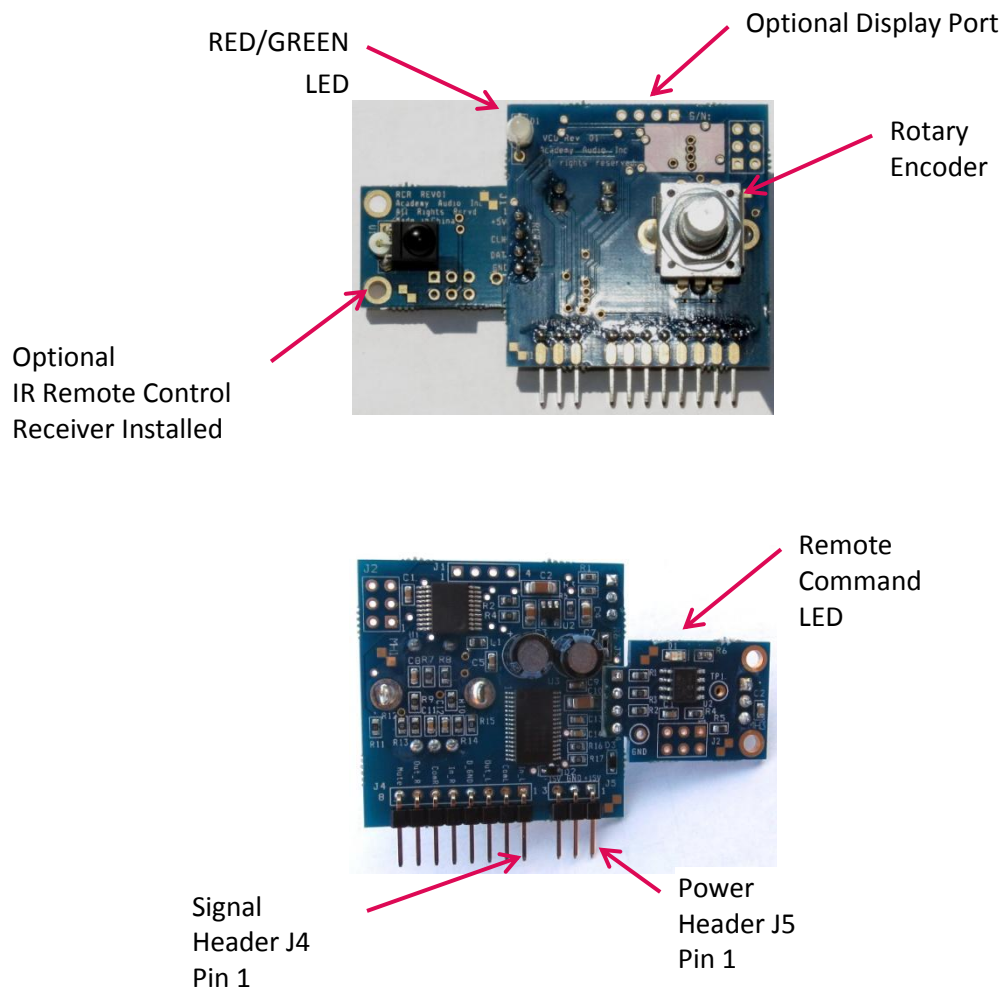
- VCU Board
- Deluxe Remote Control unit and an RCR remote control receiver board. (If a Remote Control option ordered.)

## 3. Specifications

- |                             |   |
|-----------------------------|---|
| • Power supply voltage      | +/- 9-16Vdc                                     |
| • Power supply current      | ≤ 10mA  |
| • Volume Control Range      | -120dB(Mute); -112dB to 0dB                     |
| • Volume Control Step Size  | 0.5dB   |
| • Balance Control Range     | ±12dB   |
| • 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                | 1.500"H x 1.500"W x 1.450"D (including encoder) |

## 4. Description

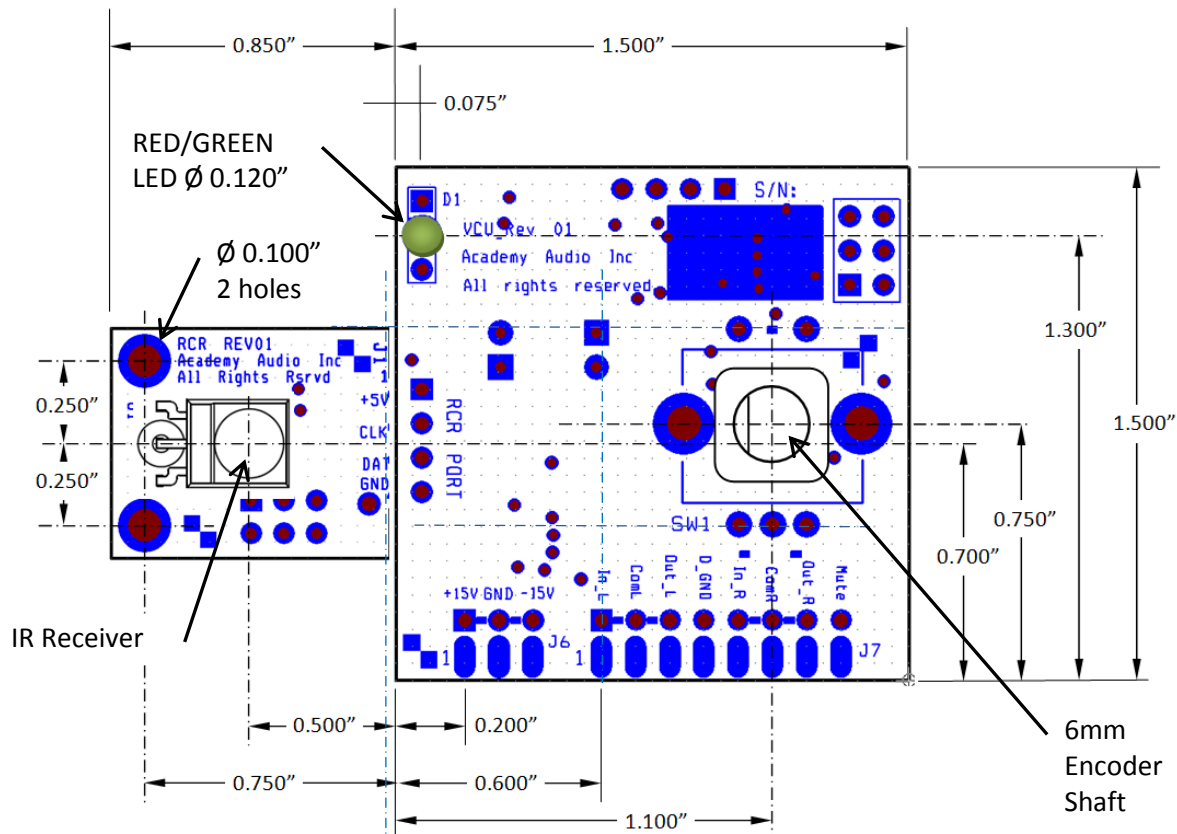
Referring to Figure 1, the front of the VCU board features a rotary encoder with a push switch function located at the center, and a dual color multifunctional LED indicator. An optional IR remote control receiver board may be installed into an RCR Port J3. There is also an optional Display Port reserved for future extensions.



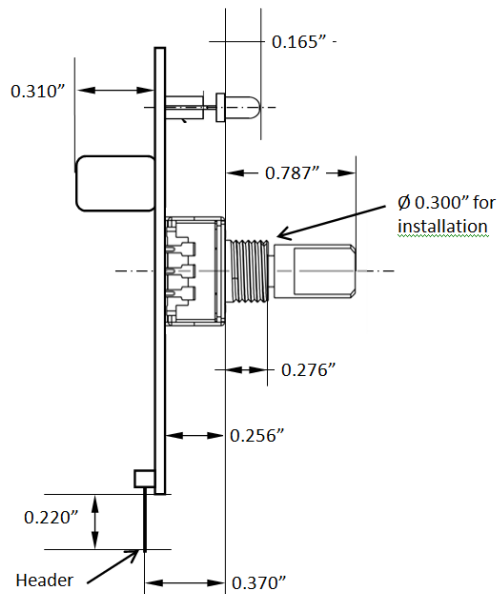
**Figure 1.** VCU Board Front View (top) and Rear View (bottom).

The back of the board features a Power Header J5 and a Signal Header J4. An LED D1 on the optional RCR Remote Control Receiver board serves as a remote command indicator when a remote control option is selected.

## 5. Mechanical



**Figure 2.** VCU board with optional RCR board dimensions.



**Figure 3.** VCU board side view.

Refer to Figure 2 and Figure 3 for mechanical dimensions and mounting holes location. The VCU 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. Provide a 0.125" hole in the panel for the dual color LED indicator. 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.

## 6. Power Supply

The VCU 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.**

## 7. Connectors Description

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

A power connector J5 is a single row 0.100" 3-pin right angle header that provides all power connection points. The connector **may not be used** as a mechanical mounting feature for the VCU board. A solder pad connector J6 provides the alternative connection means, if direct wiring is preferred.

**Table 1.** J5 and J6 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 connector J4 is a single row 0.100" 8-pin right angle header that is provided for all audio signal connections. It also provides a digital ground and a control signal for the muting relay. A solder pad connector J7 provides the alternative connection means, if direct wiring is preferred.

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

**Table 2.** J4 and J7 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	D_GND	Digital Ground
5	In_R	Right Channel Input
6	Com_R	Right Channel Common
7	Out_R	Right Channel Potentiometer Output
8	MUTE	Output to Muting relay control. (Active High – Mute Off.)

An RCR Port J3 is a footprint for a single row 0.100" 4-pin straight header for connection of an optional RCR Remote Control Receiver board. The header should be installed from the back of the board, and when the RCR board is soldered at the back of the header, the header spacer provides a 0.090" offset

required for the proper IR sensor positioning behind the faceplate. The header may be replaced with a 4-conductor cable up to 12" long, and the RCR board may be moved to a more convenient position.

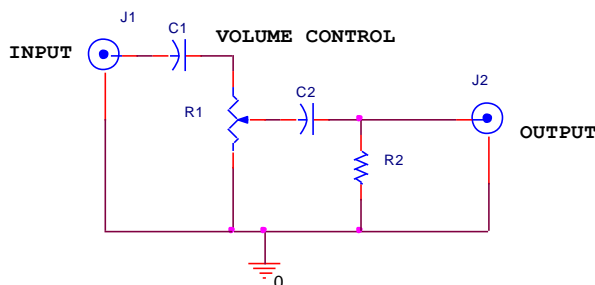
The J3 connector pin assignment is summarized in a Table 3.

**Table 3.** J3 Pin Assignment

Pin	Ref	Description
1	+5Vdc	+5Vdc power output for RCR board, 5mA max.
2	CLK	Remote Control Command Clock Input
3	DAT	Remote Control Command Data Input
4	D_GND	Digital Ground

## 8. Theory of Operation

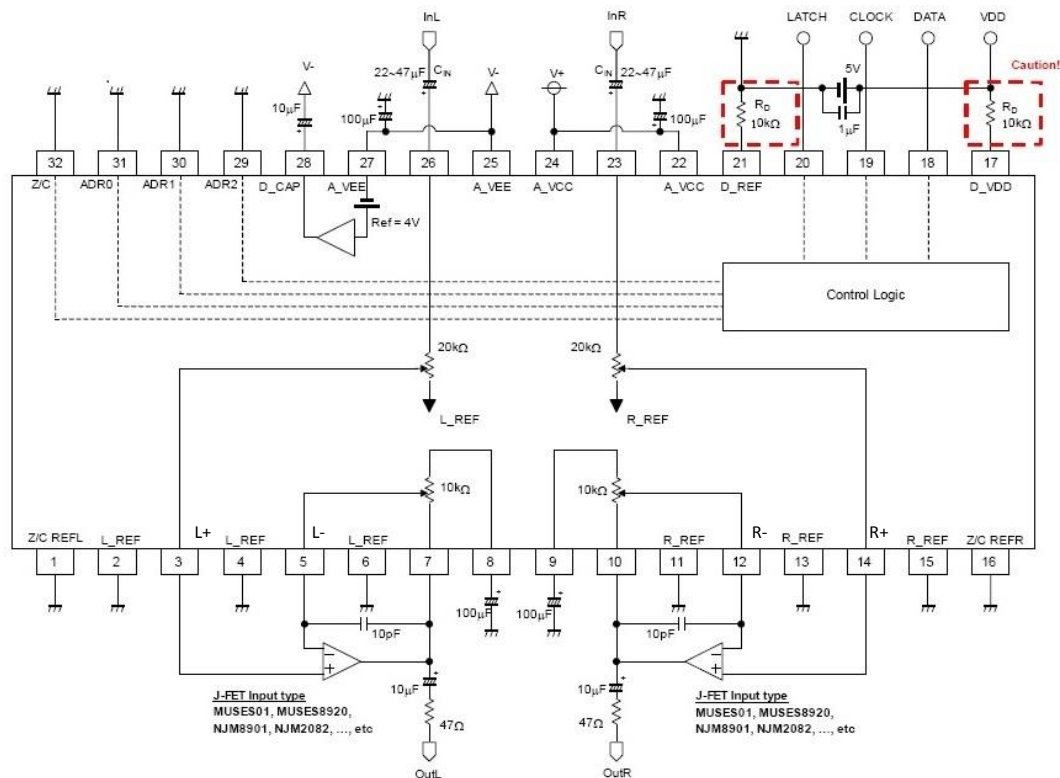
A potentiometer based volume control, shown at Figure 4, is the most traditional volume control solution.



**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.

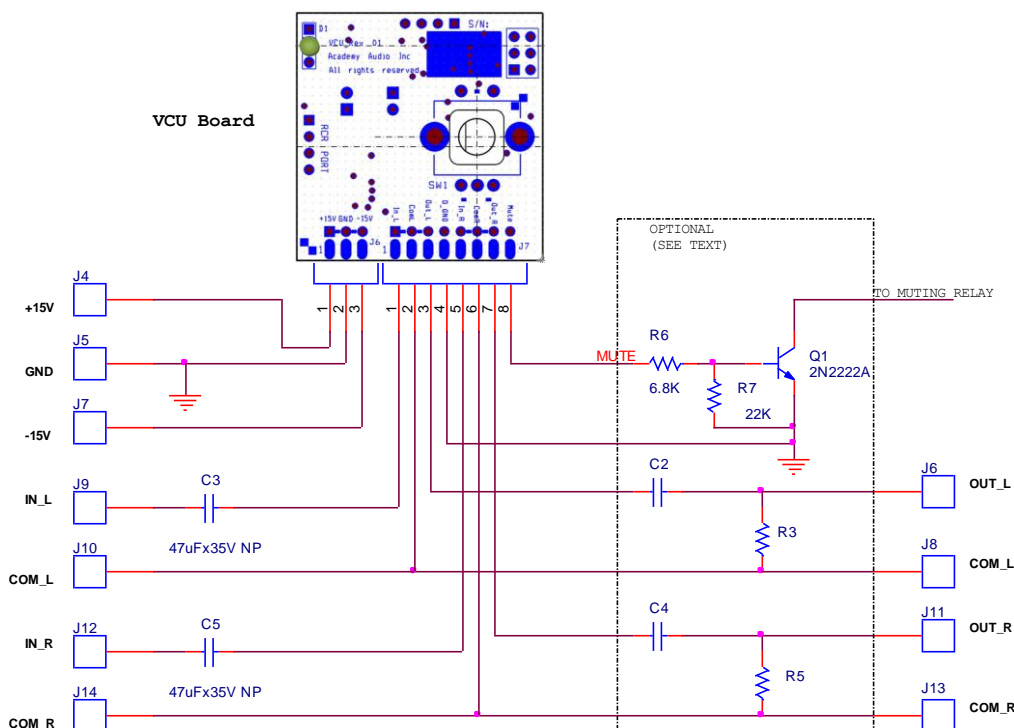
Capacitors  $C_{in}$  connected to input pins 23 – In\_R and 26 – In\_L perform the function of the capacitor C1 of Fig. 2. Capacitors equivalent to the capacitor C2 of Figure 4 are omitted due to external J-FET opamps used at the potentiometers' outputs.

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.

## 9. Application Information

### 9.1. Power and Audio Connections

The VCU 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 R3 and R5 provide a current path for their input bias currents, and capacitors C2 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 C2R3 and C4R5 may be omitted.

### ***9.2. Balanced Volume Control Applications***

The VCU board requires a Balanced Application Board (currently under development) for a balanced volume control operation. In the meantime, use a pair of VCM modules from Academy Audio Inc for balanced applications.

### ***9.3. 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. Therefore, using a muting relay is highly recommended. Note, that the relay should be activated after about 1 sec of delay upon power-up, and released immediately at power down. The VCU board provides the required muting relay control signal. Due to a very low noise of the VCU the muting relay does not change its status while the MUTE mode is activated.

### ***9.4. 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 pricey 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.

### 9.5. 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.

## 10. VCU Board Operation

### Definitions:

**Volume Control** adjusts an application board volume setting up or down. After each adjustment the volume setting is stored in a non-volatile memory, and is retained at power down.

**Balance Control** adjusts the balance of the volume control to move a perceivable sound source to the Left or to the Right. After each adjustment the volume setting is stored in a non-volatile memory, and is retained at power down.

**Mute Control** sets the volume to -120dB attenuation. The Muting relay status does not change.

### Controls Functionality:

- Turn the **Encoder** to set a **Volume** value.
- **Mute Control.** Click (press and release) the **Encoder Knob** to enable the Mute mode. The LED glows steady RED, and the audio signal is blocked. Click the **Encoder Knob** again or turn the knob to disable the MUTE mode. The LED goes off, and the control returns to the previously set Volume and Balance position. The MUTE mode is disabled also at any activation of the encoder or any remote control button.
- Press and hold the **Encoder Knob** for about 2 seconds to enable **Balance** control. The LED glows GREEN if the balance is set left from the center, and RED if the balance is set right from the center. In the center position of the balance control the LED glows RED and GREEN at the same time. Turn the encoder to the desired balance position. The unit returns to **Volume** control on the next push on the Encoder Knob, or after a time-out.

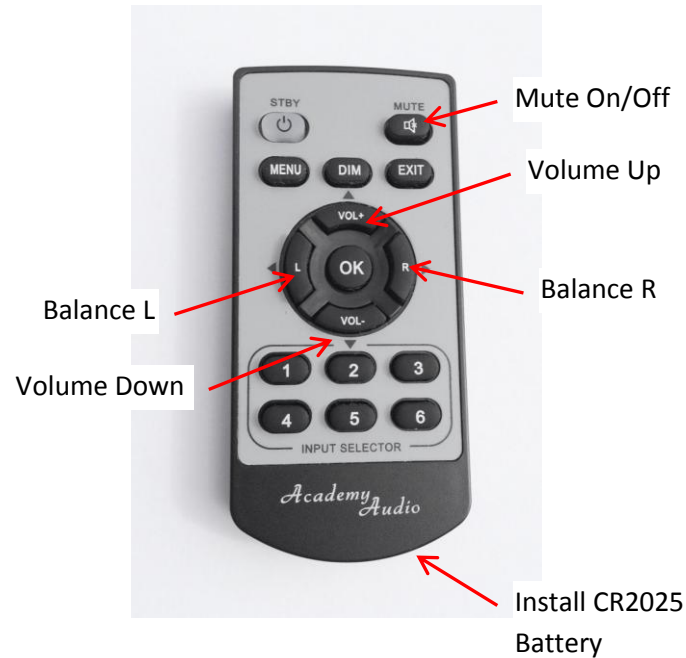
On power down, the VCU retains the Volume and Balance controls position, and restores them at power-up.

Upon power up there is a delay of about 1 second before the Muting relay control signal is generated to prevent any pops and clicks.

## 11. Remote Control Unit

A dedicated Deluxe style IR remote control unit is provided with each IR enabled VCU Board. Due to shipping regulations, the remote control unit is shipped without the battery. **Install a 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 RCR LED indicator blinks GREEN when a remote command is received.



**Figure 8.** Deluxe Remote Control Unit.

## 12. 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 VCU Volume Control board and for the latest documentation please visit us at [www.academyaudio.com](http://www.academyaudio.com).

**Happy listening!**