

# Academy Audio Inc.

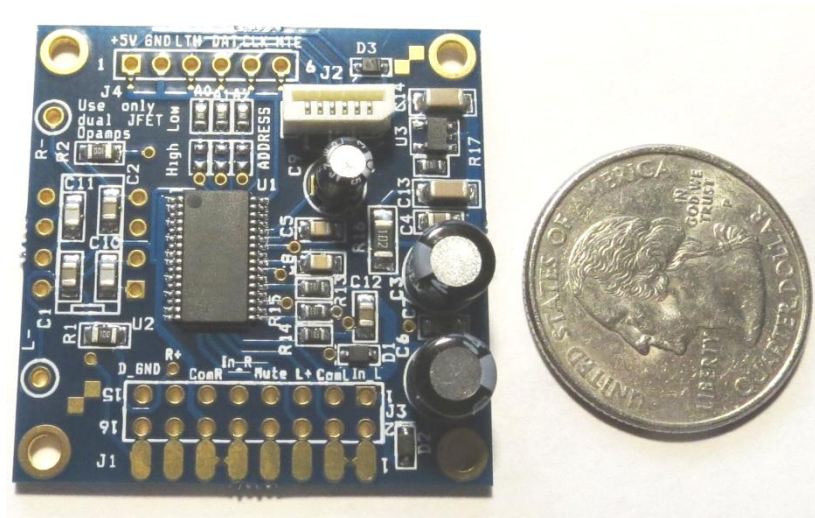
discovering the soul of music®

## Hi-End MUSES® Mini Electronic Volume Controls

Cat. No. VCM Ver. 01

## User Manual

Rev. 02



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

## 1. Introduction

Thank you for purchasing the VCM, a Hi-End MUSES® Mini Electronic Volume Control from Academy Audio Inc.

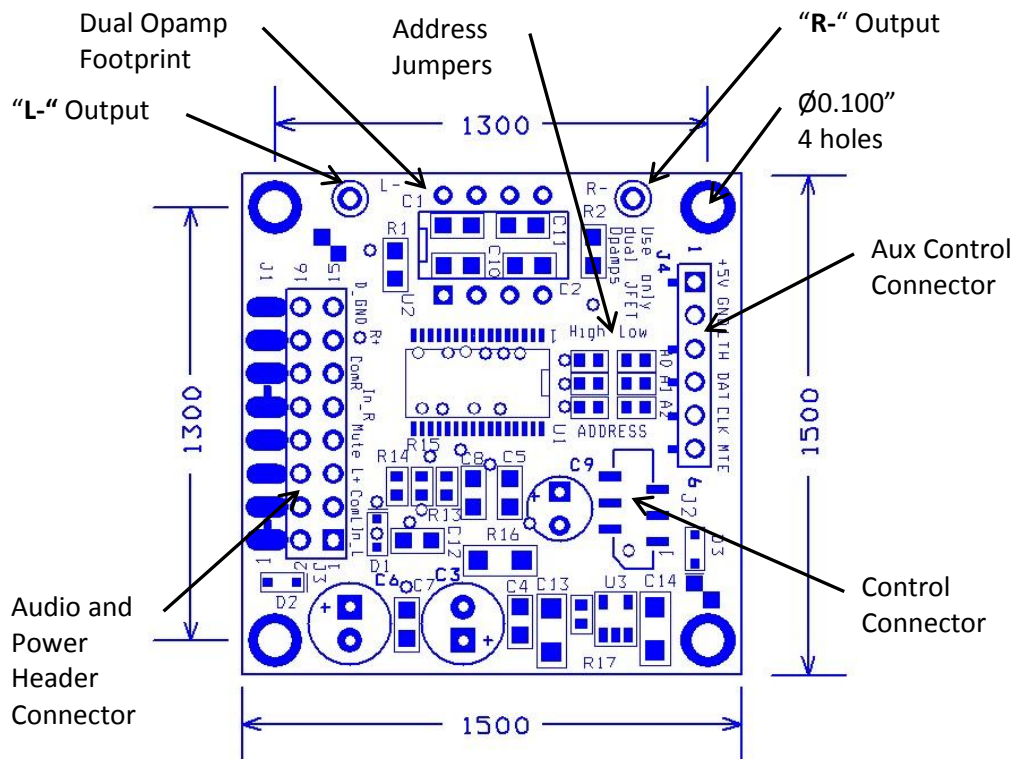
The VCM is a reduced size version of our Hi-End MUSES® Electronic Volume Control board, and is a complete ready to use two channel volume control unit that requires a +/-15V power supply and control signals to operate.

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 VCM can be used with an outboard amplifier/buffer section or without any active amplifier/buffer. A footprint is provided for a dual JFET opamp for a standalone complete volume control application.

A control signal for an external high quality MUTE relay is provided to eliminate any unwanted noises from power-up/power-down processes.

## 2. Mechanical Installation



Total assembly height is 0.300". All dimensions are in 0.001" unless noted otherwise.

Figure 1. VCM Board Connections (Top View).

Refer to Figure 1 for mechanical dimensions and mounting holes location.

The VCM board offers multiple installation options:

- **Horizontal.** Use four mounting holes provided at the corners of the board. Use spacers to elevate the board over the mounting surface. Optionally, use a 16-pin dual row 0.100"x0.100" header installed in J3 position from the bottom to connect to the application board. J3 carries all required audio and power connection. When used with one of the MCU Control boards from Academy Audio, control signals may be received through a flat cable connector J2.
- **Vertical.** Use a right angle 16-pin dual row 0.100"x0.100" header installed in J3 position from the top to connect to the application board. No extra supporting features are needed. J3 carries all required audio and power connection. When used with one of the MCU Control boards from Academy Audio, control signals may be received through a flat cable connector J2.
- **Combo Installation.** When used with an MCU-M board, the VCM may be installed as a compact module at the face plate, similar to a standard potentiometer. For this type of installation, use spacers to attach the VCM board to the MCU-M board through the matching mounting holes. Use a 6-pin straight connector inserted in J4 position to receive control signals from the MCU-M board. Use solder connectors J1 and J5 or a 16-pin header J3 to connect to power and audio circuitry.

To install multiple Volume Control boards position the VCM boards at least 0.500" from each other. Control signals shall be shared through the connector J4.

### 3. Address Selection

Up to eight MUSES Volume Controls may be independently addressed through one MUSES control bus. The VCM board is supplied with a default address of 000, which may be changed by jumpers A0, A1, and A2. Any address from "000" to "111" may be selected using jumper resistors in the ADDRESS positions A0, A1 and A2 on the VCM board.

Please note that the standard Academy Audio MCU control boards for MUSES products are supplied for a default address of 000, and will not operate other addresses. Consult the factory for other codes availability.

### 4. Power Requirements

The VCM board requires a clean analog bi-polar power source of  $V_{cc}=+12V_{dc}$  to  $+15V_{dc}$ , 10mA and  $V_{ee}=-12V_{dc}$  to  $-15V_{dc}$ , 5mA. More current will be needed if an on-board opamp is used. Digital power is generated by an onboard voltage regulator.

### 5. Connectors Description

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

A universal connector J3 combines all audio, power and control connection points. J3 is arranged as a 16-pin dual row 0.100"x0.100" PCB pattern that can accept a standard straight or right angle header. With a header installed, the connector J3 may be used as a mechanical mounting feature for the VCM board. The J3 connector pin assignment is summarized in a Table 1.

**Table 1.** J3 Pin Assignment

Pin	Ref	Description
Power		
1	+15V	+12V to +15V analog power
3	GND	Analog Ground
5	-15V	-12V to -15V analog power
Control*		
8	MUTE	Output to Muting relay control. (Active High – Mute Off.)
9	CLOCK	Not Used
11	LATCH	Not Used
13	DATA	Not Used
16	D_GND	Digital Ground
Audio		
2	In_L	Left Channel Input
4	Com_L	Left Channel Common
6	L+	Left Channel Potentiometer Output
7	Out_L	Left Channel Opamp Output (with opamp installed)
10	In_R	Right Channel Input
12	Com_R	Right Channel Common
14	R+	Right Channel Potentiometer Output
15	Out_R	Right Channel Opamp Output (with opamp installed)

\* Control signal connections may be used as input or output depending on the application.

A control connector J4 is provided for connection with an optional matching MCU-M control board. The J4 connector pin assignment is summarized in a Table 2.

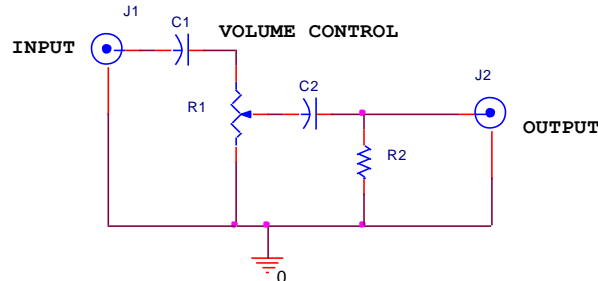
**Table 2.** J2 and J4 Pin Assignment

Pin	Ref	Description
1	+5V	Digital Power for MCU-M controller only
2	D_GND	Digital Ground
6	LATCH	LATCH MUSES Control Signal
7	DATA	DATA MUSES Control Signal
5	CLOCK	CLOCK MUSES Control Signal
8	MUTE	Mute Control Input. (Active High – Mute Off.)

If an MCU Control Board or a remotely installed MCU-M control board is used, all control signals are provided through the flat cable connector J2.

## 6. Theory of Operation

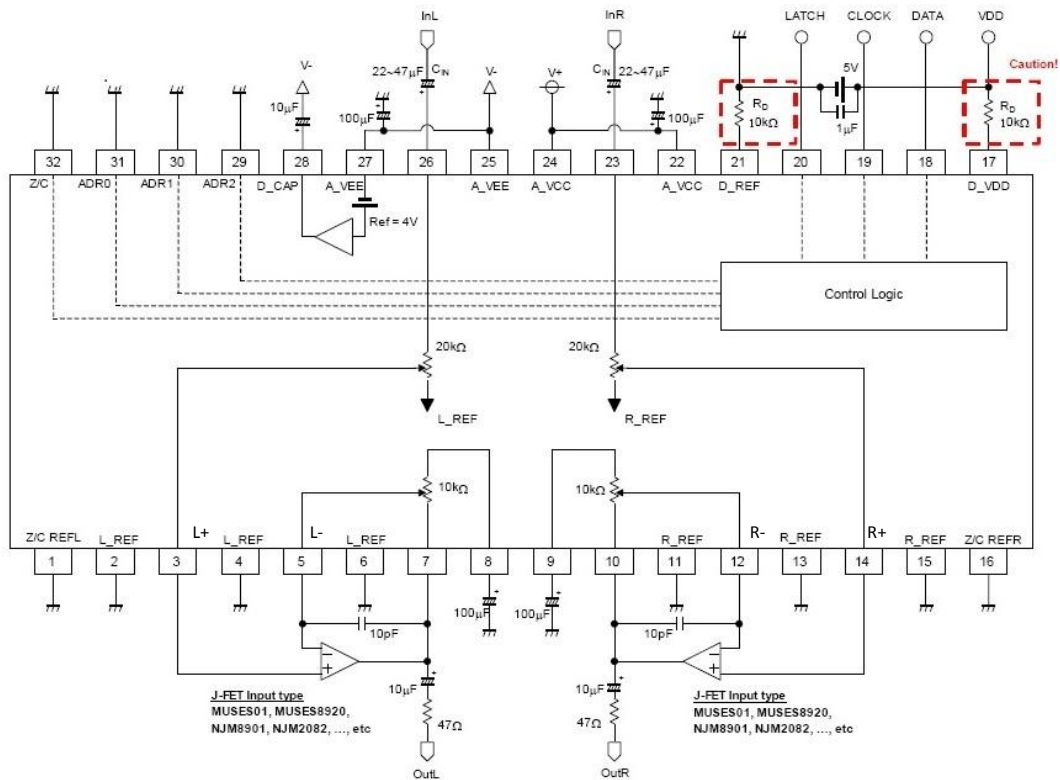
A potentiometer based volume control, shown at Figure 2, is the most traditional volume control solution.



**Figure 2.** 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<sup>®</sup>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 3 is an excerpt from the official JRC datasheet.



**Figure 3.** 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 2 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.

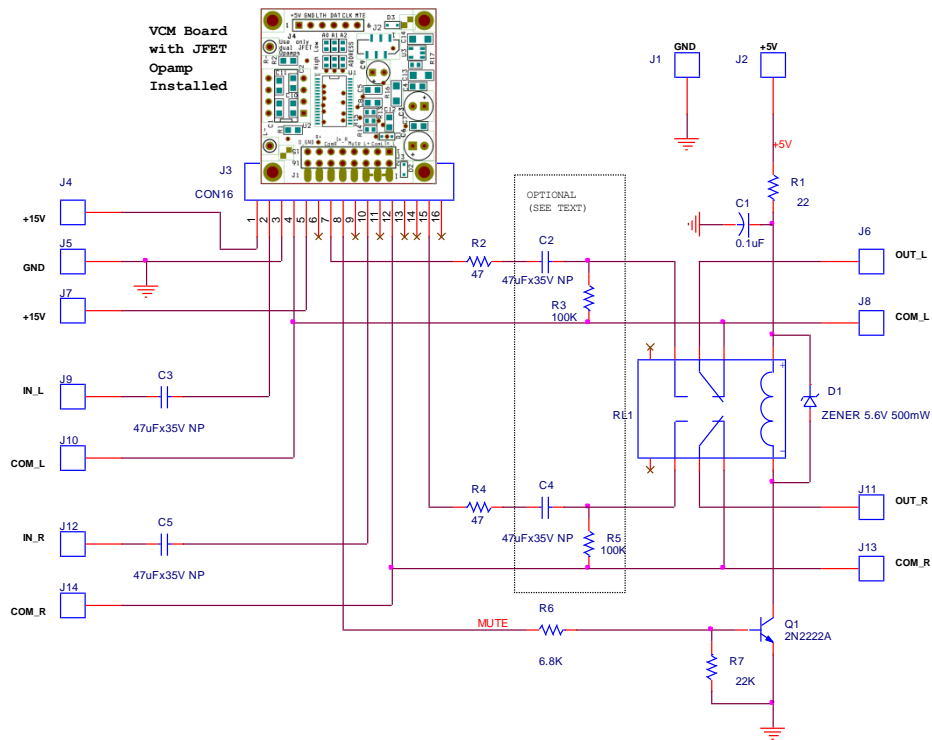
## 7. Application Information

### 7.1. Power and Audio Connections

The VCM 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.

The VCM board features a footprint U2 for a dual JFET opamp in a DIP-8 case. A high quality dual opamp such as MUSES01, MUSES8920, OPA2604, or similar installed in a position of U2 provides the most compact and efficient Volume control solution.

A single ended Volume control arrangement is presented at Figure 4.

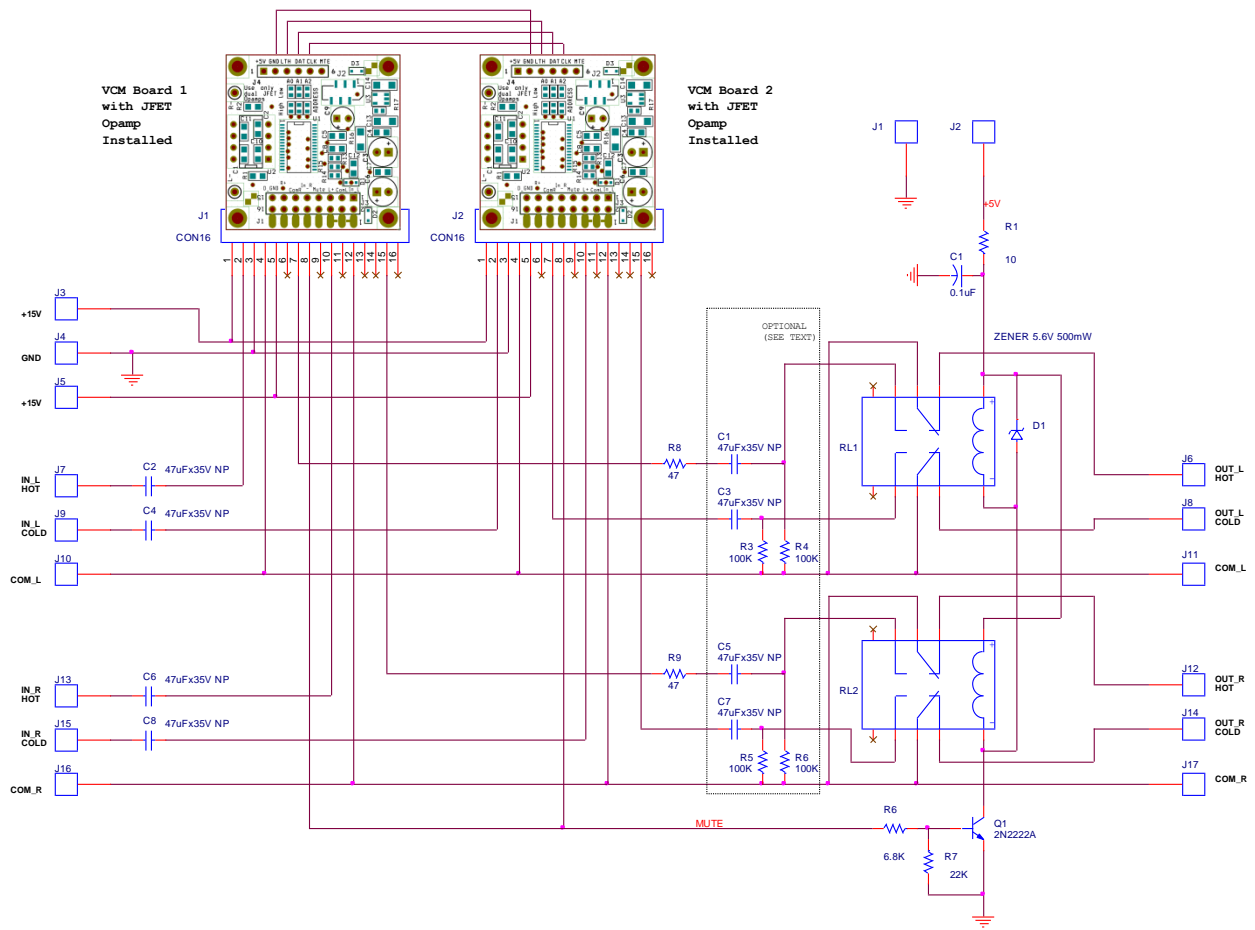


**Figure 4.** VCM with JFET Opamp. Single Ended Volume Control Application.

Capacitors C3 and C5 block DC input signals. Resistors R2 and R4 isolate the opamps' outputs from capacitive load and improve stability. Optional DC blocking networks C2R3 and C4R5 prevent a DC bias voltage of up to 10mV from opamps' outputs from reaching the downstream audio circuits. If this voltage is not a problem for the downstream circuitry, the optional networks can be omitted. The value of C2 and C4 capacitors may be greatly reduced, (and quality film capacitors may be used), if the input impedance of the downstream circuitry is high. E.g. for input impedance of 47kOhm, 1uF 63V polypropylene capacitors would provide a low frequency -3dB point of about 3.4Hz.

A muting relay RL1 controlled by a switch R8R7Q1 provides quiet startup and turn-off of the circuit. The MUTE control signal received from the control board is output at pin 8 of the VCM board.

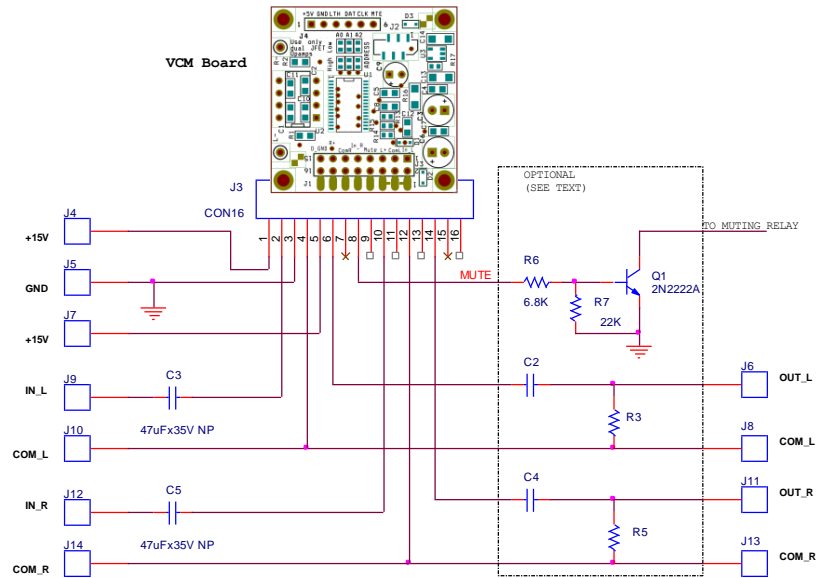
Figure 5 presents a balanced version of the Volume control that features two VCM boards with JFET opamps installed.



**Figure 5.** VCM with JFET Opamp. Balanced Volume Control Application.

The VCM board may be used as a classic potentiometer Volume control. In this case the U2 footprint should not be populated. Figure 6 depicts a single ended Volume control solution shown with an optional Muting relay control circuit R6R7Q1, and optional DC blocking networks C2R3 and C4R5. The outputs are taken from Pin 6 **L+** and Pin 14 **R+** of the 16 pin application connector.





**Figure 6.** Potentiometer Type Single Ended Volume Control Application.

Unlike previous examples, 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 <sub>load</sub> , 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 pass 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.

Figure 8 demonstrates a balanced application of the potentiometer type volume control.



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 Academy Audio MCU control boards for MUSES® products provide the required muting relay control signal. Due to a very low noise of the VCM the muting relay does not change its status while MUTE mode is activated.

## 10. 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.

## 11. Using Volume Control

Use the VCM Volume Control as a regular dual channel potentiometer based volume control. Use two boards for balanced operation. Note that Balance control and Mute functions are also available when used with Academy Audio MCU control boards for MUSES products.

Please refer to the MUSES®72320 volume control chip datasheet for detailed operation description.

## 12. 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.

## 13. Technical Support

For any questions regarding operation of the VCM board and for the latest documentation please visit our forum at [www.academyaudio.com](http://www.academyaudio.com).

Happy listening!