BENCHMARK MEDIA SYSTEMS, INC.

RGC-108 Instruction Manual

1.0 Introduction

The following introduction will familiarize the installer with the System 1000 and the RGC-108.

1.1 System 1000

The RGC-108 is one of a series of high performance audio distribution and processing modules in a series known as the System 1000. The system's concepts utilized with this series provide for the highest flexibility, a flexibility that is unparalleled in the industry.

1.2 RGC-108 Introduction

The RGC-108 System 1000 module is an 8 channel gain control amplifier. There are 8 balanced audio inputs to the module and 8 balanced outputs with 8 VCAs in between. The gain is controlled by a control voltage at the VCA control input port. The audio inputs are highly trimmed differential amplifiers with a 20 kΩ differential input impedance. The outputs are electronically balanced differential outputs with a 60 Ω balanced output impedance. The RGC-108 gain control module is ideal where numerous channels of audio gain control and high density are needed. The unit will find applications in broadcast, sound reinforcement, recording, theater, and industrial environments. See Figure 1.

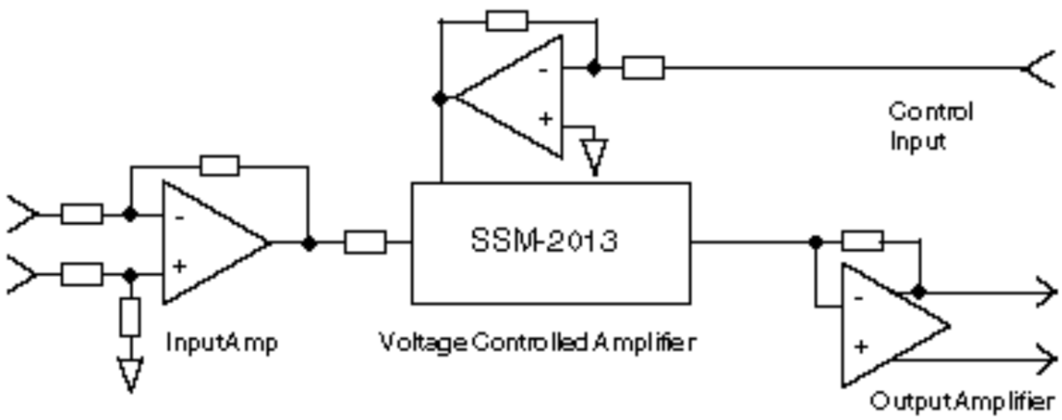

Figure 1. One of Eight Channel Block Diagram

2.0 Unpacking

Care has been taken in packing the RGC-108 module to assure it will withstand normal shipping conditions. Examine the equipment carefully as it is unpacked. If the shipping carton appears to have been damaged and if there are signs of damage, check the equipment and immediately notify the carrier and Benchmark Media Systems, Inc.

3.0 Installation

The installation of the RGC-108 follows this path. Install the System 1000 module frames in their designated locations. Install the RGC-108 modules into their designated slots. Wire the audio input and output connections. Wire the control voltage generators, typically RGC-Ps, or

RGC-12s, for power and control voltage return. Power the frames from their power supplies. Test the system.

3.1 Mechanical Installation

3.1.1 Input Connections

Inputs are made to the rear of the card frame at the RGC-108 card edge connector (a 70 pin connector). Pins 13 through 28 are reserved for the balanced inputs. Balanced input # 1 occupies pins 13 & 14. These pins are in the same horizontal plane, and connection can be made with a three pin Molex SL connector that spans the connector horizontally with the + and - inputs on the two outside pins. The center pin position does not make contact at the edge card connector. If it is important that the shield of your incoming cable make contact with analog signal reference, it will be necessary to take it to the analog ground at the uppermost power buss. This is best accomplished with a small # 24 ground wire that extends from the end of the shielded pair, with properly soldered connection and heat shrink tubing to dress the connection, to a two pin Molex SL connector that will in turn plug onto the Analog Ground buss at the very top of the 70 pin edge card connector. Input 2 utilizes pins 15 & 16, input 3, pins 17 & 18, etc. See the edge card pin-out connection diagram at the end of this manual for further information (drawing #350046) or figure 2 below.

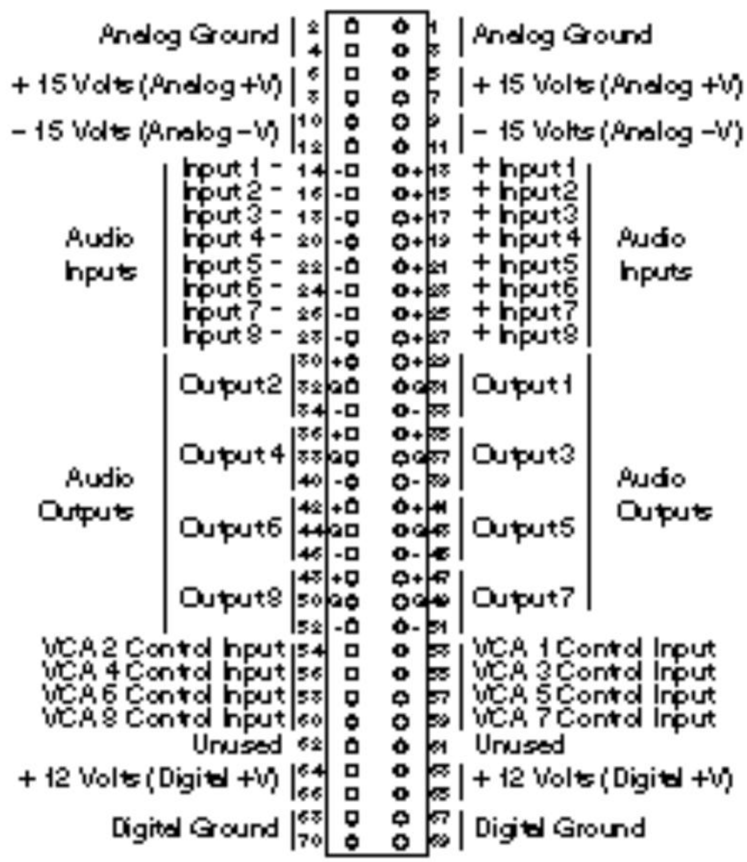

Figure 2. Rear View of RGC-108 Card Edge Connector Assignments

3.1.2 Output Connections

Output connections are also made at the rear of the card frame at the edge card connector for the RGC-108 module. Refer to drawing #350046, or figure 2 above. Pins 29 through 52 are reserved for the balanced outputs. All of the outputs use the conventional input and output assignment method where three pins are used vertically to provide the "+", "Gnd", and "-" connections. Balanced output # 1 occupies pins 29, 31, & 33. Balanced output # 2 is located at pins 30, 32, & 34. It can be seen that odd numbered outputs have odd numbered consecutive pin assignments while even outputs are assigned even consecutive pins. Please note that the shield of the output cabling is applied to the middle pin of each output pin group. This is for ease in reversal of polarity of the output signal, should it be necessary.

3.1.3 Connector Assembly

For interconnection to the System 1000 card frame, Molex® SL™ pins and housings should be used, and are available from Benchmark. Generally these are made up as either two or three pin connectors. The SIB-70 may also be used for interconnection. It is a card that plugs in from the back of the frame and has three rows of Eurostyle barrier strips for complete interconnection. A complete assembly, such as the SIB-70, has the advantage of being easier to wire, and the disadvantage of not permitting additional wiring to be added to the module position while the module is in use. Individual two or three pin assemblies may be added at any time. The three pin audio signal connectors also have the advantage of being able to be physically inverted, easily and simply effecting a polarity inversion of the signal. This is accomplished by placing the shield position as the center pin of an in line assembly.

The following are part numbers for the recommended Molex connector parts.

2 pin housing	50-57-9002
3 pin housing	50-57-9003
Individual pins	16-02-0102
Crimp tool	11-01-011

Follow the directions that come with the crimp tool for the specifics of the connector pins to be used.

3.2 Electrical Installation - General

In this and other documents we will be using the term dBu. 0 dBu is 0.7746 volts, irrespective of source and load impedance. Implicit in the term dBu, however is the understanding that for systems to operate properly they need a low (≈ 60 Ω) source impedance, and hopefully, though not absolutely necessary, a bridging input. This is the same voltage that would be found on a properly sourced and terminated "600 Ω" audio transmission line operating at 0 dBm. The use of this voltage as a reference is desirable when using the readily accepted VU meter. The "VU meter" is of course a voltage measuring device, where 0.7746 volts will give a "0" indication when fed with a steady state tone. Hence, it is desirable to maintain the same input voltages to the meter with a voltage sourced system as would be found in a 600 Ω power matched system. See “A Clean Audio Installation Guide”, a Benchmark Media Systems application note.

While the dBu is not an officially recognized standard reference in the USA, (it is found in the Nordic N-10 standard) its common usage causes us to accept it as the most logical way to define the voltage reference that relates to the more antiquated power matched system. Occasionally, in some of our older documentation, the term dBv will be seen. This has the same meaning as dBu. Others will use dB/.7 or dB/0.775 to indicate this voltage reference.

3.2.1 Signals, Noise, Headroom and Distortion

The voltage controlled amplifier is one of the weaker links in an audio chain. It is typically limited to under 110 dB of dynamic range, and its distortion levels are typically limited to 0.02%. This is in contrast to our best amplifier technology with dynamic ranges near 140 dB and distortion capability lower than 0.0005%. Therefore when using VCAs, particular attention must be paid to finding their optimum operating point if maximum performance is to be achieved.

As set up on the RGC-108, the VCAs have a dynamic range of approximately 102 dB, slightly less than the vendor's specification of 106 dB. This was done to keep distortion performance under 0.1%, worst case. With the RGC-108 board installed, the maximum output capability is approximately +27 dBu; therefore the noise floor when operating at unity gain is -75 dBu, measured 20 to 20 kHz. If the system reference is +4 dBu then the average signal to noise ratio is 79 dB with an overload factor (headroom) of 23 dB. This is generally quite acceptable since at best, 16 bit digital technology is limited to 96 dB, and in most cases does not exceed 92 dB. The analog tracks of one inch type C video tape are a scant 48 dB without the help of noise reduction circuitry. More current developments, however, such as PCM and FM “Hi-Fi” audio tracks that approach the PCM capability are pressing the state of the art in storage media. Thus the installation engineer must be careful to optimize dynamic range at every point in the audio chain. This is done by making sure that *every* stage of *every* product reaches clip at the same point. See “A Clean Audio Installation Guide” by Allen Burdick at the end of the System 1000 instruction manual binder.

3.2.2 VCA Control

Four wires are used in conjunction with the Systems 1000’s analog power voltages to fully control the RGC-108, three to take power to the remote control voltage generator, and one to return the control voltage to the VCA. We recommend that the regulated DC power available on the backplane of the System 1000 frame be used for the analog power source for the remote control voltage generator. This is in lieu of any auxiliary external supply, since this will keep to a minimum common-mode-voltages becoming a part of the control signals.

Control of the VCAs is accomplished by sending an appropriate DC voltage to the control voltage input ports. The control sensitivity of the RGC-108 is approximately +10 dB / volt. 0 volts input produces unity gain. Attenuation is achieved with a negative voltage and gain with a positive control voltage; i.e. a control voltage of -5 volts will give an attenuation of ≈ -50 dB and a control voltage of +2 volts, a gain of 20 dB. The useful limits of operation with the VCA are -10 to +2.5 volts.

The RGC-P is a potentiometer mounted PCB that contains all of the components to generate the necessary control voltage. It is very useful in constructing panels for multiple channels of gain control. The RGC-P, and the RGC-12 (essentially two RGC-P controllers in a small "modem" style chassis) are available as products from Benchmark Media Systems, Inc. The output of one RGC-P may be used to drive up to ten VCA channels. Current limiting may occur with more than this number at the extreme end of the control voltage range, -10 V.

A version of the RGC-P that has opposite extremes of control voltage, that is -2.5 to +10 V, and known as the RGC-RP, is also available. This is necessary for those who wish to place a mix amplifier in the control circuitry ahead of the various VCA channels to add, say, a master gain control that would work with the individual gain controls. See Figure 3. Muting for multiple channels of the system via a hard or soft switch may be added to the system this way. Digital control of the VCAs may be accomplished by the use of a multiplying Digital to Analog Converter and mix amplifiers to automatically override, for instance, a museum display audio system. In each instance where an inverting mix amplifier is added to the control system, a DC signal polarity inversion takes place thus requiring the opposite range of control voltage input for a correct output at the VCA.

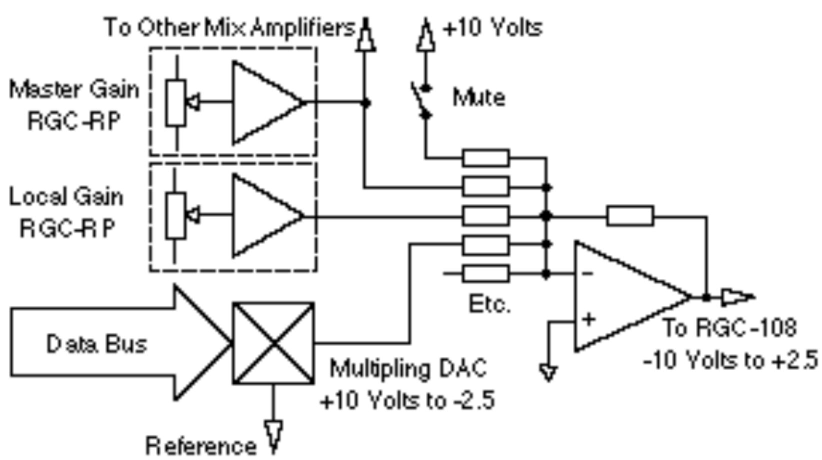

Figure 3. Possible Control Mix Amplifier Using RGC-RP

3.3 Power

Power connections are made automatically when the RGC-108 card is plugged into the card frame. This module, as with most System 1000 modules, may be inserted into the card frame while power is present.

4.0 Specifications

Inputs:	20 kΩ balanced
Outputs:	60 Ω balanced, 30 Ω unbalanced
Gain:	Variable, -100 to +20 dB
THD :	0.03%, 20 - 20 kHz, TYP
CMRR:	90 dB of rejection @ 2 kHz, ≈ 75 dB out to 20 kHz
DC Supply Voltages:	±15 VDC

5.0 Circuit Descriptions

The following circuit descriptions will aid in understanding and troubleshooting the RGC-108 gain reduction module.

5.1 Input Amplifier

The following discussion will be centered around U1801 (Channel 1) input amplifier. U1801 is a differential amplifier with a gain (A_V) of 0.499 or ≈ -6.02 dB. An RC network consisting of R1703, R2703, R1705, C2701, and C2702 is used to trim common mode rejection both resistively and capacitively. The output of U1801 at pin 1 feeds a 15.9 kΩ input resistor, and the input current is delivered to the input of the VCA (U2701).

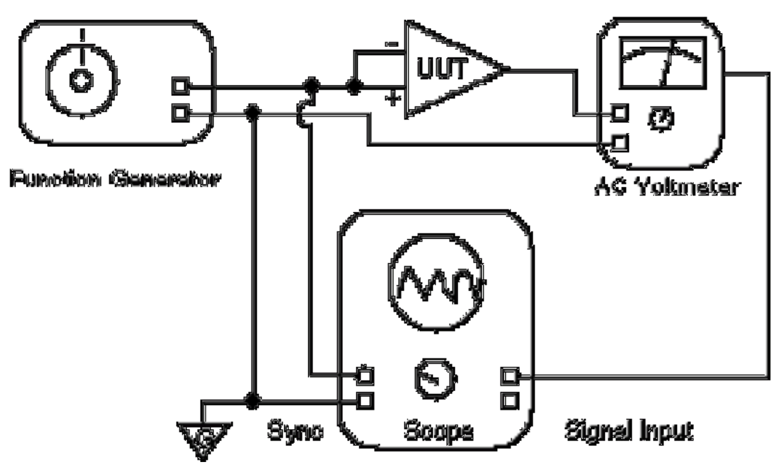

Figure 4. CMR Null Test Set-Up

5.1.1 Common Mode Rejection Null

Common mode rejection trims should never need to be readjusted once they have been set at the factory. This is a passive bridge, and normally the characteristics of the operational amplifier used do not affect the accuracy of balance on this bridge. When replacing the operational amplifier, therefore, we strongly recommend that you measure the common mode rejection *before* making any adjustments to those trims.

5.1.2 CMR Null Process

1. Feed an unbalanced signal with a level of +10 dBu, referenced to ground, into the inputs of the channel being adjusted. This signal must be exactly the same on both inputs. This is best achieved by using an oscillator with a single ended output, tying the ± inputs together and, in turn, to the single ended output of the oscillator.

2. Send a 2 kHz Signal to the input and adjust the resistive portion of the diff-amp bridge for a minimum output. Use either a logarithmic level meter with a sensitivity down below -100 dBu such as the Audio Precision System One, or a very sensitive linear meter, such as the Amber 3501 distortion and noise meter. Once a minimum on the resistive trim has been achieved, null the capacitive trim. Two or three iterations between these trims should be sufficient to achieve the best broadband null possible. A null of better than 100 dB at 200 Hz and typically 109 dB (-99 dBu), and better than 75 dB at 20 kHz, typically 80 db (-70 dBu) usually is achievable with a -6 dB input stage.

5.2 VCA Section

The following discussion will be centered around U2701, the Channel 1 VCA. The SSM2013 (U2701) is a current in, current out device. It has, from our vantage point, a peak "clip" point of +/- 800 µA. In this definition, clip is a sharp rise in distortion, rather than an abrupt signal swing limitation. While the vendor claims a 106 dB dynamic range for this part, in the interest of low distortion, its dynamic range has been limited to approximately 102 dB. Since the peak output voltage of most operational amplifiers operating at +/- 15 volts is ≈ 12 volts peak (+21 dBu), the correct input resistor for ± 800 microamp operation would be 15.4 k Ω . The VCA current to voltage converters found on the RGC-108 have the same value of feedback resistor to allow the entire section to operate at unity gain with 0 volts at the input of the control port. 0 volts at the input of the control port of the SSM2013 causes it to be a unity current gain amplifier. A current to voltage converter is placed at the output of the VCA chip.

The control port for the VCA (section B of U1801) has a DC input resistance of 10.2 kΩ . This is the sum of the input resistors of the inverting and scaling control amplifier. A large amount of AC filtering has also been placed on the input lines. Additionally, 4.7 µF capacitors have been placed in the feedback loops of the control amplifiers. This is all in the interest of:

1. Low RFI

2. Immunity from AC power line interference

3. Elimination of noise from a "dirty" control pot.

At times the noticeable response time of the control amplifier may be annoyingly slow and a smaller feedback capacitor may be substituted, i.e. a 2.2 µF capacitor, provided there are no power line signal problems.

5.2.1 THD Trim

Only one trimming potentiometer is necessary for the VCA section. This is used to trim the device for lowest distortion at high gains. This trim is factory set and should never need adjusting, unless the SSM-2013 is replaced. The procedure for adjusting this trim is as follows;

1. Feed a test signal into the channel where the VCA chip was replaced.

2. Set the gain of the VCA to approximately 20 dB. This is done by feeding a 2 kHz input signal into the System 1000 with an amplitude of 0 dBu. The gain of the VCA is then adjusted for an output amplitude of +20 dBu.

3. With the 2 kHz tone going into the system, adjust the trim for minimum total harmonic distortion. THD levels of 0.01% to 0.02% should be able to be achieved when the channel is returned to unity gain, at +20 dBu out.

5.3 Output Section

The following discussion will be centered around U2801 (Channel 1) output amplifier. U2801A produces the positive half of the output waveform. Production of the mirror image negative half of the waveform is accomplished by U2801B. U2801B is an inverting voltage follower. Both halves of the output amplifier operate at unity gain with a polarity inversion between the halves. These two amplifiers create a 6.02 dB gain for the stage when the signal is taken differentially. Build out resistors, R2801 & R2802 provide the desired 60 Ω output impedance. DC offset is nulled by the adjustment of R2607. The null should be performed by measuring the differential offset, that is, between the two outputs. The input should be terminated with a 30 Ω resistor during the measurement, and the gain of the VCA should be set to unity.

6.0 Troublshooting and Repair

The RGC-108 was designed and manufactured to the strictest commercial standards. As such, the probability of failure is very small. However, should you experience difficulty the following procedures should be employed.

6.1 Troubleshooting Techniques

Armed with the knowledge of the circuit descriptions given above, standard troubleshooting techniques should be used to determine first the general area of malfunction, and then more specifically the actual offending components. A review of the most basic of these techniques follows.

1. It is best to troubleshoot a module at a work bench using current limited lab power supplies. Set the current limiting of the power supplies to ≈200 mA for

the analog supplies and 100 mA for the logic supply. This will protect the module and still allow the location of failures to be made.

2. Since most failures are catastrophic in nature rather than a gradual degradation of performance, make a close visual inspection of the module for any discoloration of components and possible shorts on the PC board itself. Discoloration would indicate excessive heat, most likely from a component failure. Remove any component that has obviously failed, i.e. carbonized resistors or IC packages that are cracked.

3. If fuses are blown, replace them and power up the module. If there are short circuits on the module the current limiting of the power supplies will prevent any further failures, and the presence of a short will be shown by the current limited condition of the power supplies. Allow the module to operate in this condition.

4. Look for any components that are operating too hot to the physical touch. This will show where the shorts are when there are no physical symptoms. Typically one can just keep their hand on a surface at 130° F. With one exception, that of the PS-101, all of the components of the System 1000 are meant to operate at temperatures lower than this.

5. Remove any components, i.e. transistors or integrated circuits that are experiencing overheating. Most often at this point the power supplies will come out of current limiting, and the module will function in part. If further problems exist after the power supplies come out of current limiting, they can most often be found by performing voltage checks through the circuitry.

6. Follow the current path through the module by measuring the small DC millivolt voltage drop across the copper power bus circuit traces. Proceed along the trace, measuring the voltage with probes approximately 1 inch apart on the same trace. When you get to a place where there is no voltage drop between the probes, you can be sure that the current has taken a branch path. Go back and find the branch and start following it. Following the current path in this manner is especially effective when no obvious overheating is present to indicate the location of a fault. Very sharp pointed probes, such as those manufactured by Huntron, are ideal for this procedure, since they easily penetrate the solder mask on a PCB.

6.2 Circuit Board De-Soldering

Printed circuit boards are *very* easy to damage by excessive heat. Unless you have developed the specialized skills necessary to remove and replace components, we suggest that you leave the task to someone skilled in these techniques.

When servicing printed circuit boards we strongly recommend the use of a vacuum de-soldering station, such as the Hakko 470.

The proper technique with these stations is to apply the tip to the area to be de-soldered and *wait* for the solder to thoroughly melt. You can be sure of a thorough melt by observing the top side of the board. *When* the solder there has become liquid, apply the vacuum while moving the hollow tip with the component lead in a circular motion. By rotating the lead, with the tip against the board, but *without* applying pressure to the pad, you are able to most thoroughly remove solder in the plated-through hole. In turn the component will often drop out of the board when you are finished.

If the solder is not thoroughly removed from the plated-through hole, attempting to remove the component will bring with it plating from inside the hole. This may destroy the usefulness of the board. If you find that your attempt to completely remove the solder from the hole and pads has failed, do not attempt to re-heat the area with the de-soldering tool, as this will *overheat* the pad, and not the area that is in need. As a result the board is usually damaged. Rather, re-solder the joint, and then go back and apply the proper technique, by allowing the solder in the joint to thoroughly melt *before* applying vacuum. This technique uses new solder as an efficient heat conductor to the total area, eliminating hot spots.

6.3 Circuit Board Re-Soldering

NASA has developed an effective technique that ensures highly reliable solder joints. It involves first heating the component lead, since it usually has the higher mass, by applying a small amount of solder to the tip of the soldering iron at almost the same time as you apply the iron to the component lead. This will allow some flux to make it to the component lead. The iron should be approximately 1/8" above the board. When the lead has come up to temperature so that it melts the solder when placed against it and has good wetting, slide the soldering iron down the lead and heat the printed circuit board pad while applying a controlled amount of solder to the joint. All of this should take no more than a couple of seconds. If the component that is to be installed has leads that are oxidized, it will be necessary to clean them. This may be done with either a Scotch Bright® abrasive pad or fine bristle fiberglass brush, among other methods.

This completes the RGC-108 Instruction Manual. 062194

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