BENCHMARK MEDIA SYSTEMS, INC.

APA-102 SM Switchable Matrix Module Instructions

BENCHMARK MEDIA SYSTEMS, INC.

APA-102 SM Switchable Matrix Module Instructions

1.0 INTRODUCTION
The APA-102 SM, Switchable Matrix, a module from the System 1000 series, provides a unique solution to the need for control over the stereo signal source. Quality materials, advanced circuit techniques, innovative design, and precise construction are combined in the APA-102 SM to provide the highest quality performance with maximum reliability.

Innovative design makes the APA-102 SM a powerful mode control element. Modular construction allows the optimum combination of System 1000 modules to be determined by the user. As your needs expand, the System 1000 will expand with you.

2.0 GENERAL DESCRIPTION
The APA-102 SM consists of two completely independent input sections, each with its own instrumentation amplifier input stage. There are two output stages with mode control switching in between.

The APA-102 SM provides two active instrumentation type differential inputs with a 2 MΩ input impedance and high common mode rejection.

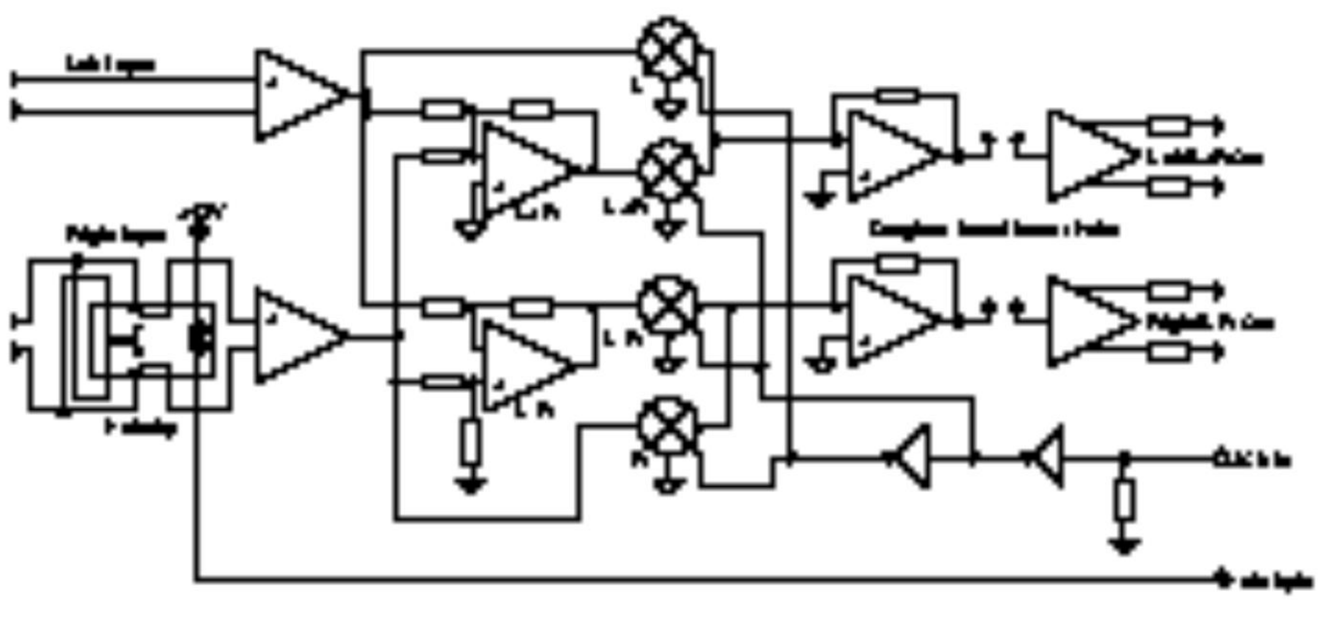

Fig. 2 - APA-102 SM Block Diagram

A 12 step green and yellow LED bar graph (not shown in block diagram) provides level indication of DIP switch selectable measurement points within the APA-102 SM. The calibration of the meter may be set at either 0, +4 or +8 dBu, depending on the house reference level. In addition to the bar graph display, a red LED peak responding onset-of-overload indicator continuously monitors input and output levels for potential clipping. It's threshold is normally set at + 20 dBu, 7 dB below peak clip, but may be set over the range of +16 to + 26 dBu.

The APA-102 SM is designed to accept plug-on "daughter" boards for insertion of optional gain control or other processing at the input of the output stages. For additional information on daughter boards, see the application section below or contact Benchmark Media Systems, Inc.

3.0 UNPACKING

Care has been taken in packing the APA-102 SM modules 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 or if there are other signs of physical damage, check the equipment and immediately notify the carrier and Benchmark Media Systems, Inc. Please check all portions of the packing material for installation accessories and manuals. Filler boxes are often used to ship interconnection wiring, instruction manuals, rack mount accessories, and small tools and fuses. Please check the contents of *all* boxes.

4.0 INSTALLATION

The installation of the APA-102 SM is a simple matter of placing the System 1000 module frames in their desired locations, inserting the APA-102 SM modules into their companion frames, making the audio input and output connections, adding the remote control connections to the remote control station or computer system.

4.1 Input and Output Pin Assignments

Figure 3 details the APA-102 SM input and output connections to the System 1000 card frame. When installing the APA-102 SM, observe the following:

Inputs to the board are made with the top two signal positions of the module edge connector labeled as such. Input 1 is considered the normal "left" channel input and input 2 the "right" channel. It is important, when measuring crosstalk, to back-terminate an unused input with 1k ohms or less. This is necessary because the extremely high input impedance will pick up a significant amount of adjacent input signal and confuse the crosstalk measurement.

Modules may be removed or inserted into a frame, with power on, without damage. When pulling a module from a powered frame, there is usually no audible disturbance in the outputs of other modules. When inserting a module into a powered frame, however, the in-rush currents that charge the 330 µF power decoupling capacitors, produce a small "tick" in the outputs of the other modules, much like a scratch on a record. This is generally not considered objectionable.

4.2 Connector Assembly

All input and output connections are made with three position Molex® SL™ pin and housing connectors. These connectors will be plugged onto the pins of the card edge connector at the rear of the card frame. All of the audio inputs and outputs must be oriented vertically. The crosspoint connections may be made in one of two possible arrangements. A single three pin housing may be used for crosspoints one and two, where the center pin position is left empty. The housing is connected by spanning horizontally across the pins of the card edge connector. Alternately, two pin housings may be used and oriented vertically, as is done with the audio inputs and outputs.

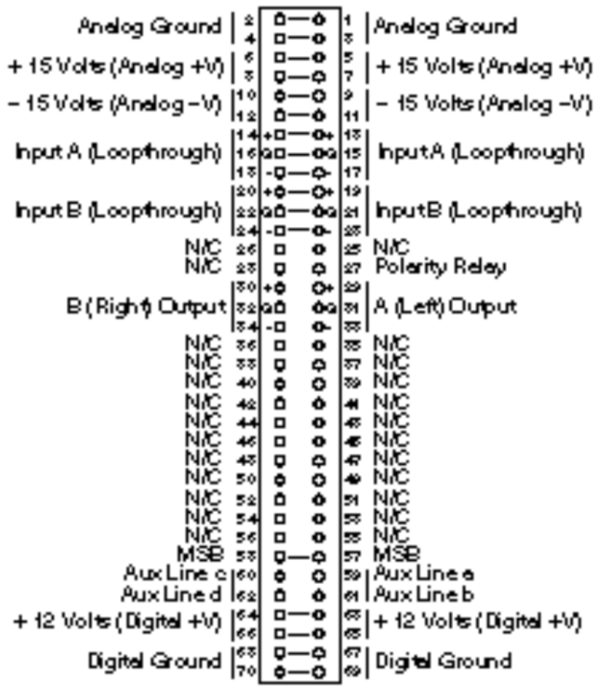

Fig. 3 - APA-102 SM Connector Pinout (View from Rear of Card Frame)

Molex housings and pins for the audio interconnect must be assembled in groups of three pins and one housing for a single shielded pair. The shield must be located in the center position of the three pin row. With this arrangement, polarity inversions are achieved simply, should the need arise, by physically inverting the connector.

AMPMODU™ connectors may be used in lieu of the Molex pins and housings if you have them in your inventory. The major problem with the AMPMODU connectors is that they are physically thicker than the Molex devices and do not stack well when spanning horizontally; they interfere with one another. Molex housings and pins will work horizontally without interference.

If you use AMPMODU connectors, care should be taken when placing the connectors on the 0.025" square posts, that the connectors are not forced to travel further than what would be a *comfortable* seating. These connectors will not necessarily go all the way to the bottom of the wire wrap pins. Forcing them further than they were designed to travel may cause physical damage to them and result in intermittent connections. This problem is not nearly as severe with the Molex SL pins and housings.

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

5.0 APPLICATION GUIDELINES

The APA-102 SM was designed to provide encoding of the stereo audio signal from discrete Left and Right inputs, to Sum and Difference outputs. Without any modifications the unit will make the reverse conversion from Sum and Difference inputs to discrete Left and Right outputs, as well.

The logic input is set for default matrix operation. That is to say, if no logic signal is present at the MSB input, the unit will operate in the “encode/decode” mode. With +12 volts present at the MSB input, the unit will operate in the “pass-through” mode.

The APA-102 SM is ideal for inclusion within the analog audio tape system enabling the recording of two channel audio in the sum and difference mode. Misalignment of playback head azimuth causes a high frequency stereo spatial shift. This is much more preferable to the far more obtrusive comb filter effect that eliminates high frequencies for the mono listener.

Satellite transmission system can also benefit from Sum and Difference transmission. With many broadcast affiliates still transmitting in mono, the mono signal is readily available without a special mix amplifier or a second subcarrier demodulator being necessary for the affiliate.

Another excellent application for the APA-102 SM is the decoding of M/S stereo microphone signals. M/S microphones are particularly suited for broadcast use since they are inherently Mono compatible. They may be used for concerts, ambiance, On Air talent pickup as well as ENG use.

6.0 CIRCUIT DESCRIPTION

It will be helpful to refer to the APA-102 SM schematic while reading the description of the module’s circuitry.

6.1 Overall

The APA-102 SM consists of two instrumentation amplifier input stages, sum and difference amplifiers, and output routing switches with a single logic input. Additionally, there are two balanced outputs. The overall gain of the module, under normal conditions, is intended to operate at or close to - 3 dB. This is done to compensate for the 6 dB signal level addition that takes place during the matrix encode and decode process.

6.2 Input Stage

The input stages are straightforward in design. The input stage consists of a capacitive input to a precision attenuator network (- 0.085 dB). This attenuator provides input overload protection and also protects the audio line from severe distortion should the module be without power. The output of the attenuators feed unity gain non-inverting buffer amplifiers. The output of the buffers feed a precision differential amplifier with 6 dB of loss. This 6 dB of loss maximizes the available headroom with relatively low voltage (±15 V) power supplies. A unity-gain operational amplifier, operating from ±15 volt supplies, will clip at between +21 and +22 dBu, (12.3 and 13.8 volts peak), with reference to ground. Since the input signal is usually balanced with respect to ground and may have levels as high as +27 dBu, we must take a 6 dB loss at this point, if we want the system input overload to also be at the +27 dBu point. This loss works well, since with the balanced output stage configuration, we pick up the 6 dB gain that was lost at the input and differentially produce the desired +27 dB out.

The internal operating level is 6 dB lower than at the input or the output. With a balanced input level of +4 dBu, the operating level at the input of the sum and difference amplifiers is -2 dB.

The differential stage has trims that allow for a very high degree of common mode rejection. The trims are adjusted with an input signal level of +20 dBu. Both the resistive and capacitive trims are adjusted at a frequency of 2 kHz. The typical null is a -80 to -90 dBu, yielding a CMRR of 100 dB or better. The typical 20 kHz null values are -75 dB below the input level. It is important to keep in mind that, while the input is a high performance differential amplifier, it is *not* a floating input; it is ground referenced. This means that, unlike a transformer input, there is a relatively low limit on the amount of common mode voltage that the device can handle. Practically, we would suggest that a limit of two to three volts be the maximum common mode level. For this reason, it is important to read and understand the Benchmark Media Systems, Inc. application note, “A Clean Audio Installation Guide”. In very rare situations, where the installer has no control over common mode voltages present at the input of the amplifier, such as with some Telco feeds, a high quality transformer, such as those manufactured by Reichenbach Engineering, or Jensen Transformers, may need to be added to the installation.

6.3 Sum and Difference Matrix Headroom Considerations

A potential problem exists in the matrix section of the APA-102 SM as it does in any encode or decode equipment. By looking at the algebra involved, (it is easy to see with amplifiers operating at unity gain) every time the signal goes through the encode - decode process a 6 dB voltage gain occurs simply as a result of the process.

$$(L+R) + (L-R) = 2L$$
$$(L+R) - (L-R) = 2R$$

These voltage gains directly reduce the headroom of the encoders and decoders. If the signals that come into the APA-102 SM are significantly above the normal system references and if the material is extremely percussive, internal clipping may occur. Also if there is significant common material between discrete Left and Right inputs then up to a 6 dB voltage addition takes place in the summing amplifier. Probably the best alternative, and the one we have followed, is to take a 3 dB loss in the sum and difference amplifiers. This means that only 3 dB, instead of 6 dB, of headroom is given up for totally correlated material. The addition of totally un-correlated material will result in a 3 dB addition and a unity gain condition. Another benefit is that if both the encoder and decoder are designed with a 3 dB loss, the system will operate with an overall unity gain.

6.4 The Sum and Difference Amplifiers

U2801A is the difference amplifier for the stereo matrix. U2801B is the sum amplifier. Both of these amplifiers have precision trims that provide excellent setup. The difference amplifier is a standard differential amplifier, as with the input stage. The amplification factor for both the sum and the difference amps is -2.9 dB under normal matrix conditions.

6.5 The Routing Switcher Section

Four CMOS single pole double throw electronic switches route the L, R, L+R, L-R signals to the Left and Right outputs. Each of these switches has a 13.3 kΩ resistor at its common input. These resistors convert the output voltage of the various amplifiers to a current and the switch either presents the current to the summing nodes of the amplifiers found in U2301 when turned on, or shunts the current to ground when turned off.

The control of the switches comes from the output of the CD4001, a quad NOR gate. Ground or + 12 volt inputs to the MSB input, switches the logic to provide the correct turn-on signals for the electronic switches, to either the matrix or the pass-through mode.

U2301 provides the needed conversion from an audio current to a voltage. The output of U2301 is then available for level control by an accessory daughterboard. The addition of an RGC-04 dual VCA daughterboard will allow full control over the output levels. In the absence of a daughterboard, shunt jumpers must be in place between daughterboard header pins 9 and 10, as well as between pins 17 and 18. These jumpers were included with the module.

6.6 The Output Stage

The output stage is a NE5532 dual operational amplifier, one half is configured as a non-inverting differential amplifier, and the other half is an inverting follower. The first amplifier does not invert, but does have a noise gain of A=2 so that it will have the same phase delay as the inverting stage. Both amplifier sections are fed from the same signal, providing a differential output with respect to ground. 30.1 Ω build out resistors set the output impedance at a balanced 60 Ω. See "A Clean Audio Installation Guide" by Allen Burdick for further information on the use of 60 Ω as an output impedance.

6.7 Meter Operation

The meter consists of two basic sections. First, is the 12 segment LED meter with a scale factor of 3 dB/step. It is driven by the BA683A chip. Second, is the 13th segment peak responding onset-of-overload indicator. The meter section has a four position DIP switch that allows the meter to monitor the two inputs and two outputs. Since the input of the meter is a mix amplifier, more than one of the switch positions may be on at one time. Remember, however, that with all signal addition there is a respective increase in level, and meter calibration will be affected.

R1202 allows calibration of the meter to system references of 0, +4, and +8 dBu. Unless otherwise requested, the modules will be calibrated to a +4 dBu system reference at the factory. R1202 is adjusted so that, with the desired system reference level coming from the board, the first (bottom) yellow LED just turns on. R4203 sets the -27 dB LED for a correct turn on point. If the system reference level is +4 dBu, then the -27 dB calibration point would be -23 dBu.

The peak indicator is a pulse stretching comparator that indicates the module may be close to overload. It has the feature of being able to monitor the levels of a number of circuit points at once via a diode "or" circuit. This circuit topology is a half wave detecting comparator. When any one of the circuit input points exceeds a predetermined level, set by the resistor string R2104, R2102, and R1103, such that the inverting input rises above ground potential, then the comparator trips and the LED turns on. R2104 is the calibration trim for the P/OL indicator and it has a range of approximately +16 to +26 dBu. The factory calibration point is +20 dBu, unless otherwise requested.

6.8 Fusing

The APA-102 SM uses three power fuses. The fuses isolate the module from the rest of the System 1000 in the event of a failure on the module. The ±15 V analog power fuses are 1/2 Amp 3AG. F1701 and F1501 fuse the ± 15 V analog power. F4701 fuses the + 12 V digital supply and should also be fused at 1/2A.

7.0 SERVICE AND CALIBRATION

7.1 Servicing Techniques

Printed circuit boards are *very* easy to damage with 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.

7.1.1 Circuit Board De-Soldering

When servicing printed circuit boards we strongly recommend the use of a vacuum de-soldering station, such as the Hako 470 or various Pace models. 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. Only 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 *lightly* against the board, and *without* applying pressure to the pad, you are able to remove solder from the plated-through hole. When this procedure is performed correctly the component will often drop out of the board of its own weight. If the solder is not thoroughly removed from the plated-through hole do not pull the component. Attempting to force the component will bring with it plating from inside the hole. This, in turn, will require the repair of the hole with an eyelet. Also, if your attempt to completely remove the solder from the hole has failed, do not re-heat the area with the de-soldering tool. Doing so will overheat the pad, and will not heat 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.

7.1.2 Circuit Board Re-Soldering

Here is an effective technique that ensures highly reliable solder joints. First, if the component that is to be installed has leads that are highly oxidized, it will be necessary to clean them. This may be done with a Scotch Bright® abrasive pad or fine bristle fiberglass brush, among other methods. After inserting the component, apply a small amount of liquid flux directly at the component leads and PCB with a needle bottle applicator or small brush. We prefer to use water soluble flux for ease of cleaning. The added flux is an immeasurable aid in achieving a good solder joint. Next, heat 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. 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, slide the soldering iron down the lead and heat the printed circuit board pad while applying a controlled amount of solder to the joint. The solder should flow into the joint with extreme ease and create an excellent fillet on the top of the PCB as well as on the bottom. The entire soldering portion of the procedure should take no more than a couple of seconds.

7.1.3 Module Extender

Service and calibration can be simplified with the use of the EX-370 Extender Board. Additionally, a 70 pin card edge connector made up with power wire pigtails is very useful for trouble shooting at the test bench. Be sure to use current limited power supplies set for a current limit at ≈ ±200 mA.

7.2 Common Mode Rejection Null

The common mode rejection trims on the input stages should never need to be readjusted, once they have been set at the factory. This is a passive bridge, and the characteristics of the operational amplifier used do not affect the accuracy of the balance on this bridge, that is, unless there is a malfunction with the op-amp. When replacing the operational amplifier, measure the common mode rejection before touching the trims.

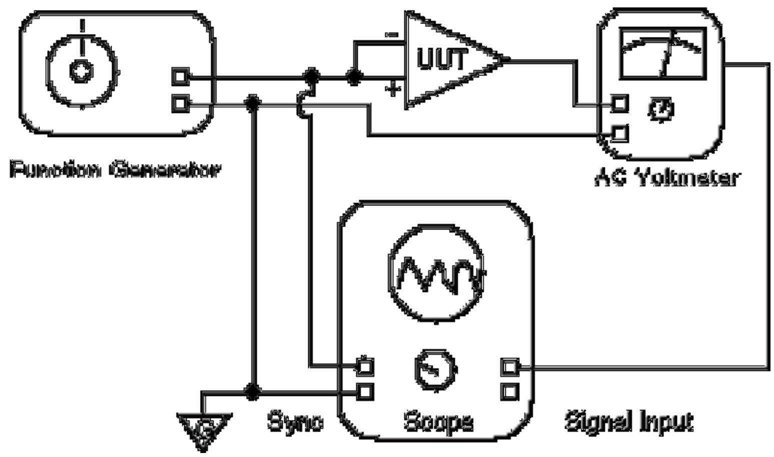

Fig. 4 - Common Mode Rejection Adjustment

The process of nulling the common mode rejection should be performed using the setup shown in figure 4.0

Feed an unbalanced signal with a level of +20 dBu, referenced to ground, into both inputs of the module 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 generator. The ground side of the generator, of course, also ties to ground.

Send a 2 kHz signal to the input and adjust the resistive portion of the differential amplifier bridge for a minimum audio output from the APA-102 SM. Use either a logarithmic level meter with a sensitivity to 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. It is very helpful to watch the audio signal from the meter output on an oscilloscope, which in turn should be synchronized to the signal source. This will allow you to quickly see the phase/amplitude nulls as they take place. Once a minimum resistive trim has been achieved, null the capacitive trim.

Two or three iterations between these controls should be sufficient to achieve the best broadband null possible. A null of better than 100 dB at 200 Hz, and better than 75 dB at 20 kHz, is achievable. Unfortunately, it is almost impossible to maintain this good a null over the operating temperature range. A degradation of up to 10 dB may be expected when the module is returned to its working environment.

7.3 Bar Graph Meter

Troubleshooting the bar graph meter is quite straightforward. The LEDs are arranged to work in groups of four. The LEDs are turned on by successive current sinks within the chip. The first LED's current sink turns on, then the second LED's sink turns on as the sink for LED 1 turns off, placing the two LEDs in series, thus reducing the internal power dissipation within the driver. This continues until a group of four have been turned on by the last current sink in the string and about 7.5 volts is developed across the LED string. Then, the next string starts with a similar process.

Troubleshooting the LED string is quite easy, once you recognize that a string of 4 LEDs is turned on by its last current sink activated. For example, if the middle four LEDs in the meter are extinguished when they should be on, it is safe to say that one of the four devices is open or the driver chip is defective. The first two LED strings (in ascending level) operate at about twice the current than that of the last string. Therefore, the last green LED and the three yellow LEDs have a slightly reduced light output, even though these positions use high efficiency LEDs. The 10 μF capacitor, C3202, and the 10 K ohm resistor, R3203, that are in parallel and are connected between pin 4 of the meter chip and ground, set the time constants to approximate a VU meter action. R3205, from pin 2 to ground, sets the current through the LEDs. Audio comes into the chip on pin number 3, along with a small amount of DC offset to establish the -27 dB trip point. If re-calibration of the meter system is ever deemed necessary (such as after replacing a meter chip), this calibration should be performed after the 0 dB calibration is performed. With the proper input level, adjust the potentiometer until the first green (bottom most) LED just turns on.

The meter amplifier, U2201, B is a standard inverting amplifier with R2201 and R2202 as a part of the feedback gain network. The calibration range is from ≈ -2 dB to ≈ +10 dB.

The peak overload comparator, as described above, is an oscillating comparator by virtue of the fact that AC coupled hysteresis is applied around the device. This assumes that the input signal does, in fact, drop below the threshold point, after seeing a peak overload, so as to allow it to reset. The diodes CR2101 through CR2204 form an analog "or" circuit; that is, any signal at any one of the input diodes may take the threshold point high enough to trip the comparator.

If further assistance is needed in trouble shooting the module, call for engineering support at the number listed below, between 9 AM and 5 PM EST. This completes the APA-102 SM Service Instructions.

120193

BENCHMARK MEDIA SYSTEMS, INC.
5925 Court Street Road
Syracuse, NY 13206-1707
(315) 437-6300