1.0 Introduction

The DA-102 is one of a series of very high performance audio distribution and processing modules, a series known as the System 1000. The systems concepts utilized with the System 1000 provide for the highest flexibility, a flexibility that that is unparalleled in the industry. Provisions have been made on virtually all of the Benchmark System 1000 modules for accessory daughter boards, such as: the RGC-02 dual remote gain control daughter board, the MTX-02 stereo control daughter board; the OSC-01 precision oscillator; and the EQ-02 dual three band semi-parametric equalizer daughter board. These daughter boards may be added to your System 1000 modules as a field modification at any time. Please check with the factory concerning the availability of additional daughter boards.

Specifically, the DA-102 is a two channel (stereo) distribution amplifier that offers some of the highest performance available to the audio professional. On board signal routing allows the selection and distribution of any one of the following: Left only, Right only, Discrete stereo or a Mono sum via either or both Left and Right outputs. The module has two balanced output sections, each of which includes five 60 ohm outputs plus a sixth output which can be specified when ordering as: a direct output capable of driving fifteen external 60 ohm outputs, a sixth, on board 60 ohm output, or a balanced high impedance mono sum. The DA-102 features input and output clip points of +27 dBu, and crosstalk performance of -100 dB at 2 kHz and -75 dB at 20 kHz. The single meter can be switched to monitor: the output of a daughter board, the left output, the right output, the sum of the left and right outputs and a derived L- R signal (accurate only at unity gain).

The flexibility of the DA-102 makes it the optimum choice for the transition from mono to stereo and thereafter.

2.0 Unpacking

3.0 Installation

For basic installation concepts follow the "Clean Audio Installation Guide." Specifically, for the DA-102 module, we suggest that only signals that are of the same program source be passed through the module. This is to eliminate any obvious effects that the small residual crosstalk may have.

3.1 Input Connections

Input to the board is made with the top two signal positions of the module edge connector labeled A and B. Input A is the left channel input and input B is the right channel input. These are loop through inputs and, since the input impedance is 2 megohms (balanced), they may be series connected to other modules with virtually no loss of amplitude. Any unused inputs should be back terminated with 1k ohms or less to prevent the pickup of unwanted electromagnetic radiation.

Since the modules may be removed and inserted into the module frame while the frame is powered, the loop through inputs have been wire wrapped from side to side so that signals that may have been daisy chained through the board are not lost if board is pulled. When pulling a board while the frame is powered, there is usually no audible disturbance in the outputs of the other boards. However, when inserting a module into a hot frame, the inrush currents that charge the power supply filter caps produce a small “tick”, much like a scratch on a record, that is generally not considered objectionable.

3.2 Output Connections

As a distribution amplifier, the module has two sets of build out resistors that provide the five balanced stereo feeds. When viewed from the back of the module frame the left side of the connector has the right outputs and the right side of the connector has the left outputs. That is outputs numbered 6 through 10 are the left outputs, while outputs numbered 1 through 5 are the right outputs. See Figure 2.0.

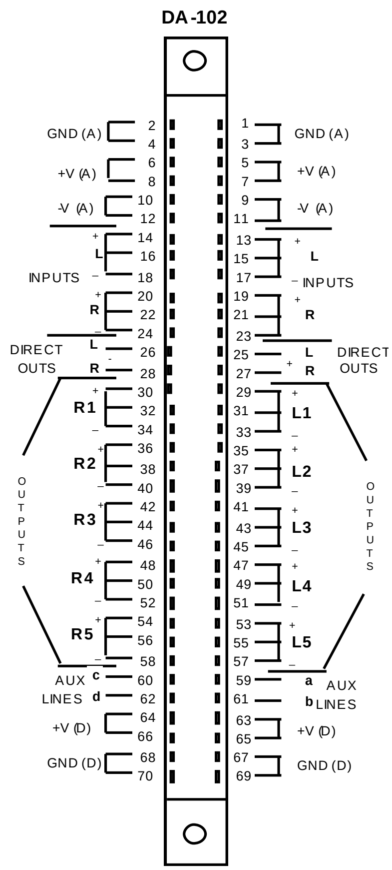

Figure 2.0, DA-102 Connector Pinout

Additional outputs may be added by use of the direct outputs These outputs may be selected either pre or post - load stabilization network. They are a low impedance source, therefore, build-out resistors must be added to provide isolation for however many additional outputs may be desired. The limitation to the number of additional outputs that may be added is the power dissipation limits of the power amplifiers under line short circuit conditions. The DA-101 has the ability to provide 10 watts from each power amplifier section, because of the size of the heat sink associate with the module. This in turn means that about 6 of the 10 outputs may be shorted while the remaining outputs will continue to carry on at near normal conditions.

Although the DA-102 has exactly the same power amplifier circuitry as the DA-101, due to the much reduced heat sink area, it cannot tolerate this number of shorted outputs. No more than two outputs per channel can be shorted without excessive temperatures occurring. Therefore, due to the increasing possibility of multiple shorted outputs, we recommend that no more than 20 outputs total, or 15 additional sets of build out resistors be added to the direct outputs from an individual channel.

The direct outputs for the left channel are the top two pins just below input B, one on the left side of the connector and one on the right side of the connector. The right channel direct outputs are just beneath the left channel outputs, and again are on opposite sides of the connector. A three position Molex SL connector may be used horizontally to pick up the two pins from side to side (no connection is made at the center pin). The standard AMPMODU connector, however, is too thick to allow stacking of two housings for both sets of direct outputs. Two pin housings may be obtained from the factory if needed. These may be used vertically with the wires for the two direct outputs sharing the two housings.

3.3 Connector Assembly

In the assembly of connectors, be sure that the drain wire of the shielded pair is physically located as the center pin of the three pin housing. If you are using the AMPMODU connectors that were previously sold by Benchmark, care should be taken when putting 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 are not designed to go all the way to the bottom of the wire wrap pins. Forcing them further than they were designed to travel will cause physical damage to them and result in intermittent connections. This problem no longer exists with the Molex SL pins and housings.

3.4 Quick Operation

The following is a quick setup procedure for use when time preasures are high. As with any piece of electronic equipment, the greatest operational performance may only be obtained via a through knowledge of the design of the module, hence we recommend studying the circuit description in section 4.0.

After making the proper inputs and outputs to the module position on the card frame, the signal flow must be set via the four position DIP switch at the center of the card.

When visualizing the signal flow through the board, (viewing the board from the component side and with the LEDs on your left) it is well to remember that the upper set of components is the left channel and the lower set of components is the right (see the electrical schematic, drawing number 450015 and the component assembly, drawing number 250003). On DIP switch, DS-1, switch position 1 routes the output of the left input into the left power amp output, switch position 2 routes the output of the right input into the left power amp. Output, switch position 3 routes the output of the left input into the right power amp output, and switch position 4 routes the output of the right input into the right power amp. Therefore, the normal switch configuration for STEREO operation would be with position 1-on, 2-off, 3-off, and 4-on. Selection for a MONO mixed output is simply a matter of closing switch positions 2 and/or 3.

For operation with a daughter board, all switch positions of DS-1 must be in the <u>off</u> position. Signal routing is handled on the daughter board itself.

Most often, the modules will be used as a unity gain amplifier. A switch is provided to change from fixed unity gain to variable gain, if necessary. The top variable control is for the left channel while the lower one is for the right channel.

The DIP switch that controls the meter functions is DS-2. Position 1 selects metering from an accessory daughter board, position 2 selects the left channel output, and position 3 selects the right channel output. Positions 2 and 3 may both be switched on to give L+R metering of the outputs of the board. Switch position 4 is L-R metering. L-R metering does not come from the outputs of the module but is derived by mixing the non -inverted left input with the inverted right input.. For it to be correct, the left channel must be in the switched unity gain position and any slight gain equalization (no more than ± 0.2 dB) between the two channels must be done with the variable gain in the right channel. It must be remembered that when operating in mono, only DS-2 position 2 or three should be used to monitor the output level. If both positions are closed then the indicated level will be 6 dB higher than actual level. See the circuit description for further information.

!!! Warning !!!

When operating the DA-102 with the MTX-02 Stereo Control daughter board, both channels must be in either the fixed unity gain position, or both must be in the variable gain position at or near unity gain, (for perfect level matching). Operating the MTX-02 with one channel in the variable mode ant the other in the fixed unity mode will cause a phase difference between signals coming into the daughter board and deteriorate the L-R null from its possible -90 dB to poorer than -40 dB.

!!! Warning !!!

While the power amplifier stages are the same circuit design as is the DA-101 the smaller heat sinks do not allow these stages to be used as speaker drivers. They may, however, be used to drive headphones provided the total parallel impedance at the direct outputs does not drop below approximately 40 ohms and operation is at normal room temperature. Indeed, high levels can be achieved operating the amplifiers as “bridged mono” power amplifiers. .The only problem is to isolate the two headphone elements from each other, i.e. a four wire stereo headphone circuit is necessary. This can usually be accomplished by changing the three wire TRS 1/4" plug to a four pin DIN connector, and separating the shields of the headphones.

4.0 Circuit Description

4.1 Overview

It will be helpful to refer to the module schematic and component assembly while reading the description of the module's circuitry.

The DA-102 consists of two instrumentation input stages, two gain stages, a configuration switch, four ten watt power amplifiers, four direct outputs, five sets of build out resistors for both the left and the right channels and a meter system.

4.2 Input Stage

Each input stage starts with two unity gain buffer amplifiers and one megohm input resistor. These buffers in turn drive a precision differential amplifier. The differential amplifier is configured to take a 6 dB loss to maximize the headroom that is available with the relatively low voltage power supplies. A unity gain operational amplifier will clip at between +21 and +22 dBu out, (11.2 and 12.6 volts) using +/-15 volt power supplies. Since the input signal to the DA is usually balanced with respect to ground, the pair of buffers, differentially, is capable of 6 dB more output than one amplifier by itself (with each input buffer handling the above mentioned +21 dBu). However, the next stage is not capable of handling +27 dBu and, therefore, we must take a 6 dB loss at this point if we want the system input overload point to be +27 dBu and have all stages reach clip simultaneously. This loss works out fine, due to the fact that with the balanced output stage configuration, we pick up the 6 dB gain lost at the input. What all this means is that, internal to the module, the operating signal level is 6 dB lower than at the input or at the output. I.e. with a balanced input level of +4 dBu, the operating level on the module is -2 dBu. When feeding the module from an unbalanced source, however, the input clip point is no longer +27 dBu because only one buffer amplifier is actually passing signal.

All of the above assumes that the gain network switches are set at the fixed unity position, not the variable position. This is the proper method of setup, as it insures the maximum signal-to-noise ratio for the system. There are times, however, when gain may be necessary to bring a signal up to the system reference. If more than 20 dB of gain is necessary we strongly recommend using the MDA-101, which is designed to optimize noise performance under large amounts of voltage amplification. The MDA-101 has an overall gain range of -2 to +73 dB.

The differential stage has trims that allow for a very high degree of common mode rejection. These trims are adjusted with an input signal level of +10 dBu. The resistive trim and the capacitive trim are both adjusted at an input frequency of 2 kHz. The typical null is a -90 dBu yielding a CMRR of 109 dB at 200 Hz, 100 dB at 2 kHz and 75 dB at 20 kHz. This null can be expected to deteriorate as much as 20 dB under temperature.

It is important to keep in mind that, while the input is a very high performance differential amplifier, it is not a floating input; that is, 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 circuit can handle. Practically, we would suggest that a limit of two to three volts be the maximum common mode voltage allowed at the inputs. Also keep in mind that any common mode voltage will reduce the headroom by the difference between it and the maximum output level. For this reason, it is very important to read and understand the Benchmark application note "A Clean Audio Installation Guide,." by Allen H. Burdick. In rare situations where the installer has no control over the common mode voltages present at the input of the amplifier, as in some Telco feeds, a high quality transformer, like those manufactured by Jensen Transformers, may need to be added to the installation.

4.3 The Gain Stage

For normal operation, the gain stage is operated at unity gain. However, the installer may, if necessary,use the "make before break " slide switches, S1 and S2, to select the variable gain mode, with gain determined by front panel amplitude controls VR4 and VR5. The front panel controls allow an overall gain range for each channel from Off +20 dB. As mentioned before, for best system headroom and S/N ratios unity gain should be selected. Operating the board with input levels that are higher than your system reference and taking a gain reduction at the variable gain stage will reduce your headroom. Operating with input levels that are lower than your system reference and increasing the amplification at the variable gain stage will reduce the possible signal to noise ratio of the system. For optimum system performance set up your system so that every stage of every piece of equipment reaches clip simultaneously.

4.4 The Configuration Switch

The output of the gain stages feed the configuration switch. This switch and the daughter boards are what give the Benchmark System 1000 modules their outstanding versatility. Normal operation of the DA-102 module switch positions are outlined in Section 2.4 , Operation.

4.5 The Power Amplifier

Next follow the power amplifier stages. They consist of an operational amplifier, which in turn drives a power-current boost stage. The current boost stage uses complimentary symmetry power transistors that have a rating of 50 watts and an f_t of 50 MHz. The driver transistors for the Darlington pair are in turn 200 MHz transistors. This provides for very low phase shift in the current boost stage, which in turn protects the phase margin of the op amp driver once the loop is closed.

The output transistors have 0.27 ohm emitter ballast resisters which help the problem of thermal stability. These resistors also provide a convenient point to measure the quiescent current in the output stage. The stage is adjusted to allow approximately 13 milliamperes of quiescent current to flow to minimize crossover distortion. Drive current for the output stage is provided by the active current source/current sink combination. This in turn is held at its proper bias voltage by the V_{be} multiplier. This multiplier circuit exhibits a constant voltage from collector to emitter. This voltage is the ratio of the resistors in the voltage divider string, a ratio of approximately 2.7, times the base-emitter voltage of the transistor. This voltage is made to vary by the temperature of the output transistors as a negative feedback factor to maintain quiescent current stability in the output stage.

The outputs of the current boost stage feed an L/R/C output stabilization network of a type recommended by Neivell Theil of Australia. The major advantage of this network over others is that the capacitor is directly across the direct output, and acts as a shunt for any stray pickup of RF power. The network has a cutoff frequency of 200 kHz. Additionally, the outputs feed two sets of ten 30 ohm build-out resistors, for five stereo balanced outputs. The compensation capacitors (across the feedback resistors) have been chosen for a nominal cutoff frequency of ≈300 kHz. This allows the overall bandwidth of the module to be ≈150 kHz.

4.6 Meter Stage

The meter consists of two basic sections, the 12-segment LED meter driven by either an EXAR XR-2279 or an ROHM BA683A, and the 13th segment peak indicator.

The 12-segment meter section may be calibrated 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. The bottommost variable resistor, VR-3, sets the level at which the -27 dB LED, D15, turns on. If the system reference level is +4 dBu then the -27 dB cal point is -23 dBu.

The peak indicator is a half wave detecting comparator with AC-coupled feedback. It has the feature of being able to monitor the levels of a number of circuit points at once. When any of the monitor points exceeds a predetermined level, the comparator trips and begins to oscillate. The trip point is determined by the resistor string R112, R113, and VR6. When the inverting input signal rises above ground potential the comparator trips. VR6 is the calibration trim for the peak indicator. It has a range of approximately +16 to +26 dBu. The factory calibration point is +20 dBu unless otherwise requested.

This completes the DA-102 circuit description.

5.0 SERVICE AND CALIBRATION

5.1 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 Pace MBT-100. 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.

5.2 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.

5.3 Power Amplifier Bias Calibration

Troubleshooting and testing should be done with current limited power supplies. The bias set potentiometers should be initially adjusted to mid position if any part of the power amplifier sections have been replaced. When turning on the power the average current should not exceed 200 mA, and will more typically be about 100 mA. A millivolt meter such as the Fluke 8050A is connected between the emitters of the power transistors, across the two emitter ballast resistors, by connecting the probes to the tops of the vertical 0.27 ohm resistors of each power amplifier. Adjust the bias trim resistor until approximately 7 millivolts is dropped across the two resistors. This establishes the normal quiescent bias current at approximately 13 milliamperes. If the unit fails to exhibit control over bias current, it is possible that the V_{be} multiplier has shorted or a solder bridge may exist at that point on the board.

If the unit fails to have a current of 200 mA or less at power up and cannot be adjusted down to that current level, then the following procedure should be used in troubleshooting. Make sure that no operational amplifier packages are in backwards and that there are no solder bridges on the board. In case of a reversed package, the IC acts as a diode shunt between the two power rails. Sometimes this will destroy the integrated circuit; other times there will be no apparent damage to the device. In either case, when finding a unit in backwards, it is well to replace it in the interest of long term reliability.

About the only other possible current path that will allow high currents to flow is through one of the power amplifier stages. It is often possible to find the offending power amp by comparing the temperatures of the individual heat sinks. An open V_{be} multiplier will allow all of the drive current to pass into the bases of the darlington transistors that drive the power output transistors, and will turn them on hard. Next, be sure that the power transistors are in their proper locations, as follows.

1. Holding the board so that you can read the numbers on the power transistors; verify on all four heat sinks that the NPN (MJE15028) transistor is on the left, and the the PNP(MJE15029) transistor is on the right.

2. If everything is correct at this point, the next area to check are the temperature compensating diodes in the current source and current sink circuits. The diodes in the current source and sink should have their bands pointed down, meaning next to the board, the glass body of the diodes should be away from the power amplifier section in both cases.

3. If these are proper, then the next area to check is the small signal transistors to verify their locations. The first transistor, observing from left to right, is a NPN device, an MPSA56; its flat side should be facing the heat sink.

4. The next device is the Darlington driver for the output stage. It is a NPN device and should be a MPSA06, again the flat side should be facing the heat sink.

5. Next in line, is the temperature sensing V_{be} multiplier. This device should be mounted on the heat sink with thermally conductive epoxy (blue or white in color). Should the V_{be} multiplier transistor have been pulled away from the heat sink, the result is, no thermal tracking for the power stage and the power transistors can go into thermal runaway. It is therefore, very important that the device be in intimate physical contact with the heat sink. If no thermally conductive epoxy is available for repair, silicone heat sink compound will make an adequate substitute.

6. The next device in the string is the MPSA56 Darlington driver for the MJE15029 power transistor. This is a PNP device. This small signal transistor should also be mounted with its flat surface facing the heat sink.

7. The final device is a NPN transistor that acts as a current sink. This will be a MPS06 and it's flat side should be facing the heat sink as well. With all of these small signal devices facing the heat sink it could cause somewhat of a problem when reading the identification numbers. About the only way to see the numbers is to bend the devices back. The number of times that this is done should be limited to two or three to prevent mechanical fatigue and failure of the leads.

8. If all of these devices are in their correct locations, and are mounted properly, and the power supply current is still excessive, make sure that there are no shorts between the power transistors and the heat sink. This is can be done by measuring the resistance from the collector of the power devices to the heat sink. If, perchance, the collectors of both the PNP and the NPN devices were shorted to the heat sink (possibly by over tightening the mounting screw), then the bipolar supplies would be shorted.

9. If, after all of the checks have been performed, the amplifiers are still drawing excessive current, then there is a defective device which must be located and replaced. The best way to test the transistors, using an ohmmeter, is by removing the devices from the board. The collector of the power is the center pin, which is electrically the same as the mounting tab of the transistor. The emitter is the right pin, while the base is the left. With the small signal transistors, the device should be held with the flat side facing the technician and the leads down: in this position the pin-out is, from left to right, emitter, base, collector.

5.3 Common Mode Rejection Null

The 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 <u>before</u> making any adjustments to those trims.

The process of nulling the common mode rejection must be done with the gain network selection switch in the unity gain position.

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.

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 the current P.C. layout.

5.4 Bar Graph Meter

Troubleshooting the bar graph meter is quite straight forward. The LEDs are arranged to work in groups of four and are turned on by successive current sinks within the chip. First, LED #1s current sink turns on, then LED #2's sink turns on and the sink for LED 1 Turns off placing the two LEDs in series, thus reducing the internal power dissipation within the driver chip. This continues until a group of four have been turned on by the last current sink in the string; and about 9.6 volts is across the LED string. Then, the next group of four starts with the same process. Troubleshooting the LED string is easy once you recognize that the string is turned on by its last activated current source. For example, if the middle four LEDs in the meter are extinguished when they should be on, if is safe to say that one of the four devices is open or is mounted backwards. You can find the offending diode by shorting successive diodes one at a time in the string of four. When you get to the problem device, shorting it will light the rest of the string.

The first two LED strings operate at about twice the current of the last string. Therefore, the last green LED and the three yellow LEDs are high output devices to compensate for the lower current. The philosophy behind the design of the chip is that the user would have red LEDs in the last positions which are much more efficient than either green or yellow LEDs and thus the higher current wasn't necessary.

The time constants necessary to approximate a VU meter action are set by the parallel 10 µF capacitor and 10 kΩ resistor connected between pin four of the meter chip and ground. The current through the LEDs is set by the resistor from pin 2 to ground. Audio comes into the chip on pin number 3, as well as a small amount of D.C. offset to establish the -27 dB trip point. The meter amplifier is a standard inverting amplifier with the calibration potentiometer as a part of the feedback network. The resistors are set up for a calibration range of -5 dBu to +10 dBu. The top most variable resistor, VR-7, is adjusted, so that, with the desired system reference level coming out of the board, the first yellow LED (D24) just comes on. This level should be sent to the module after the 0 indication calibration has been performed and then this trim is then adjusted. Adjust this variable resistor until the first green (D-15) LED just turns on.

The peak comparator, as described above, is an oscillating comparator by virtue of the fact that A.C. coupled hysteresis is applied around the device. The diodes form an analog "or" circuit. Initially the output voltage of the comparator is near the + supply voltage, the off state. As described above the comparator is held in the off state by the bias that is applied to the inverting input until an input peak overcomes the preset bias. When the comparator trips the output voltage swings to the opposite supply rail. The 0.1 µF capacitor, in turn, pulls the noninverting input negative holding the comparator in the on state. The capacitor recharges with opposite polarity through the two 220 kΩ resistors and when the threshold is passed the device turns off and is now held off, again by the charge on the capacitor.until the capacitor recharges to its original state. The action of this circuit is as a pulse stretcher which allows the operator to “see” very short peaks as they occur.

This completes the DA-102 service instructions. Ed Dec 23, 1987

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