BENCHMARK MEDIA SYSTEMS, INC.

DA-102DM Instruction Manual

1.0 Introduction
The DA-102DM is one of a series of very high performance audio distribution and processing modules known as the System 1000. The systems concepts utilized with the System 1000 provide the highest flexibility available in the industry. Provisions have been made on virtually all of the Benchmark System 1000 modules for accessory daughter boards, such as: the RGC-04 dual remote gain control daughter board; the MTX-02 stereo mode control daughter board; and the OSC-01 precision oscillator daughter board. These daughter boards may be added to your System 1000 modules in the field at any time. Please check with the factory concerning the availability of additional daughter boards.

The DA-102DM is a two channel (stereo) distribution amplifier with dual LED metering that offers the highest performance available to the audio professional. On board signal routing provides the following mode control: 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 have five 60 Ω outputs. A sixth output can be specified when ordering which can be used 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-102DM 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 dual meter monitors the stereo output of the DA. The flexibility of the DA-102DM makes it the optimum choice for the transition from mono to stereo.

2.0 Unpacking
Care has been taken in packing the DA-102DM 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 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 pigtails, instruction manuals, rack mount accessories, and small tools and fuses.

3.0 Installation
For basic installation concepts follow the "Clean Audio Installation Guide." The suitability of using the DA-102DM module for purposes other than a straight stereo application, such as dual mono or for mono and time code distribution, will be determined by the crosstalk that can be tolerated between channels. Crosstalk between channels on the DA-102DM at 20 kHz is an excellent -75 dB. However, crosstalk from module to module is *not measurable* using 50 kHz square waves as a test signal. Therefore, for signals that require extreme levels of isolation, you may wish to consider using separate modules.

3.1 Input Connections
Input to the board is made with the top two signal positions of the module edge connector labeled Left and Right. These are loop through inputs and, since the input impedance is 2

MΩ (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 (read *crosstalk*).

Modules may be removed and inserted into the frame while it is powered. 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. See Figure 3.0.

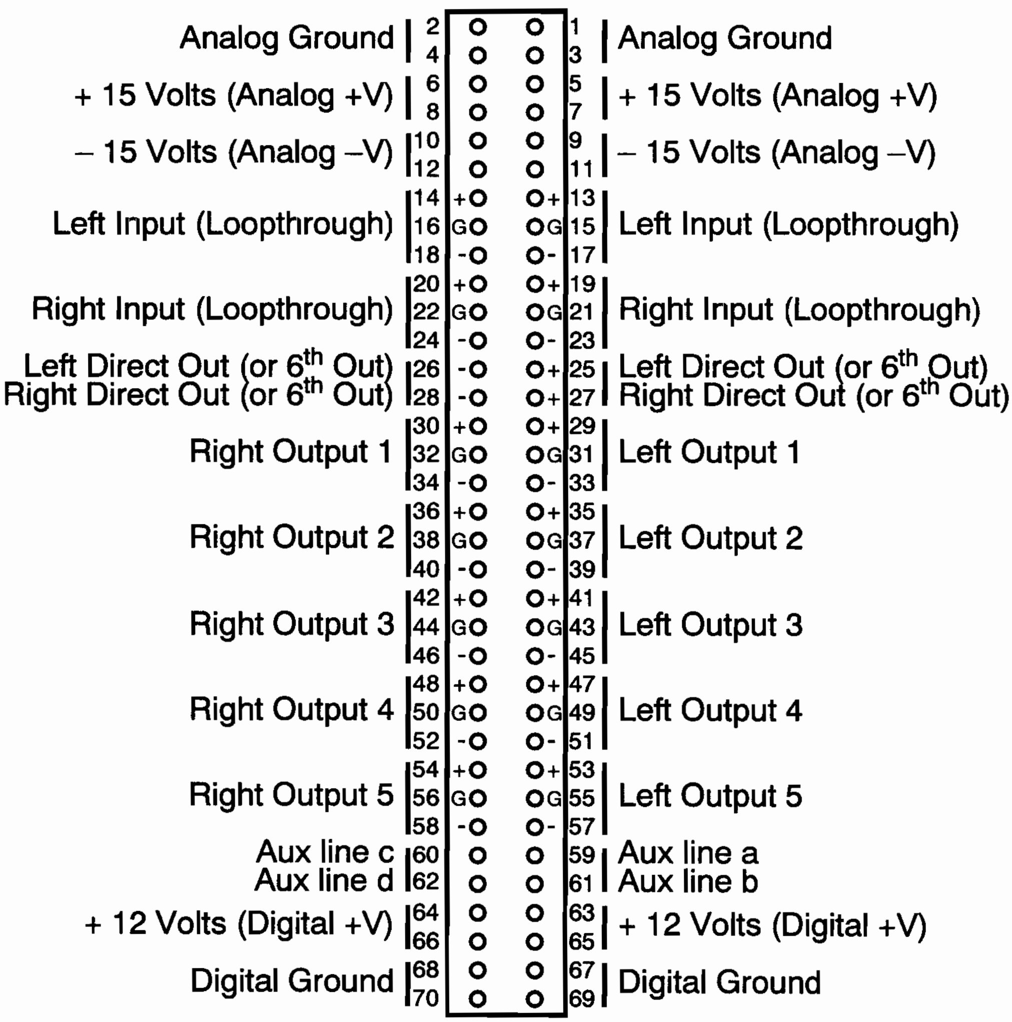

Figure 3.0, DA-102DM Connector Pinout (Rear View)

3.2.1 Direct Outs - BP-100

Additional outputs, such as the BP-100 QCP panel, may be added by use of the direct outputs These outputs are a low impedance source, therefore, build-out resistors must be added to provide isolation for however many additional outputs may be desired. (The resistor splits are conveniently on the rear of the BP-100.) 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.

!!! Warning !!!

> While the power amplifier stages are the same circuit design as found in the DA-101, the smaller heat sinks do not allow these stages to be used as speaker drivers.

The direct outputs for the left channel are the top two pins just below the Left input, 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, but please note that no connection is made at the center pin. Since there is no ground connection to the center pin, we recommend that one of the normal outputs have its buildout resistors removed and jumpers put in their place to create a direct output *with* a ground connection.

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 Setup and Operation

The following is the setup procedure.

As with any piece of electronic equipment, the greatest operational performance may only be obtained by a thorough knowledge of the design of the module. Hence, we recommend studying the circuit description in section 4.0.

Alternative input and output connection methods are the BP-100 QCP patch panel, the Berg 70 pin mating connector, the SIB-70 interface module that plugs into the rear of the MF-300 card frame, and the new MF-300MLX pluggable rear mother-board card frame. The MF-300MLX has 16 individual three-position latching and polarized Molex® SL connectors per module position. This product allows the convenience of plugging in additional outputs to modules that are "on the air." The MF-300MLX is intended for line level and mic-pre DA applications. The SIB-70 is a pluggable rear module that has

EuroStyle barrier strips for easy interconnection. Please contact the factory for additional information on these products.

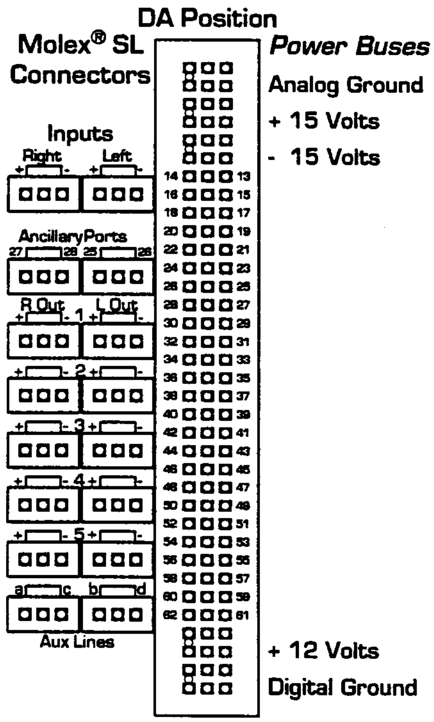

Fig. 3.1 [One of Twelve] MF-300MLX Connections

After making the proper input and output connections to the module position at the card frame, the signal flow must be set via the four position DIP switch at the center of the card. See figure 3.2

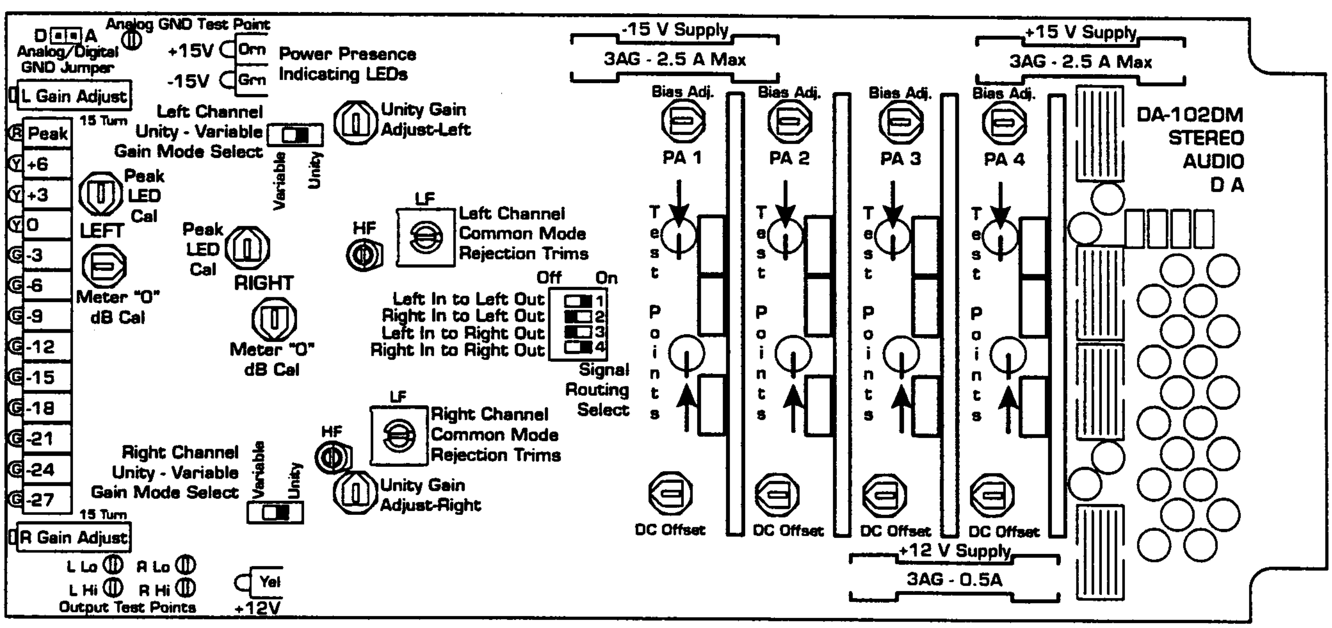

Figure 3.2 DA-102DM Controls

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 first set of components, (left to right, two heat sinks and associated parts) is the left channel and the second set of components is the right (see the electrical schematic, drawing number 450133 and the component assembly, drawing number 250003). Using the DIP switch, S2401, switch position 1 routes the signal from the left input into the left power amp, switch position 2 routes the signal from the right input into the left power amp, switch position 3 routes the signal from the left input into the right power amp, and switch position 4 routes the signal from 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. For a MONO mixed output, close switch positions 2 and 3 as well. Operation with a daughter board requires all switch sections of S2401 to be in the *off* position. Signal routing is handled on the daughter board.

Most often, modules will be used as unity gain amplifiers. Switches S1301 and S4201 provide selection between fixed unity gain operation, where the front gain controls are inactive (and therefore not adjustable by non-authorized personnel), and variable gain operation. The top variable control is the left channel; the lower one is the right channel.

!!! Warning !!!

> When using the DA-102DM with the MTX-02 Stereo Control daughter board, both channels must be in either the fixed unity gain position, or the variable gain position at or very near the same gain setting. Operating the gains otherwise will cause a phase difference between the signals coming into the daughter board and significantly deteriorate the L-R signal from its -90 dB null.

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-102DM consists of two instrumentation input stages, two gain stages, a configuration switch, four ten watt power amplifiers, four direct outputs, two groups with five sets of build out resistors each and two meter systems.

4.2 Input Stage

Each input stage has two sets of paralleled input capacitors (0.1μF film and 100 μF electrolytic caps), and a resistive attenuator consisting of a 4.99 kΩ input resistor and 1.00 MΩ shunt resistor. The resistive network provides bias current for the buffers and protection to the incoming audio line, should power to the module be lost. The attenuator additionally provides high voltage protection to the input of the module, with little sacrifice in noise performance. Following the resistive network, there are two unity gain buffer amplifiers. The outputs of these buffers drive precision differential amplifiers.

The differential amplifier is configured for the 6 dB loss necessary to maximize headroom available with the relatively low voltage ±15 volt power supplies. For example, 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 (very desirable). 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 this means is, 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, the input clip point is no longer +27 dBu because only one buffer amplifier is actually passing signal.

The above assumes that the gain network switches are set at the 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, of course, when gain is 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-101PA or MDA-102PA, which are designed to optimize noise performance under large amounts of voltage amplification. These devices have an overall gain range of -2 to +73 dB.

The differential stage has trims that allow 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 from 10 to 20 dB over the operating temperature range.

It is important to keep in mind that, while the input is a very high performance differential amplifier, it is not a floating input; rather 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. 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 important to read and apply the Benchmark application note "A Clean Audio Installation Guide", by Allen Burdick. In rare situations where the installer has no control over the common mode voltages present at the input of the amplifier, 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.

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, S1301 and S4201, to select the variable gain mode, with gain determined by front panel amplitude controls R1101 and R4101. The front panel controls allow an overall gain range for each channel from -10 to +20 dB.

For best system headroom and S/N ratios, fixed unity gain should be selected. Operating the module 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 such that each piece of equipment is running at unity gain and each stage of every piece of equipment reaches clip simultaneously.

4.4 The Signal Routing Switch

The output of the gain stages feeds the signal routing switch. This switch and the daughter boards are some of the elements that give the Benchmark System 1000 modules their outstanding versatility. Normal operation of the DA-102DM module switch is outlined in Section 2.4.

4.5 The Power Amplifier

The power amplifier stage consists of an operational amplifier, which in turn drives a power-current boost stage. The current boost stage uses complimentary symmetry topology with power transistors that have a rating of 50 watts and an f_t of 50 MHz. The driver transistors for the Darlington pair are 200 MHz transistors. This provides 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 resistors which reduce thermal instability. These resistors also provide a convenient point to measure the quiescent current in the output stage. The stage is adjusted to allow approximately 13 mA 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. These current sources are held at the proper bias voltage by the V_{be} multiplier. This multiplier circuit exhibits a constant voltage from collector to emitter. The 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, 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 pickup of RF power by output wiring. The current boosted 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 Stages

Each meter consists of two basic sections, the 12-segment LED meter driven by an ROHM BA683A, and a 13th segment peak indicator.

The 12-segment meter sections 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 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 threshold, the comparator trips and begins to oscillate. The trip point is determined by the input resistor string. When the inverting input signal rises above ground potential, the comparator trips. R2102 and R1304 are the calibration trims for the peak indicators. They have a range of approximately +16 to +26 dBu. The factory calibration point is +20 dBu, unless otherwise requested.

This completes the DA-102DM 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 Hakko 470. The proper technique with these stations is to apply the de-soldering tip to the area to be un-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 and 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, should be 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 mA. 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, the following procedure should be used in troubleshooting.

Other than a direct short between the + and - power rails, the only 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 section by comparing the temperatures of the individual heat sinks.

Barring solder problems, the only reason for high current drain 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 transistor is the center pin. 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.

Before removing any transistors for testing, a few other checks can be made that will narrow the fault window. 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. This can be checked by shorting out the Vbe multiplier, collector to emitter. If the device is open or the required bias voltage has changed, the current drain should drop.

5.4 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 *before* 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.

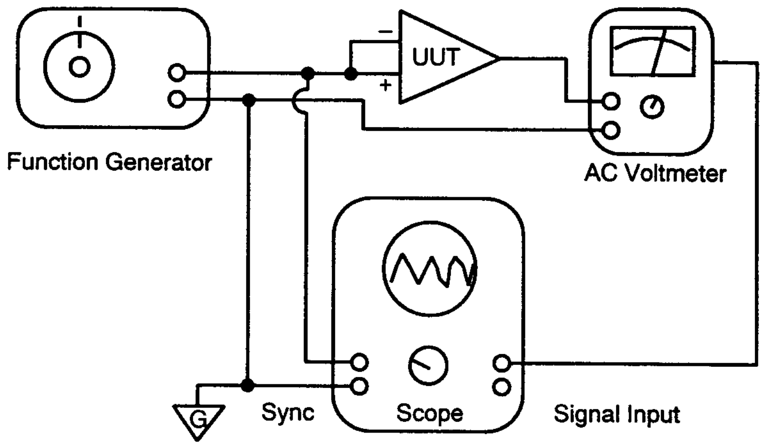

Fig. 5.4 Common Mode Test Setup

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.

5.5 Bar Graph Meter

Troubleshooting the bar graph meter is quite straightforward. The LEDs are arranged to work in groups of four and are turned on by successive current sinks within the chip. First, LED 1's 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 isn'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. 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 calibration potentiometer is adjusted, so that, with the desired system reference level coming out of the board, the first yellow LED just comes on.

The peak comparator, as described above, is an oscillating comparator by virtue of the fact that AC 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, in the off state. 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 again held off 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-102DM service instructions. 052594

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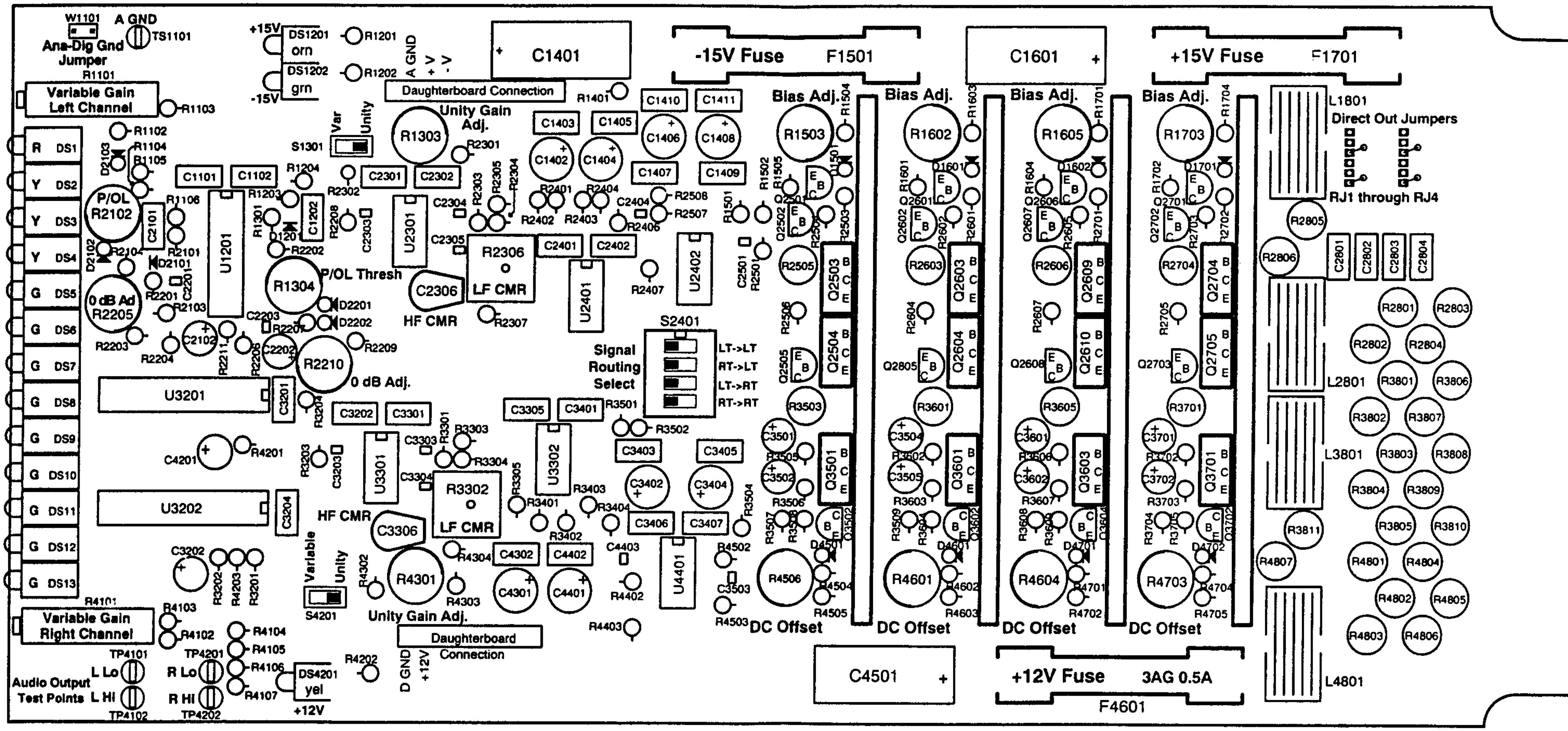

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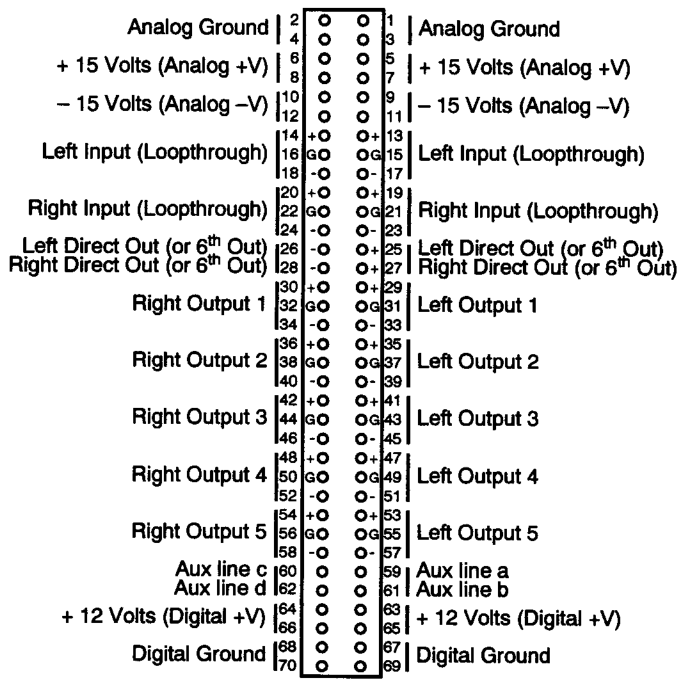
DA-102DM Component Placement

SCALE 187.5%	PCB# 300-02020-001	DRAWN BY A. H. Burdick	
DATE 5-26-94		ASSEMBLY # 500-03133-000	
SIZE B	REV/DATE	DRAWING #	


Analog Ground
+ 15 Volts (Analog +V)
– 15 Volts (Analog –V)
Left Input (Loopthrough)
Right Input (Loopthrough)
Left Direct Out (or 6th Out)
Right Direct Out (or 6th Out)
Right Output 1
Left Output 1
Right Output 2
Left Output 2
Right Output 3
Left Output 3
Right Output 4
Left Output 4
Right Output 5
Left Output 5
Aux line a
Aux line b
Aux line c
Aux line d
+ 12 Volts (Digital +V)
Digital Ground