BENCHMARK MEDIA SYSTEMS, INC.

DA-101 Instruction Manual

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DA-101 Instruction Manual

1.0 INTRODUCTION

The DA-101 Mono Audio Distribution-Power Amplifier, a module from the System 1000 series, provides a unique solution for professional broadcast and production facilities that demand the very finest. Quality materials, advanced circuit techniques, innovative design, and precise construction are combined in the DA-101 to provide the highest quality performance with maximum reliability.

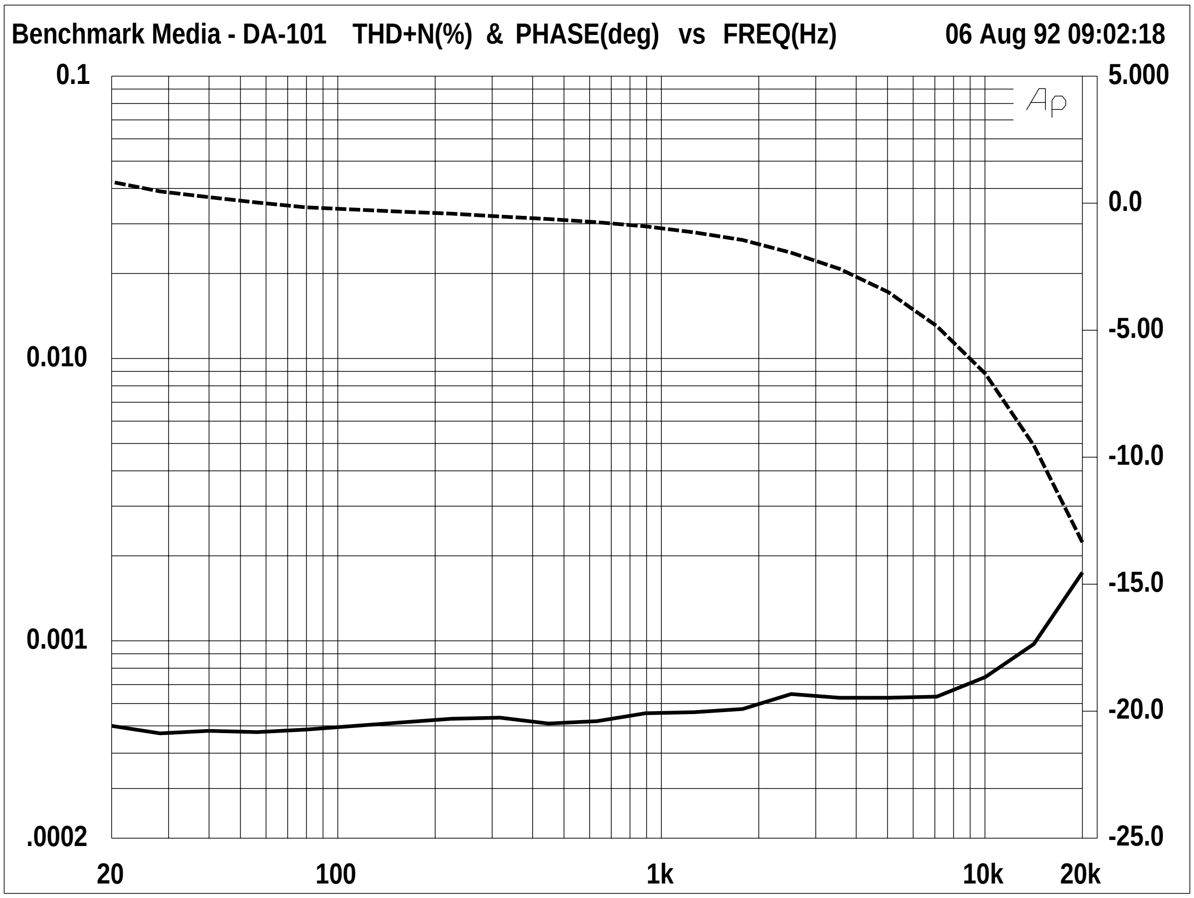

Figure 1. DA-101 Total Harmonic Distortion and Phase

Innovative design makes the DA-101 a truly universal interface and processing element. The many switching, metering and internal processing capabilities of the DA-101 provide unprecedented options. In addition, modular construction allows the optimum combination of System 1000 modules to be determined by the user. As your needs expand, the System 1000 expands with you.

2.0 GENERAL DESCRIPTION

The DA-101 is highly flexible, with many applications that are not necessarily apparent. In order to obtain maximum benefit from your investment, it is strongly suggested that you first read the “Application Examples” section of this manual.

!!! Caution !!!

Unless you set the DA-101's dip switches for your specific application, the unit will not perform as expected and may *appear* to be damaged.

The DA-101 consists of two completely independent input sections, each with its own instrumentation-differential amplifier and variable gain stage. There are also two power output amplifier sections that may be operated as a balanced output, where output 2 is a mirror of output 1, or they may be operated independently as dual single-ended outputs. Each stage will now be described.

The DA-101 provides two active instrumentation type inputs with high common mode rejection. Due to the use of balanced high impedance inputs and input connectors that may be physically inverted, the polarity of one or both input channels may be easily reversed.

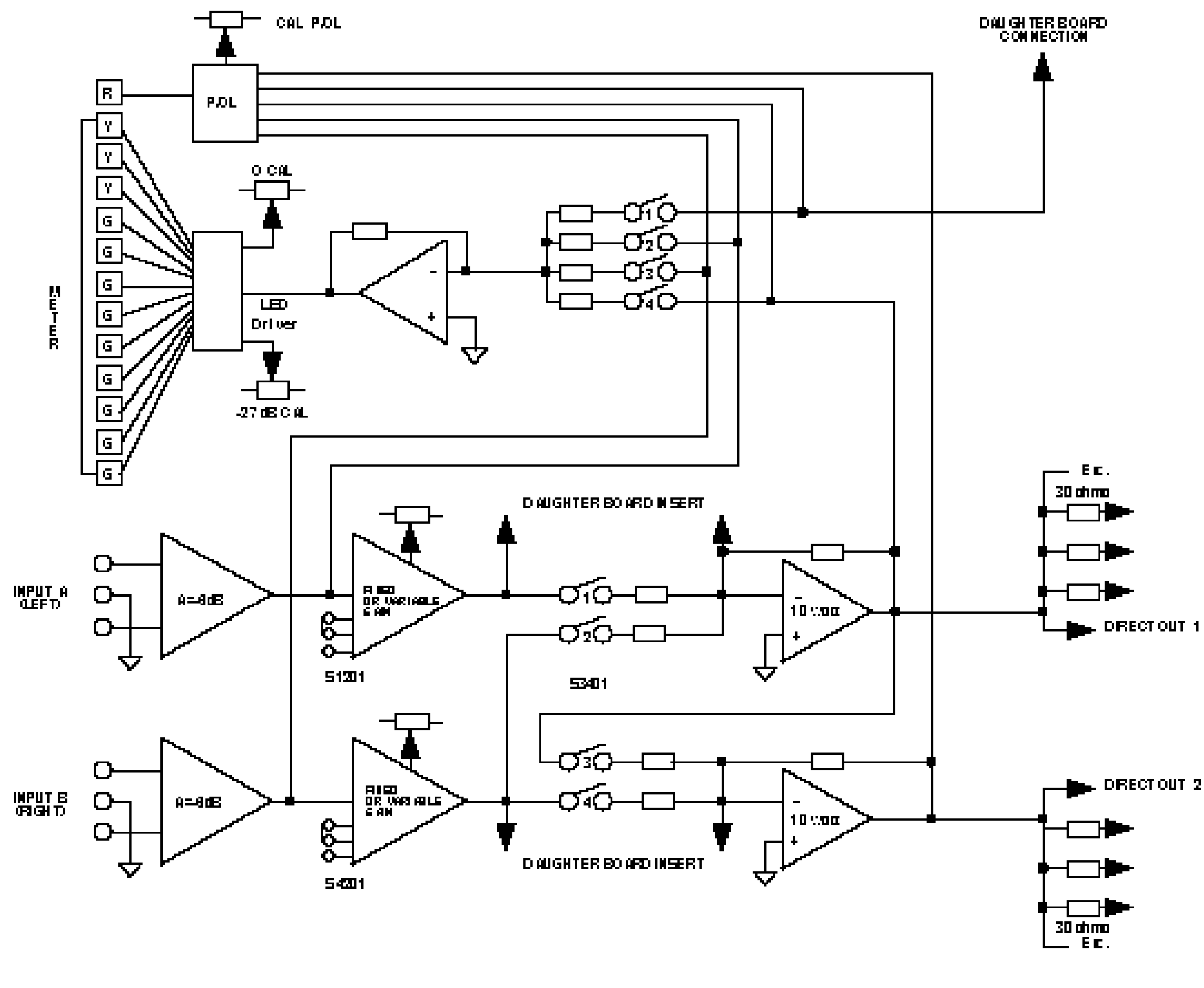

Fig 2.0 DA-101 Block Diagram

Each instrumentation input stage is followed by a variable gain amplifier. The variable gain amplifier is adjustable from -10 dB to +20 dB or it may be switched to a precise fixed unity-gain. On-board switches configure the DA-101's inputs and outputs. Switches 1 & 2 of S3401 configure the A and B inputs for independent A input or B input operation, summed (A+B), or difference (A-B) with an external input polarity inversion. Signal routing switches 3 & 4 of S3401 enable the DA-101's two power amplifiers to provide ten mono balanced 60 ohm outputs, or ten unbalanced 30 ohm stereo outputs, two 10 watt 0 Ω monitor outputs or one 40 watt 0 Ω bridged mono output.
A 12 step green and yellow LED bargraph provides level indication of selectable measurement points within the DA-101. 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 DA-101 is designed to accept plug-on "daughter" boards for insertion of optional processing modules between input and output stages. For additional information on daughter board connections, their application and availability, contact Benchmark Media Systems.

3.0 UNPACKING

Care has been taken in packing the DA-101 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 pigtails, instruction manuals, rack mount accessories, and small tools and fuses.

4.0 INSTALLATION

The installation of the DA-101 is a simple matter of installing the System 1000 module frames in their proper location, inserting the DA-101 modules into their companion frames, making the input and output connections and adjusting the gain for the conditions of use.

4.1 Input and Output Pin Assignments

Figure 2 details the DA-101 input and output connections to the System 1000 card frame. When installing the DA-101, observe the following:

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 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.

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 the 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.

4.2 Output Connections

As a distribution amplifier, the module has one set of build-out resistors that provides the ten balanced feeds. See the block diagram in Figure 1.0.

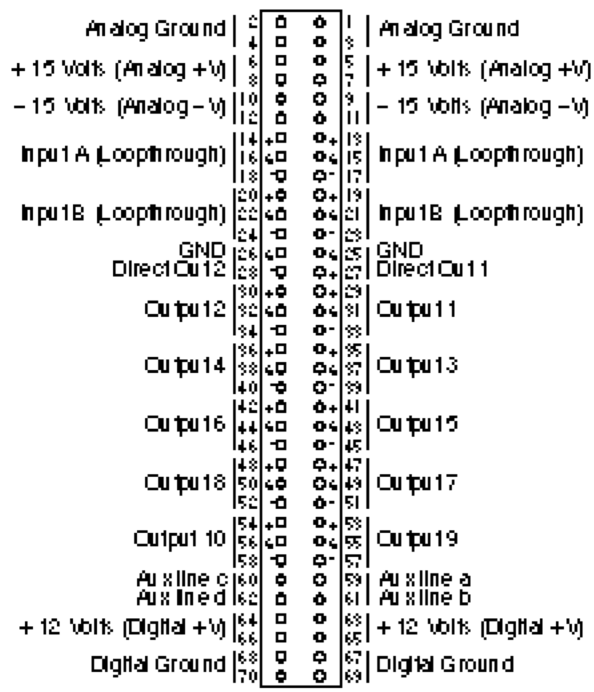

Figure 3. DA-101 Connector Pinout (View from Rear of Card Frame)

Additional outputs may be added by use of the direct outputs The direct 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 limitation to the number of additional outputs that may be added is related to 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 associated 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.

Therefore, due to the increasing possibility of multiple shorted outputs, we recommend that no more than a total of 30 outputs, or 20 additional sets of build out resistors, be added to the direct outputs from an individual channel. If you are confident of the safety of your wiring, more outputs than this may be added. The maximum current drain on the module should be 5 Amps. When calculating the current drain presented to the module, be sure to include current that will be taken by the inter-conductor cable capacitance at high frequencies, as well as any line impedance termination's, i.e. 600 Ω, 150 Ω, etc.

The direct outputs are two pins horizontally connected, two pins below input B. 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 be operated horizontally. Molex® SL™ housings and pins will work horizontally without interference.

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

4.3 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 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 no longer exists with the Molex SL pins and housings.

5.0 APPLICATION EXAMPLES
The DA-101 was designed to provide maximum flexibility, and as such, requires some explanation of the many setup options available to the user. Several applications will be described in this section. Before proceeding to those sections, refer to Fig. 1 and the following text highlights.

5.1 Single Channel, Balanced Output, Distribution Amplifier
This DA-101 configuration may use the A, B, or both inputs to provide ten 60 ohm balanced outputs.

On S3401, select the appropriate input. To sum the A and B inputs for an (A+B) output, both switches 1 and 2 must be closed. For balanced output, switch 3 must be closed. When 3 is closed, 4 should be open.

If unity-gain is required, the A and B input level controls may be defeated by switch selection (S1201 and S4201).

5.2 Using Both Inputs for (A+B) or (A-B) Operation

On S3401, switch 1 and 2 on, to select the A and B inputs. Both switches closed produces (A+B) summation at the A output.

By reversing either the A or B channel input polarity at the connector, an (A-B) or (B-A) output is produced. Switches 1 and 2 must be closed. This feature is useful for deriving an L-R matrix component.

Close matching of internal gains prevents, in most applications, the need to vary input levels for a sufficient null. The A and B input level may be trimmed, if necessary, with the controls on the DA-101. For most applications, it is strongly recommended that the gain of the DA-101 channels be switched to unity to prevent tampering by unauthorized personnel. There is much in favor of maintaining unity-gain throughout the plant, bringing levels up to the house reference right at the point of origin.

In this configuration, all ten outputs will be balanced and either sum or difference audio. For a more flexible precision matrix operation, the MTX-02 daughter board should be considered.

5.3 Stereo, Unbalanced Out, Distribution Amplifier

The DA-101's direct outs 1 and 2 may be used independently to distribute stereo programs. Balanced output operation is forfeited when the #1 and #2 outputs are used independently.

S3401 switch positions 1 and 4 should be closed (2 and 3 open) for stereo operation to route each input directly to output amplifiers 1 and 2.

Great care must be exercised when using the DA-101 as a stereo distribution amplifier. If the DAs are used to feed unbalanced inputs, which is not generally recommended, all of the destinations should be in *close* physical proximity to the DA. Extreme care must be taken with system grounds. It is much better to install balanced inputs on the destination equipment. See "A Clean Audio Installation Guide".

6 dB of amplification is lost when operating with single ended outputs. Usually this is of no consequence, since most unbalanced equipment is of the IHF type, and is designed to receive a -10dBV (-8 dBu) input amplitude.

5.4 Stereo Monitor Amplifier

Direct outputs from the DA-101's two power amplifiers may be used to drive monitor speakers with up to 10 watts of power in a stereo configuration.

To use the DA-101 as a stereo monitor amplifier, each speaker connection must be made between the corresponding direct output and ground. S3401 must be configured as above with switch positions 1 and 4 on, while 2 and 3 are left off. Two 2 pin Molex® SL™ housings and female connector pins may be used to make the connections to the module since ground is located on the pins directly above the direct outputs. Be careful to observe correct polarity with the speaker connections.

5.5 Mono Power Amplifier

In this configuration, the DA-101 is used in the "bridged mono" configuration and will provide 40 watts into an 8 ohm load for driving monitor speakers.

When used as a mono power amplifier, S3401 must have switch position 3 on and 4 off. Either input or a mix of the two may be used for source selection. For a bridged mono output, use a 3 conductor Molex® SL™ connector, orient the connector horizontally, with the speaker's red and black conductors on pins 1 and 2 of the two direct outputs. No ground connection is used in this configuration.

Once again, be careful to observe a consistent polarity from module to module. Within an excellent acoustical listening environment, there is evidence that absolute polarity inversion, (i.e., polarity from recording microphone to playback speaker) may be heard.

The RGC-01 is a useful option when used with the DA-101 as a monitor amplifier. This daughterboard allows remote single-channel gain-control and channel mute functions. This is particularly helpful when configuring control room monitoring for use with Intercom or IFB interruption. The dual channel VCA daughter board, the RGC-02, can be configured to receive the intercom or IFB signal on the second input, Input B. The daughter board has signal routing capability, allowing it to select between the normal audio on channel A or the intercom/IFB audio on channel B.

5.5.1 Energy Storage Capacitors

With using the DA-101 as a power amplifier, sufficient current must be available from the external power supplies for the given number of power amplifier modules. Using regulated power supplies with power amplifiers requires the current limit of the power supply be equal to the highest peak current demand. This is not normally practical since the peak demands are typically 2.5 times the average. Most commercial power amplifiers do not use regulated power supplies, at least at the power output stage, to allow for this peak current surge. They depend upon the filter capacitors of the power supply to provide the peak current demands of the amplifier stage. This way, the designers can use supplies with lower *average* output capability.

This extra capacity may also be achieved when using the regulated power supplies of the System 1000, by placing large electrolytic capacitors on the output of the regulated supply. Connect these capacitors directly across the power rails of the card frame. By doing so you can use their storage capacity to provide the peak currents necessary for additional numbers of power amp modules. A power supply normally rated at ± 5 amps is typically limited to two modules used as 40 watt mono power amps or four modules used as stereo 10 watt amps. By adding the external filter capacitors, the total number of amplifiers may be increased 2.5 times to five 40 watt power amp modules or ten stereo 10 watt / channel modules. If the modules are operated at less than full load, even more modules may added. The method used for calculating the necessary additional capacity is as follows:

$$C = \frac{I_l \times 6 \times 10^{-3}}{V} \qquad [1.0]$$

Where:

- C = capacitance in Farads
- I_l = load current in Amps
- V = maximum peak to peak ripple voltage allowable

at 120 Hz (most of the energy is required in the base region)

If we decide that V should be less than 0.5V and I peak is 3 amps for a 40 watt amp with 8 ohm load, and the total number of 40 watt modules is now 5 (peak current = 15 amps), then;

$$C = \frac{15 \text{ x } 6 \text{ x } 10\text{-}3}{0.5} = 0.18 \text{ Farads} = 180{,}000\ \mu f \qquad [2.0]$$

This is rather large!

If, however, we let V rise to 2 V, then C = 45,000 µf. Still high but quite a bit more practical. In real life, the probability of having all five modules reach peak at the same time is quite low (provided they are handling different program material), and 10 to 20,000 µf is usually satisfactory, under most conditions. However, you should check the amount of ripple voltage on the capacitors to be sure you have full capability.

!!! WARNING !!!

Do not short the direct outputs or connect them to a load while an input signal is present. For maximum performance, the DA-101 module does *not* incorporate short circuit protection other than power supply fusing. Operation of the direct outputs into shorted loads for *extended* periods may result in damage to the DA-101 due to overheating.

6.0 CIRCUIT DESCRIPTION

6.1 Overall

It will be helpful to refer to the DA-101 schematic while reading the description of the module's circuitry.

The DA-101 consists of two instrumentation input amplifiers, two gain stages, a signal routing switch, and two 10 watt power amplifiers. See schematic diagram.

6.1 Input Stage

The input stages are straightforward in design, with two unity-gain buffer amplifiers and 10 MΩ input resistors, followed by a precision differential amplifier with 6 dB loss. This maximizes the available headroom with relatively low voltage power supplies. Since 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, and the input signal is usually balanced with respect to ground, the pair is capable of 6 dB more than one amplifier by itself (differentially). However, the next stage is not capable of handling +27 dBu. Therefore, we must take a 6 dB loss at this point, if we want the system input overload point to be +27 dBu. This loss works well, 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, internal to the module, the operating level is 6 dB lower than the input or the output. With a balanced input level of +4 dBu, the operating level after the first stage is -2 dB.

When feeding the module from an unbalanced source, however, the input clip point is no longer +27 dBu but is back to the +21 dBu level. If the module is used as a single ended output device, then the overall gain through the module is -6 dB, when the variable gain stage is set in its precision fixed unit position. Of course, this 6 dB loss can be made up by using the variable gain stage.

The input to the unity-gain buffers has, as its second electrical element, a resistive divider network made up of a 4.99 kΩ and a 1.00 MΩ resistor. This network is intended to provide isolation from the semiconductor diodes that exist at the input of the operational amplifier, when the module has lost power for some reason. The divider networks create an insertion loss of approximately 0.043dB per network, or 0.086 dB for the balanced input. This loss is made up in the precision unity-gain trim in the variable gain stage that follows the differential amplifier.

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. The resistive and capacitive trims are adjusted at an input 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. It is important to keep in mind that, while the input is a very 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 very 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.

6.2 The Variable Gain Stage

The variable gain stage has a pair of gain determining networks that allow the operator to choose whether or not to make the front panel control active. Switches S1201 and S4201 select which network is active. The front panel control provides an overall gain range for the board from -10 to +20 dB, when used as a balanced output device. If systems levels are set properly, and if your facility has personnel that take it upon themselves to "correct" levels the engineering department has carefully set up, you may need to set the switch to the precision unity-gain position.

A properly set up audio system should *not* have levels that vary from one piece of equipment to another. Levels should be brought to the house reference, (0, +4, or +8 dBu) at the output of all pieces of equipment, and then distributed at unity gain. Ever after this level they should not vary. If -10 dBV unbalanced inputs are to be fed from the distribution amplifier, use one half of the balanced output and small resistive attenuators to make the level transition. Do not change the amplification of the module to make the level transition. This will facilitate equipment interconnection, and cross connection through patch bays without the question of "Now let's see, where did we set the level of this module?" having to be asked.

6.3 The Signal Routing Switch

The output of the gain stages feeds the signal routing switch, S3401. It is this switch and the daughter board's accessories that give the DA-101 its outstanding versatility. The signal routing is as follows. With switch position #1 closed, input A is fed to the power amplifier #1; with switch #2 closed, input B is fed to power amplifier #1; with both switches closed, power amplifier #1 mixes both of the inputs. Switch 3 routes the output of power amplifier #1 to the input of power amplifier #2, to create the mirror imaged output necessary for balanced outputs. Switch #4 alternately connects input B to power amplifier #2. Switch position four would only be activated when the module is used as a stereo monitor amplifier, or as a stereo single ended DA. See Figure 1.0.

6.4 The Power Amplifier

The next stage is the power amplifier. It consists of an NE5534 operational amplifier, which in turn drives a power-current-boost stage. The current boost power amplifier uses a complimentary symmetry transistor output stage. The power output transistors have a power 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 protects the phase margin of the overall stage, once the loop is closed. The output transistors have 0.27 ohm emitter ballast resistors which add 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 20 mA of quiescent current to flow, minimizing 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 (Q2601) exhibits a constant voltage from collector to emitter. The output voltage is the ratio of R1601 to (R1701 + R1801) a multiplication factor of approximately 2.7 times the base emitter voltage of the transistor. The V_{be} multiplier is thermally tied to the heat sink and senses the temperature of the output stage. Its output voltage varies with the change in temperature as a negative feedback factor, to maintain quiescent current stability of the output stage.

The L/R/C output stabilization network is of a topology recommended by Neville Thiele of Australia. The advantage of this network over others, is the placement of the capacitor directly across the output. This acts as an R.F. shunt to stray pick up of R.F. power from wires going to speakers. The capacitor chosen is a low inductance stacked-film type. The network has a cutoff frequency of 200 KHz, which allows S.M.P.T.E. time code to be passed in a high speed wind mode without significant waveform deterioration. The output feeds ten 30 ohm build-out resistors, for DA operation. The compensation capacitors (across the feedback resistors) have been chosen for a nominal cutoff frequency of 319 KHz. This cutoff frequency allows the overall bandwidth of the module to be greater than 150 kHz.

6.5 Meter Operation

The meter consists of two basic sections. First, is the 12 segment LED meter with a scale factor of 3dB/step. It is driven by the BA683A chip. Second, is the 13th segment peak overload indicator. The meter section has a four position DIP switch (S2201) that allows the meter to monitor both inputs, output 1 or the output of a daughter board accessory. Switch position 4 is normally on, monitoring the output of the module, and must be used during calibration of the meter. R2205 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. R2205 is adjusted so that, with the desired system reference level coming from the board, the first (bottom) yellow LED just turns on. R3205 sets the -27 dB LED for a correct turn on point. If the system reference level is +4dBu, then the -27 dB calibration point would be -23 dBu. 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 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 typology is a half wave detecting comparator. However, when the module is operating as a balanced output device, the output of both power amplifiers are feeding the detector, and thus is operating as though it were a full wave detector. When any one of these points exceeds a predetermined level, set by the resistor string R1105, R2103, and R2104, 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.

6.6 Fusing

The DA-101 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 also sized to protect the power output stage from damage under lengthy faults at the output. F1801 and F1501 fuse the ± 15 V analog power. F4801 fuses the + 12 V digital supply and should be fused at 1/2A. The ± 15 V analog fuses should be sized as follows:

Normal Distribution Amplifier (light load)	1/2 Amp 3AG
Heavy Duty Distribution Amplifier	1 Amp 3AG
Power Amplifier/Distribution Amplifier	2 Amp 3AG

Unless prior arrangements have been made the modules will be shipped with 1/2 Amp fuses in the F1801 and F1501 positions. Make sure that you have not constructed your system where higher ratings would be necessary. There is almost nothing more aggravating than having a modules fuses fail while on the air. If you have questions concerning the level at which you should fuse the module, please call the sales department, and they will run a spreadsheet on your installation conditions.

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 Pace MB-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. 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, but *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 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 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 Power Amplifier Bias Calibration

Initial power-up of either a defective module for troubleshooting, or a repaired unit, should be done at the test bench with current limited power supplies. The bias set potentiometers, R1801 and R 4805, should be set initially at mid position, if sections of the power amplifier stage have been replaced. At power turn-on, the average current should not exceed 200 mA, and will more typically be about 100 mA. Connect a millivolt meter, such as the Fluke 8050A, between the emitters of the power transistors, across the two emitter ballast resistors. This is done 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 10 millivolts is dropped across the two resistors. This establishes the normal quiescent bias current at a little less than 20 mA.

If the unit fails to exhibit control over bias current, it is possible that the V_{be} multiplier has shorted. If the unit fails to have a current of 200 mA or less at power up, then the following procedure should be used in troubleshooting the two power amplifiers.

A faulty power amplifier stage, under current limited power supply conditions, will usually be quite warm to the touch, thus indicating the starting point for the investigation.

A check of the V_{be} multiplier can easily be performed by shorting the collector to the emitter. This action should remove the bias from the transistor string and if the multiplier is defective, the power supplies should come out of current limit. Power supplies coming out of current limit do not necessarily indicate, without exception, a faulty V_{be} multiplier.

If repair has been done, be sure that there are no operational amplifier packages in backwards. Also, make sure there are no solder shorts on the board as a result of rework. In the case of a reversed package, the I.C. acts as a diode shunt between the two power rails. Such a condition may destroy the integrated circuit; other times there will be no apparent damage to the device. Either way, when finding a device in backwards, it is well to replace it, in the interest of reliability. Next, make sure that the power transistors are in their proper locations. Here are the steps to follow:

Looking at either power amplifier stage from the component side, the +V rail is at the left end of the heat sink, and the -V is at the right. The left power transistor should be a MJE15030; this is either Q2602 or Q4602, depending on which PA you are observing. These are NPN devices. The right hand power transistor is the MJE15031, either Q2603 or Q4603, which are PNP devices.

If everything is correct at this point, the next area to check includes the temperature compensating diodes in the current source and current sink circuits of the bias string. The diode in the current source (left side of the amplifier string) should have its band pointed down, that is, next to the board, and the diode in the current sink should also have its band down. Observe the silk screen nomenclature to be sure of the diode orientation. A small diode symbol is printed on the board under the diode position.

If these are proper, then the next items to check are the small signal transistors to ensure that they are in their correct locations and are installed properly. The first transistor, observing from left to right, is a PNP device, an MPSA56. Its flat side should be facing toward you.

The next device is the Darlington driver for the output stage. It is a NPN device and should be an MPSA06, and its flat side should also be facing you. This is either Q1602 or Q4502.

The next small signal transistor is the temperature sensing V_{be} multiplier, an MPSA06. This device should be mounted flat side down on the heat sink, with a thermally conductive epoxy (white/brown color) between it and the heat sink. Occasionally, it happens that the transistor is pulled away from the heat sink and as a result there is no thermal tracking for the power stage. This can allow the power transistors to go into a high current condition. It is very important that the device be in close physical contact with the heat sink. On occasion, it becomes necessary to unsolder the transistor, remove it from the board and re-bend the leads. Then re-solder the transistor into the board with a proper amount of heat conductive epoxy beneath the device, in order to re-establish a good thermal junction.

The next device in the string is the MPSA56 Darlington driver for the MJE15031 power transistor. It will be either Q1601 or Q4604 and is a PNP device. This small signal transistor should be mounted with its flat surface toward you. The final device is an NPN transistor that acts as a current sink. This will be an MPSA06, either Q1501 or Q4701, and it should also have its flat side facing the heat sink.

If all of these devices are in their correct locations, and are mounted correctly, and if power supply current is still excessive, then make sure that there are no shorts between the power transistors and the heat sink. It is highly unlikely that this will occur, since the power transistors have new insulation technology that eliminates the need for silicone grease and insulating washers by encapsulating the entire power tab in thermally conductive plastic. Resistance measurements between the collectors of the power transistors and then, to a mounting screw of the heat sink will confirm that no current paths exist.

If, after all of the above has been performed, and the amplifiers are still drawing excessive current, then there is a defective device which must be found and replaced. About the only path that is capable of being a high current path is through the power transistor stage. The best way to test the transistors, using an ohmmeter, is by removing the devices from the board. The collector of the power transistors is the center pin, which is the same point as the mounting tab for the transistor. The emitter is the right pin, while the base is the left pin, when looking from the top. 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 pinout is, from left to right, emitter, base, collector. Standard ohmmeter measurements will confirm the defective device(s).

7.3 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.

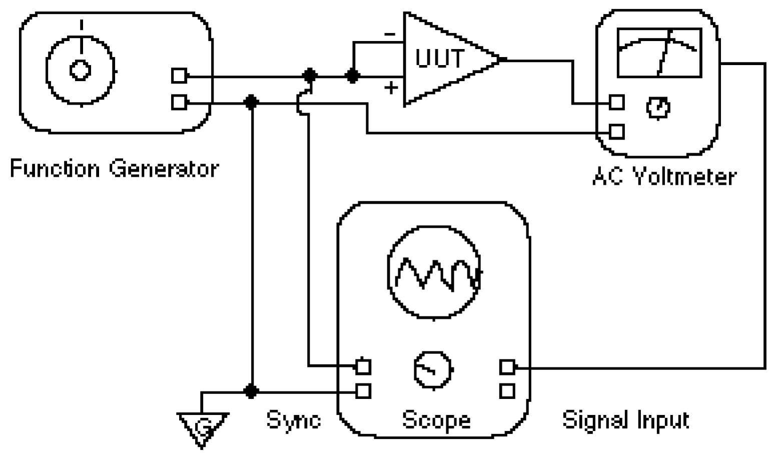

Fig 4.0 Common Mode Rejection Adjustment

The process of nulling the common mode rejection must be performed with the overall gain of the DA set at unity. See Figure 3.0

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, 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 DA. 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 with the current P.C. layout. Unfortunately, it is almost impossible to maintain this good a null over the operating temperature range. A degradation of up to 10dB may be expected when the module is returned to its working environment.

7.4 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 easy, once you recognize that the string of 4 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 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 special high efficiency LEDs. The 10 µF capacitor, C3202, and the 10 K ohm resistor, R3201, 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. R3203, 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 D.C. offset to establish the -27 dB trip point. The meter amplifier, U2201, B is a standard inverting amplifier with R2205 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 A.C. 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 CR2201 through CR2205 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 DA-101 Service Instructions. 060992

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