MAINTENANCE MANUAL
FOR
MTD™ AND DATA RADIO
900 MHz
AUDIO BOARD 19D902304G2

TABLE OF CONTENTS

DESCRIPTION

Audio Board 19D902340G2 used with the MTD™ and DATA RADIO 900 MHz mobile radio provides all Audio, Data, and Tone processing for the radio except for Volume Control and Audio Power Amplifier. The Audio Board interfaces with the logic board, and receives logic signals from the microcontroller for RX, Data/Voice, and TX Data muting. The audio board also contains the receiver squelch circuit with the internal squelch control. A Block Diagram of the audio board is shown in Figure 1.

The audio board is mounted in the top front of the radio housing assembly and connects to the logic board through an 18 pin connector, J703.

The audio board contains the following primary circuits:

- transmit audio and data
- receive audio and data

Both the transmit and receive audio and data signals include tones. A general description of the primary circuit functions followss.

CIRCUIT ANALYSIS

TRANSMIT AUDIO CIRCUITS

Transmit audio includes voice (microphone path), signal tones, and 4800 Baud data (MTX). Audio for the transmit circuit is preemphasized, limited, and coupled through a post limiter (low pass) filter.

Transmit signal tones that are generated on the logic board are filtered to remove any voice band harmonics. When the push-to-talk (PTT) is activated, transmit audio and signal tones are summed, and then coupled through a modem filter to the modulator (TX MOD). MTX data is also summed and filtered in the same circuit for modulation. A Block Diagram of the transmit audio circuits is shown in Figure 2.

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TX Preemphasis, Filter and Limiting Amplifier

Audio from the microphone (MIC HI) is applied to the audio board at J703-8. The 560-ohm resistor provides bias for the mic element. Input to the active filter is AC-coupled through C301.

Operational amplifier U301B and associated circuitry operates as an active 6 dB/octave preemphasis fil-ter (preemphasis from 300 to 3000 Hz), and limiting amplifier. The output of U301B is applied to a post limiter filter circuit.

Clamping diodes D301A and D301B with the voltage divider R302G through R302J, bias the U301B inverting Op Amp at 4 volts, and limit the output to a nominal 3.6 volts peak-to-peak. Controlled limiting is provided by use of regulated power supplies for this circuit.

Post Limiter Filter

The Post Limiter Filter (PLF) following U301B consists of two sets of High/Low Pass filters. Between the RC filters is a third order, multiple feedback low pass filter (U301A). A Chebyshev low pass filter was chosen to minimize passband ripple (0.5 dB) and provide sharp roll off at the high end of the voice band. Roll off for the Post Limiter and Summing amplifier is 28.3 dB/octave.

Summing Amplifier

The Post Limiter voice output is summed into U302A, along with subaudible tones and MTX data. Subaudible tones are audio signals generated on the Logic Board, applied to the Signal Tone input, and passed through the 200 Hz Low Pass Filter to remove the unwanted harmonic energy in the voice band. U302A sums all the TX signals.

Compensation Amplifier

When the DPTT line is low (in the transmit state), the filtered tones are summed into the compensation amp then coupled through the Modem Filter to the "TX MOD" output. A constant set level for these tones is assured with the use of a regulated power supply for the microcontroller and latches on the Logic Board.

MTX Data from the Logic Board's Modeni IC is normally in a high impedance state except when enabled to send data at standard logic levels. To maintain a symmetrical swing about the quiescent bias level, the unloaded input is biased at approximately 2.3 Vdc. Potentiometer R324 adjusts the Data Deviation level. After the MTX Data is biased, it is summed into the Summing Amplifier.

FET Gates

Field Effect Transistor (FET) gates operate as Pchannel switches. FET Q30l operates as a gate for switching the TX Audio signal on or off, and is controlled by the

Mic Mute signal from the microcontroller. When turned off, FET transistor Q302 (controlled by the $\overline{\text{DPTT}}$ line) allows Signal Tones to be summed. MTX Data is summed when Q303 is activated by the $\overline{\text{TX DATA MUTE}}$ input.

Software prevents high speed data (MTX) from being transmitted simultaneously with voice or signal tones.

Modem Filter

Modem Filter U303A and associated circuitry con-sists of two second order, low pass (Butterworth) filters with unity gain. The circuit provides flat passband response, and provides additional transmit path high end roll off (12 dB/octave). From the post limiter filter to the Modem Filter output at J703-1 1, roll off at 3000 Hz is 36 dB/octave. The 20 kHz attenuation for the radio is 84.3 dB minimum, with a 1kz reference. Nominal passband gain is 0.222 V/V.

RECEIVE AUDIO CIRCUITS

Receive audio consists of audio, signal tones, 4800 Baud data (MRX), and squelch detector (CAS). The receive audio is coupled through a 300 Hz, high-pass tone reject filter, and then applied to an audio amplifier with the required deemphasis. Subaudible data is coupled through a 200 Hz low pass, voice reject filter and limiter.

MRX data is AC-coupled to a 3400 Hz low pass filter (data limiter), and then to an inverting comparator with hysteresis. The receiver squelch path consists of a 4.2 kHz high pass filter, a noise rectifier/amplifier and a comparator.

A Block Diagram of the receiver audio circuits is shown in Figure 3.

300 Hz High Pass Filter and Audio Amp

The Discriminator input signal at J703-7 contains both receive audio (voice) and data. The voice path consists of two, third order, 300 Hz high pass (Subaudible Reject) filters. The first is a Butterworth filter (U602A) to provide low ripple in the passband. The second, a Chebyshev (U602B) is for greater attenuation of the low frequencies. The two filters provide 18 dB/Octave of low frequency attenuation and unity gain.

$\overline{\text{S Data/Voice Mute}}$ controls FET transistor Q602 to provide audio mute. $\overline{\text{RX Mute}}$ allows both voice audio and controller-generated Signal tones to be summed at Speech Audio Amplifier U603A. Capacitor C617 provides 6 dB/Octave speech deemphasis for the circuit. The RX Audio output at J703-6 is biased at 5 volts.

200 Hz Low Pass Filter and Tone Limiter

The discriminator audio from the RF Board or the signalling tones from the Logic Board are switched to U605A input. During receive, the discriminator audio at J703-7 passes through the 200 Hz Low Pass Filter and Tone Limiter for Channel Guard or low speed data decoding. During transmit, the signalling tones atJ703-9 pass through the 200 Hz Low Pass Filter for addition of Channel Guard or low speed data onto the mic audio.

The signal from U605A is passed to the 200 Hz Low Pass (Voice Reject) Filter. U604A and U604B make up Frequency Dependent Negative Resistance 1 (FDNR), of the filter. The FDNR mimics an LC ladder circuit. FDNR 1 is used to provide for a sharp roll off at high (voice) frequencies. U604C and U604D of FDNR 2, allow for smoothing of the passband, and continued attenuation of frequencies above 200 Hz.

The FDNR filters are used for transmitter subaudible wave shaping (Channel Guard or low speed data) or receiver subaudible filtering. The receiver subaudible filtering is sent to the Data Limiter (U601D and associated circuitry) for Channel Guard or low speed data decoding.

The output of the filter is passed through buffer amplifier U605B to Data Limiter U60ID. The Liniiter provides wave shaping (5 volt p-p) for the RX Tone Data output at J703-l2.

High Speed Data Limiter

4800 baud MRX data in the Discriminator Audio is AC coupled to an RC type, 3400 Hz low pass filter consisting of R636 and C625. Inverting Comparator U601C provides hysteresis at a nominal 20 dB level below the data signal magnitude.

4200 Hz High Pass Filter

The discriminator output is also applied to a 4200 Hz, fifth order, multiple feedback high pass filter consisting of U605C, U605D and associated circuitry. The filter rejects all RX Tone, Voice, and Data signals.

Squelch Rectifier/Amplifier and Comparator

The noise output of the 4200 Hz highpass Chebyshev filter is applied to Rectifier/Amplifier U603B. The gain of the amplifier is controlled by Squelch Adjust potentiometer R628.

The rectified noise is filtered by R630 and C623 to provide an average DC level proportional to the noise level. This DC level is applied to the inverting (-) input of comparator U601A. The non-inverting (+) input of U601A is referenced to 5.7 Vdc.

The gain of U603B is adjusted by R628 such that when a signal is applied to the receiver and 8 dB SINAD is measured the DC noise level will just fall below the reference voltage and the CAS line goes to + 5 Vdc. When the CAS line is high, the microprocessor on the logic board knows that the channel is busy with a carrier.

As the noise level increases (weaker signal), it will take a level of noise larger than the reference to squelch the radio. The difference between the CAS turn-on and turn-off levels provides sufficient hysteresis to prevent the squelch circuit from chattering.

Thermistors R645 and R646 vary the reference level of U601A over temperature variations to compensate for temperature variations in the receive circuitry, allowing the squelch threshold to be stabilized over a wide temperature range.

QUICK CHECKS

1. Refer to the Block Diagrams (Figures 2 and 3) for proper signal levels and gains for the vanous audio paths.

2. Note the state of the FET switches for muting. These switches are controlled by the Logic Board. If a mute line is high (+ 5 Volts), ground that pin and monitor the results. However if a mute line is low, the line may not be pulled high unless first disconnected from the Logic Board.

3. All bias points (+ 5 Volts) shown on the Audio Board Schematic Diagram are generated by Op Amp U303B. The other Op-Amp circuits will not operate properly without this voltage.

4. When measuring signal levels, remember that inverting (-) inputs of operational amplifiers with feedback, are "virtual grounds". No AC voltages should be present at these ports.

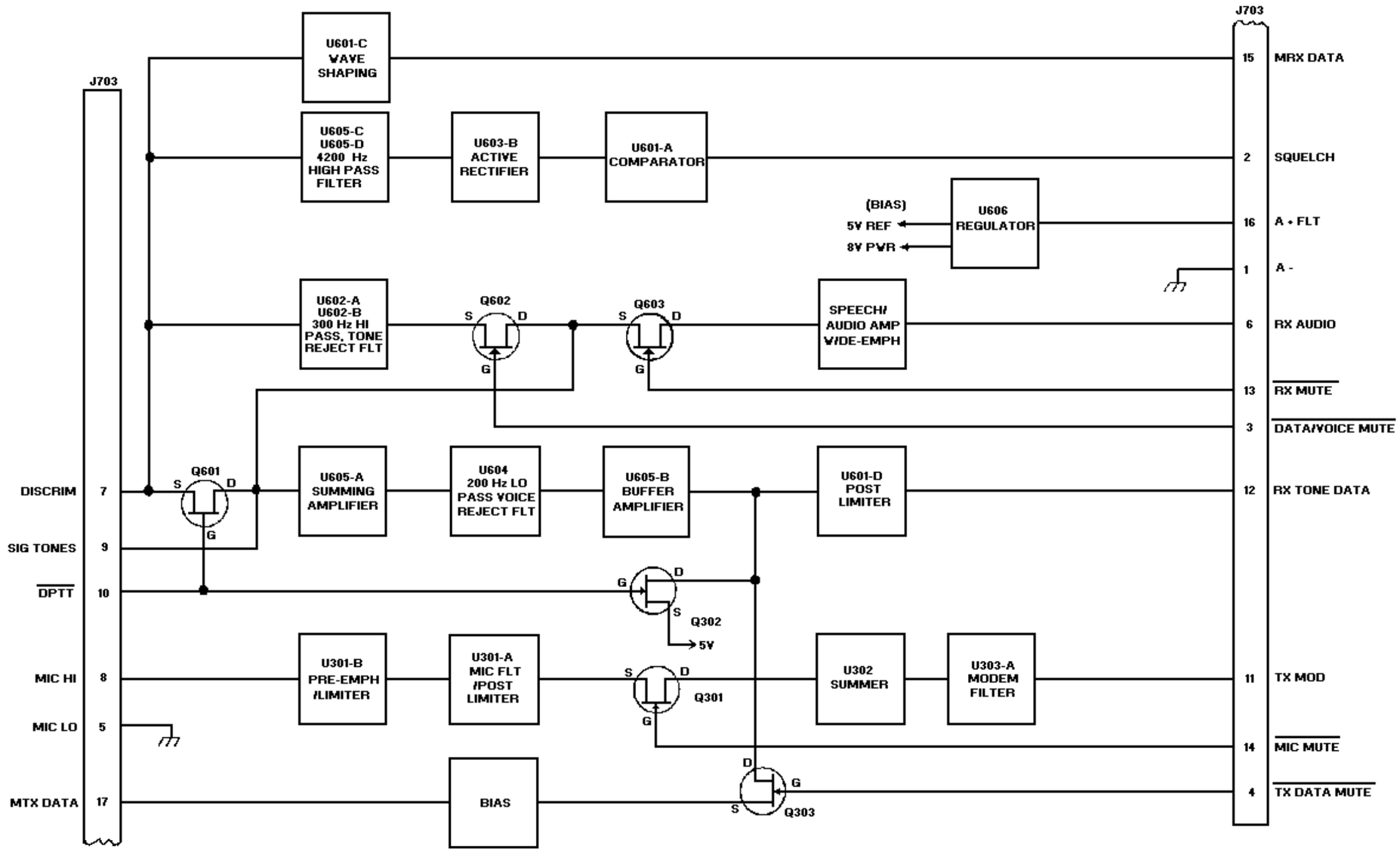


Figure 1 - Audio Board Block Diagram

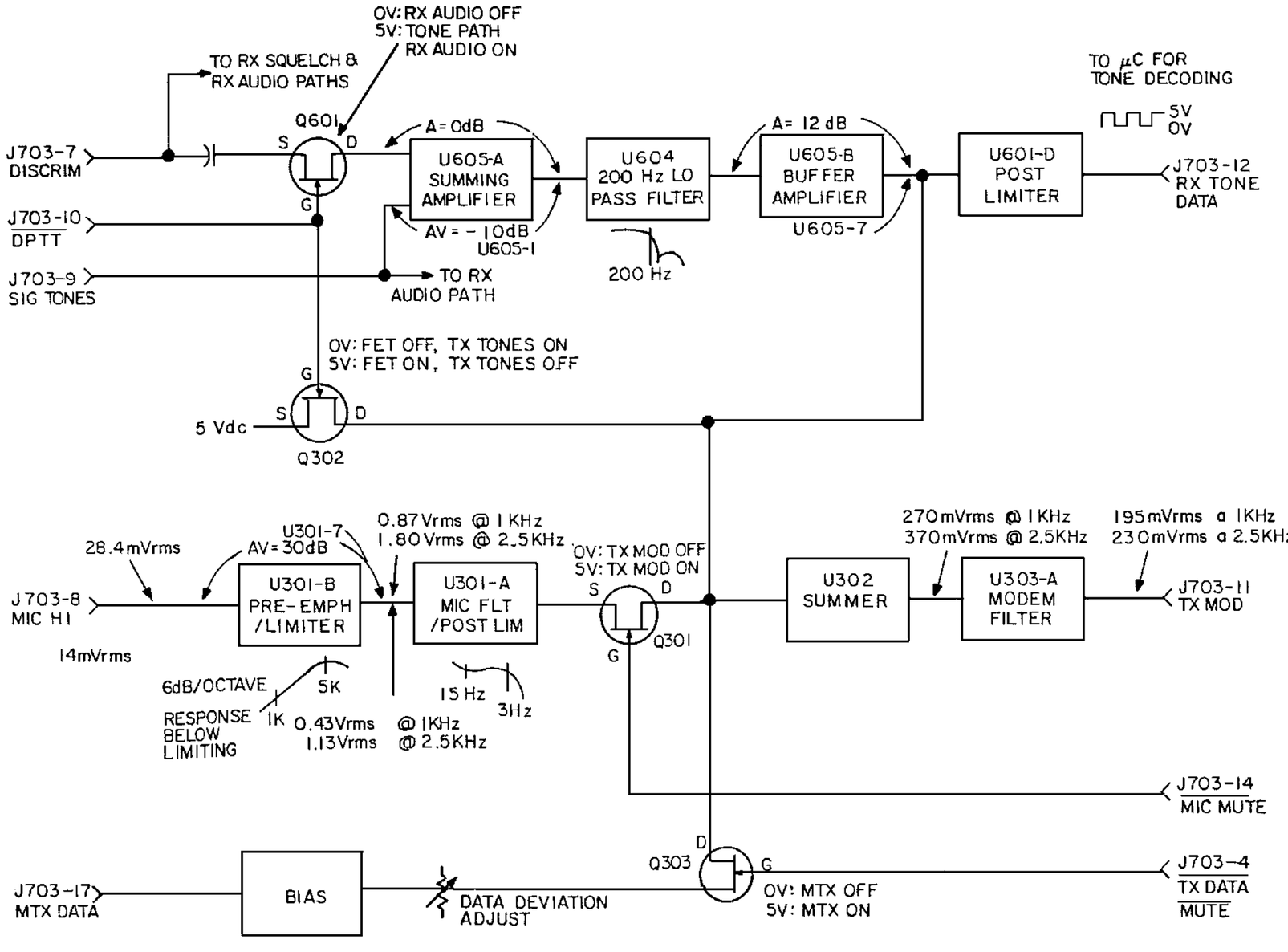


Figure 2 - Transmit Audio Circuits

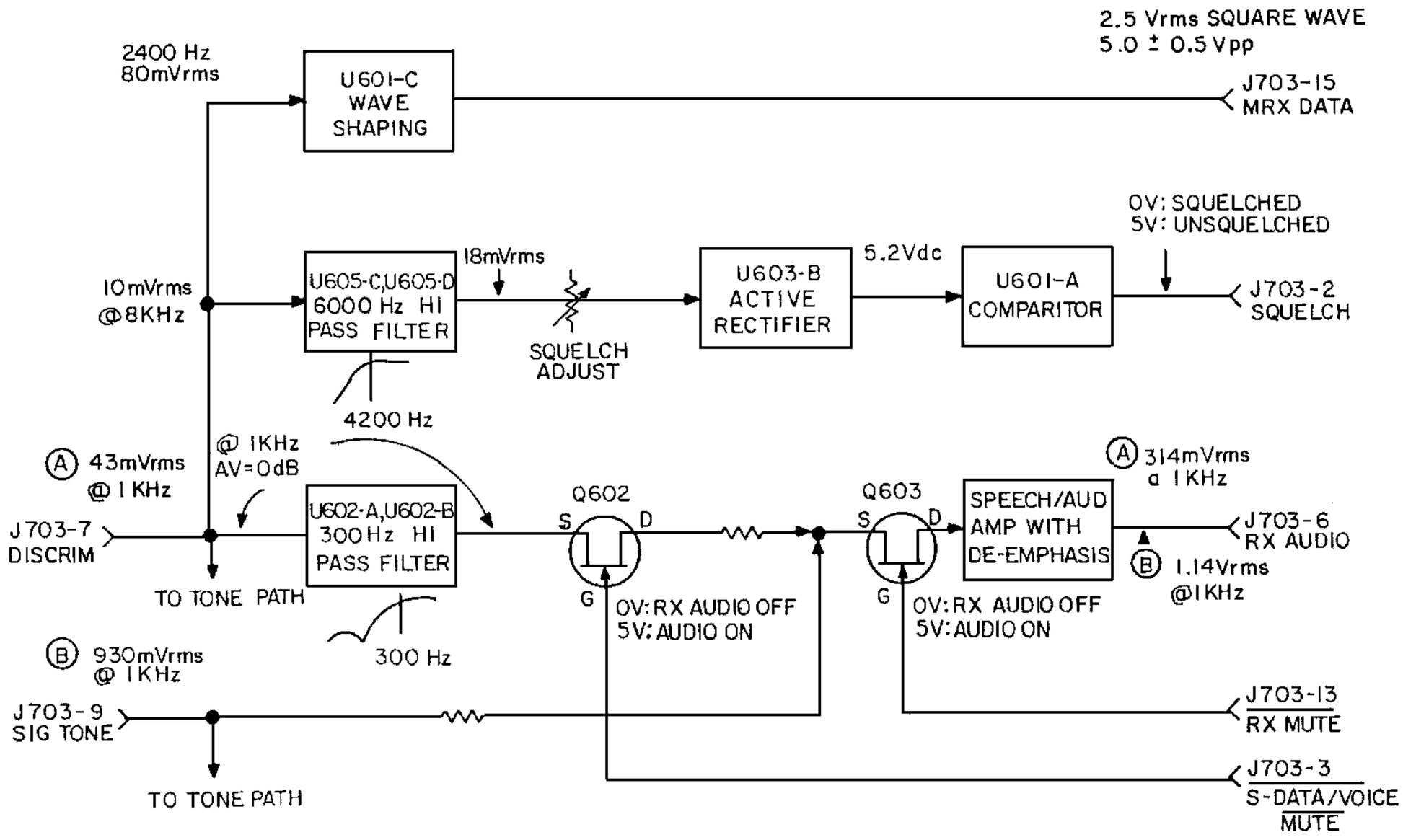


Figure 3 - Receive Audio Circuits

AUDIO BOARD
19D902304G2
ISSUE 2

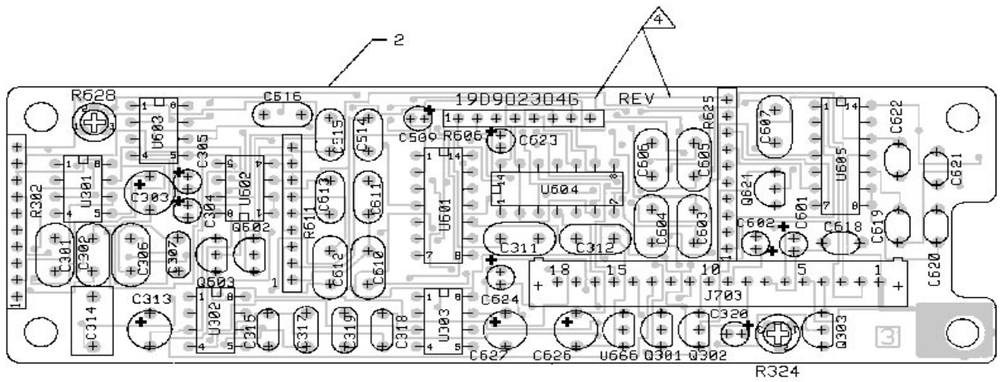
SYMBOL	PART NO.	DESCRIPTION
		---------CAPACITORS ----------
C301	T644ACP410J	Polyester: 0.1 uF ±5%, 50 VDCW.
C302	T644ACP347J	Polyester: .047 uF ±5%, 50 VDCW.
C303	19A701534P9	Tantalum: 47 uF ±20%, 6.3 VDCW.
C304 and C305	19A704879P5	Electrolytic: 10 uF ±20%, 16 VDCW.
C306	T644ACP410J	Polyester: 0.1 uF ±5%, 50 VDCW.
C307	T644ACP315J	Polyester: .015 uF ±5%, 50 VDCW.
C308 thru C310	19A702061P89	Ceramic: 1500 pF ±5%, 50 VDCW, temp coef 0 ±30 PPM.
C311	T644ACP415J	Polyester: .15 uF ±5%, 50 VDCW.
C312	T644ACP347J	Polyester: .047 uF ±5%, 50 VDCW.
C315	19A702052P3	Ceramic: 470 pF ±10%, 50 VDCW.
C316	T644ACP310J	Polyester: .010 uF ±5%, 50 VDCW.
C317	T644ACP322J	Polyester: .022 uF ±5%, 50 VDCW.
C318	T644ACP222J	Polyester: .0022 uF ±5%, 50 VDCW.
C319	T644ACP322J	Polyester: .022 uF ±5%, 50 VDCW.
C320	19A704879P4	Electrolytic: 22 uF ±20%, 50 VDCW.
C601 and C602	19A704879P8	Capacitor, Electrolytic: 2.2 uF ±20%, 50 VDCW.
C603 thru C607	T644ACP368J	Polyester: .068 uF ±5%, 50 VDCW.
C608	19A702052P20	Ceramic: 0.033 uF ±10%, 50 VDCW.
C609	19A704879P6	Electrolytic: 4.7 uF ±20%, 16 VDCW.
C610	T644ACP368J	Polyester: .068 uF ±5%, 50 VDCW.
C611	T644ACP333J	Polyester: .033 uF ±5%, 50 VDCW.
C612	T644ACP368J	Polyester: .068 uF ±5%, 50 VDCW.
C613 thru C616	T644ACP333J	Polyester: .033 uF ±5%, 50 VDCW.
C617	19A702061P93	Ceramic: 2200 pF ±5%, 50 VDCW; temp coef 0 ±30 PPM.
C618 thru C622	T644ACP210J	Polyester: .0010 uF ±5%, 50 VDCW.
C623	19A704879P9	ELectrolytic: 1 uF ±20%, 50 VDCW.
C624	19A704879P8	Capacitor, Electrolytic: 2.2 uF ±20%, 50 VDCW.
C625	19A702052P14	Ceramic: 0.01 uF ±10%, 50 VDCW.
C626	19A701534P7	Tantalum: 10 uF ±20%, 16 VDCW.
C627	19A701534P4	Tantalum: 1 uF ±20%, 35 VDCW.
		---------- DIODES ----------
D301	19A700053P2	Silicon: 2 Diodes in Series; sim to BAV99.
D601	19A700053P2	Silicon: 2 Diodes in Series; sim to BAV99.
		----------JACKS ----------
J703	19A704874P1	Connector: sim to: Elco 00-9021-18-12-00-339.
		-------- TRANSISTORS ----------
Q301 thru Q303	19A134137P7	N-type, field effect.
Q601 thru Q603	19A134137P7	N-type, field effect.

* COMPONENTS ADDED, DELETED OR CHANGED BY PRODUCTION CHANGES

SYMBOL	PART NO.	DESCRIPTION
		--------RESISTORS ----------
R301	19B800607P561	Metal film: 560 ohms ±5%, 1/8 w.
R302	19A704885P6	Resistor Network, Custom: 10 Pins, .125 W.
R303	19B800607P332	Metal film: 3.3K ohms ±5%, 1/8 w.
R304	19A702931P381	Metal film: 68.1K ohms ±1%, 200 VDCW, 1/8 w.
R305	19A702931P401	Metal film: 100K ohms ±1%, 200 VDCW, 1/8 w.
R306 thru R308	19A702931P301	Metal film: 10K ohms ±1%, 200 VDCW, 1/8 w.
R309	19B800607P122	Metal film: 1.2K ohms ±5%, 1/8 w.
R310	19B800607P222	Metal film: 2.2K ohms ±5%, 1/8 w.
R311	19B800607P473	Metal film: 47K ohms ±5%, 1/8 w.
R312	19B800607P564	Metal film: 560K ohms ±5%, 1/8 w.
R313	19B800607P104	Metal film: 100K ohms ±5%, 1/8 w.
R315 and R316	19B800607P333	Metal film: 33K ohms ±5%, 1/8 w.
R318	19A702931P269	Metal film: 5110 ohms ±1%, 200 VDCW, 1/8 w.
R319	19A702931P201	Metal film: 1000 ohms ±1%, 200 VDCW, 1/8 w.
R320	19A702931P322	Metal film: 16.5K ohms ±1%, 200 VDCW, 1/8 w.
R321	19A702931P210	Metal film: 1240 ohms ±1%, 200 VDCW, 1/8 w.
R322	19B800607P124	Metal film: 120K ohms ±5%, 1/8 w.
R323	19B800607P104	Metal film: 100K ohms ±5%, 1/8 w.
R324	19B800779P10	Variable: 10K ohms ±25%, 100 VDCW, .3 watt.
R325	19A702931P301	Metal film: 10K ohms ±1%, 200 VDCW, 1/8 w.
R326	19B800607P471	Metal film: 470 ohms ±5%, 1/8 w.
R601	19B800607P104	Metal film: 100K ohms ±5%, 1/8 w.
R602	19B800607P683	Metal film: 68K ohms ±5%, 1/8 w.
R603	19B800607P224	Metal film: 220K ohms ±5%, 1/8 w.
R604	19B800607P683	Metal film: 68K ohms ±5%, 1/8 w.
R605	19A704885P9	Resistor Network, Custom: 10 pins, .125 W.
R606	19A704885P10	Resistor Network, Custom: 8 pins, .125 W.
R607	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R608	19B800607P105	Metal film: 1M ohms ±5%, 1/8 w.
R609	19B800607P125	Metal film: 1.2M ohms ±5%, 1/8 w.
R610	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R611	19A704885P8	Resistor Network, Custom: 9 pins, .125 W.
R612	19A702931P289	Metal film: 8250 ohms ±1%, 200 VDCW, 1/8 w.
R613	19A702931P333	Metal film: 21.5K ohms ±1%, 200 VDCW, 1/8 w.
R614	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R615	19B800607P822	Metal film: 8.2K ohms ±5%, 1/8 w.
R616	19B800607P224	Metal film: 220K ohms ±5%, 1/8 w.
R617	19B800607P563	Metal film: 56K ohms ±5%, 1/8 w.
R618	19A702931P409	Metal film: 121K ohms ±1%, 200 VDCW, 1/8 w.
R619	19A702931P289	Metal film: 8250 ohms ±1%, 200 VDCW, 1/8 w.
R620	19A702931P281	Metal film: 6810 ohms ±1%, 200 VDCW, 1/8 w.
R621	19A702931P385	Metal film: 75K ohms ±1%, 200 VDCW, 1/8 w.
R622	19A702931P374	Metal film: 57.6K ohms ±1%, 200 VDCW, 1/8 w.
R623	19A702931P341	Metal film: 26.1K ohms ±1%, 200 VDCW, 1/8 w.
R624 and R625	19A702931P301	Metal film: 10K ohms ±1%, 200 VDCW, 1/8 w.
R626	19B800607P562	Metal film: 5.6K ohms ±5%, 1/8 w.
R627	19B800607P223	Metal film: 22K ohms ±5%, 1/8 w.
R628	19B800779P16	Variable: 100K ohms ±25%, 100 VDCW, .3 watt.
R629	19B800607P332	Metal film: 3.3K ohms ±5%, 1/8 w.

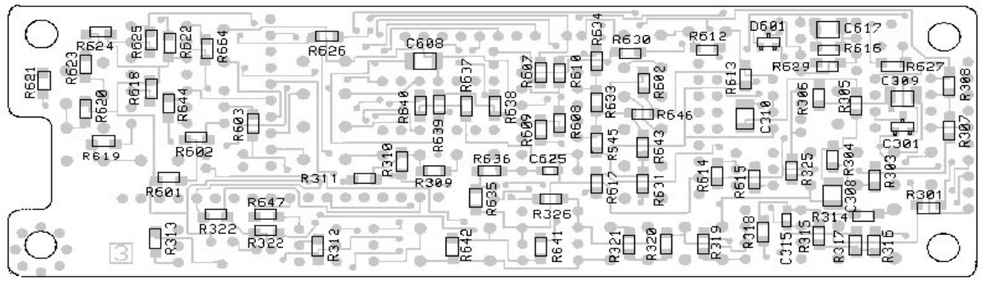
SYMBOL	PART NO.	DESCRIPTION
R630	19B800607P223	Metal film: 22K ohms ±5%, 1/8 w.
R631	19A702931P312	Metal film: 13.0K ohms
R632	19A702931P255	Metal film: 3650 ohms 1%, 200 VDCW, 1/8 w.
R633	19B800607P104	Metal film: 100K ohms 5%, 1/8 w.
R634	19B800607P332	Metal film: 3.3K ohms ±5%, 1/8 w.
R635	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R636	19B800607P472	Metal film: 4.7K ohms ±5%, 1/8 w.
R637	19B800607P153	Metal film: 15K ohms ±5%, 1/8 w.
R638	19B800607P105	Metal film: 1M ohms ±5%, 1/8 w.
R639	19B800607P125	Metal film: 1.2M ohms ±5%, 1/8 w.
R640	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R641	19B800607P562	Metal film: 5.6K ohms ±5%, 1/8 w.
R642	19B800607P103	Metal film: 10K ohms ±5%, 1/8 w.
R643	19B800607P272	Metal film: 2.7K ohms ±5%, 1/8 w.
R644	19B800607P104	Metal film: 100K ohms ±5%, 1/8 w.
R645	19A705813P1	Thermistor: sim to AL03006-624-73-G100.
R646	19A705813P2	Thermistor: sim to AL03006-58.2K-97-G100.
R647	19B800607P223	Metal film: 22K ohms ±5%, 1/8 w.
		-----INTEGRATED CIRCUITS ------
U301 thru U303	19A700086P4	Linear: Dual Op Amp; sim to 4558.
U601	19A134764P1	Linear: Quad Voltage Comparator; sim to LM339N.
U602 and U603	19A700086P4	Linear: Dual Op Amp; sim to 4558.
U604 and U605	19A701789P1	Linear: Quad Op Amp; sim to LM324.
U606	19A704073P2	Linear: 8 Volt Regulator; sim to MC78L08CP.

COMPONENT SIDE



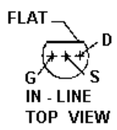
(19D902304, Sh. 1, Rev. 3)
(19D902305, Component Side, Rev. 3)

SOLDER SIDE



(19D902304, Sh. 1, Rev. 3)
(19D902305, Solder Side, Rev. 3)

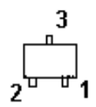
LEAD IDENTIFICATION
FOR Q301 - Q303 & Q601 - Q603



IN - LINE
TOP VIEW

NOTE: CASE SHAPE IS DETERMINING FACTOR FOR LEAD IDENTIFICATION

LEAD IDENTIFICATION
FOR D301 & D601



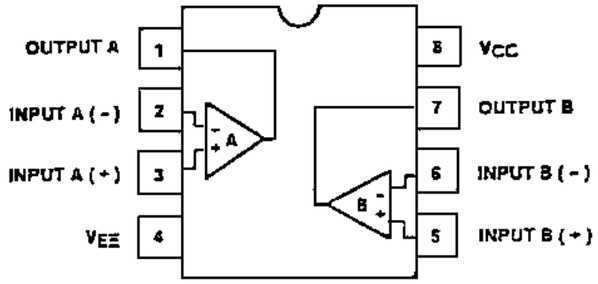
VIEW FROM SOLDER SIDE

(1) NOTES:

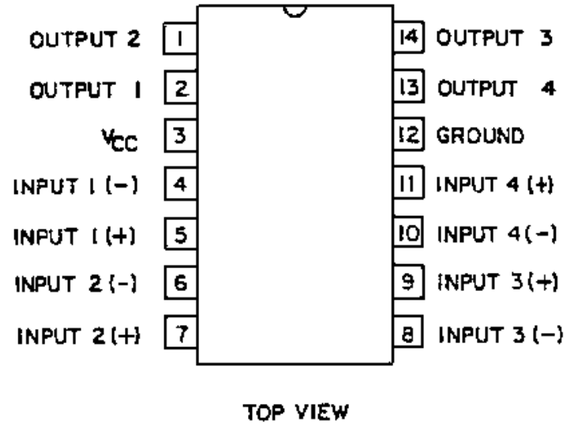
1. SOLDER ALL ELECTRICAL CONNECTIONS.
2. COMPONENT LEDS TO PROTRUDE 2 MAX. BELOW SOLDER SIDE OF BOARD.
3. INDICATES FRONT OF COMPONENT AUTO - INSERTION MACHINES.
4. MARK APPLICABLE GROUP AND REVISION PER 19A115740P1, 2.3 HIGH, COLOR BLACK FOR LATEST REVISION, SEE REVISION LETTER INDEX 19C851659.
5. P703 SHALL BE FLUSH TO PWB WITHIN 0.25.
6. THE MAX HEIGHT ABOVE THE PWB OF ALL PARTS IN THE AI GROUP MUST BE MAINTAINED WHEN THOSE PARTS ARE NOT AI'D.
7. PIN 1 OF R605, R606, R611, & R302 IDENTIFIED BY DOT, COLOR STRIPE, VENDORS LOGO, OR NOTCH.

CAUTION
OBSERVE PRECAUTIONS FOR HANDLING
ELECTROSTATIC SENSITIVE DEVICES

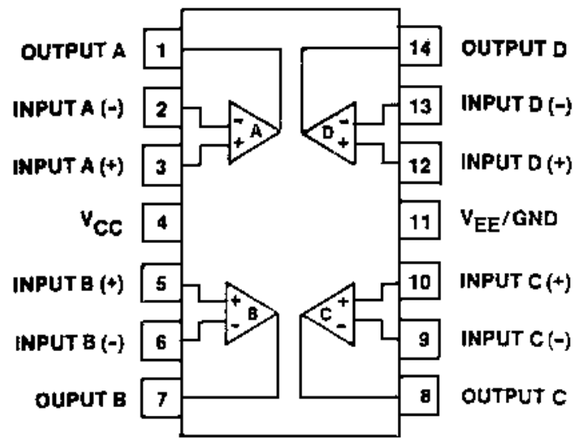
OPERATIONAL AMPLIFIER
U301-U303, U602 & U603
19A700086P4



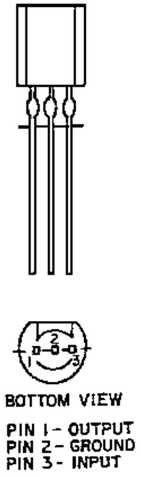
OPERATIONAL AMPLIFIER
U601
19A134764P1

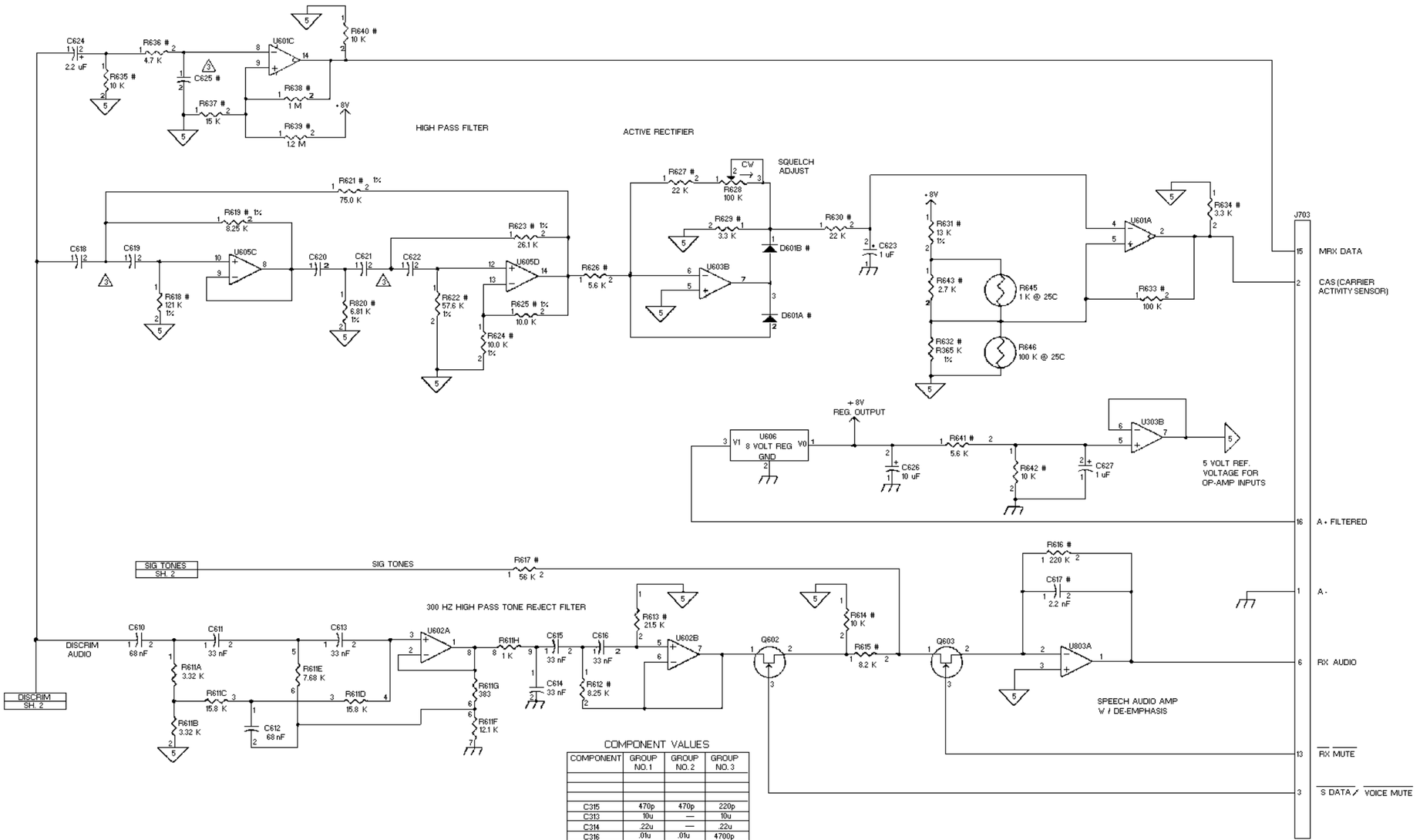


OPERATIONAL AMPLIFIER
U604, U605
19A701789P1



VOLTAGE REGULATOR
U606
19A704073P2





MODEL NO.	REV. LETTER
19D902304G1	B
19D902304G2	
19D902304G3	

COMPONENT VALUES

COMPONENT	GROUP NO.1	GROUP NO.2	GROUP NO.3
C315	470p	470p	220p
C313	10u	—	10u
C314	.22u	—	.22u
C316	.01u	.01u	4700p
C317	.022u	.022u	.01u
C318	2200p	2200p	
C319	.022u	.022u	.01u
C618	1000p	1000p	680p
C619	1000p	1000p	680p
C620	1000p	1000p	680p
C621	1000p	1000p	680p
C622	1000p	1000p	680p
C625	.01u	.01u	—
R311	47K	47K	47K
R312	470K	560K	150K
R313	47K	104K	47K
R314	33K	—	47K
R315	270K	33K	270K
R316	270K	33K	270K
R317	10K	—	10K
R603	220K	220K	680K

NOTES:
1. ALL RESISTORS ARE 1/8 WATT UNLESS OTHERWISE SPECIFIED AND RESISTOR VALUES IN OHMS UNLESS FOLLOWED BY K = 1000 OHMS OR M = 1,000,000 OHMS. CAPACITOR VALUES IN PICOFARADS (EQUAL TO MICROMICROFARADS) UNLESS FOLLOWED BY u = MICROFARADS. INDUCTANCE VALUES IN MICROHENRYS UNLESS FOLLOWED BY MH = MILLIHENRYS OR H = HENRYS.
2. # INDICATES CHIP COMPONENT LOCATED ON SOLDER SIDE OF PWB.
3. SEE CHART FOR COMPONENT VALUES.

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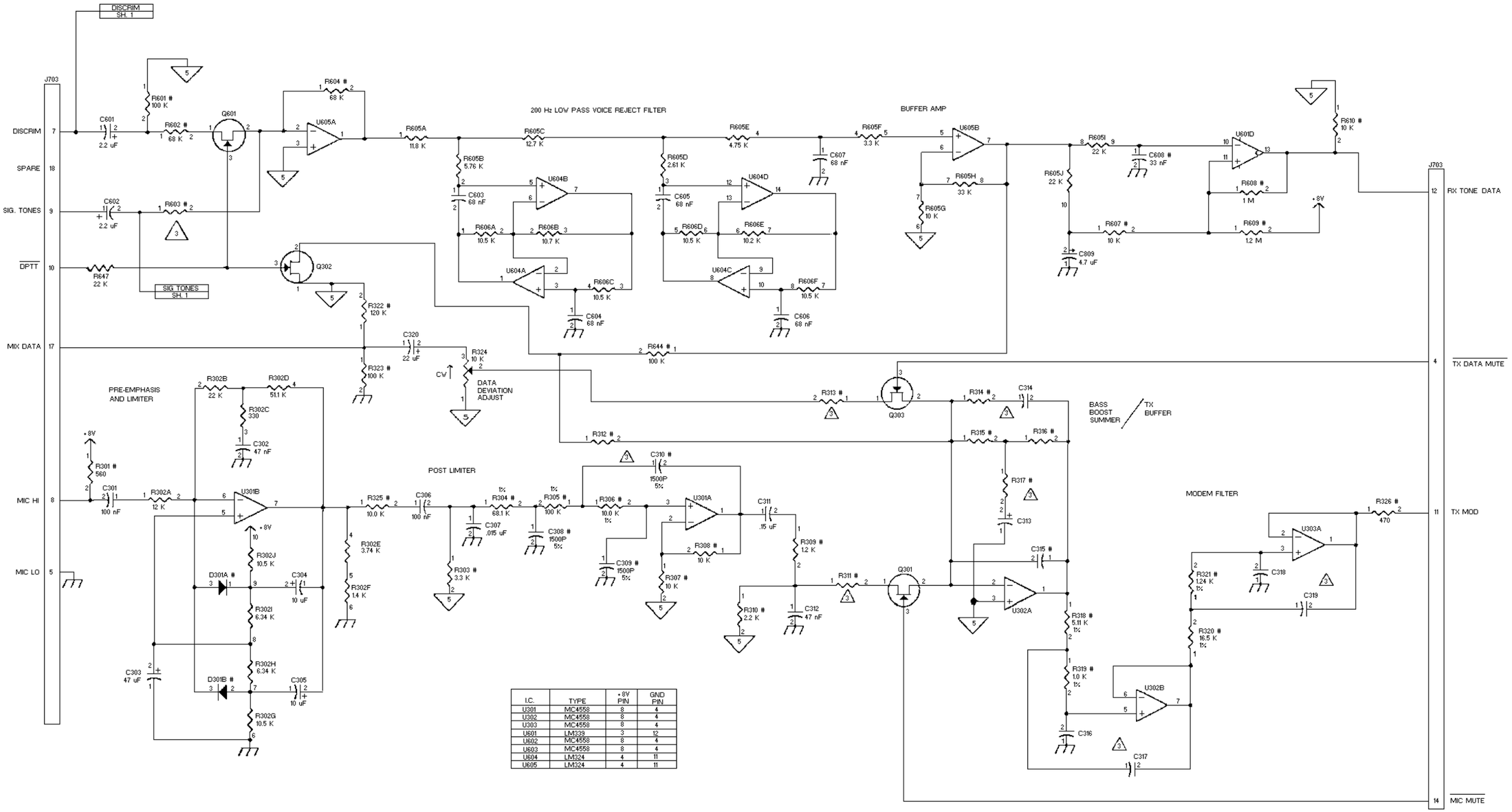

AUDIO BOARD
19D902304G2

(19D902306, Sh. 2, Rev. 7)