# MAINTENANCE MANUAL FOR GE-NET TMX™ AUDIO BOARD 19D902047G1

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## DESCRIPTION

Audio Board 19D902047G1 used with the GE-NET TMX™ 900 MHz trunked 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 follows.

## 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 ($\overline{PTT}$) 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 before modulation. A Block Diagram of the transmit audio circuits is shown in Figure 2.

#### TX Preemphasis, Filter andLimiting Amplifier

Audio from the microphone (MIC HI) is applied to the audio board at J703-8. The 560-ohm resistor sets the input impedance. Input to the active filter is DC-coupled through C301. The +8 Volts developed across R301 provides for microphone signal reception.

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

lamping 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 (0.5dB) 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.

19D902304G1





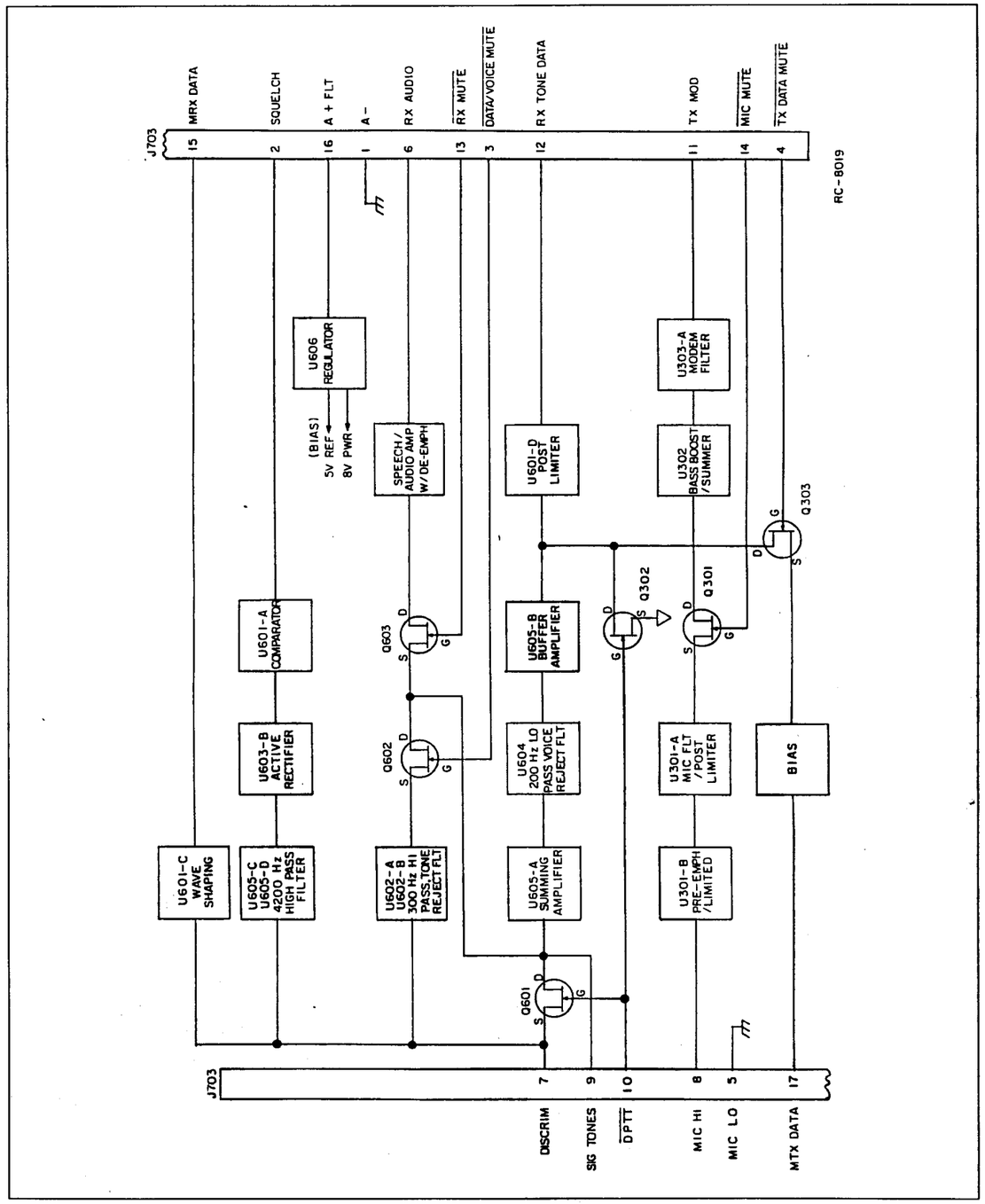



Figure 1 - Audio Board Block Diagram

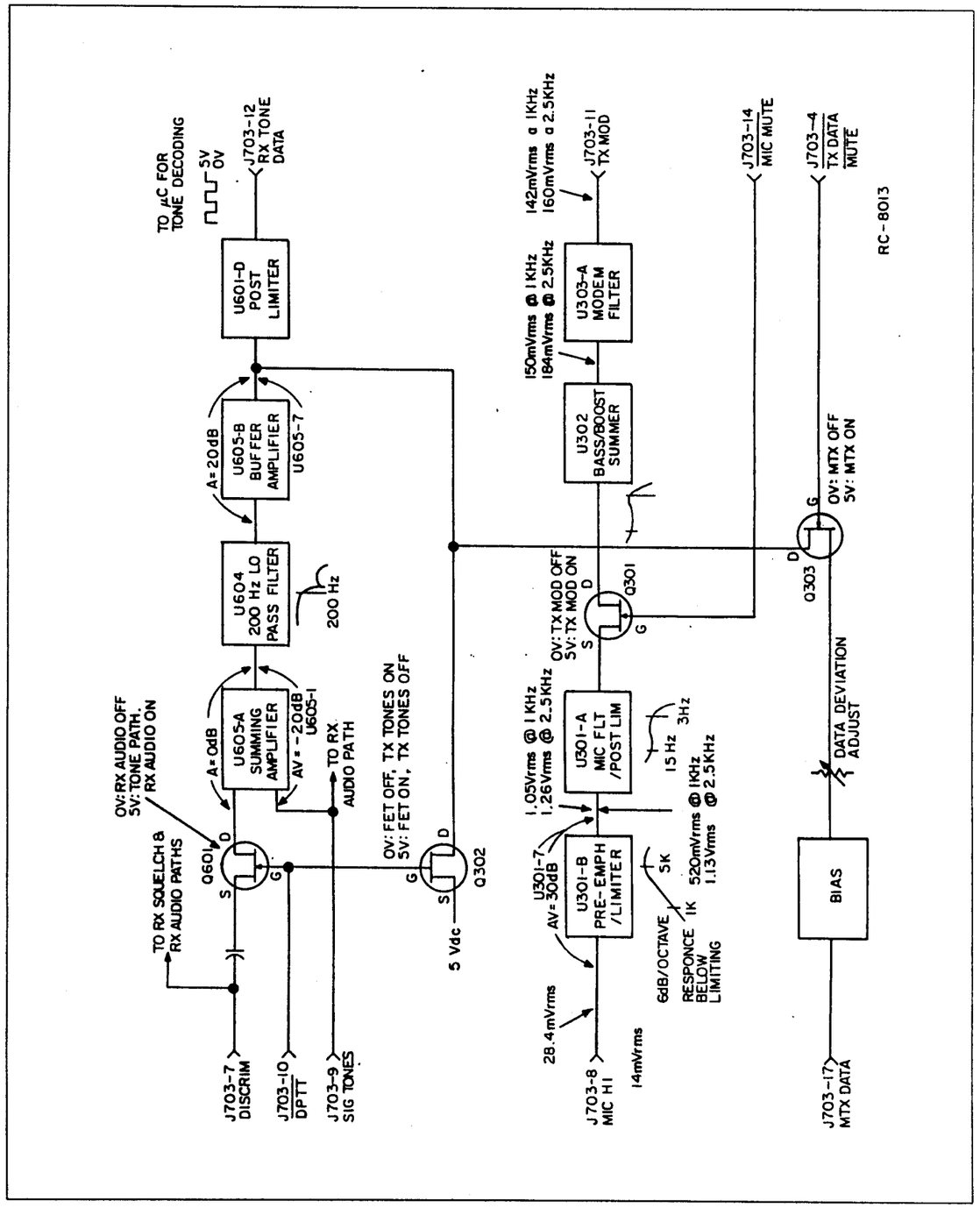



Figure 2- Transmit Audio Circuits





Summing Amplifier

The Post Limiter Filter sums the voice input into the low frequency compensation (Bass Boost) amplifier, 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 the TX signals while amplifying those frequencies below 10 Hz. The gain is required to provide low frequency compensation for synthesizer modulation.

Compensation Amplifier

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

MTX Data from the Logic Board's Modem 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 Bass Boost Amplifier.

FET Gates

Field Effect Transistor (FET) gates operate as P-channel switches. FET Q301 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.

Modem Filter

Modem Filter U303A and associated circuitry consists 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 J703-11, roll off at 3000 Hz is 36dB/Octave. The 20 kHz attenuation for the radio is 84.3 dB minimum, with a 1K 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

Subaudible RX Signals at J703-9 are summed at U605A when the $\overline{\text{DPTT}}$ is low (FET Q601 enabled). This path is also used by TX Signals. The gate also allows for bypassing the filter for decoding transmitting signals greater than 200 Hz. The signal from the summer 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 output of the filter is passed through buffer amplifier U605B to Data Limiter U601D. The Limiter

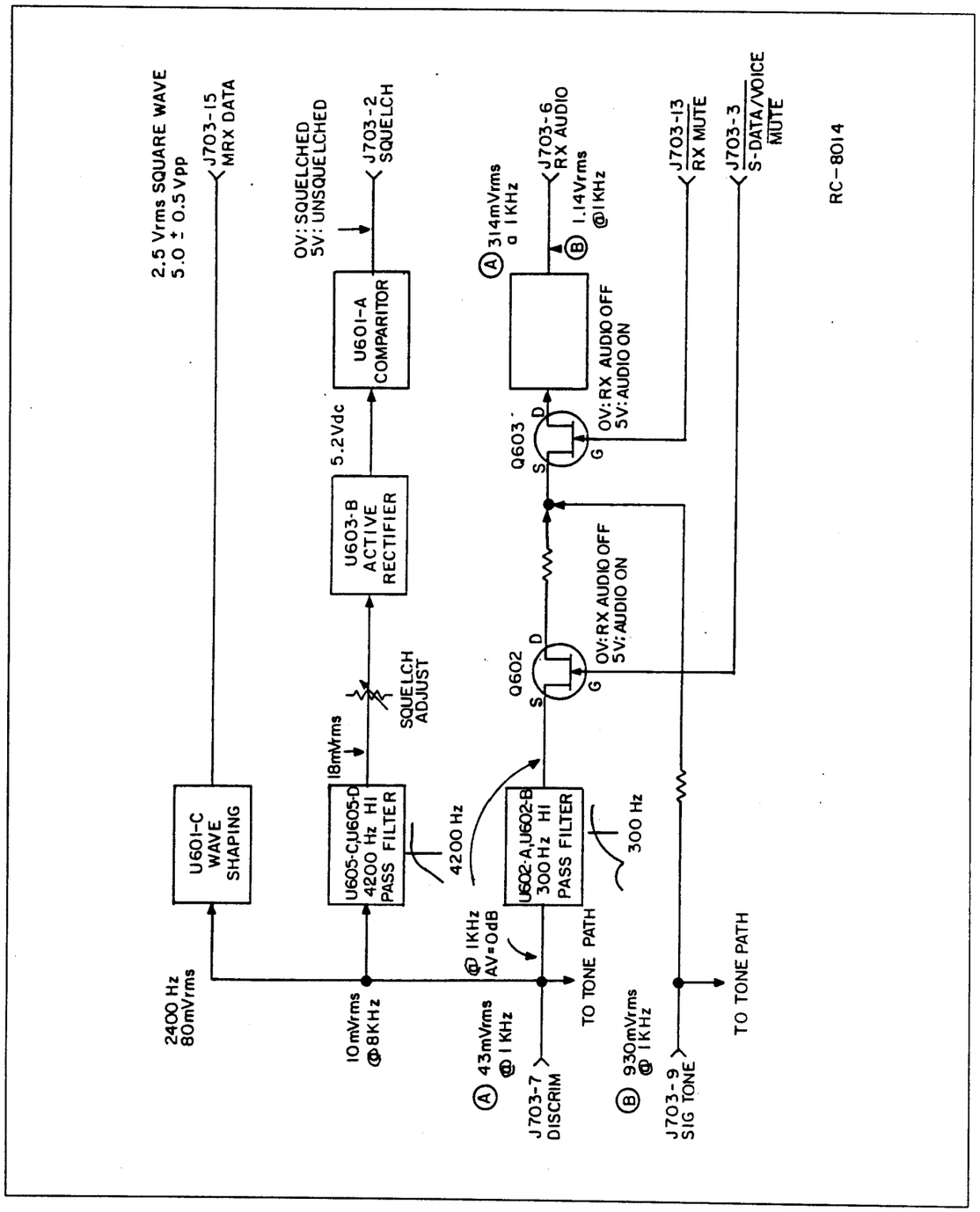



Figure 3 - Receive Audio Circuits





provides wave shaping (5 volt p-p) for the RX Tone Data output at J703-12.

3400 Hz Data Limiter

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.

Rectifier/Amplifier and Comparator

The noise output of the 4200 Hz highpass Chebyshev filter is applied to Rectifier/Amplifier U603B for comparison to the + 5 Volt reference at the Squelch Comparator (U601A).

A channel exhibits more noise when no signal is being received. When the receiver is squelched, the comparator CAS output (squelch) at J703-2 is low. Hysteresis is provided to prevent the squelch circuit from chattering. Receive sensitivity (signal to noise/distortion) is set nominally to an 8 dB sinad level with R628.

## QUICK CHECKS

1. Refer to the Block Diagrams (Figures 2 and 3) for proper signal levels and gains for the various 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 (+5Volts), 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, with feedback, are "virtual grounds". No AC voltages should be present at these ports.

GE Mobile Communications

General Electric Company
Lynchburg, Virginia 24502

Printed in U.S.A.

## PARTS LIST

AUDIO BOARD
19D902047G1
ISSUE 2

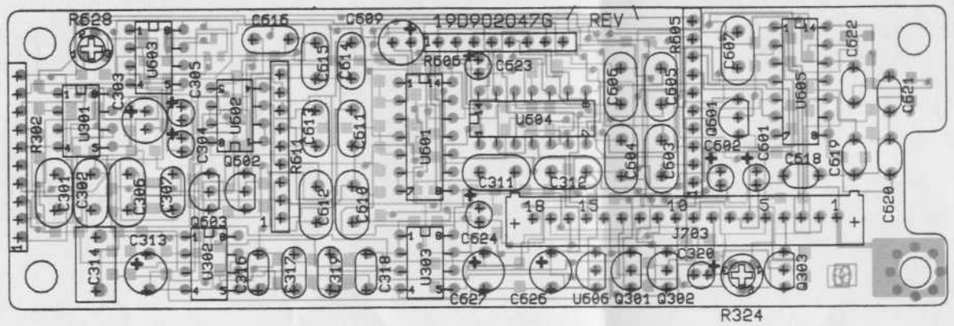
| SYMBOL | GE PART NO. | DESCRIPTION |
|---|---|---|
| | | - - - - - - - - - - CAPACITORS - - - - - - - - - - |
| C301 | T644ACP410J | Polyester: 0.1 uF + or -5%, 50 VDCW. |
| C302 | T644ACP347J | Polyester: .047 uF + or -5%, 50 VDCW. |
| C303 | 19A704879P2 | Electrolytic: 47 uF + or -20%, 16 VDCW. |
| C304 and C305 | 19A704879P5 | Electrolytic: 10 uF + or -20%, 16 VDCW. |
| C306 | T644ACP410J | Polyester: 0.1 uF + or -5%, 50 VDCW. |
| C307 | T644ACP315J | Polyester: .015 uF + or -5%, 50 VDCW. |
| C308 thru C310 | 19A702061P89 | Ceramic: 1500 pF + or - 5%, 50 VDCW, temp coef 0 + or - 30 PPM. |
| C311 | T644ACP415J | Polyester: .15 uF + oor -5%, 50 VDCW. |
| C312 | T644ACP347J | Polyester: .047 uF + or -5%, 50 VDCW. |
| C313 | 19A701534P7 | Tantalum: 10 uF + or -20%, 16 VDCW. |
| C314 | 19A700004P4 | Metallized polyester: 0.22 uF + or - 10%, 63 VDCW. |
| C315 | 19A702052P3 | Ceramic: 470 pF + or - 10%, 50 VDCW. |
| C316 | T644ACP310J | Polyester: .010 uF + or -5%, 50 VDCW. |
| C317 | T644ACP322J | Polyester: .022 uF + or -5%, 50 VDCW. |
| C318 | T644ACP222J | Polyester: .0022 uF + or -5%, 50 VDCW. |
| C319 | T644ACP322J | Polyester: .022 uF + or -5%, 50 VDCW. |
| C320 | 19A704879P4 | Electrolytic: 22 uF + or -20%, 50 VDCW. |
| C601 and C602 | 19A704879P8 | Capacitor, Electrolytic: 1.2uF + or - 20%, 50 VDCW. |
| C603 thru C607 | T644ACP368J | Polyester: .068 uF + or -5%, 50 VDCW. |
| C608 | 19A702052P20 | Ceramic: 0.033 uF + or - 10%, 50 VDCW. |
| C609 | 19A704879P2 | Electrolytic: 47 uF + or -20%, 16 VDCW. |
| C610 | T644ACP368J | Polyester: .068 uF + or -5%, 50 VDCW. |
| C611 | T644ACP333J | Polyester: .033 uF + or -5%, 50 VDCW. |
| C612 | T644ACP368J | Polyester: .068 uF + or -5%, 50 VDCW. |
| C613 thru C616 | T644ACP333J | Polyester: .033 uF + or -5%, 50 VDCW. |
| C617 | 19A702061P93 | Ceramic: 2200 pF + or - 5%, 50 VDCW, temp coef 0 + or - 30 PPM. |
| C618 thru C622 | T644ACP210J | Polyester: .0010 uF + or -5%, 50 VDCW. |
| C623 | 19A704879P9 | Electrolytic: 1 uF + or -20%, 50 VDCW. |
| C624 | 19A704879P8 | Capacitor, Electrolytic: 2.2uF + or - 20%, 50 VDCW. |
| C625 | 19A702052P14 | Ceramic: 0.01 uF + or - 10%, 50 VDCW. |
| C626 and C627 | 19A701534P7 | Tantalum: 10 uF + or -20%, 16 VDCW. |
| | | - - - - - - - - - - DIODES - - - - - - - - - - |
| D301 | 19A700053P2 | Silicon, fast recovery (2 diodes in series). |
| D601 | 19A700053P2 | Silicon, fast recovery (2 diodes in series). |
| | | - - - - - - - - - - JACKS - - - - - - - - - - |
| J703 | 19A704874P1 | Connector: sim to: Elco 00-9021-18-12-00-339. |

| SYMBOL | GE PART NO. | DESCRIPTION |
|---|---|---|
| | | - - - - - - - - - - TRANSISTORS - - - - - - - - - - |
| Q301 thru Q303 | 19A134137P7 | N-type, field effect. |
| Q601 thru Q603 | 19A134137P7 | N-type, field effect. |
| | | - - - - - - - - - - RESISTORS - - - - - - - - - - |
| R301 | 19B800607P561 | Metal film: 560 ohms + or - 5%, 200 VDCW, 1/8 w. |
| R302 | 19A704885P6 | Resistor Network, Custom: 10 Pins, .125 W. |
| R303 | 19B800607P682 | Metal film: 6.8K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R304 | 19A702931P381 | Metal film: 68.1K ohms + or -1%, 200 VDCW, 1/8 w. |
| R305 | 19A702931P401 | Metal film: 100K ohms + or -1%, 200 VDCW, 1/8 w. |
| R306 thru R308 | 19A702931P301 | Metal film: 10K ohms + or -1%, 200 VDCW, 1/8 w. |
| R309 | 19B800607P272 | Metal film: 2.7K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R310 | 19B800607P102 | Metal film: 1K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R311 | 19B800607P473 | Metal film: 47K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R312 | 19B800607P474 | Metal film: 470K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R313 | 19B800607P473 | Metal film: 47K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R314 | 19B800607P333 | Metal film: 33K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R315 and R316 | 19B800607P274 | Metal film: 270K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R317 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R318 | 19A702931P269 | Metal film: 5110 ohms + or -1%, 200 VDCW, 1/8 w. |
| R319 | 19A702931P201 | Metal film: 1000 ohms + or -1%, 200 VDCW, 1/8 w. |
| R320 | 19A702931P322 | Metal film: 16.5K ohms + or -1%, 200 VDCW, 1/8 w. |
| R321 | 19A702931P210 | Metal film: 1240 ohms + or -1%, 200 VDCW, 1/8 w. |
| R322 | 19B800607P124 | Metal film: 120K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R323 | 19B800607P104 | Metal film: 100K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R324 | 19B800779P16 | Variable, 100K ohms, + or -25%, 100 VDCW, 3 watt. |
| R325 | 19A702931P269 | Metal film: 5110 ohms + or -1%, 200 VDCW, 1/8 w. |
| R326 | 19B800607P471 | Metal film: 470 ohms + or - 5%, 200 VDCW, 1/8 w. |
| R601 | 19B800607P104 | Metal film: 100K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R602 | 19B800607P683 | Metal film: 68K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R603 | 19B800607P224 | Metal film: 220K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R604 | 19B800607P683 | Metal film: 68K ohms + or - 5%, 200 VDCW, 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 + or - 5%, 200 VDCW, 1/8 w. |
| R608 | 19B800607P105 | Metal film: 1M ohms + or - 5%, 200 VDCW, 1/8 w. |
| R609 | 19B800607P125 | Metal film: 1.2M ohms + or - 5%, 200 VDCW, 1/8 w. |
| R610 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R611 | 19A704885P8 | Resistor Network, Custom: 9 pins, .125 W. |
| R612 | 19A702931P289 | Metal film: 8250 ohms + or -1%, 200 VDCW, 1/8 w. |
| R613 | 19A702931P333 | Metal film: 21.5K ohms + or -1%, 200 VDCW, 1/8 w. |
| R614 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R615 | 19B800607P822 | Metal film: 8.2K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R616 | 19B800607P224 | Metal film: 220K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R617 | 19B800607P563 | Metal film: 56K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R618 | 19A702931P409 | Metal film: 121K ohms + or -1%, 200 VDCW, 1/8 w. |

| SYMBOL | GE PART NO. | DESCRIPTION |
|---|---|---|
| R619 | 19A702931P289 | Metal film: 8250 ohms + or -1%, 200 VDCW, 1/8 w. |
| R620 | 19A702931P281 | Metal film: 6810 ohms + or -1%, 200 VDCW, 1/8 w. |
| R621 | 19A702931P385 | Metal film: 75K ohms + or -1%, 200 VDCW, 1/8 w. |
| R622 | 19A702931P374 | Metal film: 57.6K ohms + or -1%, 200 VDCW, 1/8 w. |
| R623 | 19A702931P341 | Metal film: 26.1K ohms + or -1%, 200 VDCW, 1/8 w. |
| R624 and R625 | 19A702931P301 | Metal film: 10K ohms + or -1%, 200 VDCW, 1/8 w. |
| R626 | 19B800607P562 | Metal film: 5.6K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R627 | 19B800607P223 | Metal film: 22K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R628 | 19B800779P16 | Variable, 100K ohms, + or -25%, 100 VDCW, 3 watt. |
| R629 | 19B800607P332 | Metal film: 3.3K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R630 | 19B800607P223 | Metal film: 22K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R631 | 19A702931P212 | Metal film: 13K ohms + or - 1%, 200 VDCW, 1/8 w. |
| R632 | 19B800607P332 | Metal film: 3.3K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R633 | 19B800607P104 | Metal film: 100K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R634 | 19B800607P332 | Metal film: 3.3K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R635 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R636 | 19B800607P472 | Metal film: 4.7K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R637 | 19B800607P153 | Metal film: 15K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R638 | 19B800607P105 | Metal film: 1M ohms + or - 5%, 200 VDCW, 1/8 w. |
| R639 | 19B800607P125 | Metal film: 1.2M ohms + or - 5%, 200 VDCW, 1/8 w. |
| R640 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R641 | 19B800607P562 | Metal film: 5.6K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R642 | 19B800607P103 | Metal film: 10K ohms + or - 5%, 200 VDCW, 1/8 w. |
| R644 | 19B800607P104 | Metal film: 100K ohms + or - 5%, 200 VDCW, 1/8 w. |
| | | - - - - - - - - - INTEGRATED CIRCUITS - - - - - - - |
| U301 thru U303 | 19A700086P4 | Operation Amplifier, Dual OP AMP; sim to 4558 Type. |
| U601 | 19A134764P1 | Linear: (VOLTAGE COMPARATOR). |
| U602 and U603 | 19A700086P4 | Operation Amplifier, Dual OP AMP; sim to 4558 Type. |
| U604 and U605 | 19A701789P1 | Linear, Low Power OP AMP; sim to LM324N. |
| U606 | 19A704073P2 | Voltage Regulator, positive. |

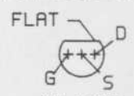
*COMPONENTS ADDED, DELETED OR CHANGED BY PRODUCTION CHANGES.

## COMPONENT SIDE



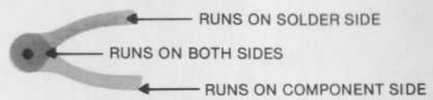

(19D902047, Rev. 0)
(19D902046, Sh. 1, Rev. 0)
(19D902046, Sh. 2, Rev. 0)

LEAD IDENTIFICATION
FOR Q301-Q303 & Q601-Q603

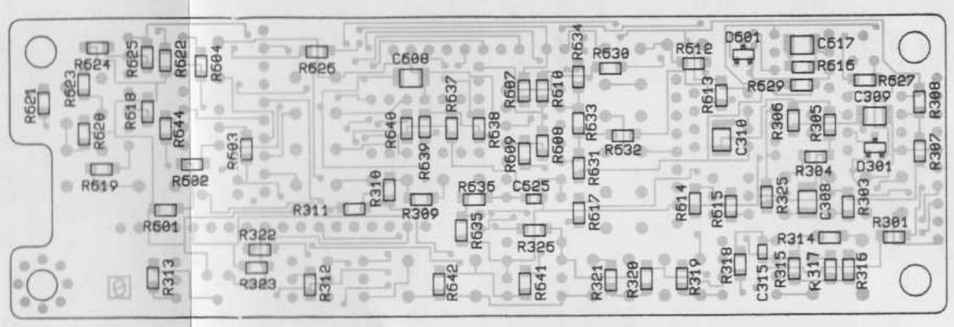



IN-LINE
TOP VIEW

NOTE: CASE SHAPE IS DETERMINING FACTOR FOR LEAD IDENTIFICATION




## SOLDER SIDE

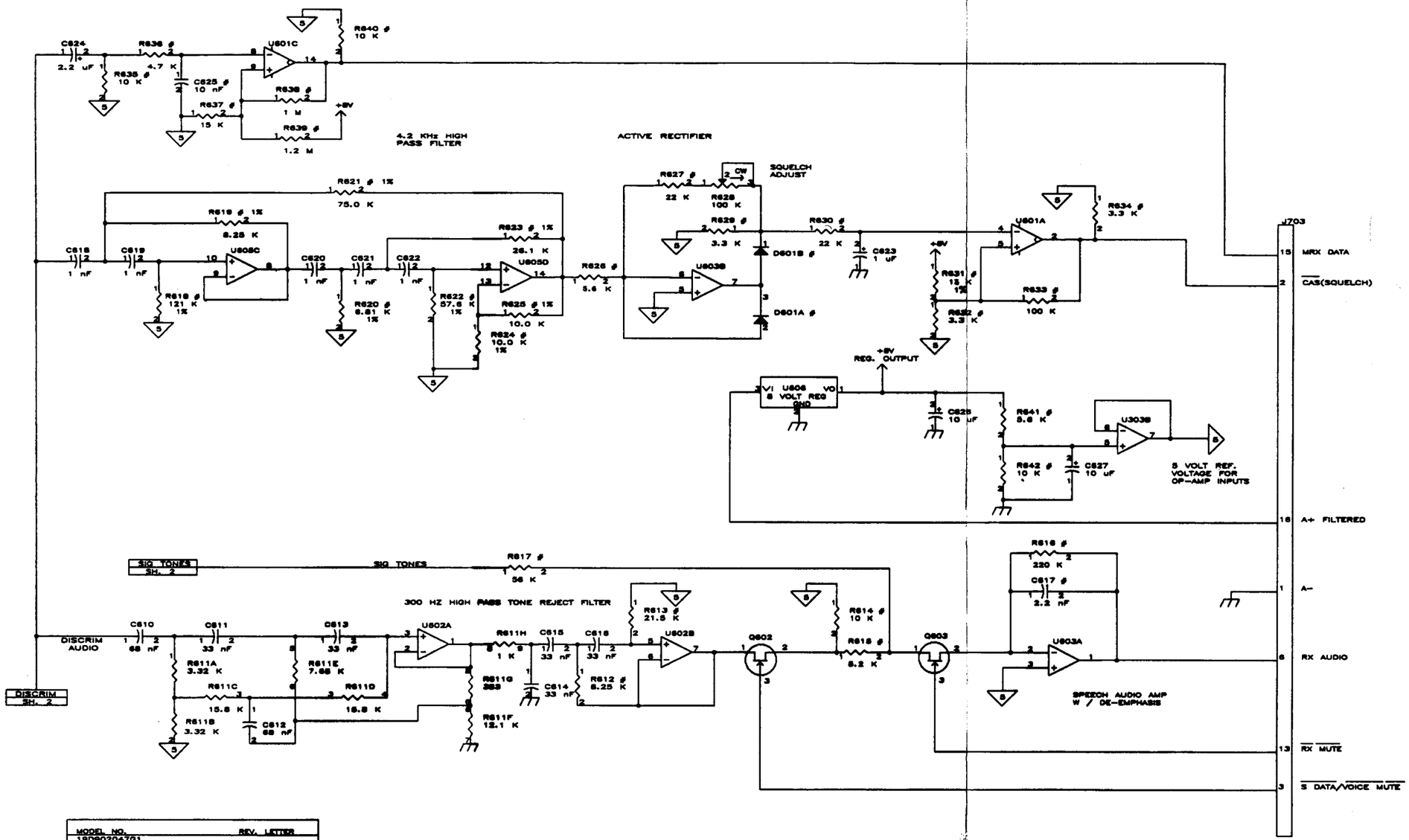



(19D902047, Rev. 0)
(19D902046, Sh. 2, Rev. 0)

LEAD IDENTIFICATION
FOR D301 & D601


VIEW FROM SOLDER SIDE

**GE-NET TMX**
Audio board

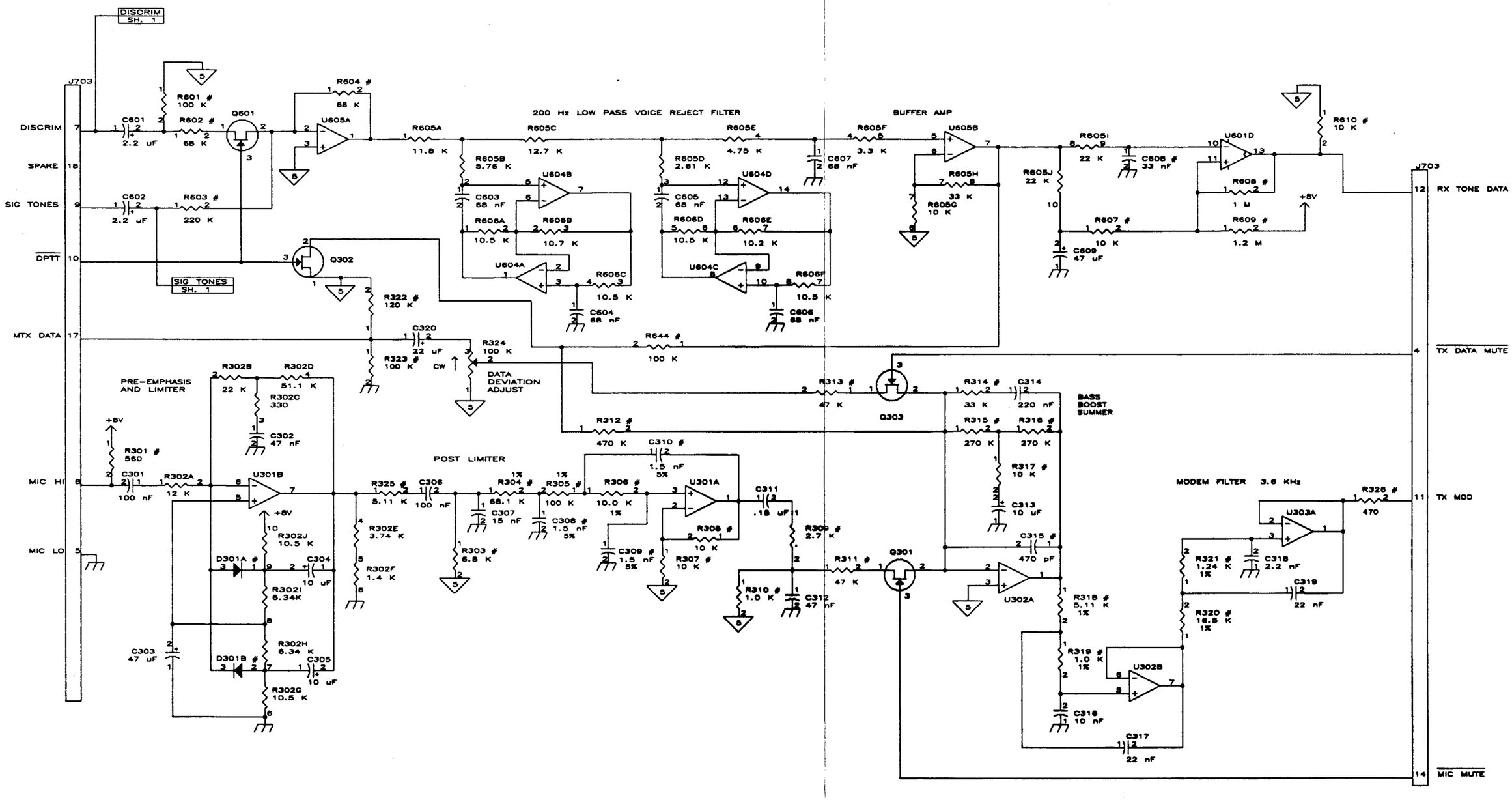



| MODEL NO. | REV. LETTER |
|---|---|
| 19D902047G1 | |

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.

(19D902194, Sh. 1, Rev. 1)



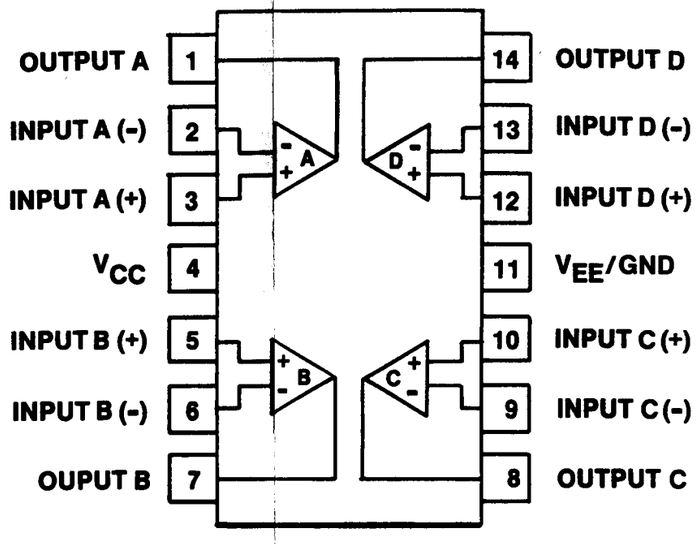

| I.C. | TYPE | +8V PIN | GND PIN |
|---|---|---|---|
| U301 | MC4558 | 8 | 4 |
| U302 | MC4558 | 8 | 4 |
| U303 | MC4558 | 8 | 4 |
| U601 | LM339 | 3 | 12 |
| U602 | MC4558 | 8 | 4 |
| U603 | MC4558 | 8 | 4 |
| U604 | LM324 | 4 | 11 |
| U605 | LM324 | 4 | 11 |

(19D902194, Sh. 2, Rev. 1)

**GE-NET TMX**
Audio Board

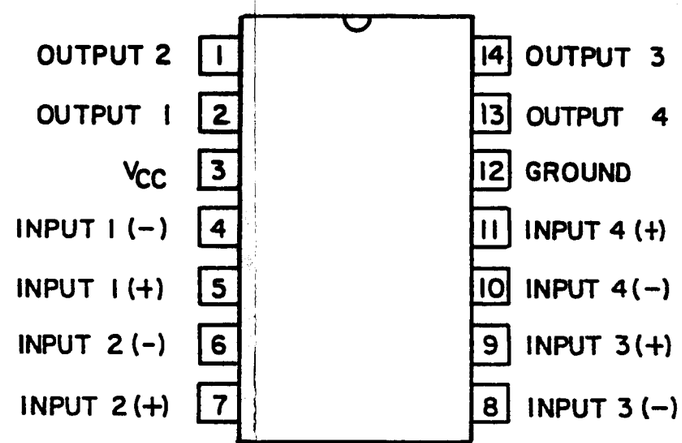
**OPERATIONAL AMPLIFIER**
**19A701789P1**

(U604 & U605)




RC-5887

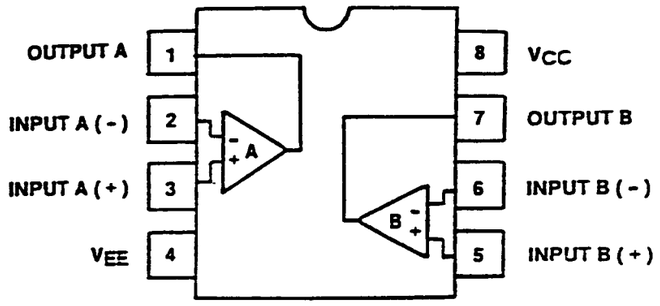
OPERATIONAL AMPLIFIER
19A134764P1
**(U601)**
PIN CONNECTIONS




TOP VIEW

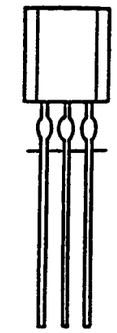
RC-8042

**OPERATIONAL AMPLIFIER**
(U602 & U603)
19A700086P4




RC-8041

**VOLTAGE REGULATORS**
(U606)
19A704073P2




BOTTOM VIEW

PIN 1 - OUTPUT
PIN 2 - GROUND
PIN 3 - INPUT

RC-5289

**GE-NET TMX**
Audio Board