INSTRUCTION MANUAL

MODEL 500

"ACOUSTIC ANALYZER"

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I. GENERAL DESCRIPTION AND SPECIFICATIONS

The Inovonics 500 Acoustic Analyzer combines into one compact unit the functions of both a one-third-octave Real Time Analyzer and a Reverberation or Decay Time (RT_{60}) Analyzer. The 500 features advanced digital logic with simplified keyboard data entry, and a bright, high resolution 13 x 31 LED matrix for display of frequency response and decay characteristics. A built-in Pink Noise source yields either wideband noise for response measurements, or noise in octave bands for RT_{60} analysis. The 500 is fully portable, operating from either the AC line or its internal rechargeable battery.

Model 500 Specifications

Analyzer Sensitivity: (for 0dB Reference Level) 40 to 139dB-SPL or dBA-SPL, microphone; -60 to +39dBm, line. Maximum display range extends measurement limits to +9 and -27 re. ref. level.

Display Range / Accuracy: 0.5, 1 or 2 dB/step with relative Reference Level and indicated display error less than ±0.25dB; 3dB/step with less than ±0.5dB error.

Filter Characteristics: 2 pole-pair filters on ISO one-third-octave centers, 25Hz to 20kHz. Response exceeds ANSI S1.11/Class II/1971 Standard. Relative filter accuracy ±0.5dB.

Rectifier Characteristics: Peak or 0.25, 1 or 4 second log-averaging response. Crest factor greater than 20dB above indicated reference level.

Reverberation Analysis: RT_{60} readout internally extrapolated from 30 or 15dB initial decay. Measurements to 9.99 seconds with 10ms resolution; an exclusive averaging systems increases low frequency measurement accuracy. Accuracy ±3%, ±2 counts for decays greater than 0.1 second.

Decay plot has vertical resolution of 0.5, 1, 2 or 3dB/step; horizontal integration periods of 7.5, 15, 30 or 60ms/step.

Microphone Input: 200 ohms, balanced with XLR connector. MIC CALIB adjustment accommodates microphone sensitivities between -60 and -48dB re. 10µbar. +12 VDC phantom power is provided (see p. 7).

Line Input: 100K-ohms, unbalanced; calibrated to ±0.5dB.

Pink Noise Source: Digitally-synthesized, pseudo-random; ±0.5dB spectral accuracy. Selectable wideband or octave band output with 2-pole filters on ISO centers, 63Hz to 8kHz. Manually-gated, unbalanced output is variable to +5dBm.

External Oscilloscope Output: BNC connectors for 'scope vertical and sweep trigger; external 'scope display has 7.5, 15, 30 or 45dB dynamic range.

Interface Connector: Permits external control of memory storage, pink noise gating and decay plot scan; provides display data output and internal clocking signals for interfacing with digital peripherals.

Power Requirement: 100/120/220/240 VAC, ±10%; 50/60Hz; 25 watts.

Internal Battery: 3-hour typical operating life; recharges in 8 hours.

Operating Environment: 0°C to 50°C; 0 to 90% relative humidity at 40°C.

Size and Weight: (including cover) 135mm H x 394mm W x 292mm D; 7.7kg.

II. UNPACKING AND CONNECTING THE 500

Unpacking and Inspection

Immediately upon receipt the Analyzer should be carefully unpacked and inspected for evidence of shipping damage. Should any signs of damage be observed, the carrier should be notified at once. It is recommended that the original shipping carton and materials be retained should future re-shipment become necessary. In the event of return for Warranty repair, shipping damage sustained as a result of improper packing for return of the unit may invalidate the Warranty.

Warranty Registration

It is most important that the Warranty Registration Card found at the front of this manual be promptly completed and returned. Not only does this provide registration of the equipment, both for Warranty and theft recovery purposes, but the user will be placed on a list to automatically receive specific servicing or modification information should such be made available.

Rack Mount Adapter

For semi-permanent laboratory or studio installations, the 500 may be mounted in a standard 19" equipment rack with the addition of an optional kit available from Inovonics. The two 6-32 screws on each side of the panel bezel are removed, and mounting "ears" installed. The unit requires seven inches of panel space, leaving just under an inch above and below the instrument case for cabling and the plastic feet. It is not recommended that the Analyzer be transported while mounted by its optional rack "ears."

A.C. Line Considerations

A four-way voltage selector associated with the linecord connector and fuseholder facilitates operation of the 500 at nominal line voltages of 100, 120, 220 and 240, ±10%, 50 or 60Hz. To select the proper operating voltage:

1. Remove the linecord.
2. Slide the cover from over the fuse.
3. Remove the fuse.
4. Remove and re-orient the selector card.

5. Replace the fuse with the proper value and slide the cover back.
6. Replace the linecord.

Battery

A rear-panel switch selects AC line or battery operation. The internal battery is charged as the 500 operates from the AC line; 8 hours line operation required for a full charge. This allows 2 to 3 hours of continuous portable operation.

The front-panel BATT indicator extinguishes when the battery reaches 80% charge during line operation. During portable use, this same indicator begins to flash when about one-half hour of battery life remains.

Rear-Panel Connectors

MICROPHONE

A wide variety of 150/250-ohm instrumentation- and studio-grade microphones may be used with the 500. The input is transformer-isolated and the connector a conventional 3-pin XLR.

By utilizing an auxilliary, calibrated SPL meter, Analyzer sensitivity can be adjusted with the CALIB control for accurate dB-SPL and dBA-SPL measurements with nearly any microphone chosen. If the unit has been pre-calibrated at the factory for use with a particular microphone, this will be noted next to the input connector.

LINE INPUT

A standard phone jack gives access to the 100K-ohm, unbalanced line input which is pre-calibrated at the factory for precise dBm measurements. Although battery operation of the unit does provide a quasi-"floating" input, it should be kept in mind that one side of the line input is connected to the chassis.

GATED NOISE OUT

The manually-gated Pink Noise Source (or externally-applied test signal) is available at this phone jack. The unbalanced output is adjusted with the front-panel LEVEL control, and the maximum available output is +5dBm.

GATED EXT. INPUT

Test signals such as steady-state tones, warble tones, etc. may be applied to this input, and will then be available at the GATED NOISE OUT jack in leiu of internally-generated Pink Noise.

Unless the front panel FREQ selector is in the WB position, however, any external test signal will be routed through the selected one-octave noise "send" filter.

The characteristic impedance of this unbalanced input is approximately 2.5K-ohms, and an input level of -12dBm is required to yield a full +5dBm output at the GATED NOISE OUT jack.

SCOPE VERT / SCOPE TRIG

Both vertical drive and time base trigger outputs are provided for auxilliary oscilloscope "bar graph" display of the LED-matrix Real Time frequency response plot. Oscilloscope sensitivity should be set for a full screen display of the +6 volt, full scale output signal corresponding to a dynamic range of 7.5, 15, 30 or 45dB as selected by the DISPLAY RANGE keys. The oscilloscope time base, if set for 1ms/div. or a little less, will accommodate the 7.5ms Analyzer scan of all 31 channels. The time base should be adjusted to externally trigger on the positive-going leading edge of the pulse provided.

DIGITAL INTERFACE

This 10-pin connector provides a dual function. First, it gains the user access to certain logic control lines, thus allowing microprocessor or other external programming and control of Analyzer operation. Secondly, the internal clocking signals and multiplexed LED-matrix information are made available for further processing of this data, or for interfacing with a chart recorder, three-dimentional display, or fully automated data-aquisition system.

The control lines are activated by a contact or semiconductor closure to ground. Open collector TTL logic or grounded-emitter NPN transistors may be used. The control lines operate in parallel with the associated front panel keys, but do not light the LED status indicators.

The control line pin assignments and functions are:

Pins 1 and 2 - SYSTEM GROUND

Pin 3 - EXTERNAL GATE - gates Pink Noise or external test signal on and off.

Pin 5 - EXTERNAL PLOT - initiates the Decay Plot for reverberation analysis.

Pin 9 - MEMORY "B" ENTER - enters display data into Memory "B."

Pin 10 - MEMORY "A" ENTER - enters display data into Memory "A."

The data lines present internal clocking signals and LED-matrix data in serial form. A study of the Waveforms and Timing chart is helpful in the understanding of this data presentation.

+12 volt C-MOS logic levels are used, but the inclusion of internal 10K-ohm series buildout resistance places limits on interconnecting cable capacitance. Pin assignments are:

Pins 1 and 2 - SYSTEM GROUND

Pin 4 - DISPLAY DATA - in serial form, groups of 4 bits, most significant bit first. 0000 defines the maximum level (+3dB row of LED's), and 1111 the minimum level (-9dB row).

Pin 6 - SCAN SYNC

Pin 7 - STROBE

Pin 8 - DATA CLOCK

Data for the first (25Hz) column occurrs during the SCAN SYNC pulse. The DATA CLOCK pulse shifts data out serially on the positive transition. A STROBE pulse indicates a shift to the next column.

III. USING THE 500

The Inovonics 500 Analyzer has numerous applications in the fields of acoustics, sound re-enforcement, audio recording and reproduction, noise abatement and other areas involving frequency domain and time domain analysis of signals in the audible range. The balance of Section III is devoted to operation of the Analyzer in some of its more common applications. Section IV suggests additional uses and contains a bibliography for further study.

A Note on Microphone Selection

The Model 500 is essentially "flat," electronically. Accuracy of measurement will thus largely depend of proper selection of a microphone.

Although a microphone is not normally supplied with the Analyzer, one can be optionally supplied should the user so wish. The type and manufacture of this microphone, and similarly of any microphone recommended by Inovonics, will be dictated by what is currently available as the best value without compromise of performance. Of course, true instrumentation microphones such as the B & K or General Radio are consistently the first (but most expensive) choice.

The microphone chosen must have a linear frequency response from 25Hz to 20kHz in order to cover the full audible range handled by the Analyzer. The omnidirectional microphone is a must for measurements from multiple sound sources or in a reverberant field. Because of interference effects at audio wavelengths approaching the microphone diameter, small diameter units have generally better omnidirectionality at high frequencies.

Condenser microphones are typically first choices due to their stability and high frequency response accuracy. All condenser units except the electret require a polarizing voltage, often necessitating an external power supply. The Inovonics 500 Analyzer provides +12 VDC which may be user-connected to the microphone transformer primary centertap to provide phantom powering to those microphones which will operate at this voltage. A piece of wire soldered between the two terminals at the top edge of the Audio Input Module board, near the microphone connector, is all that is required to enable the phantom powering.

Microphone Level Calibration

The microphone input of the Model 500 matches 150/250-ohm microphones with sensitivities between -48 and -60dB re. 10μbar. If the Analyzer has been factory-adjusted for a particular microphone, it will be so noted next to the rear-panel CALIB control. This control is otherwise used to match Analyzer sensitivity to the selected microphone output level utilizing an auxiliary Sound Level Calibrator. Alternately, a calibrated SPL meter can be used by adjusting the CALIB control for an indentical Model 500 Wideband reading of a steady-state noise source. A 1kHz octave band of noise from the internal Pink Noise Source is ideal for this calibration. Both the microphone to be calibrated and the calibrated SPL meter should be placed together, a few feet from, and on axis with the loudspeaker being fed the 1kHz octave-band noise. A display range of 0.5dB/STEP and an averaging time of 0.25SEC should be used.

General Operation

A rear-panel switch selects either AC-line or battery operation. See Section II for powering considerations.

The Model 500 has two basic modes of operation. The first, Real Time Spectrum Analysis, is selected by depressing the REAL TIME or MEMORY A and B keys. The Reverberation Analysis mode is selected by the RT_{60} key.

Reference Level Set

The Analyzer Reference Level, indicated by a dB-SPL, dBA-SPL or dBm readout on the digital display, corresponds to the "0dB" row of matrix-LED's. This level can be manually set with the ∧ and ∨ keys. When momentarily depressed, these keys will increment or decrement Analyzer input gain in 1dB steps. When held down, the keys program gain up or down at a rate of about 10dB/sec. THE ∧ KEY RAISES THE REFERENCE LEVEL OR DECREASES SENSITIVITY. THE ∨ KEY LOWERS THE REFERENCE LEVEL OR INCREASES SENSITIVITY.

Auto-Level Function

In the Real Time Analysis mode, except as noted below, the AUTO LEVEL key permits the Analyzer to automatically program its own gain to follow the input signal level. The Auto Level circuit will attempt to keep the "0dB" LED of the Wideband channel illuminated, raising gain for low level signals and lowering gain for high level signals. In this mode, the 500 functions as a digital SPL or dBm meter, the digital readout indicating the actual wideband input level.

To prevent endless "hunting" of the Auto-Level function, however, this mode is inhibited for LED-matrix resolutions of 0.5 or 3dB/STEP, and for PEAK or 4 second-averaged readings.

Readout Blanking (INPUT OVERLOAD)

The Model 500 incorporates a feature that, in the Real Time mode, alerts the operator to the fact that input amplifier stages are being overloaded and that the Reference Level should be increased. Whenever an input signal approaches the clipping level of the input amplifier, the digital readout blanks. This may be observed as a "flicker" on occasional noise peaks, or as complete blanking of the readout for abnormally high input levels. An occasional flicker can generally be disregarded, as overload recovery is essentially instantaneous and does not affect readings. Accuracy is questionable, however, should the input stages be overloaded for a significant portion of the measurement period.

Display Range

A set of four indicating keys selects an LED-matrix resolution of 0.5, 1, 2 or 3dB/STEP for both Real Time Analysis measurements and for the Reverberation Decay Plot. At 1dB/STEP, the panel designations next to the LED-matrix hold true; for other selected resolutions a proper multiplying factor must be used. Of course at 3dB/STEP the LED-matrix displays an expanded range 27dB below and 9dB above "odB," for a total dynamic range display of 36dB. The 0.5dB/STEP resolution has a total dynamic range of 6dB for precise, "fine-tune" adjustments.

The Display Range keys also control the dynamic range of the external oscilloscope display. See Section II - Oscilloscope Output.

Averaging Time

A set of four indicating keys performs the dual function of selecting the rectifier time constant for Real Time Analysis and the scanning rate for Reverberation Decay Plot displays.

In the Real Time mode, either PEAK or 0.25-, 1- or 4-second-averaged measurements may be taken. PEAK readings respond to the instantaneous peak value of the input signal, with sufficient decay of the reading to permit observation of transients. The 4-second-averaged readings are useful for analysis of sound pressure levels integrated over a long period (eg., noise surveys), or for accurate measurement of low frequency random noise.

The Decay Plot scanning rate is set by these same keys when the Analyzer is programmed for RT_{60} analysis. (See Reverberation Analysis discussion)

Gated Pink Noise Source

The Inovonics 500 contains an internal Pink Noise generator. The front-panel FREQ switch selects either wideband Pink Noise (WB), or noise in one-octave bands on ISO centers from 63Hz to 8kHz. The associated LEVEL control varies the noise output, and the indicating GATE key manually gates the noise output on and off. WHEN THE GATE KEY INDICATOR IS LIT, NOISE IS GATED OFF.

Section II discusses the noise output level, external gating and external noise source inputs.

Real Time Spectrum Analysis

The REAL TIME key performs a dual function. The first depression of this key transfers the Analyzer into the Real Time mode; second and successive depressions cycle the input selection circuit between flat microphone, "A"-weighted microphone and line inputs. The selected input is indicated by the dB-SPL, dBA-SPL and dBm function indicators, respectively.

Real Time Analysis of microphone or line input signals involves no more than selection of the proper input, an appropriate Reference Level and a desired Display Range and Averaging Time.

Memories

The 500 contains two independent memories for storage and/or accumulation of LED-matrix data. For each of the Memories A and B, an indicating ENTER key transfers the LED-matrix display data into memory. As long as the key indicator remains lit, the data in memory is updated with any subsequent higher-level Real Time information. The associated CLEAR key erases the memory. A memory is displayed on the LED-matrix by depressing the A or B MEMORY DISPLAY MODE key.

To enter a particular Real Time measurement into Memory A, for instance, first depress A-CLEAR to erase any previous data. Then depress A-ENTER once to enter the data, then again to prevent further updating. This operation can be performed while observing either the Real Time analysis (REAL TIME key) or the memory itself (A MEMORY DISPLAY MODE key). The same may be done for a subsequent measurement using the B Memory. Then both A and B Memories may be compared with the current Real Time display by alternately selecting the MEMORY A, MEMORY B and REAL TIME DISPLAY MODE keys. REMEMBER, HOWEVER, THAT IF THE REAL TIME KEY IS DEPRESSED TWICE IN SUCCESSION, THE INPUT SELECTOR WILL BE CYCLED!

Either memory may be used for data accumulation as, for example, in noise surveys. The same procedure is employed, but the ENTER key is depressed only once. The key indicator will remain lit, indicating that the associated memory is being updated with any higher-level input data. During accumulation either the accumulating memory or the Real Time analysis may be selectively observed. To initiate a new accumulation, simply depress the associated CLEAR key.

Use of the memories for Decay Plot displays is covered in the <u>Reverberation Analysis</u> discussion.

Reverberation Analysis

The Model 500 has two separate, but functionally-related modes for analysis of reverberant field signals. An RT_{60} counter yields a digital readout of time-in-seconds for 60dB of signal decay, and the LED-matrix displays an actual Decay Plot of the signal in level vs. time.

The internal Pink Noise Source is normally utilized for Reverberation Analysis, although other test signals may be substituted as noted in Section II. The principal utility of Pink Noise in octave-width bands is realized when a frequency-weighted "profile" of the reverberant field is plotted, based on measurements taken at the various octave-spaced frequencies. In order to minimize the effect of ambient noise on measurement accuracy, however, a one-octave-wide "receive" filter, identical with (and slaved to) the noise "send" filter, is placed in the return signal path. Thus the measurement is actually one of a one-half-octave-width reverberant signal. The GATE key, which gates the noise on and off, also initiates the RT_{60} measurement and the Decay Plot.

The Analyzer is placed in the Reverberation Analysis mode by depressing the RT_{60} key. It is suggested, however, that noise output levels and Analyzer sensitivity be set in the Real Time mode, as no quantitative display of signal levels is presented in the Reverberation Analysis mode.

RT_{60} Counter

In normal operation, the RT_{60} Counter actually records the first 30dB of signal decay; the 60dB figure displayed is extrapolated from this measurement. In analysis situations where even a 30dB signal-to-noise ratio cannot be realized, the 15dB DCY key permits the reading to be extrapolated from the initial 15dB of decay.

The RT_{60} counter, enabled by depressing the RT_{60} key, operates only within a 10 or 12dB "window" of return-signal amplitude. Digital display blanking is used to indicate this "window," and the Reference Level must be programmed up or down until the display indicates "all zeroes." In addition to blanking, the readout decimal point is extinguished when the input amplifier stages are overloaded, providing further indication for proper Reference Level adjustment.

Once a proper Reference Level adjustment has been made, and the digital readout indicates 0.00, depressing the GATE key will gate the noise off and start the RT_{60} counter running. The counter will continue to run until the return signal falls precisely 30dB (15dB, optionally), at which time the counter will stop and display the correct RT_{60} measurement. Depressing the RT_{60} key again will clear the counter and gate the noise on, and a successive depression of the GATE key will initiate another measurement.

The "blind" RT_{60} readings thus obtained should have a high degree of repeatability and may be considered quite accurate. Nevertheless, a graphic display of reverberation decay (plotted on the LED-matrix) lends credence to the RT_{60} measurements, as it will permit visual observation of multiple-slope decays, "early" decay times and the reverberation measurement noise floor.

Decay Plot

A Decay Plot presents reverberation decay as a level vs. time (rather than level vs. frequency) representation on the LED-matrix. The dynamic range of the display is set by the DISPLAY RANGE keys, usually for a maximum range of 36dB, and the time base by the DECAY PLOT-ms/STEP keys. A full-screen horizontal display of 1.86 seconds is possible when 60ms/STEP is selected. Other display resolutions and scanning rates may be selected for close examination of initial decay, short reverberation times, etc.

The Decay Plot works in association with Memory B. When the RT_{60} key is depressed, Memory B is automatically selected for LED-matrix display. When the MEMORY B ENTER key is depressed and left in an indicating position, a Decay Plot should result when a subsequent RT_{60} measurement is made. It may be necessary, however, to adjust the Reference Level and the LED-matrix DISPLAY RANGE and ms/STEP keys for a meaningful Plot. The MEMORY B ENTER key should be left in its indicating position, but a momentary depression of the MEMORY B CLEAR key will clear the screen for the next Decay Plot.

Memory A may similarly be used for storage of Decay Plots, but must manually be selected for viewing after the Plot has been recorded. Proper use of the MEMORY A and B ENTER keys will allow two Decay Plots to be recorded and compared.

IV. TECHNIQUES AND APPLICATIONS

Several typical applications of the Inovonics 500 are briefly described in this section, and it is anticipated that the user will have at least an elementary working knowledge of acoustics and related measurement techniques. A bibliography is included at the end of this section which would direct the reader to several good sources of information on acoustics and acoustical measurements.

Room Reverberation Analysis

Since most sounds, including music and speech, are dynamic in nature, the reverberation decay time of a performance or other listening environment greatly affects the perceived sound. For instance, an auditorium with excessive low frequency decay will sound "muddy" and unintelligible regardless of the amount of frequency equalizaion. In this case absorption characteristics of the auditorium at various frequencies would be modified by adding and tuning acoustical absorbers with the required center frequencies.

In reverberation analysis the microphone must be centrally located within the reverberant field, away from reflecting objects. The noise source should project freely into the space with its axis pointed toward the center.

For accurate RT_{60} measurements in the preferred 30dB decay extrapolation mode, the measurement noise floor must be at least 36dB below the noise source level. If this is not possible, the 15dB decay mode can be used. The measurement signal-to-noise ratio can be observed on the Decay Plot, and an inadequate ratio will be further evidenced by very erratic, non-repeatable measurements. Due to the random nature of Pink Noise, there will be increased variation between readings at the lower frequencies. A unique averaging circuit increases repeatability of readings at low frequencies, and the noise source should remain on for at least 1.5 seconds prior to gating for full benefit of this feature. Statistical averaging may still be necessary, however, for a final low-frequency result.

The Decay Plot provides a visual display of dynamic measurement range, the slope (or multiple slopes) of decay and consistency of decay. An erratic Decay Plot indicates a room with a particularly bad resonance or "flutter echo" at the measurement frequency.

By proper selection of vertical display range and of the horizontal time-base, any portion of the decay may be observed. For example, the first 10dB of decay has maximum contribution to the nature of the perceived sound, and may easily be observed with optimum display resolution.

Artificial Reverberation Devices

Reverberation spring or plate units and echo chambers can be matched, adjusted or measured for desired characteristics in much the same manner as are true spaces. The delay of tape delay systems or digital delay lines can also be measured on the Decay Plot display.

As the Reverberation Analysis mode of the 500 functions only with the microphone input, line-level signals must be appropriately padded to prevent input circuit overload. An attenuated input thus applied has the advantage of being "balanced."

Time Delay Measurement

The measurement of time delay in an acoustical space as required, for example, in the adjustment of digital delays in concert re-enforcement systems, cannot be accomplished in the same manner as artifical devices since the sound in this case does not end abruptly. Instead, if the noise source is turned "on," rather than "off" as the Decay Plot is initiated, the delay time will be indicated with no error from reflections. This technique requires a SPDT switch wired to the DIGITAL INTERFACE connector, N.O. to pin 12, N.C. to pin 3 and wiper to pin 6. With the Analyzer in the RT_{60} mode and the GATE key indicator off, actuation of the switch will gate the noise on and initiate the Plot.

Room Equalization

Many methods of room "tuning" are in common practice and adequately covered in the bibliography references. In general, nevertheless, wideband Pink Noise from the Model 500 or other source is fed to the sound system input, received by the 500's microphone and analyzed in the Real Time mode. The sound system equalizer is then adjusted for flattest "house response" as measured at various listening locations.

For initial "rough" adjustments, the 3dB/STEP and 1-second-averaging ranges can be used. For final tuning, the 4-second-averaging time and a greater amplitude resolution should be employed. Use of the two memories, in addition to a final Real Time measurement, will permit comparison of different measurement locations or the effects of various equalization attempts.

Noise Surveys

Measurement and statistical analysis of noise data has become a priority responsibility of public agencies and private sector alike with the increased awareness of the part man-made noise plays in human physiological and psychological health.

The Inovonics 500 lends itself handily to such measurements, for unlike the simple broadband or even the "A"-weighted Sound Pressure Level Meter, the 500 provides information as to the spectral content, and thus the relative annoyance or hazard factors of the measured noise source. In addition, the selectable measurement averaging times may be correlated with psycho-acoustical perception of certain noise sources, and the "accumulate" feature can be used to record the highest noise level within a specified measurement period.

Product Noise and Vibration Analysis

In early stages of mechanical product design, spectral content of emitted noise can be analyzed with the aid of the 500, and vibration-absorbing or sound-insulating materials tested to lessen sound output. Moreover, production-line testing of mechanical assemblies can compare noise emission with a production-standard or "known-good" assembly to reveal manufacturing defects such as bad bearings, etc.

Audio Recording and Broadcast Uses

During the many phases of sound recording and transmission, the Model 500 may be utilized to provide an instant indication of frequency response discrepencies or frequency overload conditions, either with actual program material or by utilizing the unit's internal Pink Noise Source.

Many recording and transmission systems depend upon complementary high-frequency pre-emphasis and subsequent de-emphasis to increase overall signal-to-noise ratio. This is true of slow-speed tape recorders, phonograph disc mastering systems, FM broadcasting and optical film recording. The tradeoff in all these cases is a reduction in the maximum recording or modulation level at high frequencies, and a potential high frequency overload situation. By monitoring the program source with a unit such as the Model 500, however, potential problems can be observed and steps taken to prevent them, either by overall gain reduction, re-equalization, or frequency-selective limiting.

Audio dynamic range compression is another technique commonly employed, often to excess, in an attempt to gain S/N ratio or simply to generate a "louder" perceived signal. Again, the Inovonics 500, with its selectable measurement averaging times, can be put to good use in measuring dynamic compression by its effect on program average-to-peak ratio. The effects of adjustments made to compressors and limiters may be easily observed, lessening the dependence on purely subjective analysis of these effects.

Several seconds of recorded Pink Noise at the start of a tape or film recording will serve as a reference for adjustment of playback machines for "flat" reproduction. If this Pink Noise recording is made at the time of an original recording, and processed and re-recorded along with the program, necessary corrections can be made at the time of ultimate reproduction to insure "flat" response. Because of the 500's built-in memory, such a reference recording need only be a few seconds in length.

<u>Equipment Calibration</u>

The Analyzer is a perfect instrument for rapid alignment or testing of tape recorders, telephone line equalizers, loudspeaker enclosures, microphones, etc. With a LED-matrix "overlay," which can easily be fashioned by the user, the 500 becomes a production-line tool for response calibration or go/no-go testing.

Using the 500 and its internal Pink Noise Source for multi-track audio recorder alignment obviates the necessity for recording the usual discrete tones. "Pink Noise" Standard Alignment Tapes are available from several sources, and reproduce equalization, bias "peaking" and record equalization adjustment can be easily and rapidly made.

As as aid in circuit development work, the 500 permits observation of circuit noise levels for proper orientation of transformers, etc., and the memories can store system noise or response information while circuit changes are made or selected components installed.

Bibliography

The following is a listing of several good sources for additional study; in particular, those dealing with measurement applications and techniques. By no means itself complete, this listing can further serve to direct the reader to other, even more theoretical literature. Additional sources for reading material on the subject are the various trade periodicals directed to the acoustics, noise control, audio recording and broadcast markets.

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V. THEORY OF OPERATION

All circuitry of the Inovonics 500 Acoustic Analyzer is contained on seven interconnected PC subassemblies. Listed with their primary functions, these are:

1. Audio Input Module - includes input selection switching and programmed-gain amplification.
2. Filters-Low Module - one-third-octave bandpass filters for the 25 - 630Hz range, associated rectifiers and multiplexer.
3. Filters-High Module - bandpass filters, 800Hz - 20kHz; Wideband signal channel; rectifers and multiplexer.
4. Keyboard Module - except for power and Pink Noise level, all panel switches and the digital readout.
5. Display Module - contains the 13 x 31 LED-matrix display.
6. Logic Module - contains the bulk of Analyzer logic circuitry, RT_{60} counter and Decay Plotter, Memories and Pink Noise generator and filter.
7. Power Supply - negative switching and positive regulators, battery-charging circuit.

The following discussion of Analyzer operation is keyed to the Block Diagram on page . For sake of simplicity, only primary signal paths and functions are shown. Moreover, the two Filters Modules are blocked as one, and basic logic and RT_{60} functions have been separated.

Audio Input Module

Signals to the Analyzer are fed to either the Microphone or Line Inputs. Microphone inputs pass through an adjustable MIC CALIB. control to the microphone preamplifer, the gain of which is programmed at 6 or 56dB as required. Similarly, Line Input signals are routed through a separate input amplifier with a +1 or -49dB programmed gain.

An input switching circuit selects either unweighted or "A"-weighted microphone signals or the line input. The succeeding four amplifier stages have a combined programmable gain of 0 to 49dB in 1dB steps. Thus the gain-controlling up/down counters can program Analyzer input sensitivity over a 100dB range, either by manual actuation of front panel buttons or by enabling the "Auto-Level" function. Information from the up/down counter is also routed via the Tristate Bus to the digital display to provide a direct readout of dB - SPL or dBA - SPL for microphone signals, or dBm for line inputs.

From the Audio Input Module the signal is fed to the one-third-octave filters and RT_{60} circuitry.

Filters

The gain-programmed audio input signal is fed to the one-third-octave filter set. The output of each of the thirty filters is precision-rectified, the derived d.c. then programmably-filtered to achieve the desired peak or averaged response to the input waveform. The resultant outputs, including a similarly-rectified Wideband channel, are multiplexed and routed to the logarithimic Levels Detector portion of the Logic Assembly.

Keyboard

Operator control of the Analyzer is afforded by keyboard data entry keys. Associated LED's indicate selected control functions, and the 3-digit readout indicates Reference Level or RT_{60} count.

Display

The 13 x 31 LED-matrix is addressed by row and column selectors. The display can be fed either Real Time analysis data or information stored in either of the two memories. In the RT_{60} mode, Memory B is displayed for viewing the Decay Plot.

Logic

Multiplexed information from the filters is encoded by a log level detector into a 4-bit digital word corresponding to the level in dB for each one-third octave signal. Gain of the level detector may be manually set for a presentation of 0.5, 1, 2 or 3dB/step.

The Column and Filter Selector synchronously scans the filter multiplexer and matrix display, providing the display for Real Time Analysis. Concurrently, an oscilloscope output provides dB-linear bar graph information for display by an external oscilloscope, if desired.

In the Automatic Reference Level Mode the 4-bit word representing the level of the wideband channel is digitally compared with a "reference" word. Gains in the Audio Input Module are programmed for parity, at which point the digital display indicates the actual wideband audio input level.

The Tristate Bus Logic controls multiplexing of both the Reference Level readout and the RT_{60} Counter information for display by the digital readout. An Audio Input Overload Detector blanks the readout when an input overload occurrs in any operating mode, signaling the operator that a sensitivity change is necessary.

RT_{60} Counter, Decay Plotter, Pink Noise Source

The Analyzer contains an internal generator which delivers either wide-band Pink Noise for Real Time analysis, or Pink Noise on user-selected octave band-centers for reverberation measurements.

In RT_{60} operation the internal noise or, if desired, an external test signal source, is gated on and off by a keyboard command. When the noise is gated off, the RT_{60} counter and Decay Plot scanning begin.

The reverberant signal, received through the Audio Input Module, is fed to a full-wave rectifier either directly or through the Receive Line Filter slaved to the Pink Noise Filter.

At the user's option, a 15 or 30dB decay is measured by the Decay Detector. The RT_{60} Counter extrapolates the measurement to yield a reading of time-in-seconds for 60dB decay. The RT_{60} count is multiplexed via the Tristate Bus to the digital readout.

The Decay Plotter generates level information for each keyboard-selected time increment for conversion by the 4-bit Log Level Detector to a dB-linear decay plot on the LED matrix via Memory B.

Power Supply

This assembly supplies bipolar 12V to Analyzer circuits, providing operation from the AC line or from an internal battery. The negative supply is derived from the positive by a switching regulator, and the LED Matrix is powered from a constant current source. Internal circuitry maintains the battery charge when the unit is operated from the AC line.

VI. CIRCUIT DESCRIPTIONS

Audio Input Module

This assembly performs input signal selection and pre-amplification, and is digitally gain-programmable. It is connected to the Logic Module with a 16 conductor ribbon cable.

The Analyzer microphone input is isolated by T1. MIC CALIB control R8, user-accessable at the rear apron, affords a 12dB microphone sensitivity adjustment. IC1A buffers the signal and feeds gain-programmable stage IC1B. When FET's Q1 and 2 are off, the gain is 56dB; with Q1 and 2 on, the gain drops to 6dB. R8 trims the 50dB gain shift.

IC1C and the associated filter form an "A-Weighting" network for dBA-SPL measurements. R15 is adjusted for a 1kHz level equal to the unweighted signal.

IC1D is a gain-programmable stage for line level signals. When Q3 is off, gain is fixed at 1dB; with Q3 on, gain drops to -49dB. R18 trims the 50dB shift, and R21 the absolute value of line level measurements.

FET switches Q4, 5 and 6 are the input selectors, and are controlled by mode selection logic. The various sections of IC2 complete the gain-programming function.

IC2A is controlled by Q7 and 8 for gains of 0, 10 or 20dB. Similarly, IC2B is controlled by Q9 and 10 for gains of 0, 10 and 20dB. IC2C and FET's Q11 through 15 provide additional gains of 0 to 9dB in 1dB steps. R33 is trimmed for a 5dB shift when Q11 is turned on.

The UP COUNT and DOWN COUNT lines control IC's 4 and 5. These up/down counters provide the basic gain-programming control. C20 and R51 reset both counters to zero when power is first applied.

IC4, counter for the least significant digit, is decoded by IC's 3, 18, 19, 20 and 21 to control FET's Q11 through 15 for a gain-programming range of 10dB in 1dB steps. Similarly, IC5, counter for the most significant digit, is decoded by IC's 6, 18, 19, 22 and 23 to control FET's Q1, 2, 3, 7, 8, 9 and 10 for a gain-programming range of 90dB in 10dB steps.

The logic outputs of IC's 4 and 5 are also decoded by the logic gate array and multiplexed by IC7 onto the TRISTATE BUS lines to provide Reference Level readout information in dB - SPL and dBm. For microphone input measurements from 40 to 139dB - SPL, counter information is gated to IC7 by IC's 11 and 12. SPL measurements above 99 cause the "1" ON line to go high. For line input measurements with an indicated Reference Level readout of OdBm or above, counter information is gated to IC7 by IC's 11 and 12. For measurements below OdBm, counter information is modified by the logic gate array to generate the negative readout data and to drive the "–" SIGN ON line high.

An INPUT SELECT code of 00 turns on Q4, selecting the unweighted microphone input. A code of 10 turns on Q5, selecting the "A" - weighted input. A code of 01 turns on Q6, selecting the line input.

The output of IC2 (AUDIO line) has a nominal level of -10dBm for a matrix display indication of OdB. From the following table the on/off status of the gain-programming FET's can be ascertained. The letter designation refers to the FET gate line similarly identified on the schematic. When the particular line is at +12 volts(H), the FET is off; when it is at ground (L), the FET is on. The tabulated readout display digits refer to SPL indications. For dBm readouts, subtract 100.

MOST SIGNIFICANT DIGITS	FET LINES F G H J K	LEAST SIGNIFICANT DIGIT	FET LINES A B C D E
13	L L L L L	9	L L L L H
12	H L L L L	8	H L L L H
11	H H L L L	7	H H L L H
10	H H H L L	6	H H H L H
9	H H H H L	5	H H H H H
8	L L L L H	4	L L L L L
7	H L L L H	3	H L L L L
6	H H L L H	2	H H L L L
5	H H H L H	1	H H H L L
4	H H H H H	0	H H H H L

Filters Modules

With exception of component values in each of the thirty, one-third octave bandpass filters, both the Filters-Hi and Filters-Lo Modules are identical. Because of the inclusion of the Wideband channel, the Filters-Hi Module will be discussed.

The two filters modules are interconnected to one another and to the Logic Module with a single, 16-conductor ribbon cable.

The AUDIO bus is applied to the inputs of all filters, and to the Wideband channel. The filters are each a two-pole, stagger-tuned pair. The first section is tuned with R3 to a frequency 7.8% below center, and the second section tuned 8.5% above center with R8.

The output of each filter is fed to its associated rectifier through amplitude calibration control R11. The two op-amp sections and associated diodes form a "precision" full-wave rectifier. Rectifier time-averaging characteristics can be programmed from the Analyzer front panel for Peak or selectable Averaging response. When the PEAK line is high, Q1 is turned on and C5 charges to the peak value of the full-wave rectified signal. With Q1 off, C5 is charged and discharged through R17. This long time constant provides the 4-second averaging. Analog switches of IC10 can be selectively enabled by the .25 SEC and 1 SEC control lines to connect R18 or 15, respectively, in parallel with R17 to provide the indicated averaging times.

The Wideband channel functions in much the same manner as the filtered channels, with the obvious difference that all frequency components are contained. Rectification and time-averaging are identical.

8-channel multiplexer IC's 7 and 8, controlled by the various SELECT lines, sequentially scan the filter/rectifier outputs, routing the analog information to the MULTIPLEXER OUTPUT line.

Keyboard Module

With exception of the Pink Noise Level control, Power switch and Battery indicator, the Keyboard Module contains all data entry switches and status indicators. Also part of this assembly is the 3-digit readout for display of Reference Level and RT_{60} time. There is no analog circuitry in the Keyboard Module, input and output lines carry only digital information. This module is interconnected with the Logic Module by two 16-conductor ribbon cables. Reference to the Logic and RT_{60} circuit descriptions will supplement this description of data line signals and functions.

The digital readout is controlled by the four TRISTATE BUS lines. These are time-multiplexed and synchronized with DIGIT SELECT and "– " sign information to present the proper display of Reference Level and RT_{60} time. The 7-segment decoder/driver IC1 selectively applies anode voltage to the numerical readouts D1, 2 and 3. Half of IC2, a dual 1-of-4 decoder, drives transistors Q1, 2 and 3, sequentially grounding the readout cathodes.

The other half of IC2 decodes the FUNCTION INDICATOR lines to illuminate the readout decimal point and to indicate the selected Analyzer operating mode. Note that although driver transistors Q6 through 9 provide a current path for each of the mode indicators I1 through 4, the illuminated LED is placed in series with one of the Averaging Time indicators I5 through 8, and one of the dB/STEP indicators I9 through 12. These other two indicator groups are decoded by the two halves of IC3 and driven by Q's 11 through 18. R21 establishes current through the 3-LED string.

Averaging Time keys S2 through 5 set and reset the appropriate flip-flops of IC4 to generate a RECTIFIER SELECT code. Similarly, the dB/STEP keys control IC5 for dB STEPS SELECT logic. These codes are tabulated below.

Avg Time Key	dB/Step Key	B	A
Peak	0.5dB	1	1
0.25 sec	1dB	1	0
1 sec	2dB	0	0
4 sec	3dB	0	1

Inverter-pair IC's 8, 9 and 10 perform a keyboard debouncing function to provide a clean positive edge when the associated key is depressed, and return to low level when released. MEMORY A, MEMORY B, RT_{60} and REAL TIME display mode logic is routed directly to the Logic and RT_{60} Module, as is ERASE B, ERASE A and up/down count logic, but without debouncing.

The AUTO, GATE, MEMORY A and MEMORY B commands trigger IC's 6 and 7, connected as divide-by-two flip-flops. Thus when one of these keys is depressed the logic output line goes high and stays until the key is again depressed. The associated status indicators are in series and driven by current source Q10. Driver transistors Q13 through 16 are normally held on by the flip-flop inverting outputs. When a logic output line goes high, the associated driver turns off, permitting the LED to indicate proper control status. The "Auto" function is inhibited in various operating modes. When AUTO INHIBIT input logic is high, the AUTO output logic line is held low.

C1 and R36 generate a momentary reset pulse when power is first applied to the Analyzer. This presets RECTIFIER SELECT and dB STEPS SELECT codes to 00, and MEMORY A ENTER, MEMORY B ENTER, AUTO and GATE logic output lines to a low state.

The Pink Noise Frequency selecting switch position is coded into binary form by diodes CR 2 through 15. The four NOISE SELECT logic lines control the state-variable filters in the Logic Module.

<u>Display Module</u>

This PC subassembly contains the 13 x 31 display matrix and means for selectively addressing each LED. The display is controlled by the Logic Module, and interconnected with a single, 16 conductor ribbon cable.

The vertical LED columns are sequentially scanned left-to-right. Data received via the COLUMN SELECT lines is decoded by IC's 1 - 5 to sequentially saturate transistors Q1 - 31, thus providing a path from the LED cathodes to DISPLAY GND. Transitions from one column to the next occur on the positive edge of the STROBE pulse.

Data from the ROW SELECT lines is entered into the latches of IC6 when the STROBE pulse is high. This data remains until the next STROBE pulse. IC6 decodes the ROW SELECT information, saturating one of the transistors Q32 to 44 and routing DISPLAY V+ to the LED anodes. The DISPLAY V+ is from a current source located on the Power Supply board.

A ROW SELECT address of 0000 enables the top row of LED's, an address of 1100 the bottom row. An address greater than 1100 will inhibit the display, as will the BLANKING pulse present during column-to-column transitions.

Logic Module

The Logic Module provides the interconnection, clocking, waveform generation and control functions for the other Analyzer subassemblies. As by far the most complex of the modular subassemblies, the Logic Module is best described when broken into separate, but functionally-related subsections.

Clock and Program Counter

IC1, the main clock, is adjusted to 100kHz by R2. IC2A divides the clock frequency by 16 for the RT_{60} measurement circuitry. IC's 9A, 3, 8A, 11A, 6A and 10A form a 5-bit counter to generate a "program" 23 clock pulses in length. The output of IC10A resets IC3 on the 23rd pulse and generates the PROGRAM RESET pulse. The various outputs of IC3 are decoded by IC9B to generate the BLANKING pulse, by IC9C to generate a STROBE pulse, by IC's 11B and 8B to generate the DATA CLOCK pulse and by IC12B to generate the RAMP RESET pulse.

Levels Detect Circuit

Conversion of the multiplexed analog filter outputs to digital form for matrix display is accomplished in the following manner.

At the end of the RAMP RESET pulse, the switch of IC14D is opened and C3, clamped to a "starting" voltage selected by IC13A, is discharged to ground at a rate selected by IC13B. Both the initial "starting" value and the rate of discharge are selected by dB STEPS A and B logic from the Keyboard Module to yield a desired display range and resolution.

As C3 discharges, the resultant logarithmic ramp is buffered by IC16B and presented to one input of comparator IC15. At the same time, the selected multiplexed output from the Filters Modules is buffered by IC16A and presented to the other comparator input. When the two voltages are equal, the output of IC15 toggles high, setting flip-flop IC6B. The next negative clock pulse transition is inverted by IC11A, clocking IC7A to stop counter IC2B which has been running since the last RAMP RESET pulse. IC4 then serially shifts the LEVELS DATA out of IC2B, most significant digit first. A data "word" of 0000 represents the top row of matrix LED's, 0011 the OdB row, and 1100 the bottom row. In Real Time operation, IC33 switches the LEVELS DATA information to the DISPLAY DATA line, IC28 decoding this information into ROW SELECT logic to illuminate the proper matrix LED for the column scanned in synchronism with the selection of the proper filter output. This entire "program" is repeated for each of the one-third-octave filters and the one wideband channel approximately one-hundred-forty times per second.

Oscilloscope Output

IC22A and C8 form an integrator which generates a linear ramp started concurrently with the log ramp of the Levels Detect circuit. IC23B resets the ramp generator at PROGRAM RESET, and integration is stopped by IC23A when IC6B is set by the Levels Detect comparator. At this point, the voltage at the output of IC22A is the log-dB equivalent of the measured level. With the next STROBE pulse, this voltage, buffered by IC22B, is fed to the sample-and-hold circuit of R25, C9 and IC22C. The voltage level is thus maintained throughout the next "program," after which it is again updated with the next column's information. IC22D is an inverter and level-shifter yielding an oscilloscope-compatible output. A SCOPE TRIG pulse is provided by the SCAN SYNC circuit.

Column Counter / Filter Select

The STROBE pulse at the end of each "program" advances counter IC24 to sequentially scan the vertical display matrix columns. This same logic, with some additional encoding by IC26, provides sequential scanning of the various filter outputs. A BLANKING pulse generated by the clock and associated dividers inhibits IC26 during inter-filter transitions to prevent adjacent filter interaction.

Further decoding of the filters and column select data by IC's 25, 27B, 12C and 27C results in a SCAN SYNC pulse concurrent with the beginning of each scan cycle. This is used as the external oscilloscope trigger output and for Decay Plot processing in the RT_{60} mode. IC's 12D and 27D generate a WB SYNC pulse concurrent with the levels detect "program" for the Wideband channel for use by the Auto Reference Level circuitry.

Reference Level Control

The ⋀ and ⋁ lines are controlled directly by the associated data entry pushbuttons on the Keyboard Module. Schmitt trigger IC18A is connected as an astable multivibrator which free-runs at about 10Hz when either button is held down. Circuit time constants are such, however, that momentary button depressions result in single output pulses. When the ∧ button is selected, IC's 19A and 20A route the pulses via the UP COUNT line to the Audio Module. A ∨ command causes IC20B to route these pulses to the DOWN COUNT line.

A similar scheme is employed for Auto Reference Level operation. IC5, a digital magnitude comparator, generates an appropriate AUTO REF UP or DOWN command when the detected level is below or above a logic 0011, or "OdB." When the Auto Reference Level circuitry is activated, WB SYNC and BLANKING pulses clock the appropriate up or down command into the two halves of IC21 concurrent with detection of the level in the Wideband channel. Astable multivibrator IC18C is routed to the Audio Module via the UP COUNT and DOWN COUNT lines in a manner similar to manual level commands. Thus the Wideband channel level information automatically programs Analyzer input gain to maintain that level at OdB. Auto Reference Level operation is enabled by the appropriate keyboard button, but inhibited for peak-responding and 4-second-averaging measurements and for 0.5dB- and 3dB-per-step sensitivities to prevent endless "hunting."

<u>Digital Readout Control</u>

The digital readout, contained on the Keyboard Module, displays either the dB-Reference Level or RT_{60} count. The readout is addressed via the TRI-STATE Bus, SPL or dBm data coming from the Audio Input Module, and RT_{60} count information from the RT_{60} circuits.

The DIGIT SELECT A and B lines are controlled by a 3 state, 2 bit counter comprised of IC30A and B and clocked by SCAN SYNC pulses. IC16D is a comparator monitoring the output of the Audio Input Module. When the monitored level indicates a probable input overload condition, C14 is charged through CR8 which sets both halves of IC30 and blanks the display.

In Real Time operation, the MODE line is high. Data concerning the last two digits of information comes directly from the Audio Input Module via the TRISTATE BUS lines, and when a "1" is required for SPL readings, IC29 provides the additional Tristate Bus encoding.

For RT_{60} measurements the MODE line is taken low. This provides DIGIT INHIBIT logic to the Audio Input Module so that TRISTATE BUS data from the RT_{60} circuitry can be displayed.

<u>Keyboard Control</u>

This section of the logic circuitry translates operator commands from the Keyboard Module into control logic for all Analyzer functions.

When power is first applied to the unit, a pulse generated by C15 resets IC34A and B, and clears IC36A and B. This places the Analyzer in a desired, predictable mode at initial turn-on.

The four display modes are selected by the REAL TIME, MEMORY A, MEMORY B and RT_{60} keys, the associated lines setting or resetting IC34A and B via the gates of IC35. In all modes except RT_{60}, the MODE line is high and IC33A routes either LEVELS DATA, MEMORY A DATA or MEMORY B DATA to the DISPLAY DATA line. The MODE line is low for RT_{60} operation, and MEMORY B DATE is displayed.

IC36A and B form a 3 state, 2 bit counter advanced by the REAL TIME line via IC's 35B and 37B. As the REAL TIME key is repeatedly depressed, INPUT SELECT A and B lines control the Audio Input Module, selecting either dB-SPL, dBA-SPL or dBm measurements. FUNCTION INDICATOR A and B lines light the appropriate panel indicators. IC's 33B, 7B and 37B inhibit the counter from advancing until the second and successive depressions of the REAL TIME key.

IC's 37C, 38D and 32E control the Analyzer response, translating the 2 bit keyboard command into 3 bit logic for the rectifier filters.

IC's 38C and 37D inhibit the Auto Reference Level circuit in either the Peak or 4-second averaging modes, and for 0.5dB and 3dB-per-step display resolutions.

<u>Memories</u>

As both A and B Memories are identical, only A will be discussed.

When the MEMORY A ENTER line is high, or EXTERNAL MEMORY A ENTER line low, the serial LEVELS DATA information is entered into 4-bit register IC1A, clocked by the DATA CLOCK line. Assuming IC9A, controlled by IC8A and IC3, is "closed," as the data is shifted out of IC1A it is entered into a 124-bit shift register comprised of IC10A and IC11A. The output of IC11A is entered into the 4-bit register IC1B and compared with the current data by magnitude comparator IC3. As long as the shifted data is of higher magnitude than the current data, IC8A "opens" IC9A and "closes" IC9B, causing the data to be recirculated indefinitely. Should a 4-bit "word" of current LEVELS DATA be greater than the corresponding "word" in memory, IC8A toggles to update the data in memory. In this manner, the memory functions as an "accumulator." When the MEMORY A ENTER line is taken low, or the EXTERNAL ENTER line allowed to go high, the memory can no longer be updated and the same data recirculates. The memory is cleared when IC5 opens the recirculation path. C3 clears both memories when power is first applied.

<u>Pink Noise Source</u>

"White" noise is generated by IC's 26, 28 and 27A and B, a pseudo-random, binary-sequence generator. The circuit is clocked by the 100kHz CLOCK line, and started by a POWER RESET pulse. The -3dB/octave network ahead of IC21D dyes the "white" noise "pink."

Either the internal Pink Noise or, if applied to a rear-panel jack, an external test signal is fed to a state-variable filter composed of IC 29A, B and C and associated components. This is a one-octave-wide filter on ISO centers selected by NOISE SELECT A, B and C lines controlling IC's 30 and 31. IC's 17D and E, 7D and 19C and D are controlled by the NOISE SELECT D and GATE lines, gating on and off either Q3 for wideband noise, or Q4 for filtered noise. IC29D buffers the signal feeding the GATED OUTPUT.

Receive Line Filters

IC25A, B, C and D with associated components comprise a state-variable filter identical to the Pink Noise filter, and slaved to it insofar as center frequency and "filtered" or "wideband" output selection is concerned.

IC21B and C form a "precision" full-wave rectifier for the filtered audio signal. The rectifier output is fed to both the Decay Plotter circuit and to the RT_{60} analog circuitry.

RT_{60} Counter-Analog

Rectified audio is fed to a sample-and-hold circuit consisting of IC33B, R84, C22 and buffer IC34B. The sample-and-hold level is monitored by the "window detector" circuit of IC34C and D. Should the FWR AUDIO signal rise above or fall below values established for accurate, reliable operation of the RT_{60} measurement function, the digital readout is blanked as an indication that the Reference Level must be readjusted.

Rectified audio is also applied to IC34A which normally has a 30dB gain, but can be switched to a 15dB gain with IC33A, controlled by the 15dB DECAY key and line. When the Gate key is depressed, IC33B opens, maintaining a charge on C22 established by the audio level at that time. This level is applied to one input of comparator IC32, while the amplified level, integrated by R85 and C23, is applied to the other. When the level drops exactly 30dB (or 15dB with IC33A "closed"), IC32 toggles taking the STOP COUNTER line high.

RT_{60} Counter-Digital

In order for the RT_{60} counter to extropolate 60dB decay figures from a 30 or 15dB decay, the counter must count 2 or 4 times faster than normal, respectively. The CLOCK/16 line is further divided by IC36A and B. Depending upon the state of the 15dB DECAY line, pulses at the proper repetition rate will be applied to the RT_{60} digital counter consisting of IC's 39A and B and 37B. When the GATE line goes high, all counters held at "reset" by IC35E are enabled. IC37A introduces a fixed 20ms delay to correct for integration by R85, C23 and C24 in the analog section. The RT_{60} counter then runs, and its output is multiplexed onto the TRISTATE BUS by IC's 40 and 42. When the measured decay initiates STOP COUNTER logic, IC36B stops the RT_{60} count and it is held on the digital readout.

Decay Plotter Circuitry

The Decay Plot feature operates in conjunction with the "B" memory. Either an EXTERNAL PLOT or a manual GATE command will initiate the Decay Plot in the RT_{60} mode. When a command is received, IC18A passes the next SCAN SYNC pulse which "sets" IC12A. This permits STROBE pulses to pass through IC18C and be counted by IC's 13A and 14. Each integration period (or Decay Plot "step") is a predetermined-number-of-STROBE-pulses-plus-one. The TIME SELECT A and B lines, controlled by the ms/STEP keys, determine the count via IC15A. IC16B "adds" the extra required count and then resets the entire circuit to begin the process again for the second and remaining columns.

The output of IC15A is high coincidentally with a SCAN SYNC pulse only twice during the Decay Plot cycle; once at the beginning and again after the last column is scanned. IC15A is clocked ahead each time, but at the second coincidence it "sets" IC12B to inhibit further circuit operation until the next Decay Plot initiating command.

The full-wave-rectified audio signal from the Receive Line Filter is integrated by IC's 21A and 20. The integration time is selected by IC15B to correlate with the Decay Plot scan time in ms/STEP. IC22D "clears" the integrator after each integration period, and IC22B switches the integrated signal via the DECAY PLOT line to the Levels Detect circuit at the end of each integration period.

Because of the "count-plus-one" nature of circuit operation, the Levels Data for each of the 31 columns is entered into the "B" memory sequentially and in the appropriate time slot regardless of the number of SCAN SYNC pulses counted during each integration period. IC22C guards the DECAY PLOT line against spurious noise inputs between memory entries.

Power Supply Assembly

The Power Supply Assembly and associated chassis-mounted components supplies the bipolar 12 VDC required by the various Analyzer analog and digital modules. Primary power is supplied either by the 100/120/220/240 VAC line or the internal battery. A second function of this Assembly is to maintain battery charge when the unit is operated from the AC line.

Rectifier diodes CR1 and 2 and the chassis-mounted filter capacitor yield a "raw" positive supply of about 18 volts from nominal AC line. "3-terminal" regulator IC3 reduces this to the positive, regulated 12 volt supply used by the CMOS digital circuitry. L1 and C5 further filter the supply for analog signal circuits.

When the Analyzer is operated from the AC line, charging current is supplied to the battery by IC1 through R3. Voltage developed across R3 is sensed by Q2 and fed to Q1 in the ground leg of IC1. This feedback serves to current-limit the battery-charging current. R2 sets the float voltage of the battery charger to 13.9 volts.

The voltage drop across R3 is also monitored by a section of quad op-amp IC2B. When the charging current drops, indicating full battery charge, the output of this stage toggles negative, extinguishing the front panel BATT indicator.

With S1 switched from the AC to BATT position, the internal battery is substituted for the regulated 12 volt supply. IC2D monitors the positive supply, comparing it with reference diode CR8. When the positive supply falls to approximately 10.0v, as in the case of extended battery operation, IC2D toggles negative, back-biasing CR7 and permitting IC2C to oscillate at an approximate 1Hz rate. This flashes the panel indicator, signalling a low-battery condition.

IC4 and associated circuitry form a negative switching regulator to provide -12 volts to the analog circuits. The input to this regulator is the "raw" positive supply in the case of AC-line operation, and battery voltage through CR9 when the analyzer is self-powered. Comparator IC4 is connected as an astable multivibrator, free-running at about 30kHz. IC4 drives switching transistor Q4, "charging" L2 each time Q4 saturates. When Q4 turns off, L2 induces back-EMF into filter capacitors C7 and 8 through CR11. Q3 and CR10 form a reference amplifier which senses the inverted supply, controlling the frequency of IC4 to maintain the negative supply at -12 volts. L3 and C9 perform further filtering.

3-terminal regulator IC5 is connected as a constant-current source to provide a fixed 230mA to the matrix display.

ASSEMBLY 153000

X - Y RECORDER INTERFACE

(ADDENDUM TO MODEL 500 MANUAL)

I GENERAL INFORMATION

The Inovonics 153000 Assembly provides direct interface between the digital data output bus of the Model 500 Acoustic Analyzer and nearly any X-Y recorder with a full-scale input sensitivity of 2v.d.c. With the 153000 and a suitable X-Y recorder, a permanent "hard copy" can be secured of either real-time or reverberation-time acoustic measurements.

II THE X - Y RECORDER

As noted above, nearly any X-Y recorder with 2v.d.c. full-scale input sensitibity will operate satisfactorily with the 153000 and the Model 500 Analyzer. The plotter must have zero and full-scale sensitivity adjustments, and should accommodate an 8½ X 11 inch page in order to utilize the data form provided.

As the total plot of either real- or reverb- time measurements takes about 16 seconds to complete, slew rate of the recorder is not a critical factor; most available units are more than fast enough for this application. Should, on the other hand, the recorder have excessive speed and bandwidth, digital "feedthrough" noise from the Analyzer may be visible on the plot. If this is a problem, some sort of low-pass filtering may have to be inserted ahead of the recorder.

One of the most compact, versatile and affordable X-Y recorders is the Hewlett Packard 7015B. Much the same unit is also available from UREI as their Model 200/2020. This recorder has proved to be an excellent choice for use with the 500 Analyzer, and has many general laboratory uses as well.

III INSTALLATION

The 153000 Assembly conveniently mounts within the recess of the back panel of the 500 Acoustic Analyzer. It is necessary only to loosen

ASSEMBLY 153000

X - Y RECORDER INTERFACE

(ADDENDUM TO MODEL 500 MANUAL)

I GENERAL INFORMATION

The Inovonics 153000 Assembly provides direct interface between the digital data output bus of the Model 500 Acoustic Analyzer and nearly any X-Y recorder with a full-scale input sensitivity of 2v.d.c. With the 153000 and a suitable X-Y recorder, a permanent "hard copy" can be secured of either real-time or reverberation-time acoustic measurements.

II THE X - Y RECORDER

As noted above, nearly any X-Y recorder with 2v.d.c. full-scale input sensitibity will operate satisfactorily with the 153000 and the Model 500 Analyzer. The plotter must have zero and full-scale sensitivity adjustments, and should accommodate an 8½ X 11 inch page in order to utilize the data form provided.

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One of the most compact, versatile and affordable X-Y recorders is the Hewlett Packard 7015B. Much the same unit is also available from UREI as their Model 200/2020. This recorder has proved to be an excellent choice for use with the 500 Analyzer, and has many general laboratory uses as well.

III INSTALLATION

The 153000 Assembly conveniently mounts within the recess of the back panel of the 500 Acoustic Analyzer. It is necessary only to loosen three of the 4-40 screws which appear in a rectangular pattern on the rear of the Model 500, and to slide the slotted "ears" of the 153000 Assembly beneath and to retighten them. The 153000 may then be left permanently attached to the 500 without compromising portability or other use of the Analyzer.

The 153000 is provided with three interconnect cables; two mate with the "phono-" style jacks of the X and Y outputs and are left unterminated at the recorder end. The third cable is a short 10-conductor "ribbon" type to interconnect the 153000 with the 500 Analyzer. This cable is pre-dressed to lie flat against the 500 back panel on its run between the Analyzer DIGITAL INTERFACE connector and the 153000 DIGITAL DATA BUS IN connector. The auxilliary BUS OUT connector is simply in parallel with the BUS IN so that additional digital peripherals may be used without disconnecting the 153000.

Power for the 153000 is provided by the Model 500 in the case of Analyzers with a serial number of 185 and up; earlier units are either easily field-modified to provide power, or the EXT. PWR. OPTION may be used. This jack, of the variety commonly used for powering hand-held calculators and cassette recorders, need only be connected to one of the popular "battery eliminators" supplying +7.5 to +15 v.d.c.

If, however, the user wishes to modify an early 500 Analyzer to supply power to the 153000, it is necessary only to provide +12 v.d.c. to pin 2 of the DIGITAL INTERFACE connector. This is most conveniently done by:

1. Remove the RT_{60}/LOGIC Assembly from the Analyzer.
2. Remove three screws and separate the two circuit boards.
3. Locate J7 of the RT_{60} board. This is the socket that accepts the ribbon cable to the back panel.
4. Carefully pry the plastic portion of the J7 socket away from the circuit board, and being careful not to deform the socket contacts, remove the plastic part completely.
5. Locate the now exposed PC trace which interconnects pins 15 and 16 of J7. Wtih a sharp knife, cut this trace, removing sufficient copper to insure an open circuit.
6. Carefully replace the plastic socket body and press firmly back into place.
7. Turn the assembly over and locate the trace on the back of the board which interconnects pins 6 and 15 of J7. Cut this trace, removing sufficient copper to insure an open circuit.
8. With a short length of wire, interconnect pins 6 and 16 of J7.
9. Similarly, interconnect pin 15 of J7 to +12 v.d.c. from pin 14 of IC19 (the type 4071 IC nearest J7).
10. Reassemble and replace the RT_{60}/LOGIC Assembly.

IV SETUP AND USE

With the 153000 Assembly connected to the recorder inputs, and a copy of the data form on the recorder, the recorder X and Y zero controls are adjusted to position the pen over the "zero cal" mark for the upper grid. Next, while holding down the F.S. CALIB. button on the 153000, adjust the recorder X and Y vernier attenuators so that the pen rests above the "f.s. cal" mark. These two adjustments, zero and full-scale, have some amount of interaction. It may take several tries to align the pen with both marks, but once done should not require further attention. The lower data grid is used simply by adjusting the recorder Y-zero control so that the pen aligns with the lower "zero cal" mark.

A "hard copy" plot is best made from data in memory. Either the A or B memory of the Model 500 can be used to store data in the usual way; the display is transferred to paper with a momentary depression of the "PLOT" button on the 153000 Assembly.

V CIRCUIT DESCRIPTION

When the PLOT button is depressed, IC5B is set by the very next Analyzer "Scan Sync" pulse. This gates timing signals into the controller portion of the interface circuit via IC1D. Pulse width considerations require that IC1A generate an "and" product of the Analyzer "Strobe" and "Scan Sync" signals; this is a pulse at the beginning of each complete 31-column display data scan.

For each such pulse received, a preset-enable command is given to the programmable down-counter comprised of IC's 2 and 3. This loads binary data from counter IC4, wihch is clocked by these same pulses. Thus the first pulse received loads in a zero, yielding an immediate "carry-out" pulse concurrent with digital data from the first display column. Because of the binary division afforded by IC4, however, a second "carry-out" pulse is not given until the 64th. "Scan Sync" pulse from the Analyzer, this time when data is received from the second display column. In similar manner, "carry-out" pulses are generated for each of the 31 columns of display information, and the entire controller circuit is reset by the Q12 output of IC4 following the transfer of data from the 31st. column.

Serial level data from each display column is continually shifted into IC5A with "Data Clock" pulses from the Analyzer. The parallel data representing a particular column is transferred into IC6 when the proper "carry-out" pulse is received from the controller circuit. The digital word latched into IC6 is converted to an analog d.c. voltage by the resistor network and op-amp IC8A. IC8B inverts the signal and adds a fixed offset required to suppress the unused three lowest logic levels. The output of IC8B is a d.c. voltage between zero and 2V which drives the Y channel of the recorder.

As IC4 counts in time to the sequential presentation of column data, IC10 both decodes and is clocked by IC4's binary output to regenerate a proper binary sequence representing the column displayed. This is converted to incremental analog form by the resistor network and IC8C and D. A reset delay, afforded by C3, permits the recorder pen to return to the bottom of the plot before returning to the left-hand starting point.

The CAL button, which sets the recorder pen at X and Y full-scale, simply jams both outputs positive by a reverse polarity command to IC6 and with the "or" gates of IC9.

INOVONICS WARRANTY

Inovonics, Inc. products are warranted to be free from defects in material and workmanship. Any discrepancies noted within 90 days of the date of purchase will be repaired free of charge. Additionally, parts for repairs required between 90 days and one year from the date of purchase will be supplied free of charge, with installation billed at normal rates. It will be the responsibility of the purchaser to return equipment for warranty service to the dealer from whom it was originally purchased unless prior arrangement is made with the dealer to inspect or repair at the user's location.

This warranty is subject to the following conditions:

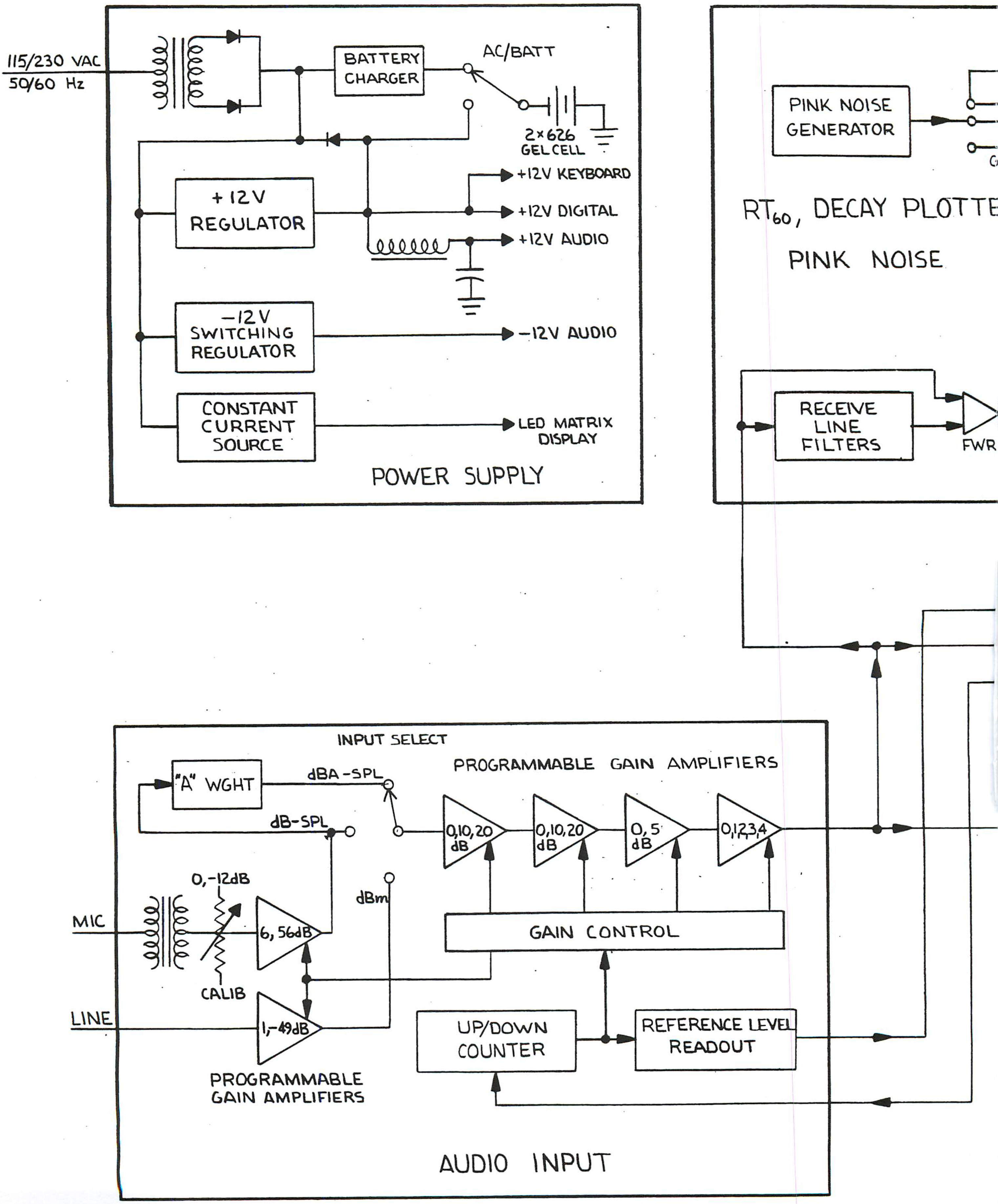
1. Warranty card supplied with the equipment must be completed and returned to the factory within 10 days of purchase.

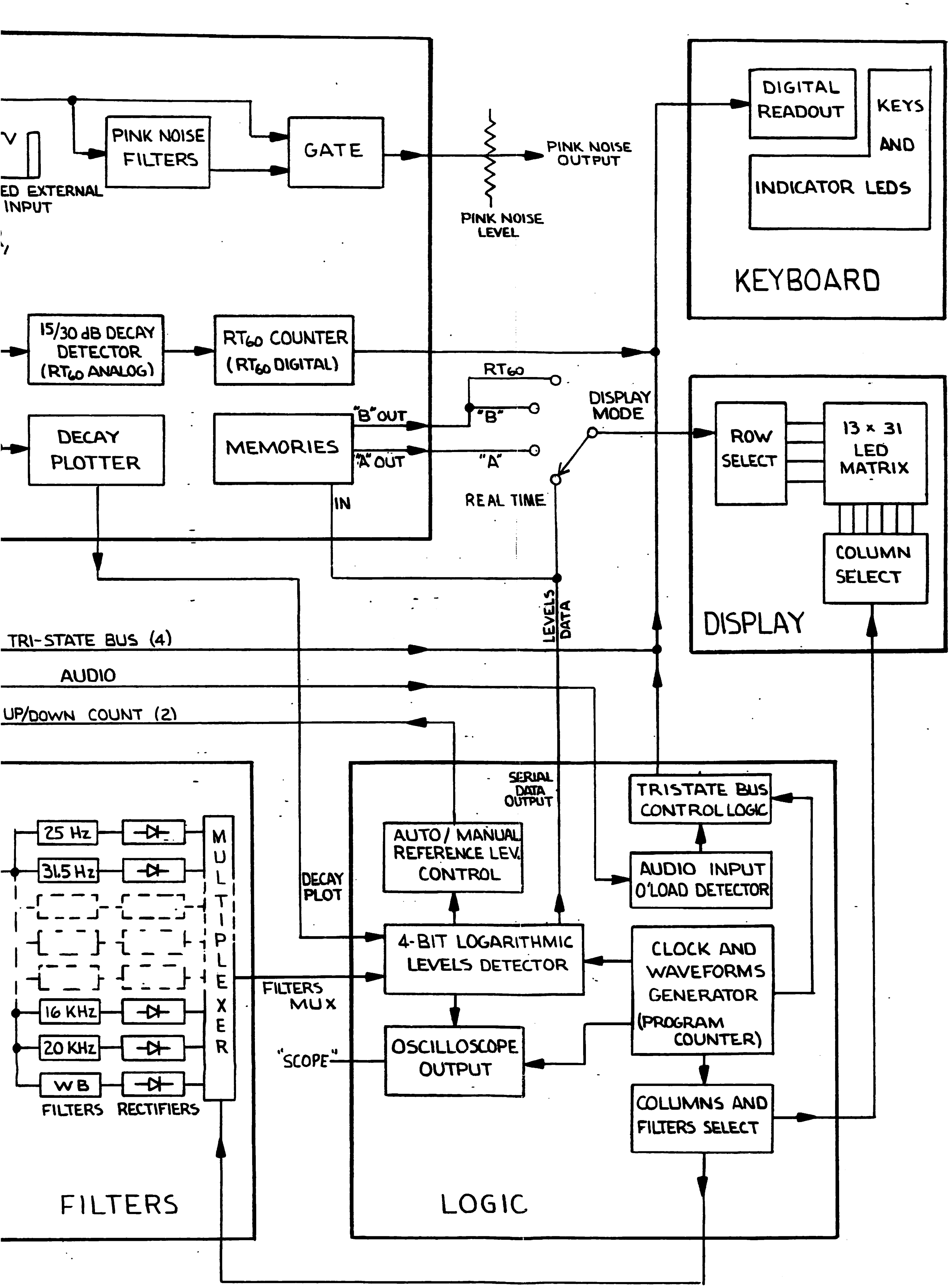
2. Warranty is void if unauthorized attempts at repair or modification have been made, or if serial identification has been defaced, removed, or altered.

3. Warranty does not apply to damage caused by misuse, abuse, or accident.

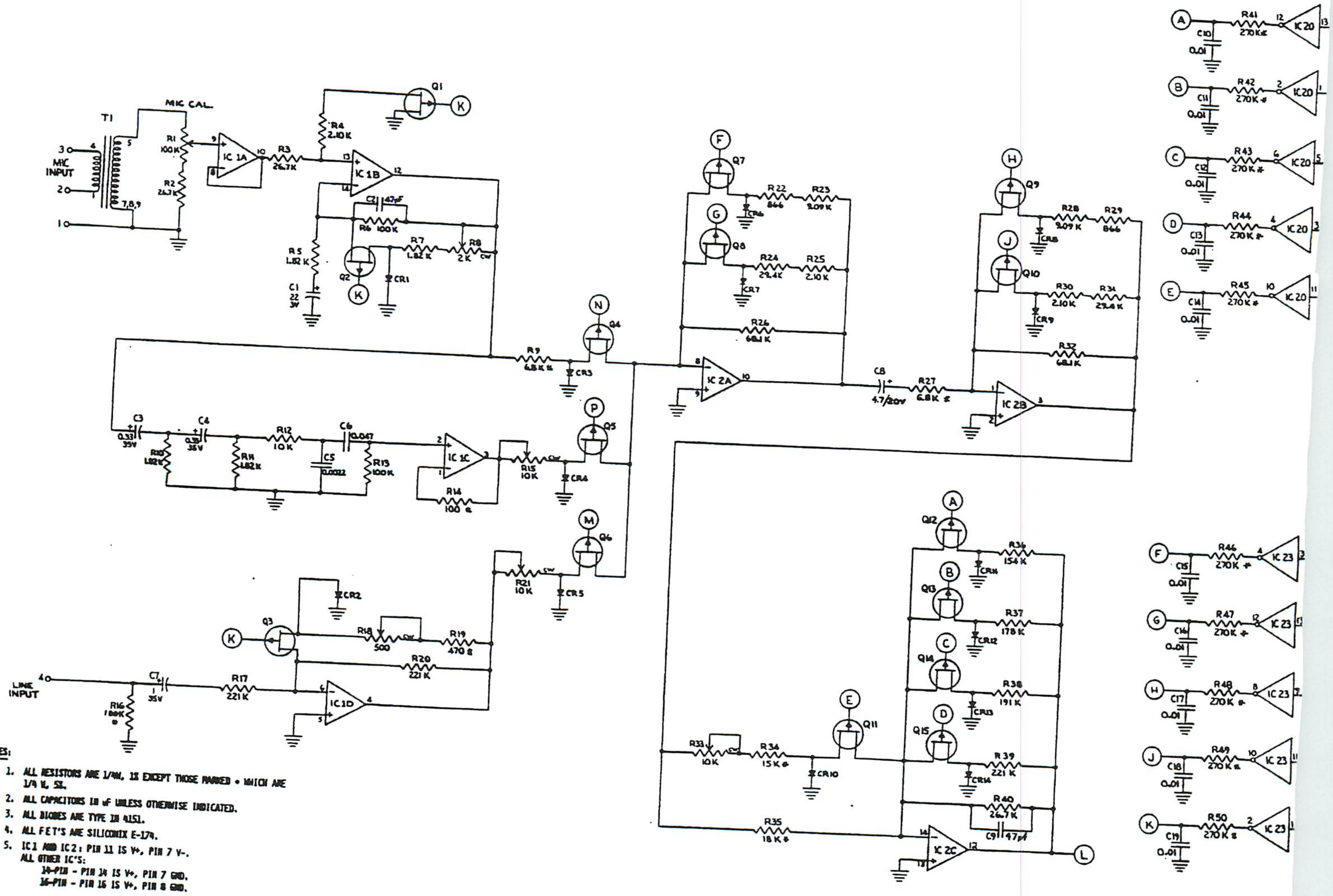
4. Warranty valid only to original purchaser.

INOVONICS INCORPORATED


115/230 VAC
50/60 Hz
BATTERY CHARGER
AC/BATT
2×626
GEL CELL
+12V REGULATOR
+12V KEYBOARD
+12V DIGITAL
+12V AUDIO
−12V SWITCHING REGULATOR
−12V AUDIO
CONSTANT CURRENT SOURCE
LED MATRIX DISPLAY
POWER SUPPLY
PINK NOISE GENERATOR
RT60, DECAY PLOTTE
PINK NOISE
RECEIVE LINE FILTERS
FWR
INPUT SELECT
"A" WGHT
dBA-SPL
dB-SPL
PROGRAMMABLE GAIN AMPLIFIERS
0,10,20 dB
0,10,20 dB
0, 5 dB
0,1,2,3,4
0,−12dB
dBm
MIC
6, 56dB
CALIB
LINE
1,−49dB
GAIN CONTROL
UP/DOWN COUNTER
REFERENCE LEVEL READOUT
PROGRAMMABLE GAIN AMPLIFIERS
AUDIO INPUT

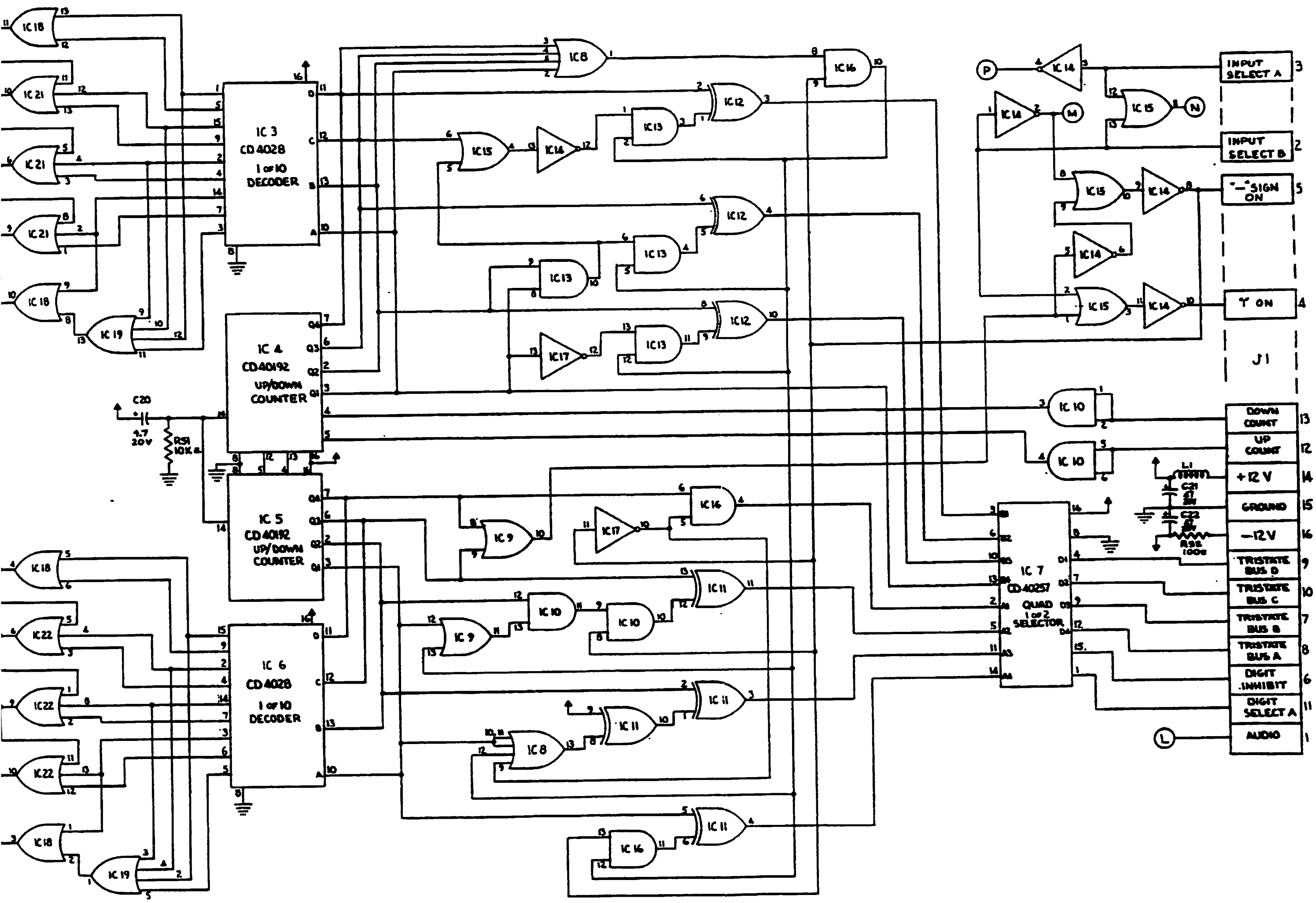


9-1 Block Diagram, Model 500 Acoustic Analyzer

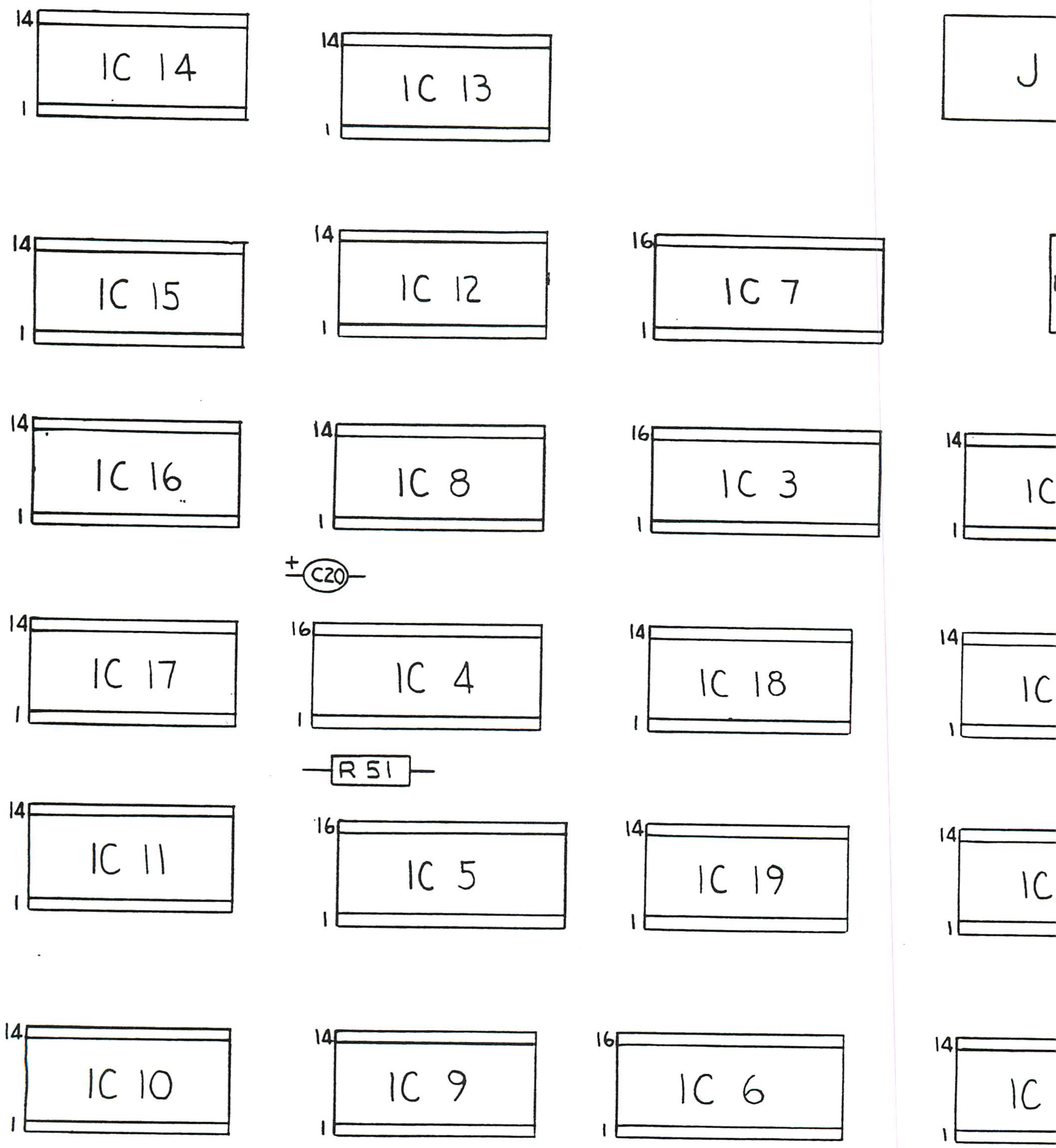


NOTES:

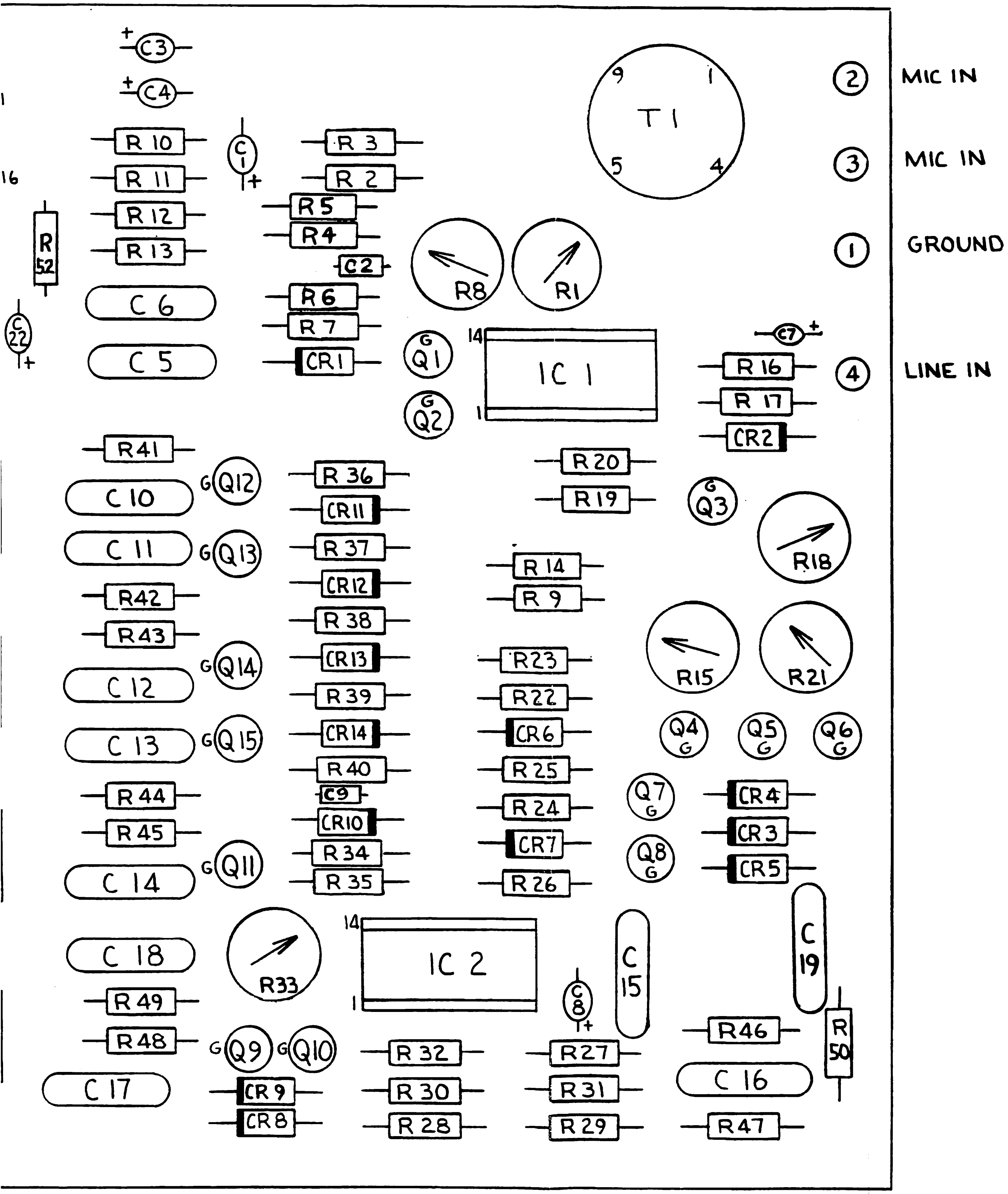
1. ALL RESISTORS ARE 1/4W, 1% EXCEPT THOSE MARKED • WHICH ARE 1/4 W, 5%.
2. ALL CAPACITORS IN uF UNLESS OTHERWISE INDICATED.
3. ALL DIODES ARE TYPE 1N 4151.
4. ALL FET'S ARE SILICONIX E-174.
5. IC1 AND IC2: PIN 11 IS V+, PIN 7 V-.
   ALL OTHER IC'S:
   14-PIN - PIN 14 IS V+, PIN 7 GND.
   16-PIN - PIN 16 IS V+, PIN 8 GND.



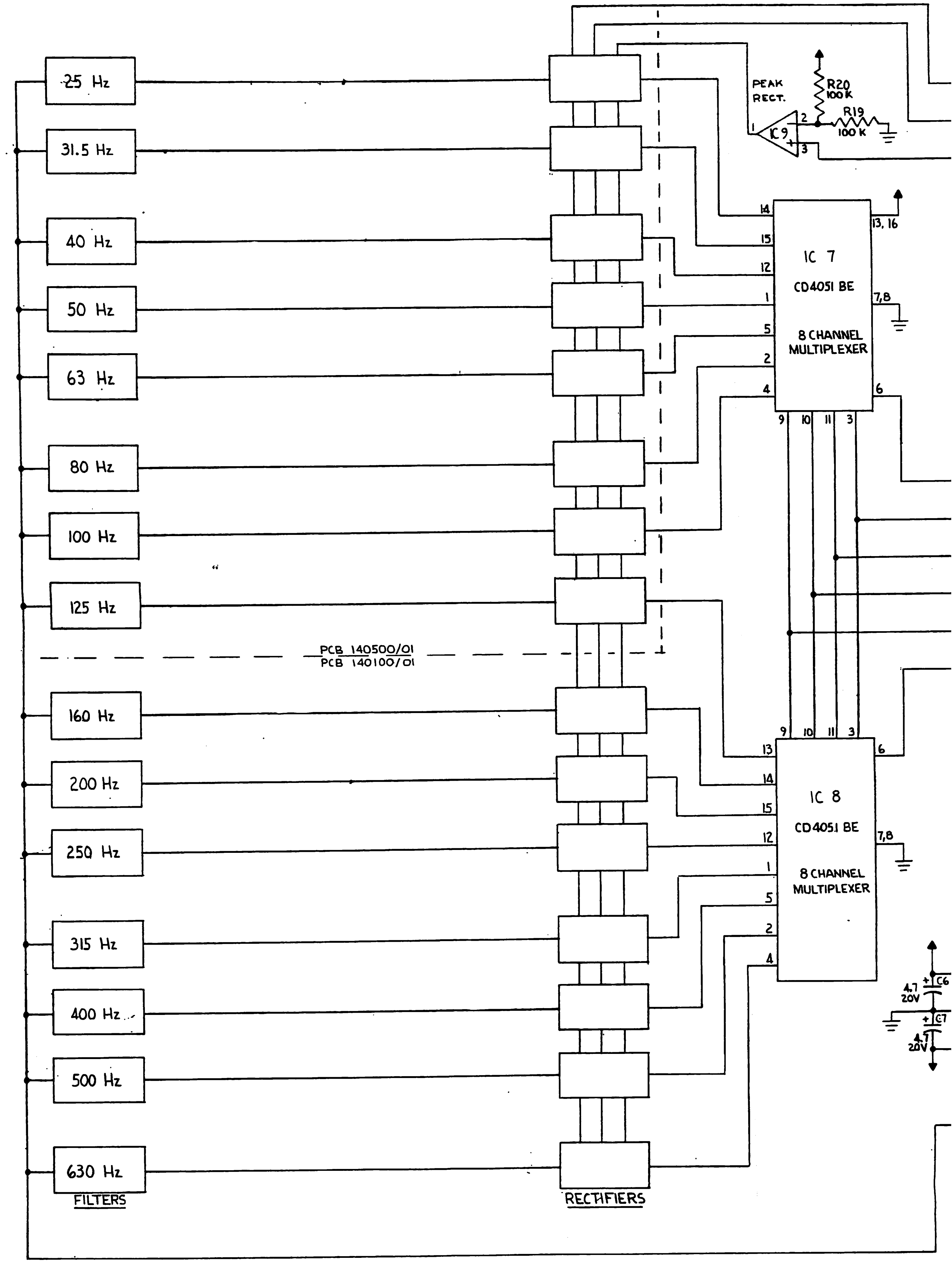
9-2 Schematic, Audio Input Module

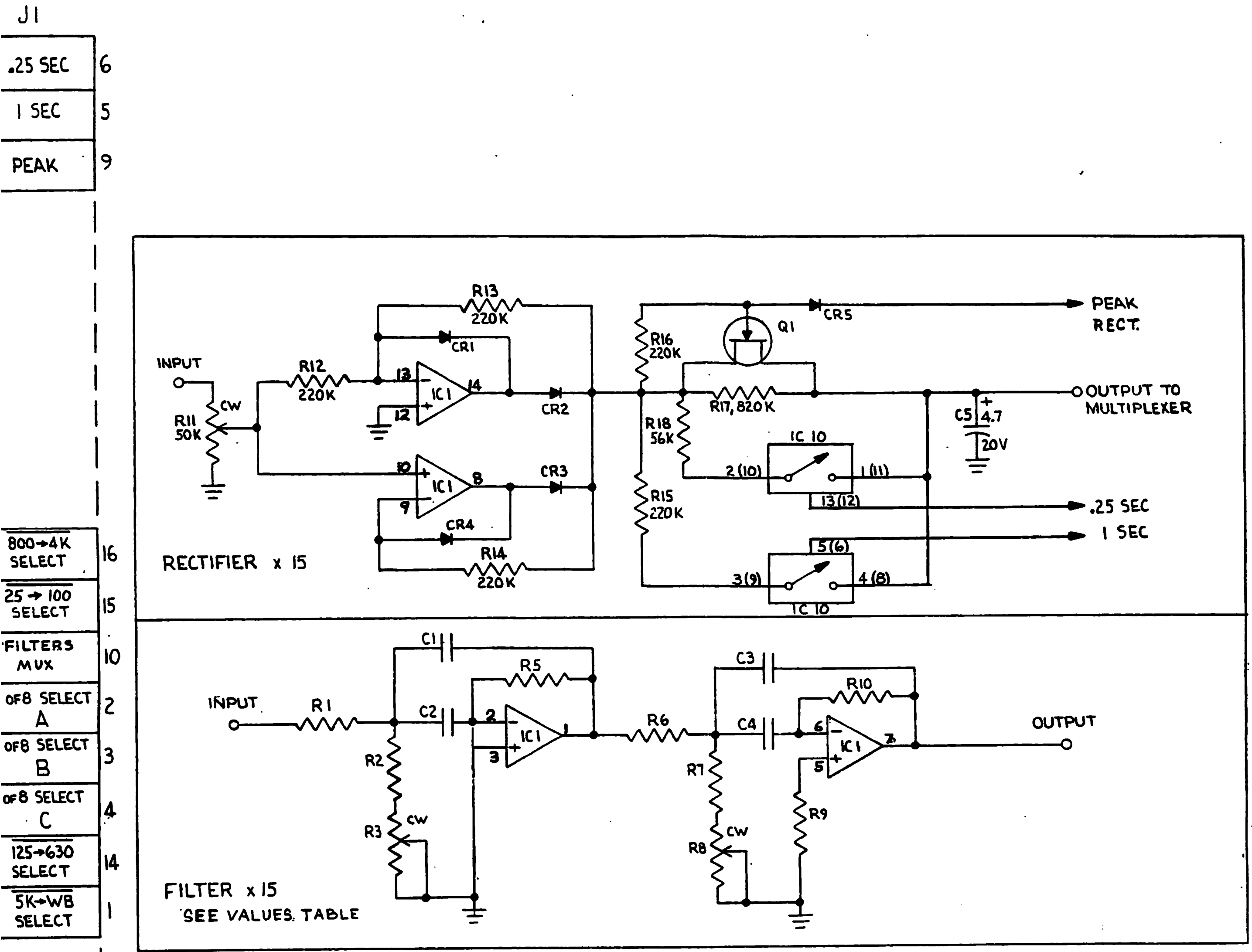


IC 14
IC 13
J
IC 15
IC 12
IC 7
IC 16
IC 8
IC 3
IC
+ C20
IC 17
IC 4
IC 18
IC
R 51
IC 11
IC 5
IC 19
IC
IC 10
IC 9
IC 6
IC



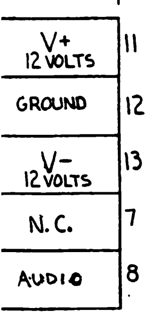
9-3 Component Locations, Audio Input Module


25 Hz
31.5 Hz
40 Hz
50 Hz
63 Hz
80 Hz
100 Hz
125 Hz
PCB 140500/01
PCB 140100/01
160 Hz
200 Hz
250 Hz
315 Hz
400 Hz
500 Hz
630 Hz
FILTERS
RECTIFIERS
PEAK RECT.
IC9
R20 100 K
R19 100 K
IC 7
CD4051 BE
8 CHANNEL MULTIPLEXER
13, 16
7,8
IC 8
CD4051 BE
8 CHANNEL MULTIPLEXER
C6
C7
4.7 20V



FILTER COMPONENT VALUE TABLE

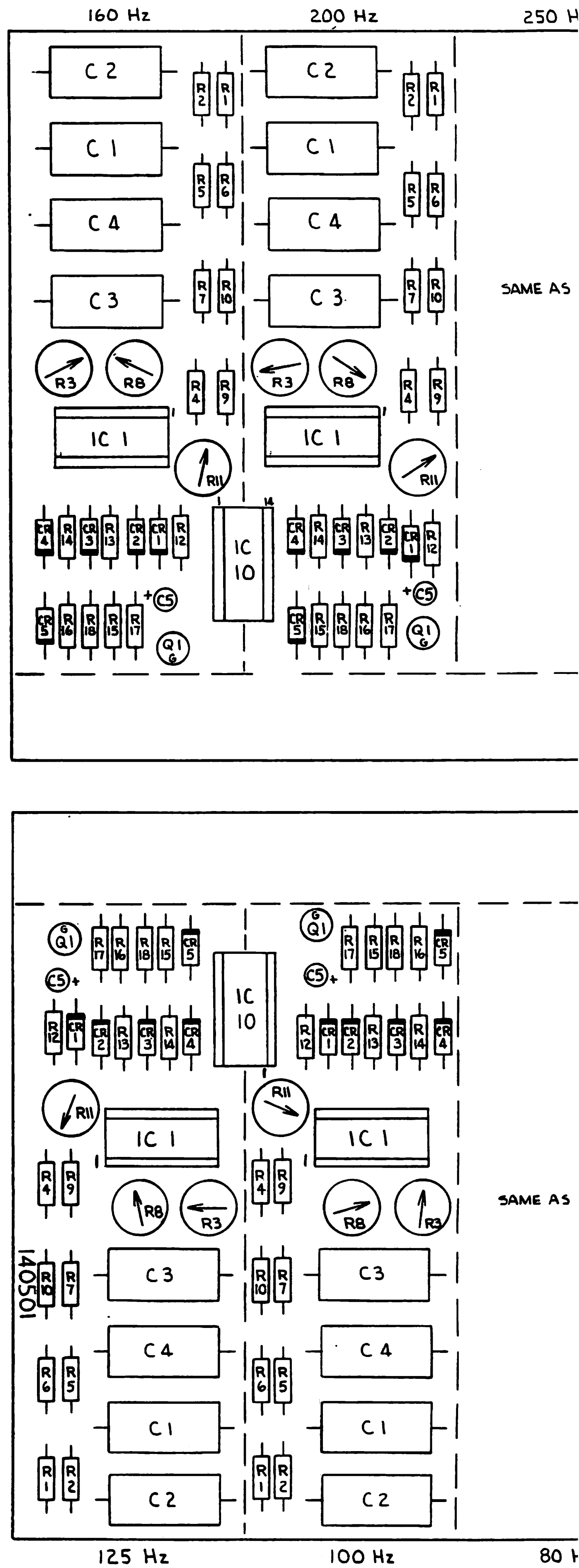
FILTER	C1,2,3,4	R1	R2	R3,8	R4,5	R6	R7	R9,10
25Hz	.039	150K	12K	5K	2.2M	620K	10K	1.8M
31.5	"	120K	10K	"	1.8M	510K	6.8K	1.5M
40	"	91K	6.8K	"	1.3M	390K	5.6K	1.1M
50	"	75K	6.8K	"	1.1M	330K	5.6K	910K
63	"	56K	4.7K	"	820K	270K	3.9K	750K
80	"	47K	3.9K	"	680K	200K	3.3K	560K
100	.015	100K	6.8K	"	1.5M	430K	5.6K	1.2M
125	"	75K	6.8K	"	1.1M	330K	5.6K	910K
160	"	62K	4.7K	2K	910K	270K	3.9K	750K
200	"	47K	3.9K	2K	680K	220K	3.3K	620K
250	"	39K	3.3K	1K	560K	180K	2.7K	470K
315	"	30K	2.7K	"	430K	130K	2.2K	360K
400	"	24K	1.8K	"	360K	110K	1.5K	300K
500	"	18K	1.5K	"	270K	82K	1.2K	240K
630Hz	"	15K	1K	"	220K	62K	820	180K

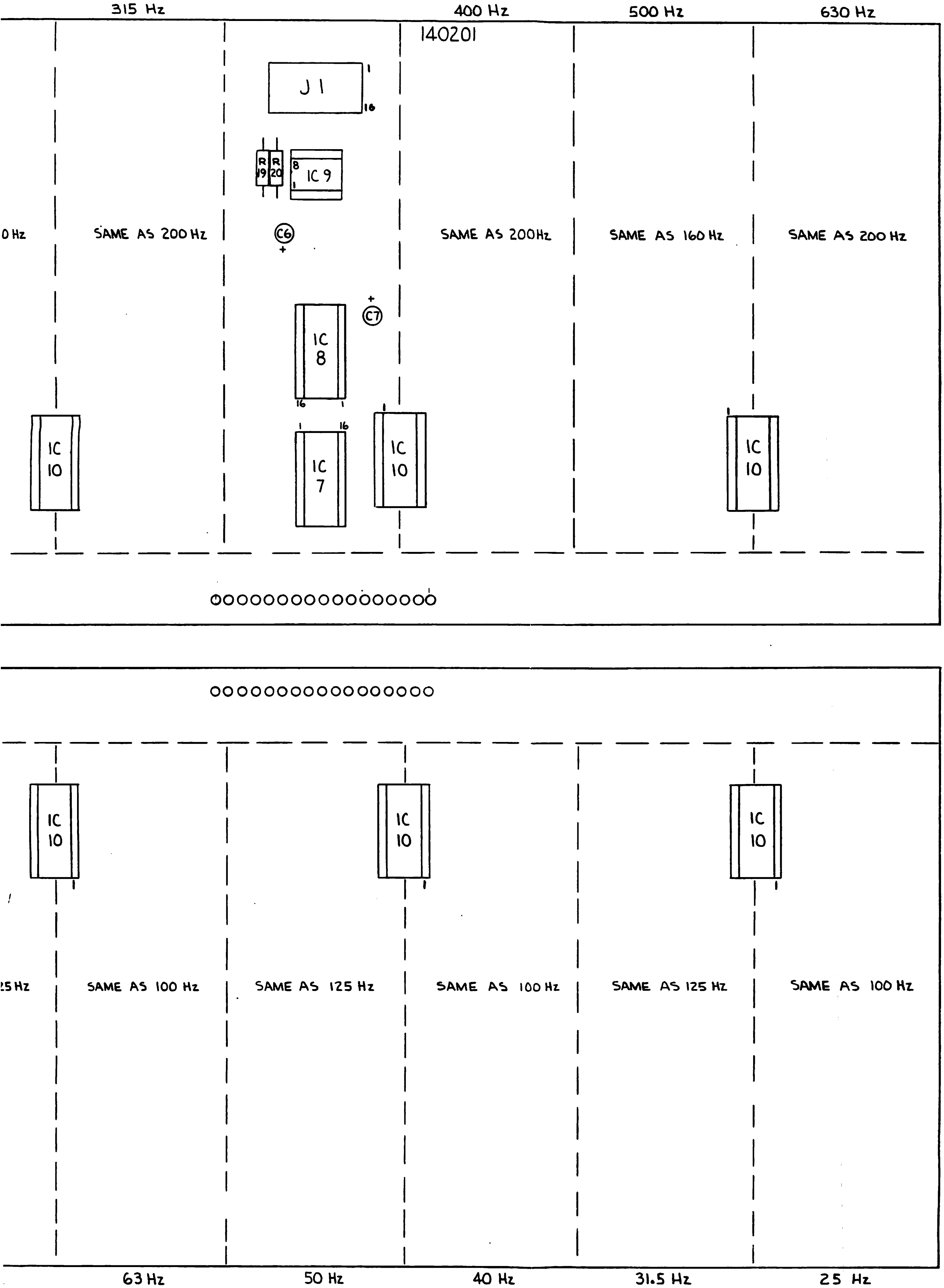


NOTES: (UNLESS OTHERWISE SPECIFIED . . . .)

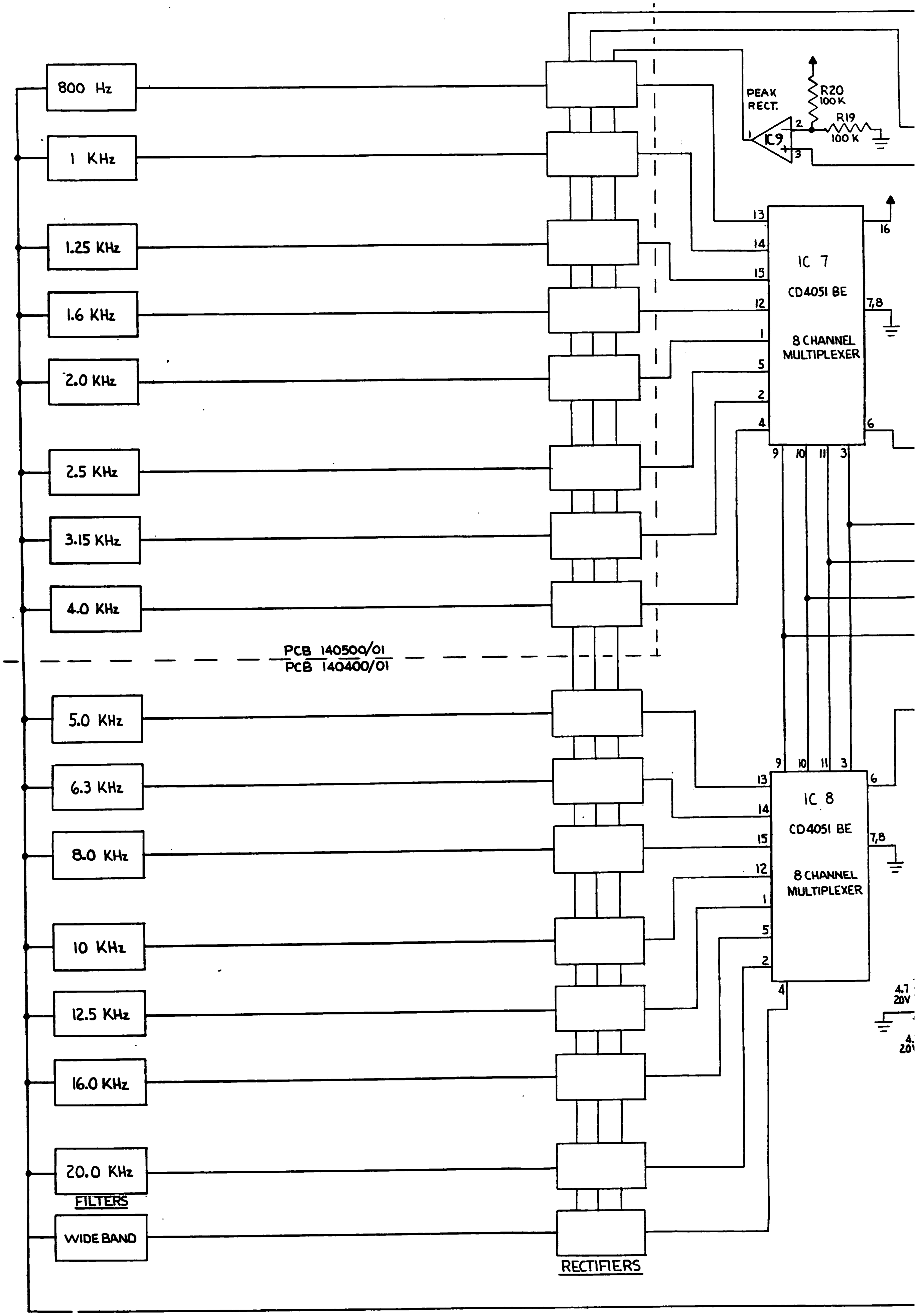
1. RESISTORS ARE ¼W, 5%.
2. CAPACITORS ARE IN µF.
3. DIODES ARE 1N4151.
4. IC's 10 ARE CD4066BE; IC's 1 ARE LM324.
5. FET's ARE SILICONIX E111.

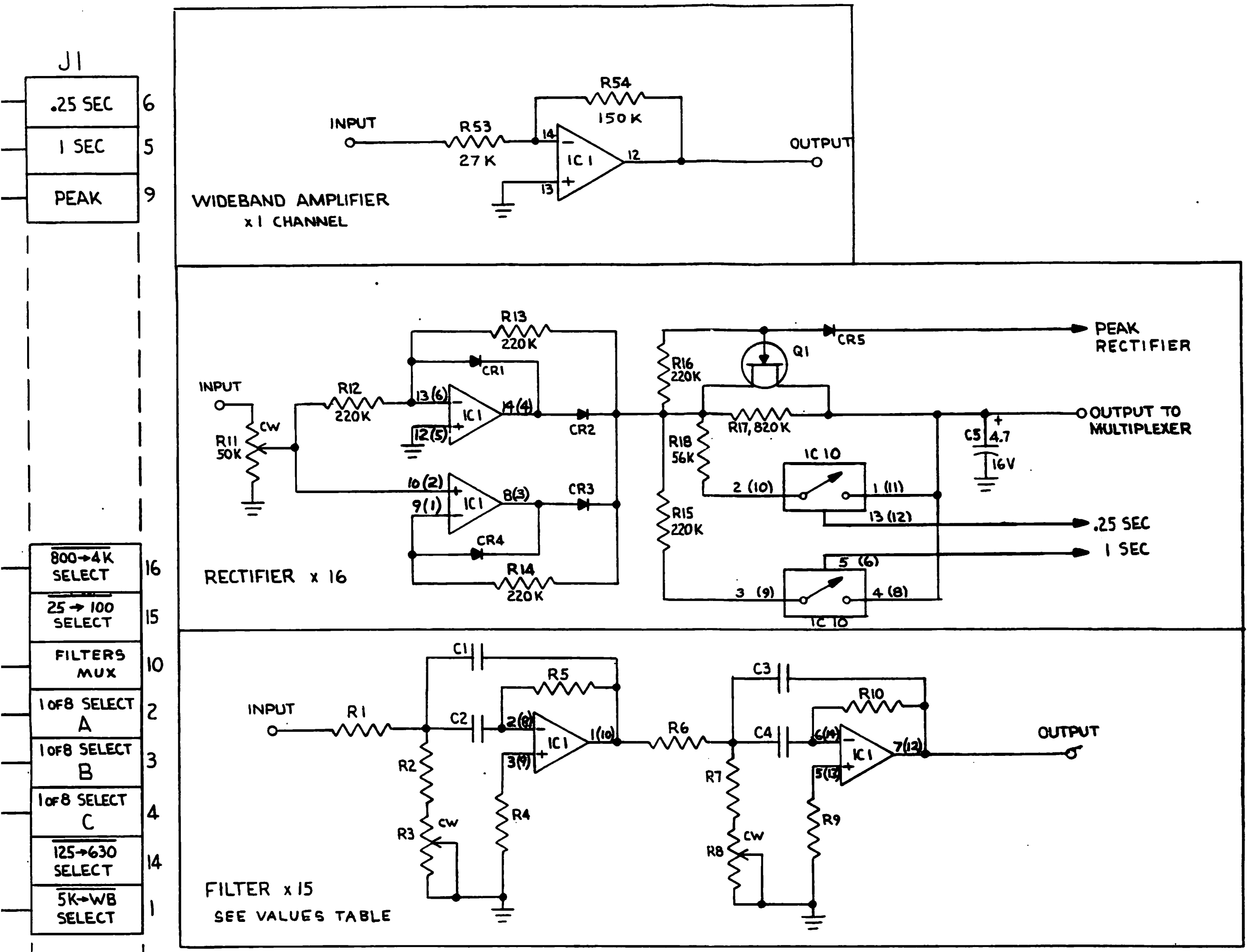
9-4 Schematic, Filters—Low Module

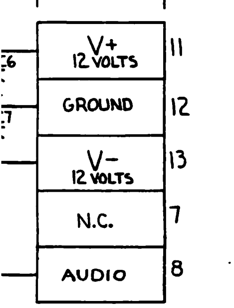

160 Hz
200 Hz
SAME AS
SAME AS
140501
125 Hz
100 Hz



9-5 Component Locations, Filters—Low Module


800 Hz
1 KHz
1.25 KHz
1.6 KHz
2.0 KHz
2.5 KHz
3.15 KHz
4.0 KHz
PCB 140500/01
PCB 140400/01
5.0 KHz
6.3 KHz
8.0 KHz
10 KHz
12.5 KHz
16.0 KHz
20.0 KHz
FILTERS
WIDE BAND
RECTIFIERS
PEAK RECT.
IC9
R20 100 K
R19 100 K
IC 7
CD4051 BE
8 CHANNEL MULTIPLEXER
IC 8
CD4051 BE
8 CHANNEL MULTIPLEXER





FILTER COMPONENT VALUE TABLE

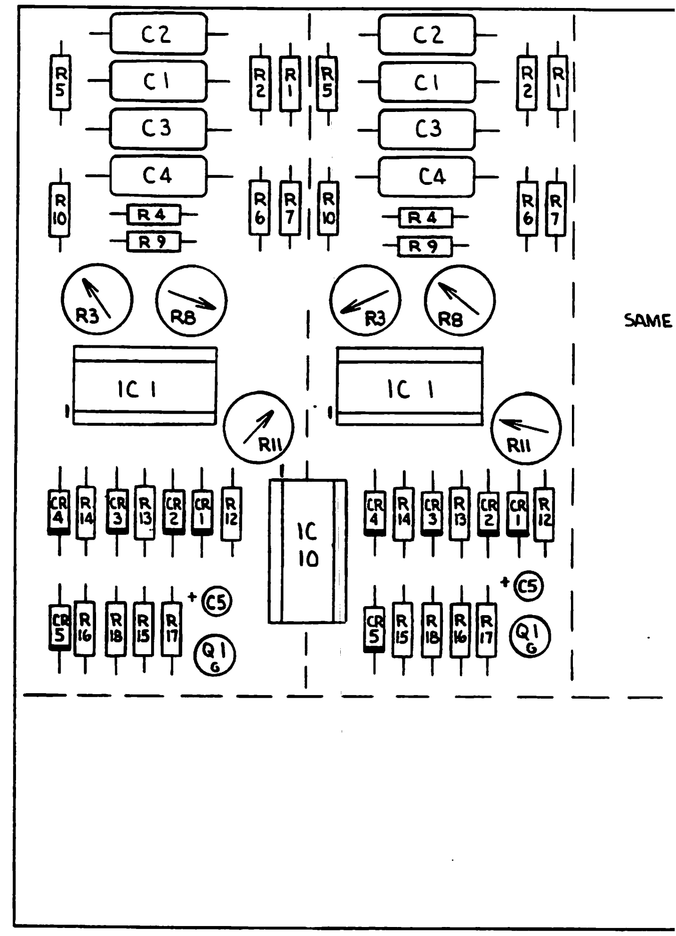
FILTER	C1,2,3,4	R1	R2	R3,8	R4,5	R6	R7	R9,10
800Hz	.0047	39K	3.3K	2K	560K	180K	2.7K	470K
1K	"	33K	2.7K	1K	470K	130K	2.2K	390K
1.25K	"	24K	2.2K	"	360K	110K	1.8K	300K
1.6K	"	18K	1.5K	"	270K	82K	1.2K	240K
2K	"	15K	1K	"	220K	62K	1K	180K
2.5K	"	12K	820	"	180K	51K	820	150K
3.15K	.001	47K	3.9K	2K	680K	200K	3.3K	620K
4K	"	36K	2.7K	"	510K	150K	2.7K	430K
5K	"	30K	2.7K	1K	430K	130K	2.2K	360K
6.3K	"	22K	2.2K	"	330K	100K	1.8K	270K
8K	"	18K	1.8K	"	270K	75K	1.2K	220K
10K	"	15K	1K	"	220K	62K	1K	180K
12.5K	470pF	24K	1.8K	2K	360K	110K	1.8K	300K
16K	"	18K	1.5K	"	270K	82K	1.2K	240K
20K	"	15K	1K	"	220K	62K	1K	180K

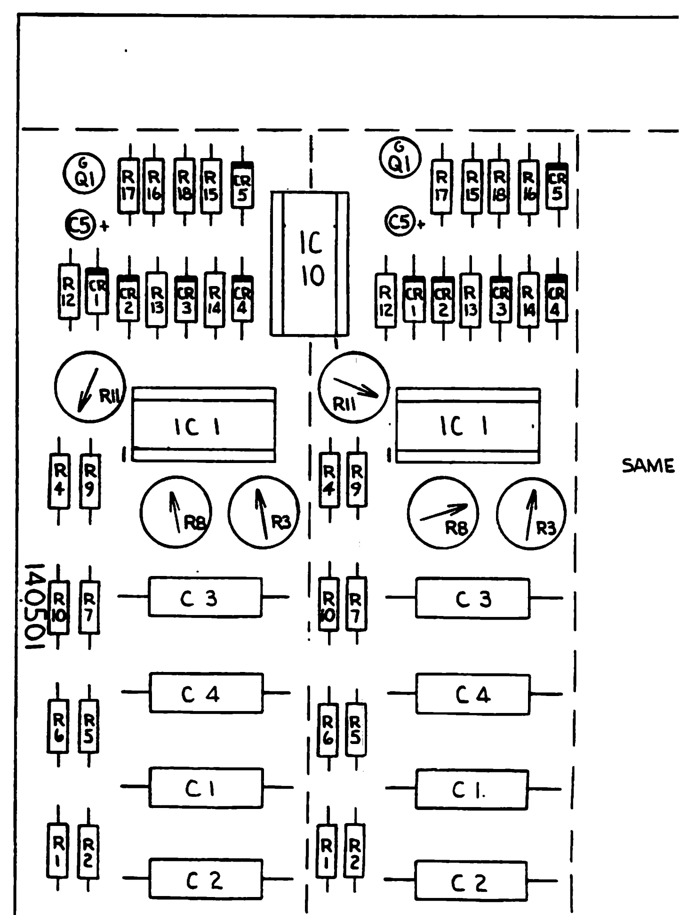
NOTES: (UNLESS OTHERWISE SPECIFIED . . . .)

1. RESISTORS ARE ¼W, 5%.
2. CAPACITORS ARE IN µF.
3. DIODES ARE 1N4151.
4. IC's 10 ARE CD4066BE; IC's 1 ARE LM324 - 800Hz THROUGH 4kHz, RC4136 - 5kHz THROUGH 20kHz. (PIN NO.)
5. FET's ARE SILICONIX E111.

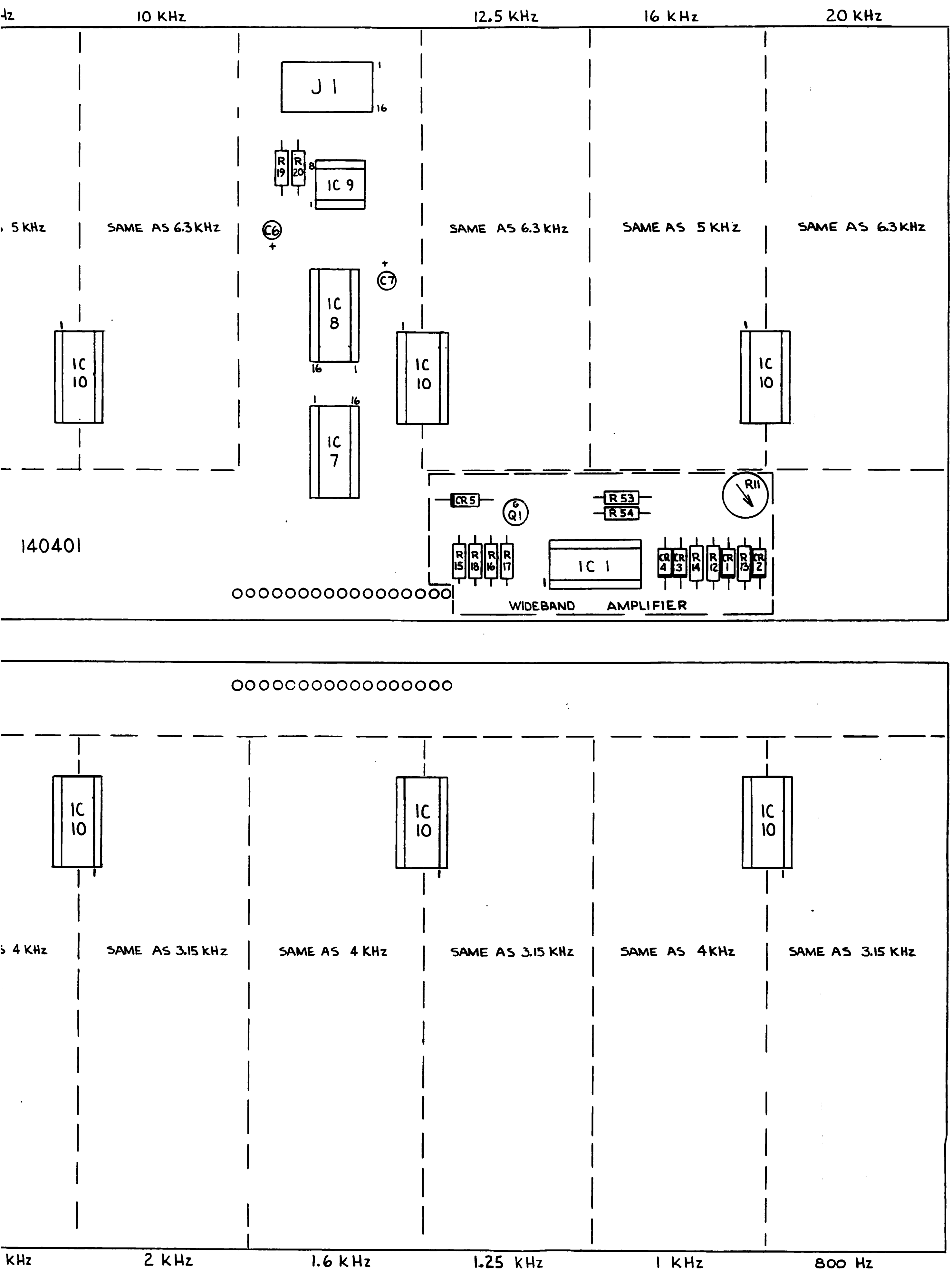
9-6 Schematic, Filters—High Module

5 KHz 6.3 KHz

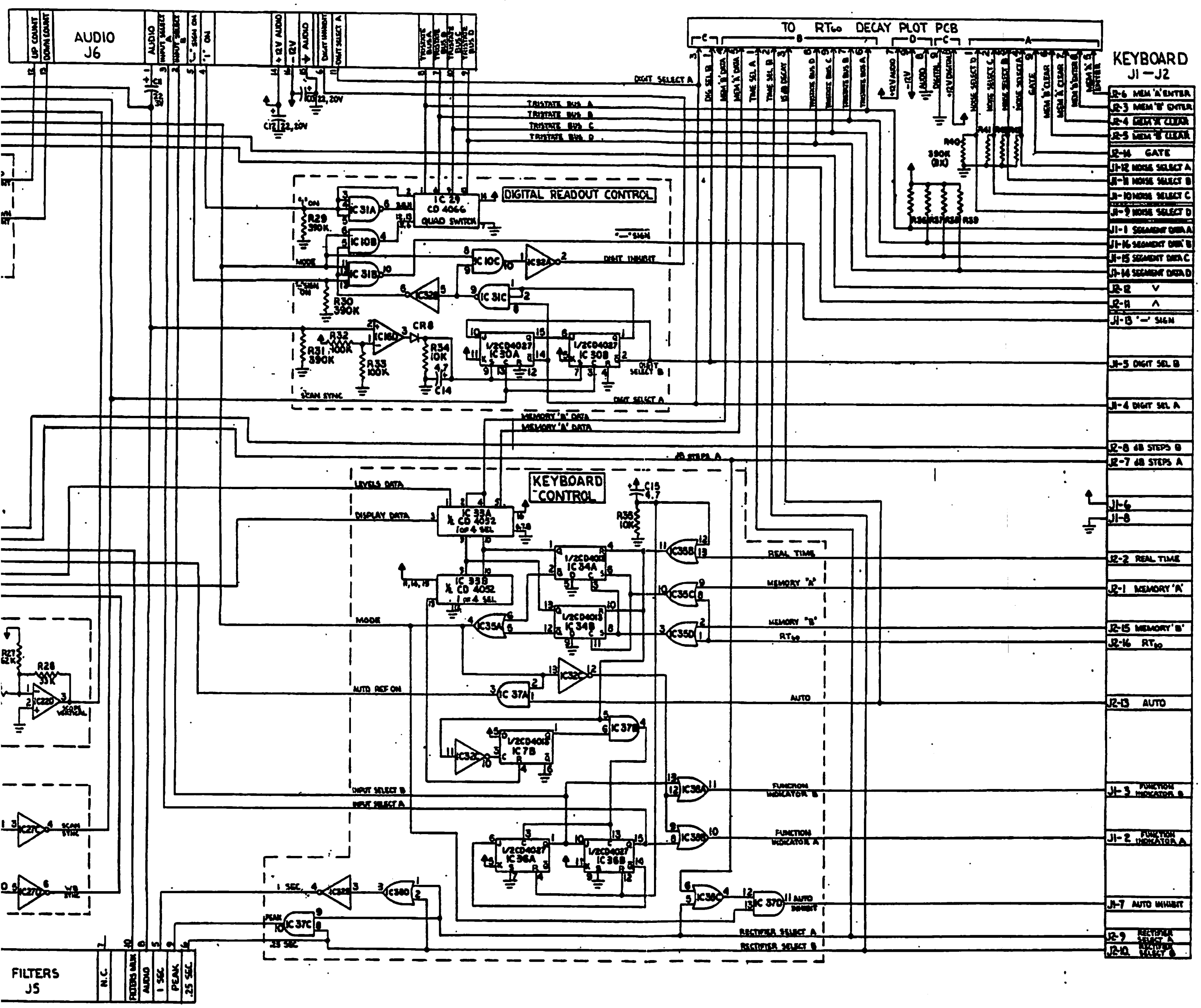




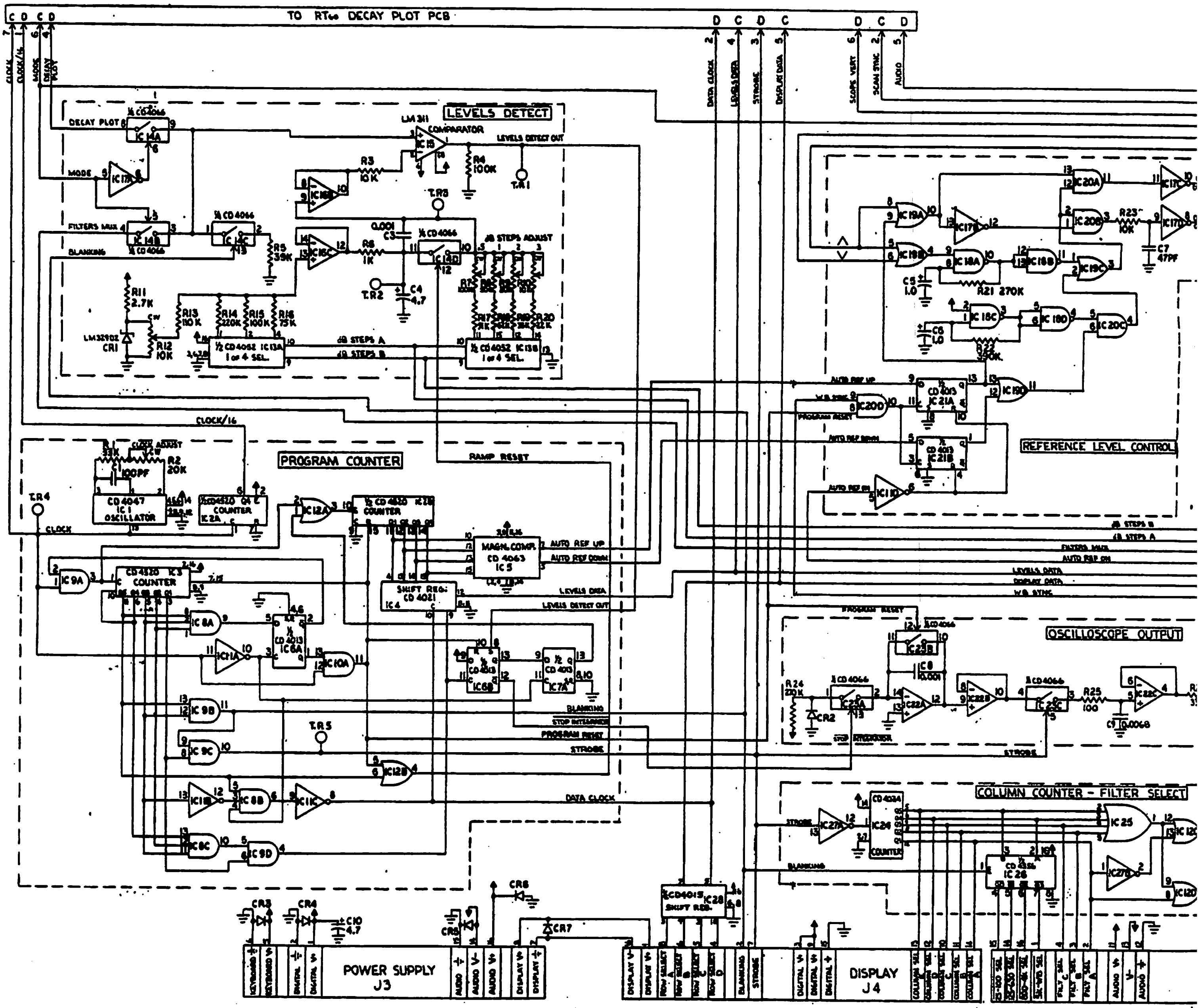
4 KHz 3.15 KHz



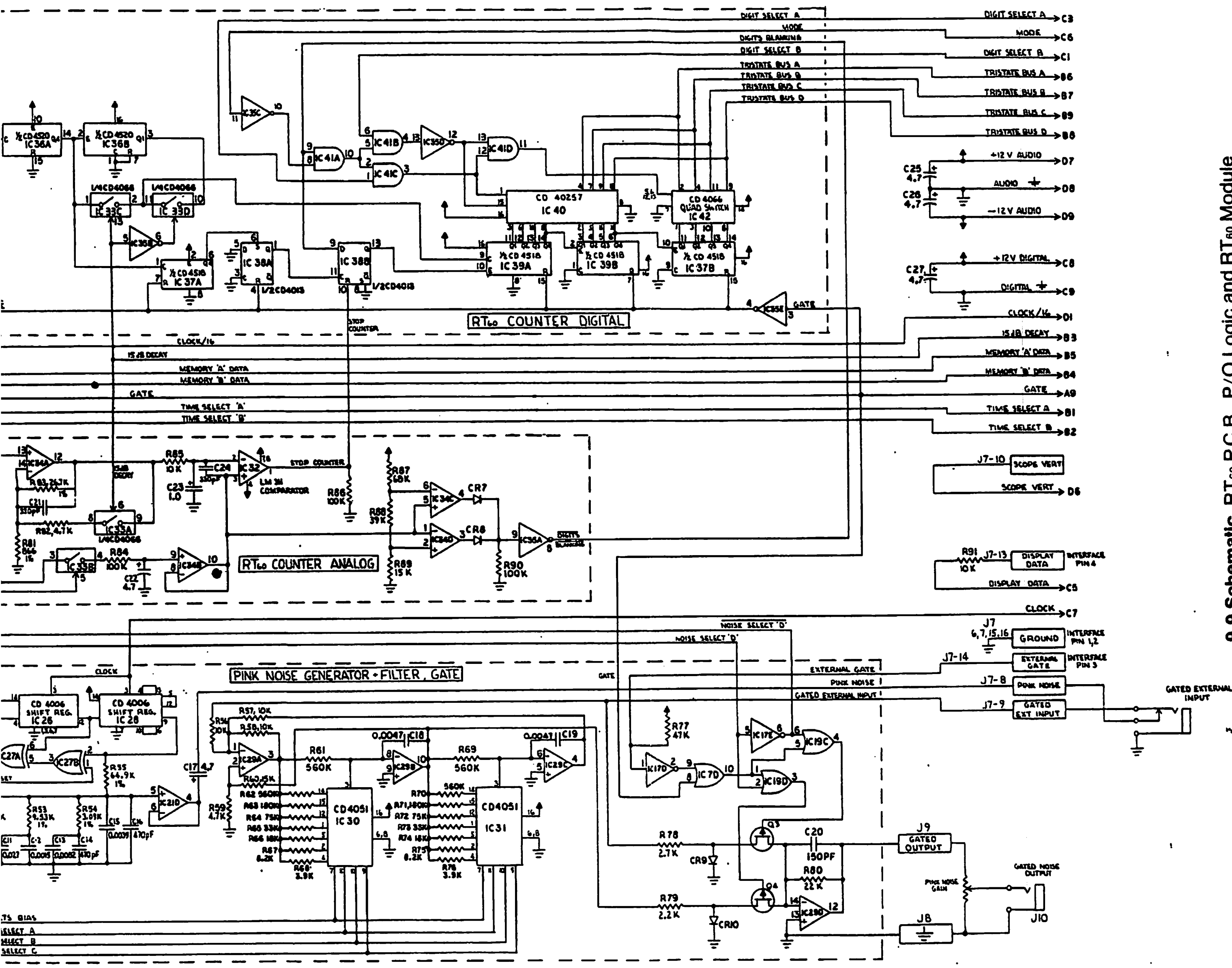
9-7 Component Locations, Filters—High Module



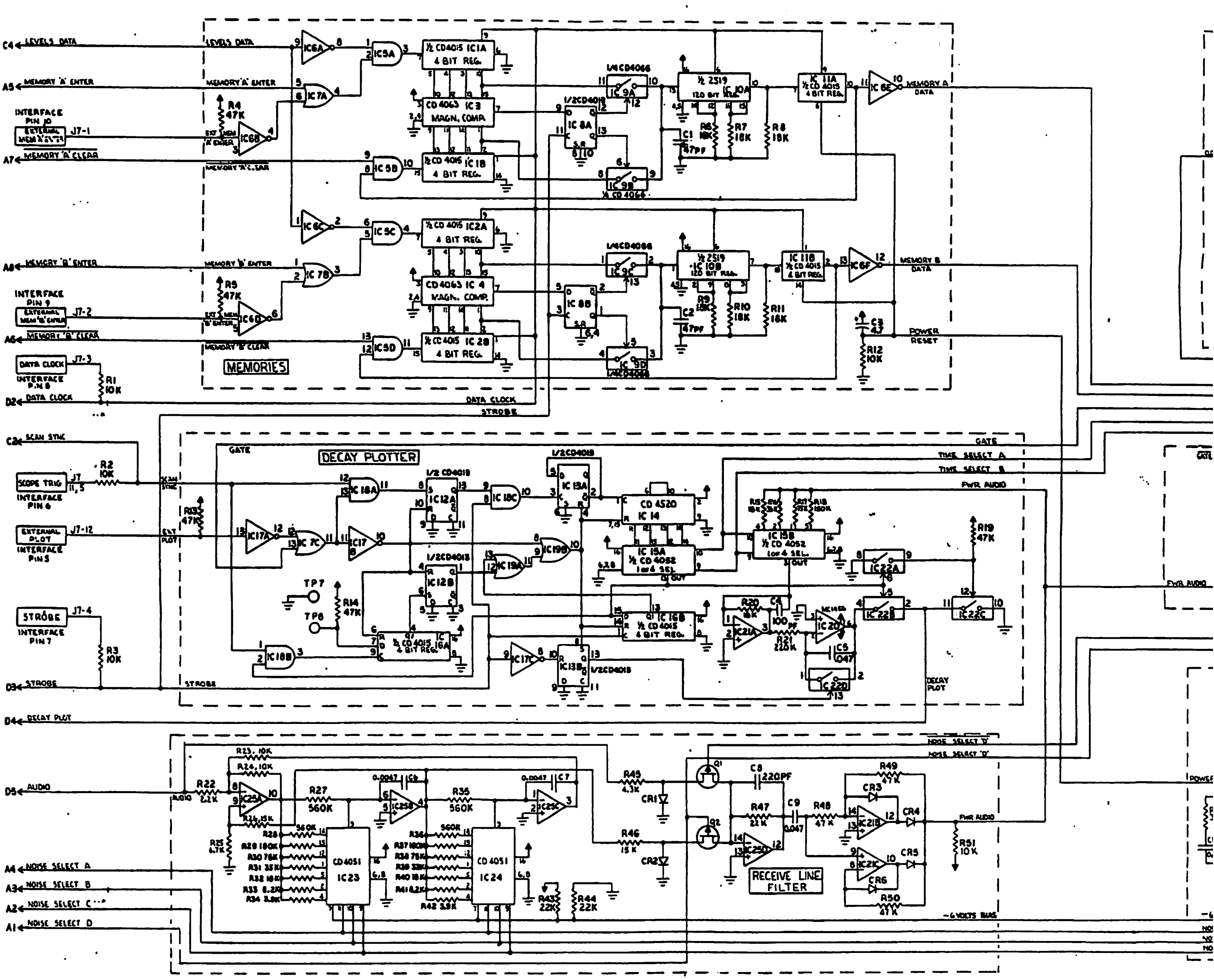
9-8 Schematic, Logic P.C.B., P/O Logic and RT60 Module



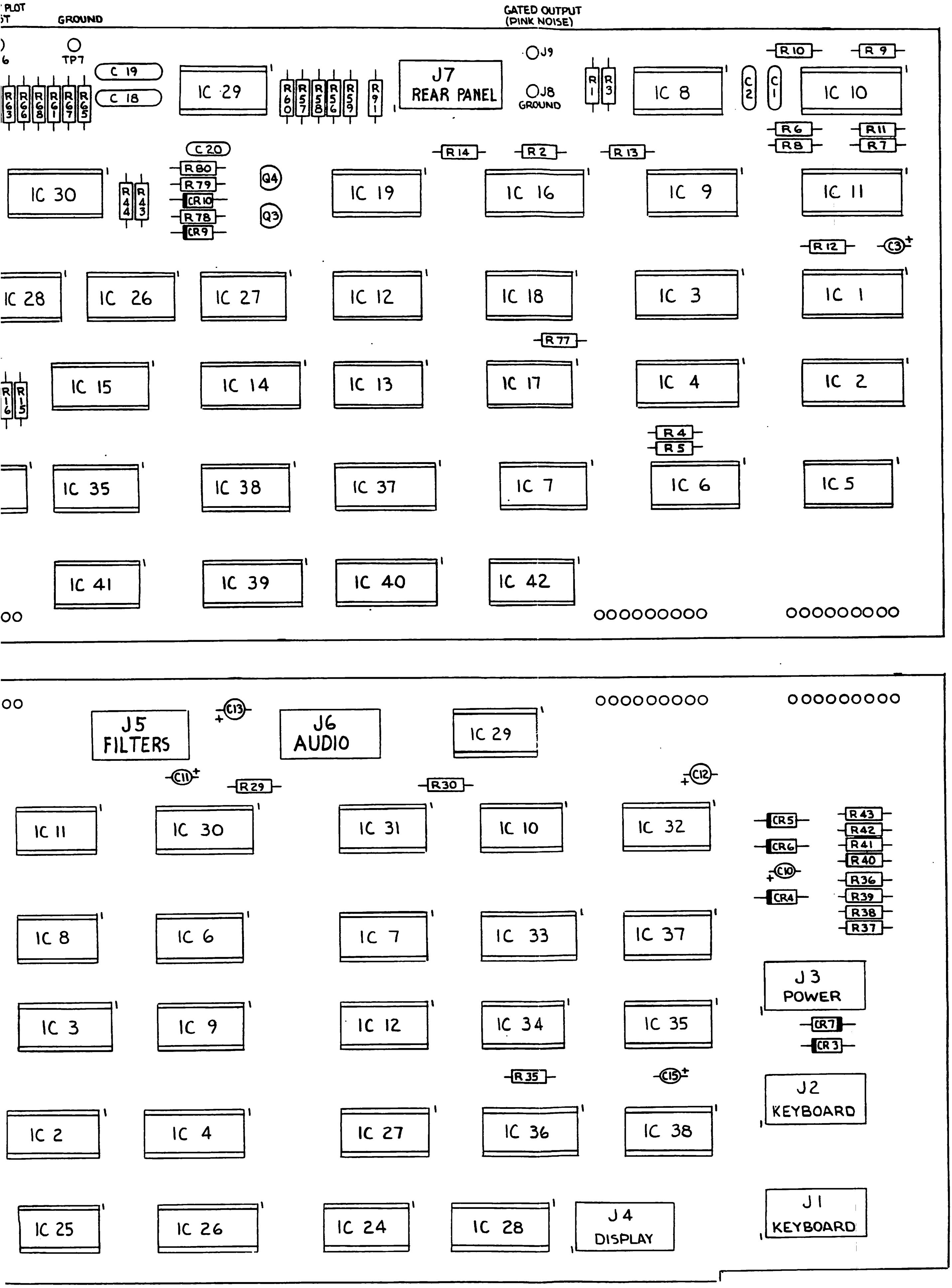
TO RT60 DECAY PLOT PCB
LEVELS DETECT
LM 311 COMPARATOR
LEVELS DETECT OUT
dB STEPS ADJUST
dB STEPS A
dB STEPS B
PROGRAM COUNTER
CLOCK ADJUST
CD 4047 IC 1 OSCILLATOR
RAMP RESET
MAGN. COMP. CD 4063 IC 5
AUTO REF UP
AUTO REF DOWN
SHIFT REG. CD 4021
LEVELS DATA
BLANKING
STOP INTERRUPT
PROGRAM RESET
STROBE
DATA CLOCK
REFERENCE LEVEL CONTROL
OSCILLOSCOPE OUTPUT
COLUMN COUNTER - FILTER SELECT
SHIFT REG.
POWER SUPPLY J3
DISPLAY J4



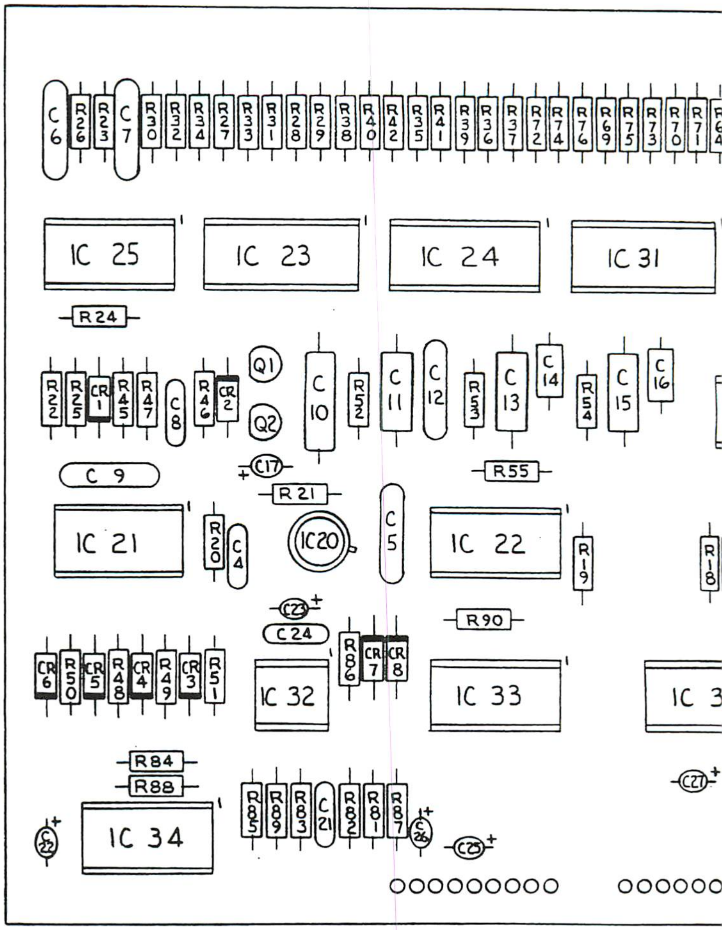
9-9 Schematic, RT60 P.C.B., P/O Logic and RT60 Module

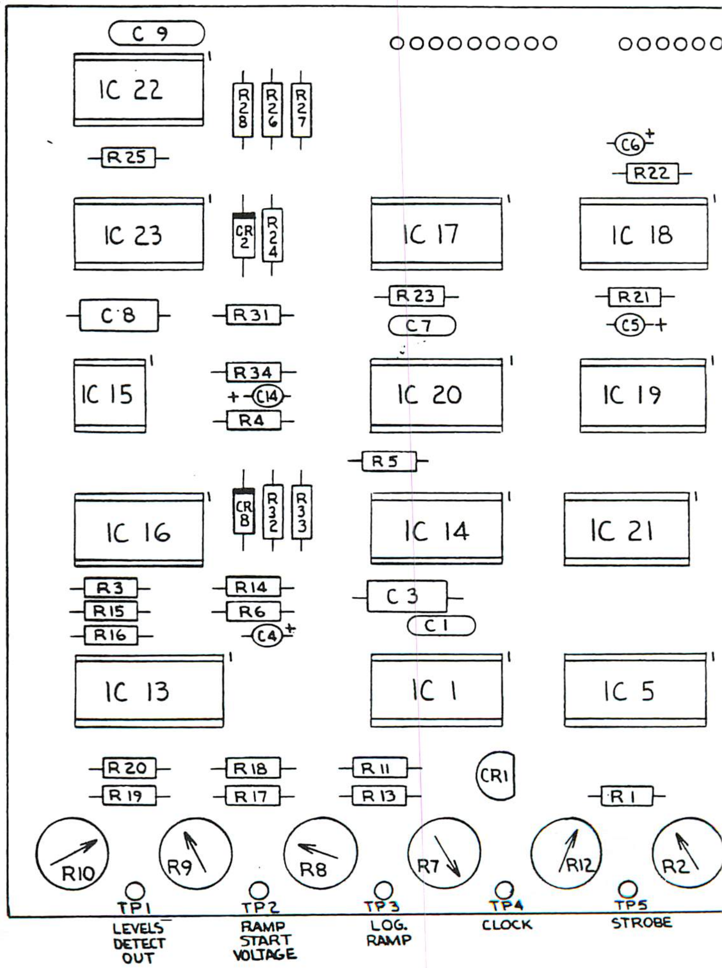


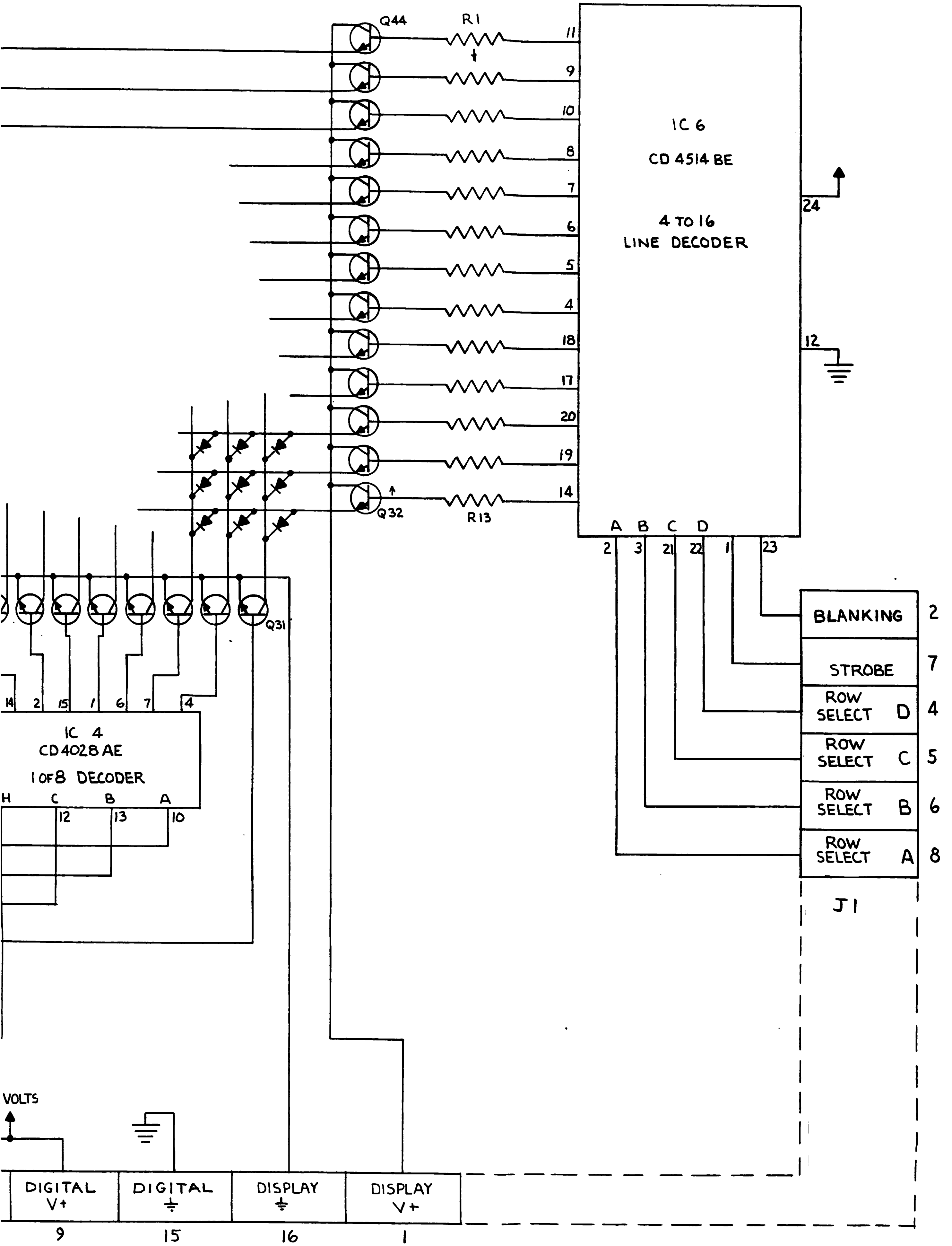
C4 LEVELS DATA
A5 MEMORY 'A' ENTER
INTERFACE PIN 10
J7-1
A7 MEMORY 'A' CLEAR
A8 MEMORY 'B' ENTER
INTERFACE PIN 9
J7-2
A6 MEMORY 'B' CLEAR
DATA CLOCK
J7-3
INTERFACE PIN 8
D2 DATA CLOCK
MEMORIES
½ CD4015 IC1A 4 BIT REG.
CD4063 IC3 MAGN. COMP.
½ CD4015 IC1B 4 BIT REG.
½ CD4015 IC2A 4 BIT REG.
CD4063 IC4 MAGN. COMP.
½ CD4015 IC2B 4 BIT REG.
½ 2519 IC10A 120 BIT REG.
½ 2519 IC10B 120 BIT REG.
IC 11A ½ CD 4015 4 BIT REG.
IC 11B ½ CD 4015 4 BIT REG.
MEMORY A DATA
MEMORY B DATA
POWER RESET
C2 SCAN SYNC
SCOPE TRIG
INTERFACE PIN 6
EXTERNAL PLOT
J7-12
INTERFACE PIN 5
STROBE
J7-4
INTERFACE PIN 7
D3 STROBE
DECAY PLOTTER
GATE
TIME SELECT A
TIME SELECT B
PWR AUDIO
CD 4520 IC 14
IC 15A ½ CD 4052 1 of 4 SEL.
IC 15B ½ CD 4052 1 of 4 SEL.
½ CD 4015 IC 16A 4 BIT REG.
IC 16B ½ CD 4015 4 BIT REG.
DECAY PLOT
D4 DECAY PLOT
D5 AUDIO
A4 NOISE SELECT A
A3 NOISE SELECT B
A2 NOISE SELECT C
A1 NOISE SELECT D
CD 4051 IC23
CD 4051 IC24
RECEIVE LINE FILTER
-6 VOLTS BIAS



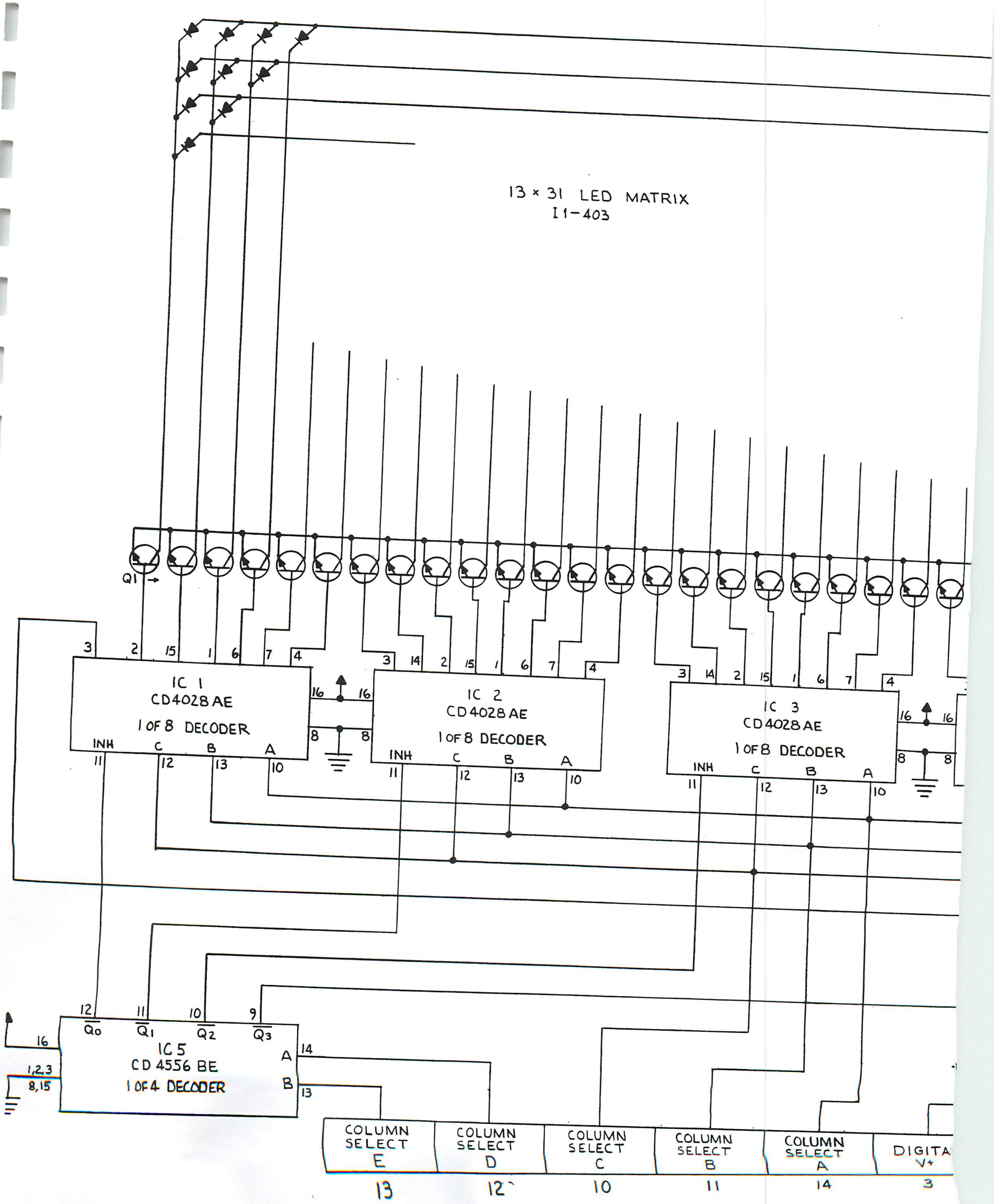
9-10 Component Locations, Logic and RT$_{60}$ Module


C6
R26
R23
C7
R30
R32
R34
R27
R33
R31
R28
R29
R38
R40
R42
R35
R41
R39
R36
R37
R72
R74
R76
R69
R75
R73
R70
R71
IC 25
IC 23
IC 24
IC 31
R24
R22
R25
CR1
R45
R47
C8
R46
CR2
Q1
Q2
C10
R52
C11
C12
R53
C13
C14
R54
C15
C16
C9
C17
R21
R55
IC 21
R20
C4
IC20
C5
IC 22
R19
R18
C23
C24
R90
CR6
R50
CR5
R48
CR4
R49
CR3
R51
IC 32
R86
CR7
CR8
IC 33
IC 3
R84
R88
C27
C22
IC 34
R85
R89
R83
C21
R82
R81
R87
C26
C25

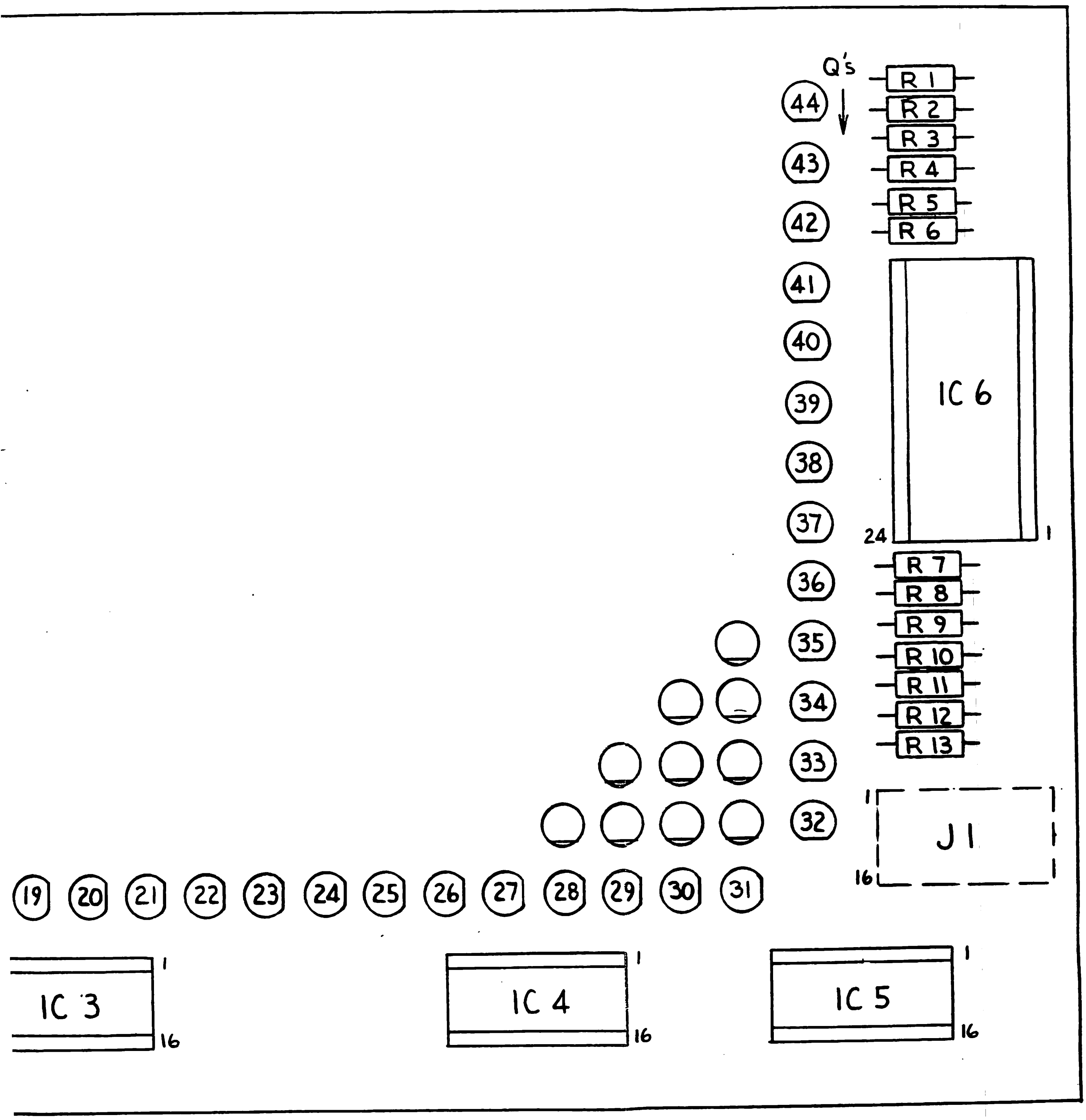

C 9
IC 22
R28
R26
R27
C6
R25
R22
IC 23
CR2
R24
IC 17
IC 18
C 8
R31
R23
C7
R21
C5
IC 15
R34
C14
R4
IC 20
IC 19
R5
IC 16
CR8
R32
R33
IC 14
IC 21
R3
R15
R16
R14
R6
C4
C 3
C 1
IC 13
IC 1
IC 5
R20
R19
R18
R17
R11
R13
CR1
R1
R10
R9
R8
R7
R12
R2
TP1
LEVELS DETECT OUT
TP2
RAMP START VOLTAGE
TP3
LOG. RAMP
TP4
CLOCK
TP5
STROBE



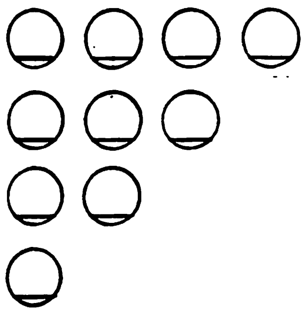
9-11 Schematic, Display Module



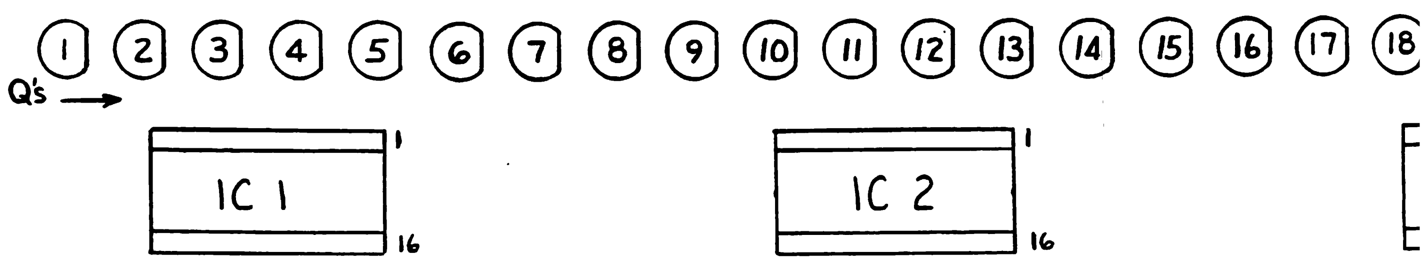
13 × 31 LED MATRIX
I1-403
Q1
IC 1
CD4028AE
1 OF 8 DECODER
IC 2
CD4028AE
1 OF 8 DECODER
IC 3
CD4028AE
1 OF 8 DECODER
INH
C
B
A
IC 5
CD 4556 BE
1 OF 4 DECODER
$\overline{Q_0}$
$\overline{Q_1}$
$\overline{Q_2}$
$\overline{Q_3}$
1,2,3
8,15
COLUMN SELECT E
COLUMN SELECT D
COLUMN SELECT C
COLUMN SELECT B
COLUMN SELECT A
DIGITA
V+
13
12
10
11
14
3

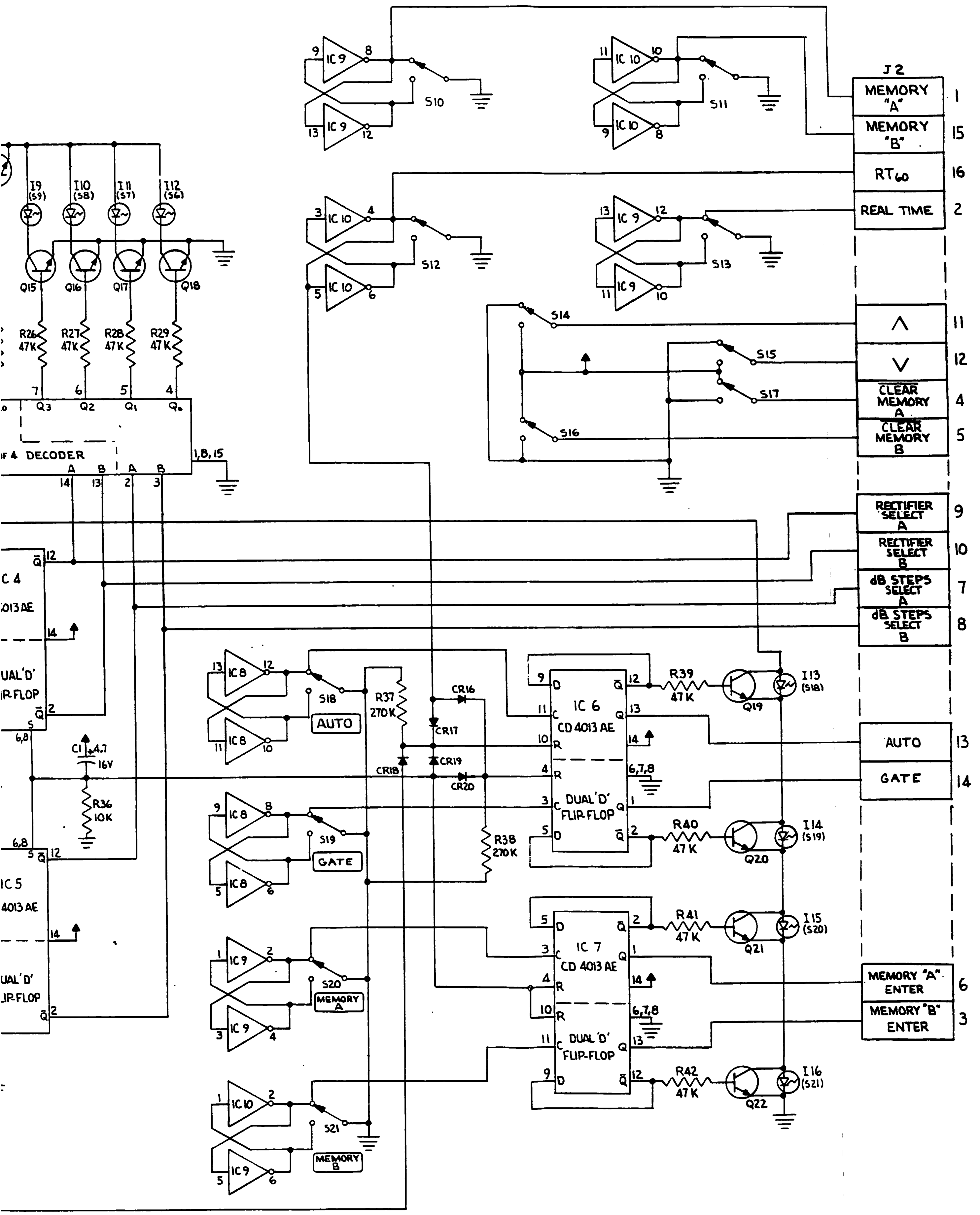


9-12 Component Locations, Display Module

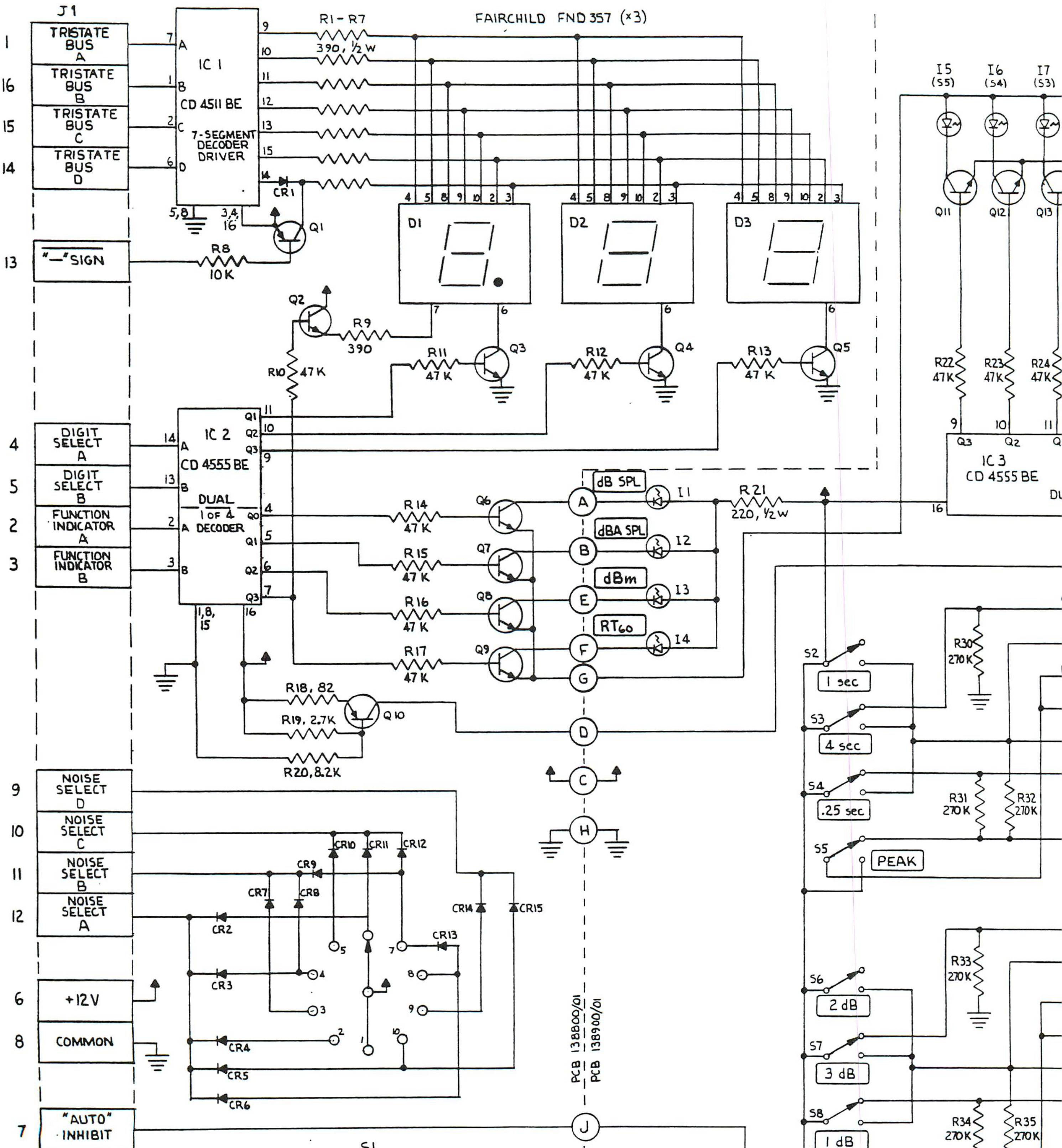


138601



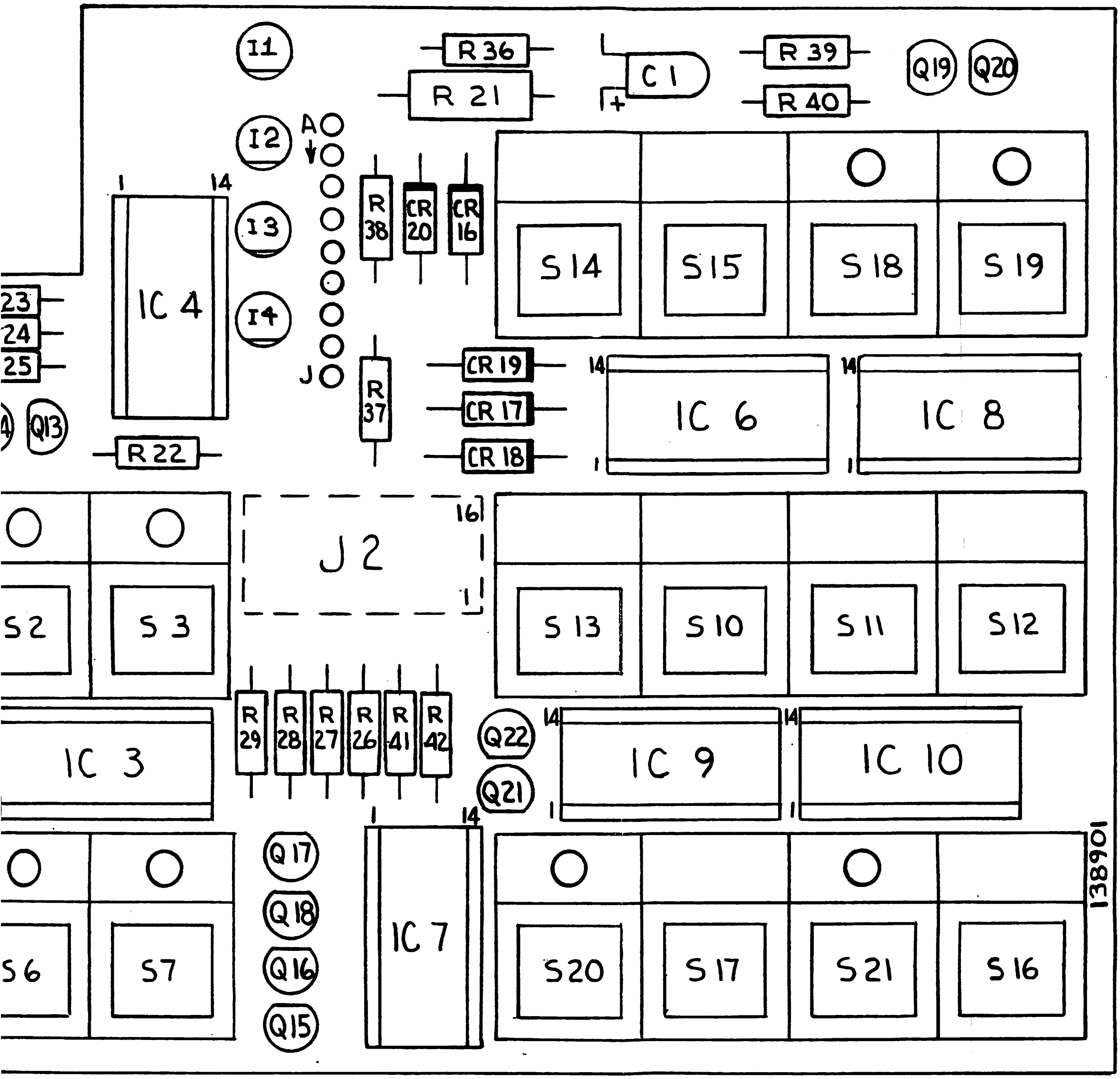


9-13 Schematic, Keyboard Module

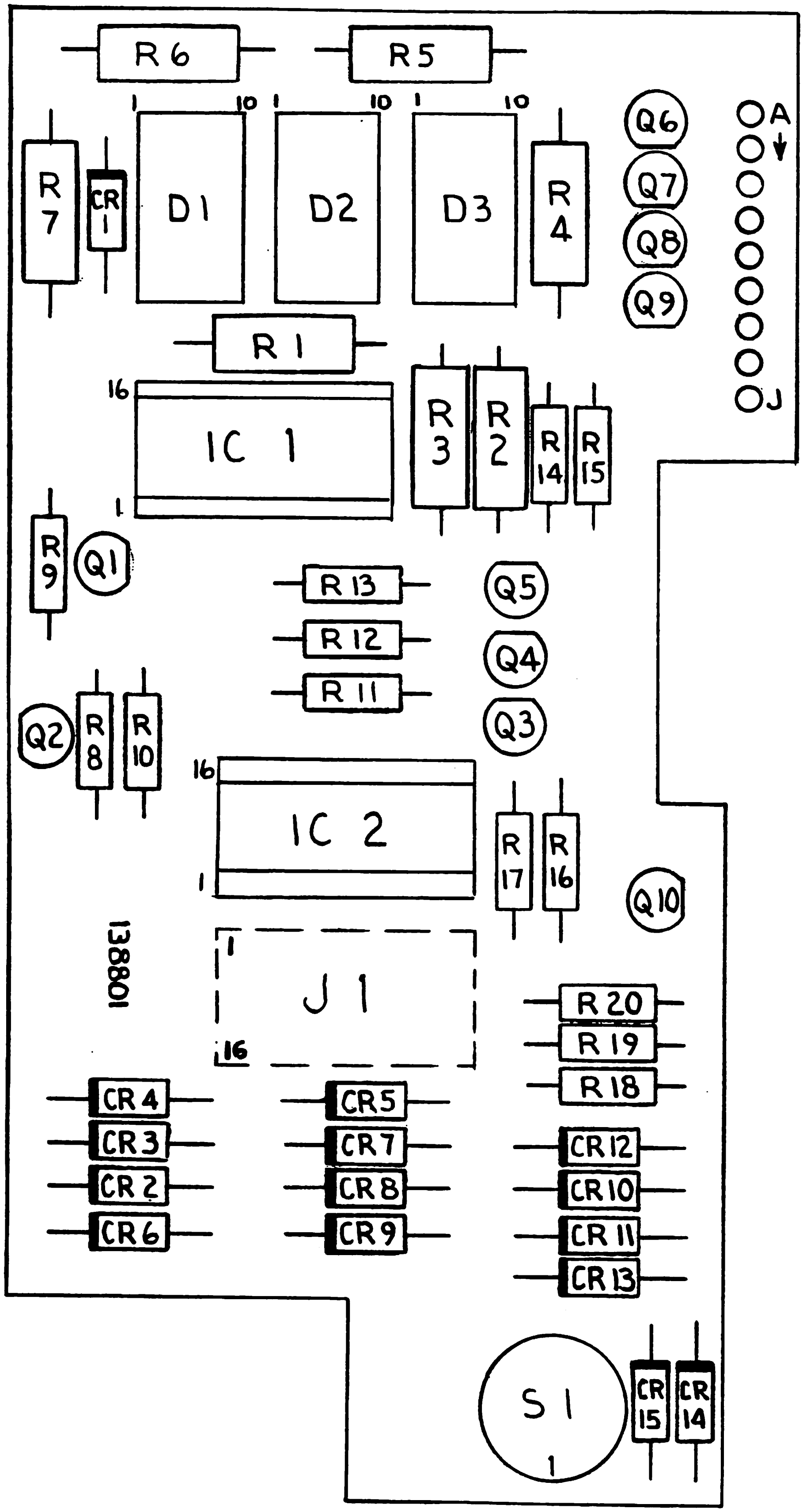


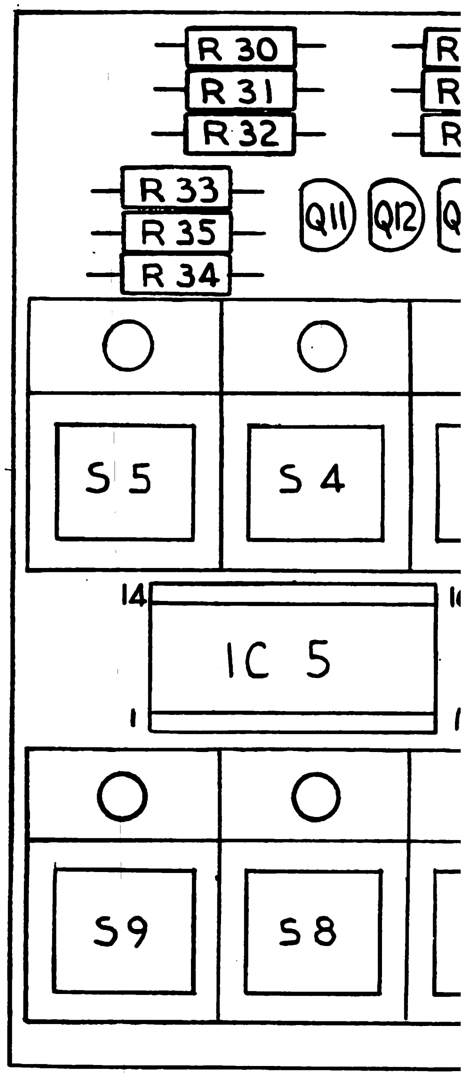
NOTES:

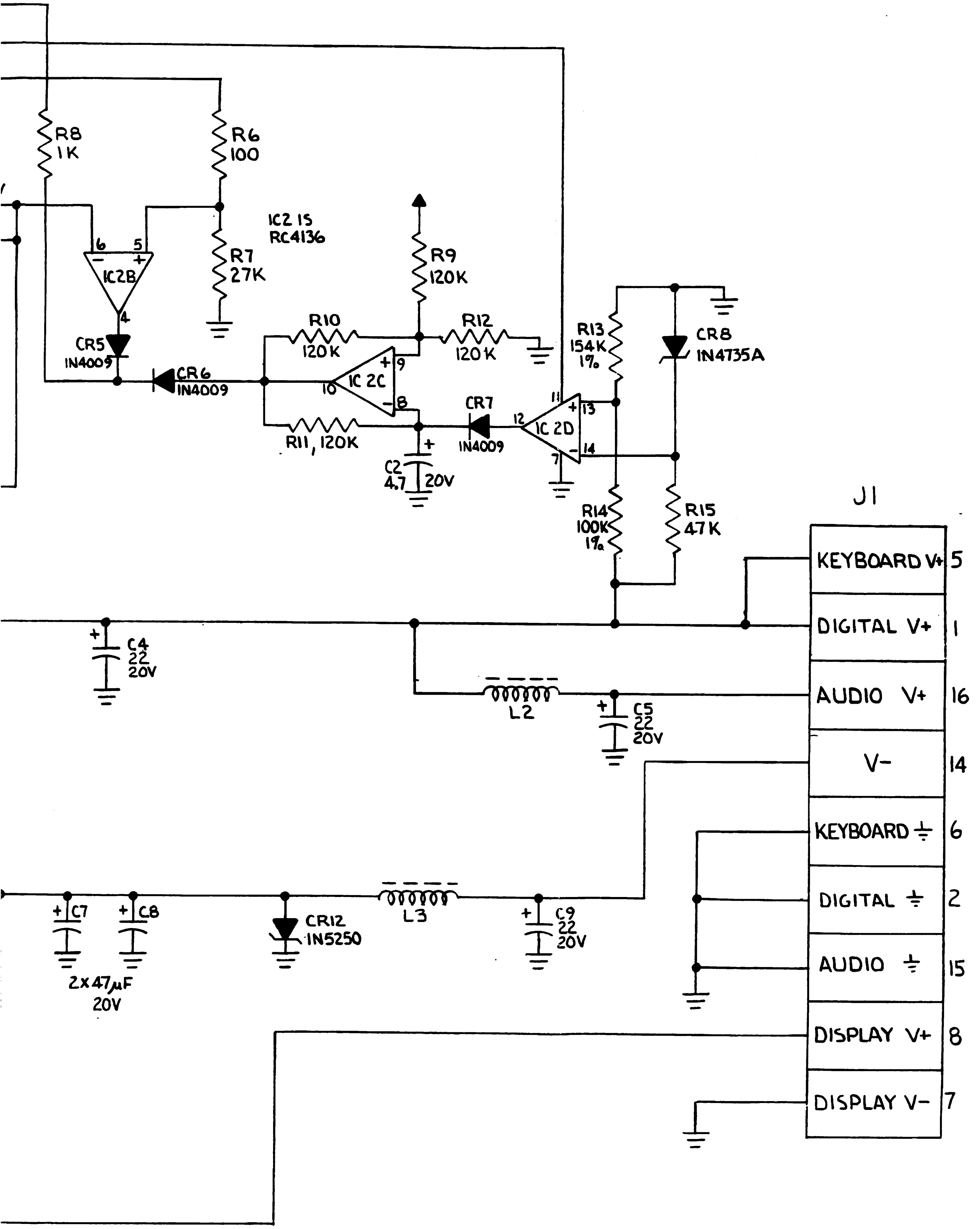
1. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE INDICATED.
2. ALL NPN TRANSISTORS ARE TYPE MPS-A14.
3. ALL PNP TRANSISTORS ARE TYPE 2N 3645.
4. ALL DIODES ARE TYPE 1N 4151.
5. ALL SWITCHES AND CONNECTIONS ARE LABELED AS USED IN "REAL TIME" MODE.
6. INDICATOR LAMPS I 5 THROUGH I 16 ARE PART OF SWITCHES S 2 THROUGH S 9 AND S 18 THROUGH S 21.
7. IC'S 8,9 AND 10 ARE CD-4069BE; PIN 14 V+, PIN 7 GND.



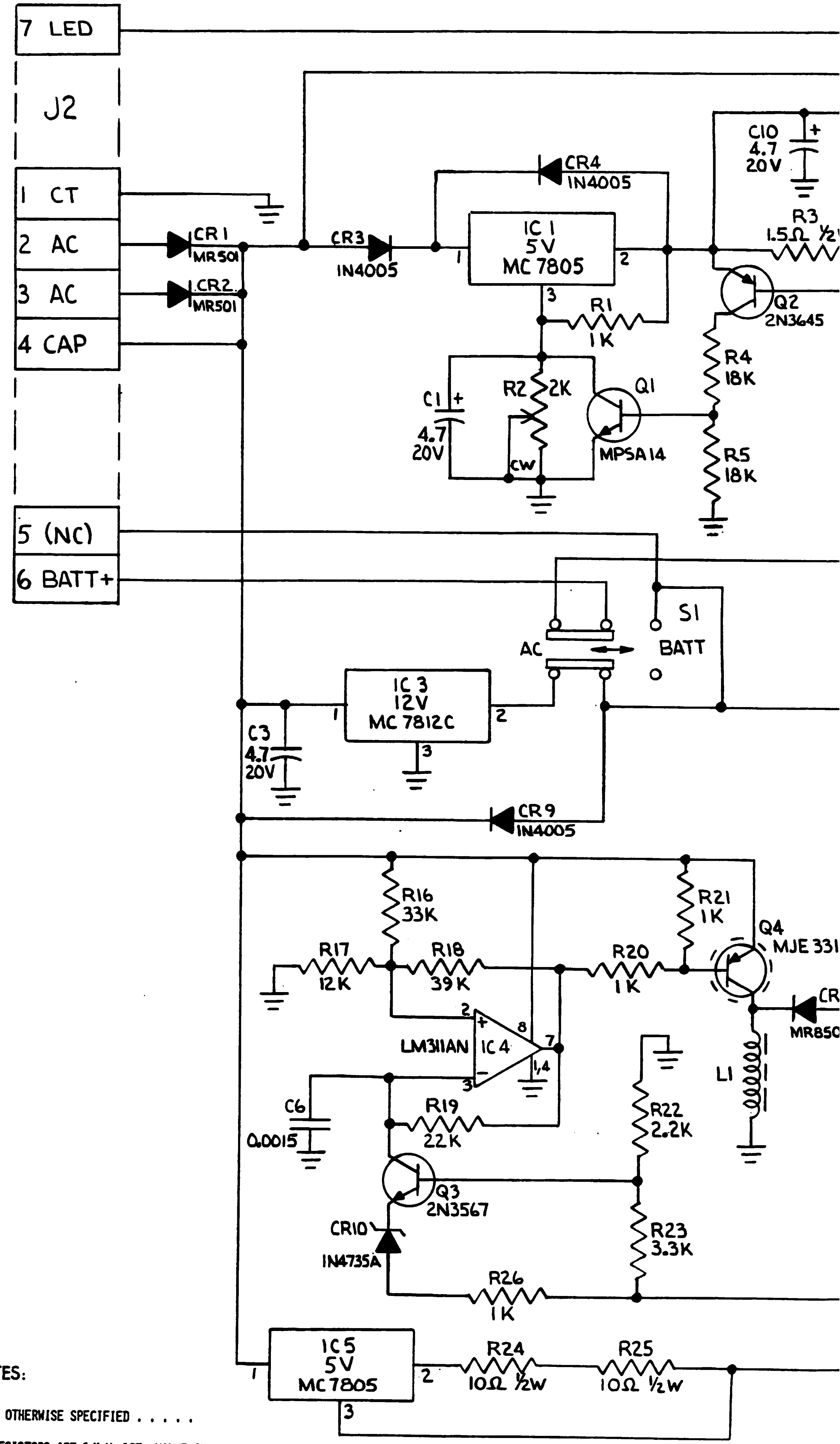
9-14 Component Locations. Keyboard Module


R 6
R 5
1 10
D1
D2
D3
R 7
CR 1
R 4
Q6
Q7
Q8
Q9
A
J
R 1
16
IC 1
1
R 3
R 2
R 14
R 15
R 9
Q1
R 13
R 12
R 11
Q5
Q4
Q3
Q2
R 8
R 10
IC 2
R 17
R 16
Q10
138801
J 1
R 20
R 19
R 18
CR 4
CR 3
CR 2
CR 6
CR5
CR7
CR8
CR9
CR12
CR10
CR 11
CR 13
S 1
CR 15
CR 14


R 30
R 31
R 32
R 33
R 35
R 34
Q11
Q12
S 5
S 4
14
IC 5
1
S9
S 8



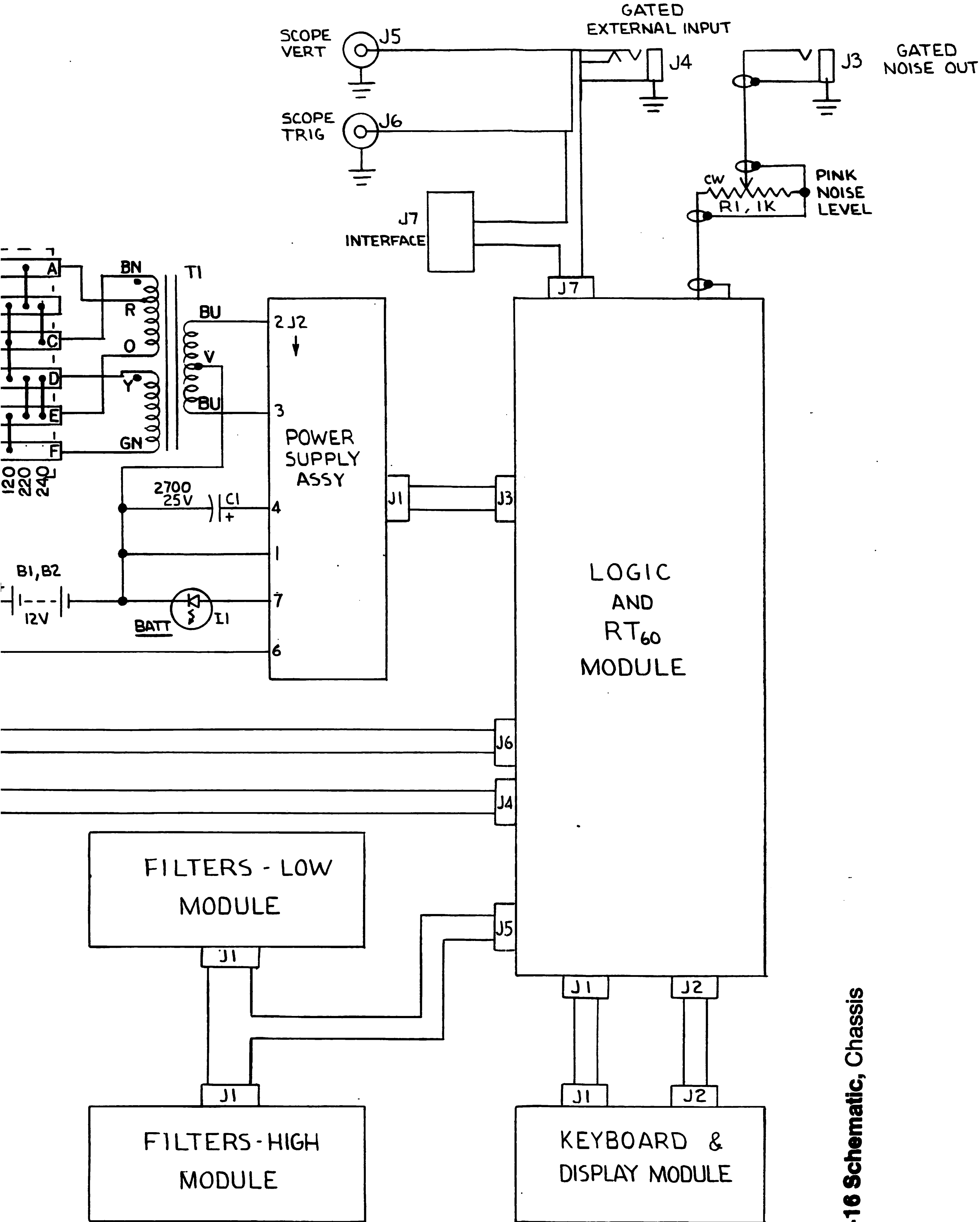
9-15 Schematic, Power Supply P.C.B.



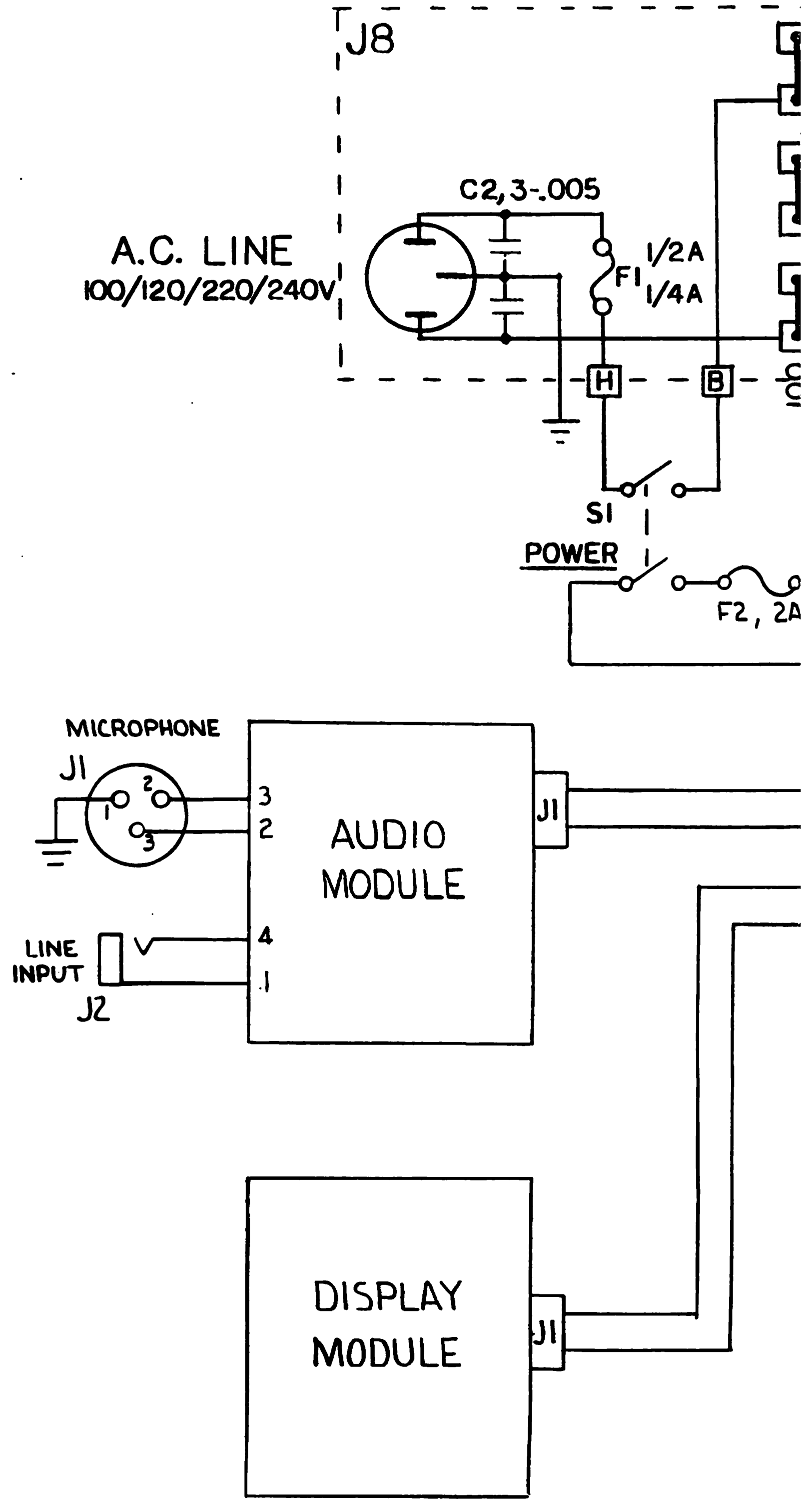
NOTES:

UNLESS OTHERWISE SPECIFIED . . . . .

1. RESISTORS ARE 1/4 W, 10%; VALUE IN OHMS.
2. CAPACITORS ARE 50 V, OR BETTER; VALUE IN μF.



9-16 Schematic, Chassis


J8
C2, 3-.005
A.C. LINE
100/120/220/240V
1/2A
F1
1/4A
H
B
S1
POWER
F2, 2A
MICROPHONE
J1
3
2
AUDIO
MODULE
J1
LINE
INPUT
J2
4
1
DISPLAY
MODULE
J1