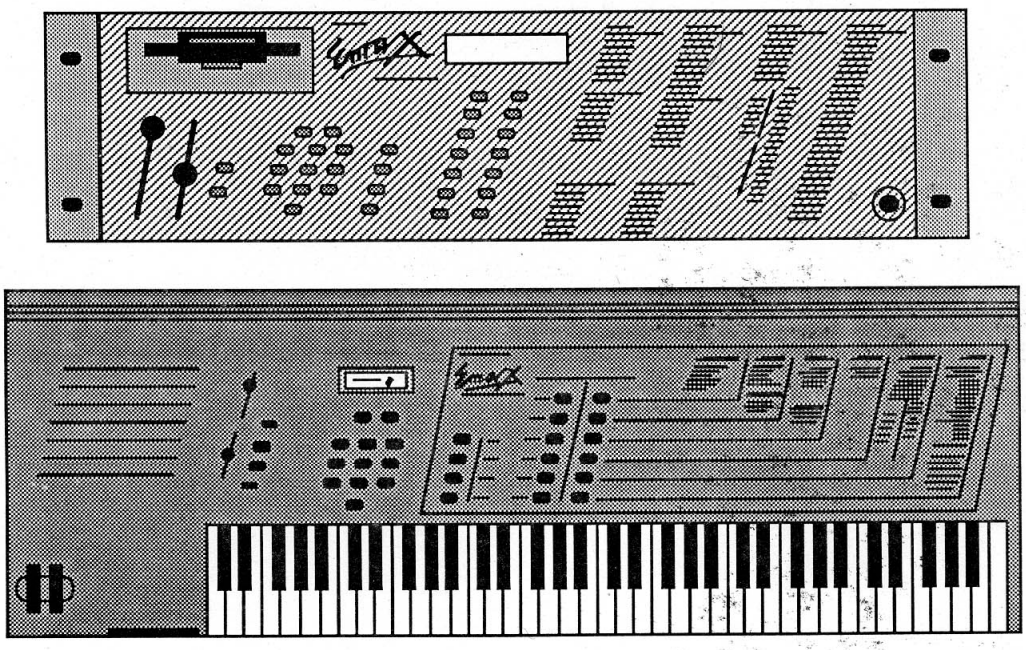
EMAX
DIGITAL SAMPLER
TECHNICAL
MANUAL

by

Riley B. Smith



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INTRODUCTION

The Emax Digital Sampler is a powerful and complex instrument. E-mu Systems Inc. intends this manual to be an aid to the experienced service technician only.

To service Emax you should be familiar with the 7400 series of digital logic, floppy disk drives, ADC's and DAC's, op-amps as well as microprocessor troubleshooting techniques, and current music synthesizer technology. The minimum equipment required to service and repair Emax are: a digital multimeter, a 100MHz dual trace oscilloscope and basic technician hand tools.

Because Emax has so many complex functions, we have not included brief operating instructions in this manual. Instead, we highly recommend having a complete Emax operational manual on hand to help you understand all the functions.

The information contained in this manual is proprietary to E-mu Systems Inc. The entire manual is protected under copyright and none of it may be reproduced by any means without written permission from E-mu. This manual is available only to approved service people and is property of E-mu Systems. Please consider all of the data secret and use it only to service Emax.

We feel obliged to remind you that any modification of an Emax other than as specified by a factory authorized E-mu Change Order (ECO) will void the warranty of the instrument.

Please read this manual thoroughly before attempting to service Emax. If you feel unsure about working on the instrument, contact our service department.

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INTERFACE SPECIFICATION

THE MIDI INTERFACE

Hardware: MIDI is a serial, 5 milliamp current loop interface between two or more computer controlled musical instruments. It uses optoisolators and non-grounded inputs to prevent ground loops. MIDI operates at a 31.25K Baud rate and does not use any handshaking. Each MIDI connection requires two wires to complete the loop. The hardware used is very simple. The output is usually an open collector driver, typically a 7407 and a series resistor. On Emax, the driver is not an open collector driver but a leftover NAND gate (74S00) and a 1N914 diode (see schematic). This is not a typical MIDI driver circuit, but it works just fine. The return line is a series resistor connected to 5 volts. The MIDI input current runs through a 150 Ω resistor and the directly into a PC900 optoisolator. Emax uses the standard 5 pin DIN connectors for MIDI IN and MIDI OUT/THRU.

MIDI Thru: MIDI Thru on Emax is a software selectable function (under MIDI in the Preset Definition module), which simply routes incoming MIDI data to the MIDI OUT jack when MIDI THRU is selected.

MIDI Analyzer: Emax contains a MIDI analyzer function (Special 6 in the Master Module), which can be very useful in diagnosing MIDI interconnection problems. The analyzer displays all incoming and outgoing MIDI information except System Exclusive and Active Sensing messages.

Continuous Controllers: Note that Emax's continuous controller channels are programmable on any of the 32 channels for each preset. This allows for much flexibility and (unfortunately) much confusion for many users. When MIDI problems are encountered, make sure that the problem is not due to incorrect preset programming (or outside MIDI connections) before assuming hardware or software faults. See also MIDI implementation chart at the end of this section.

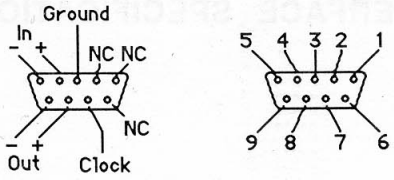
System Exclusives: Emax contains a full complement of MIDI system exclusive commands. These include the front panel controls and machine status information as well as MMA sample dump commands. This information can be transmitted and recieved via MIDI or by the faster RS-422 port. For more information on the system exclusive specifications, contact our Customer Service department.

RS-422 CONNECTION

The RS-422 connector is a high-speed serial communication port which allows data to be transferred to and from an external computer at a very high rate (500K baud). The 422 port uses a differential mode of operation in order to reduce noise and the chance of transmission error. The connection cable to the external computer will generally be supplied with a software package (such as Sound Designer by Digidesign) and does not come with Emax. Emax contains built in diagnostics which will test the RS-422 interface. Refer to the Diagnostics section for information on these tests.

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CLOCK IN and CLOCK OUT

Clock In: The clock in jack allows an external device such as a drum machine or sequencer to control the tempo of the sequencer or arpeggiator. Emax can receive input clock rates of 24, 48, or 96 pulses per quarter note. The pulses should be **at least 1 millisecond wide and have a level of 1 to 5 volts.**

Clock Out: The clock out jack allows Emax to be the master clock and drive sequencers and drum machines at a rate of 24 pulses per quarter note. This is a **5 volt pulse which is about 6 milliseconds wide.** Note that the clock out is not a metronome. Emax does not have it's own metronome, but can be syncronized with drum boxes or other sequencers to provide the function.

FOOTSWITCH AND PEDAL CONNECTION

Footswitch: Two control footswitch jacks are provided for performance control of sequencer, arpeggiator, sustain, release, Xswitch, and preset advance. The footswitches should be of the **momentary contact type** but can be **either normally-open or normally-closed.** The type of footswitch can be selected in the Recalibrate menu, under SPECIAL, in the **MASTER** module.

Pedal: The control pedal is used as a realtime control in the same manner as the wheels. It can be programmably routed to a destination by using the realtime control section of the preset definition module. The pedal can either be a **voltage type**, (which outputs a DC voltage from 0-9 volts at the tip of the jack) **or a resistance type** (which varies a 10K ohm resistance from the tip to ground of the jack). Any 0-10 volt control voltage can be input to the pedal input jack.

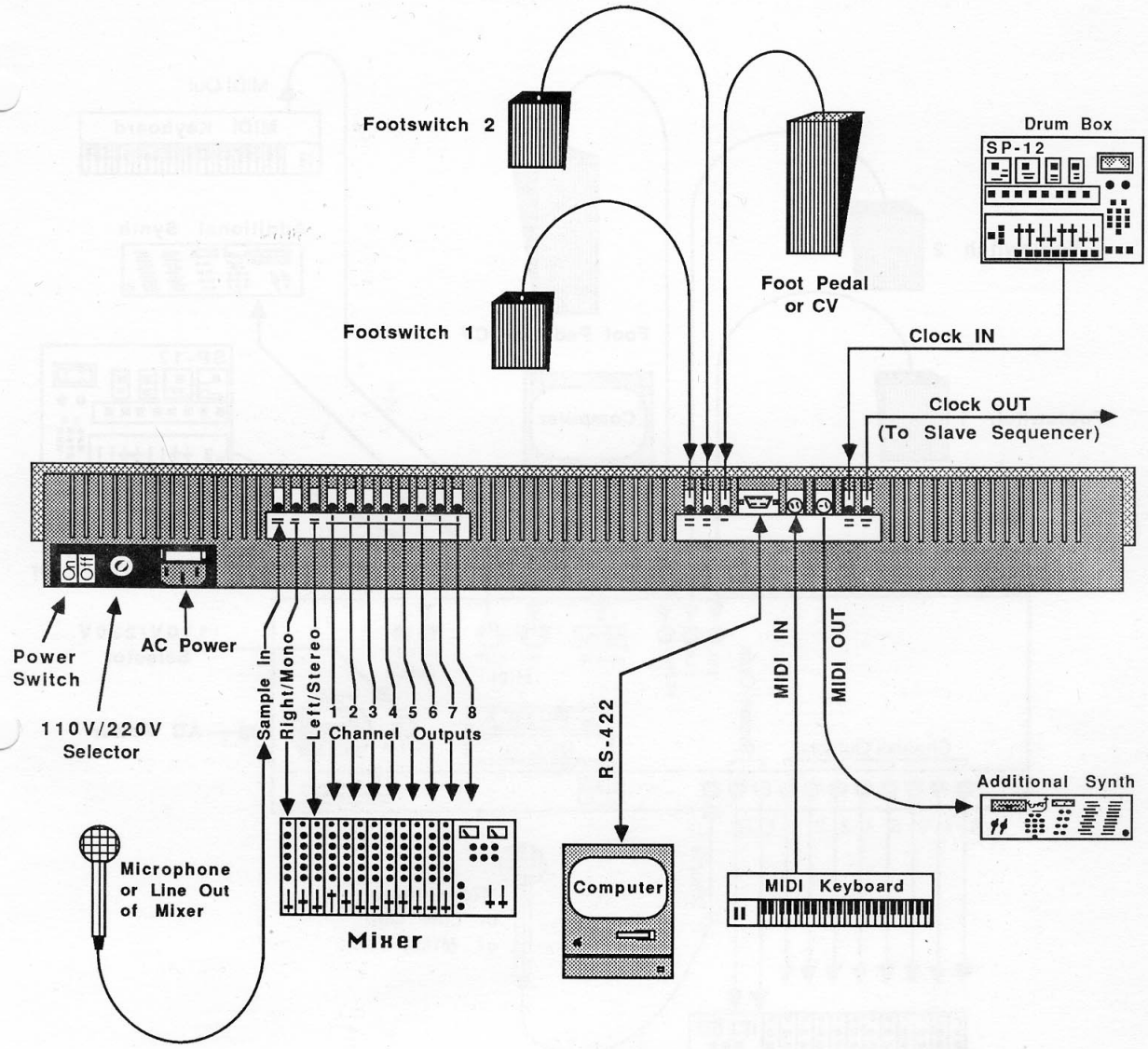
AUDIO CONNECTIONS

1. Stereo: Emax has provisions for a variety of output connection schemes. The most common hookup will probably be for stereo operation. Stereo operation allows the use of Emax's panning features and adds another dimension to the sound. Connect the left and right audio out phone jacks to the inputs of your mixer or stereo preamp. **Emax will also drive stereo headphones**, which can be plugged directly into the left/stereo output. When setting levels, keep in mind that Emax sounds best when it's front panel volume control is set to maximum since attenuation is done digitally inside the E-Chip.

2. Mono: If a monophonic amplifier is used, simply connect the right/mono output to the input of the amplifier. Guitar amps are not recommended because they are generally noisy and low fidelity. The output level of Emax is somewhere in between instrument

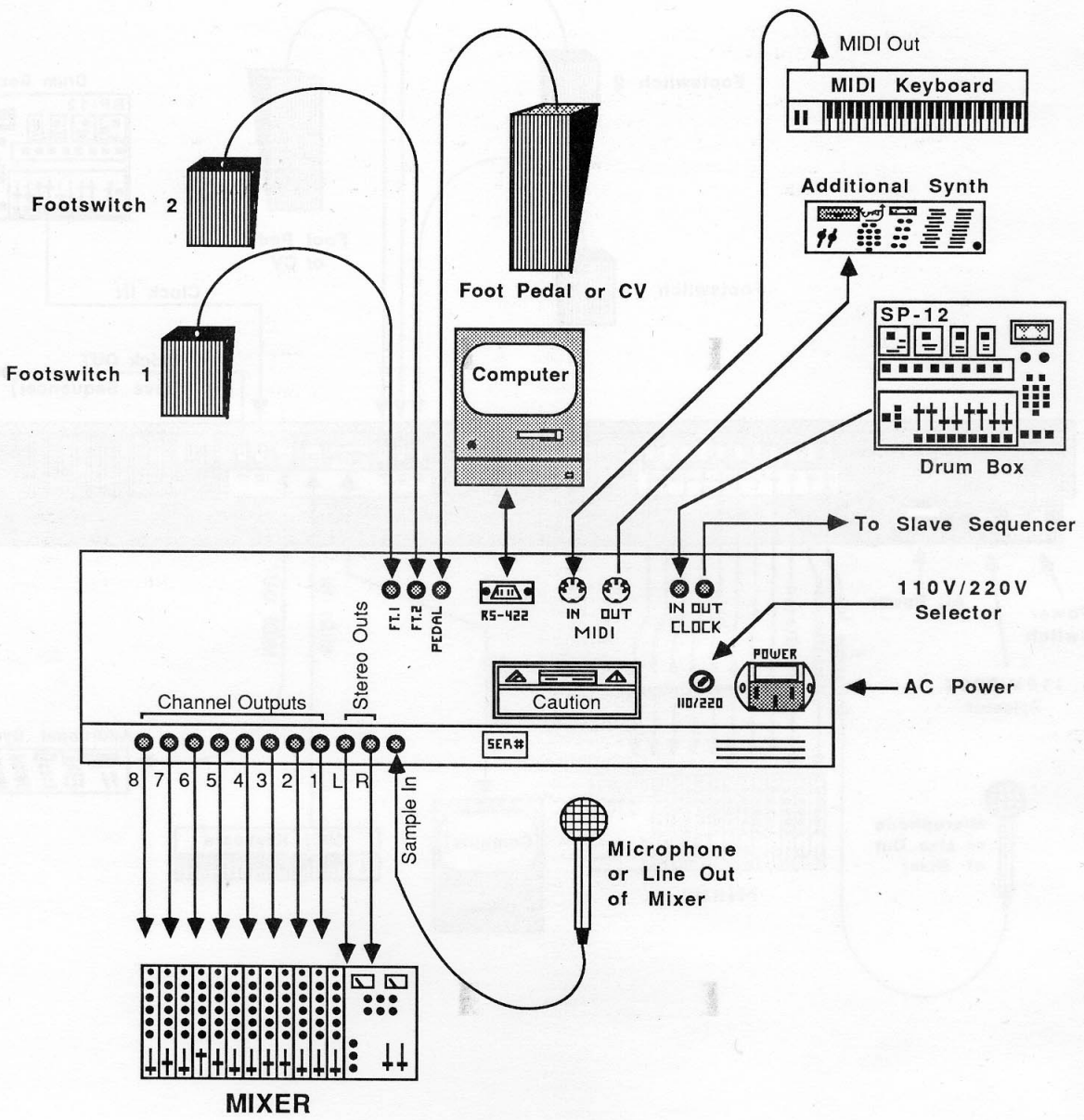
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Emax Keyboard
Rear Panel Connection Diagram

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Emax Rack
Rear Panel Connection Diagram

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and line level. Care should be taken when connecting to an instument amplifier so that the delicate nerve cells in your ears are not destroyed.

3. Individual Outputs: There may be times when different equalization or reverb settings are desired on the various instruments that have been sampled. Emax has eight monophonic channel outputs that can be used when individual processing on specific instruments is desired. Voices are assigned to output channels using the edit assignment function in the preset definition module. Dynamic Allocation defeats the channel assignments. Note that the stereo outputs are summed from the individual outputs. Output impedance is 1 K Ω.

4. Sample Input: The sample in jack can accept any signal level from microphone level to line level. The gain is adjusted with the data slider while in VU/gain mode in the sample module. The level can be read in the liquid crystal display while in this mode. Input impedance is 10K Ω.

AC POWER CONNECTION and FUSE

The AC power connector is how Emax gets power (obviously). The fuse receptacle is not as obvious. It is located directly over the power receptacle. Before changing or checking a fuse, UNPLUG the power cord. To remove the fuse holder, squeeze the two tabs located on either side of the fuse holder together. The fuse holder will now pop out with it's fuse in the right fuse socket. **Emax uses a 1 amp, 250 volt fast-blo mini-fuse.** Emax should not normally blow fuses. If a fuse that has been replaced blows again, suspect the switching power supply.

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Emax MIDI Implementation Chart

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12/16/86

X = item implemented
- = item not implemented

MIDI command	Transmitted?	Received?	Comments
Note off	X	X	keys#21 thru 108 (A1thru C7)
Note on	X	X	keys#21 thru 108 (A1thru C7)
Poly key pressure	-	-	
Control change	X	X	controllers # 0 thru 31
Program change	X	X	program # (preset#) 0 thru 99
Channel pressure	X	X	
Pitch wheel	X	X	
Sustain footswitch	X	X	controller #64
Local control on/off	-	X	
All notes off	-	X	
Omni mode off/on	-	-	ignores mode, turn all notes off
Mono mode	-	-	ignores mode, turn all notes off
Poly mode	-	-	ignores mode, turn all notes off
Song position pointer	-	-	
Song select	X	X	
Tune request	-	-	
Timing clock	X	X	
Start sequence	X	X	
Continue sequence	-	-	
Stop sequence	X	X	
Active sensing	-	-	
System reset	-	-	
System exclusives	X	X	Call for documentation

Supermode

"Supermode" is an Emax MIDI mode designed to enhance the Sequencer / MIDI interface. It is basically equivalent to "Poly Mode On" for all 16 MIDI channels simultaneously. When Supermode is on, the OMNI/POLY setting is ignored, but the MIDI Notes/Wheels flag of the current preset is still checked by Emax to determine whether to accept or ignore incoming MIDI performance data.
Emax's sequencer has 16 tracks and each track has an independant preset assigned to it. These presets are referred to as"Sequencer Presets".
The following chart shows the Emax sound mapping.

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FOR SUPERMODE ON

Source	What you Hear	What the Sequencer Records	What is Transmitted over MIDI
MIDI ch 1	seq preset 1	seq track 1	nothing
MIDI ch 2	seq preset 2	seq track 2	nothing
MIDI	.....	.....	nothing
MIDI ch 16	seq preset 16	seq track 16	nothing
Emax Keyboard	current preset	nothing	current preset's basic channel
Seq. track 1	seq preset 1	nothing	each track transmits
Seq. track 2	seq preset 2	nothing	over basic channel
Seq.	.....	nothing	defined in it's
Seq. track 16	seq preset 16	nothing	sequencer preset

FOR SUPERMODE OFF

Source	What you Hear	What the Sequencer Records	What is Transmitted over MIDI
MIDI Ch. 1-16	current preset (if it passes omni/poly basic channel tests)	single enabled track	nothing
Emax Keyboard	current preset	single enabled track	current preset's basic channel
Seq. track 1	seq preset 1	nothing	each track transmits
Seq. track 2	seq preset 2	nothing	over basic channel
Seq.	.....	nothing	defined in it's
Seq. track 16	seq preset 16	nothing	sequencer preset

Realtime Controllers

Emax has 6 realtime sources: left wheel, right wheel, pressure, pedal, MIDI A, and MIDI B. These sources may be the on board controls, or coming in over MIDI, or both. Each realtime control source can be assigned to any MIDI continuous controller channel from 0 to 31.
Emax has 9 realtime destinations: pitch, filter, level, LFO to pitch, LFO to filter, LFO to level, attack, pan, and crossfade.

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MECHANICAL PROCEDURES

PRECAUTIONS

Observe the following precautions when working on Emax:

Switch power off and check 110/220 switch before connecting Emax to power outlet or amplifier.

NEVER toggle the 110/220 switch with power on.

Troubleshooting must be done with power on. Avoid the switching power supply which contains lethal voltages.

Do not bend or strain the PCBs or you may cause tiny breaks in the printed circuit traces which will be very difficult to find.

Switch power off before disconnecting or connecting any circuitry, or removing or installing PCBs.

To replace soldered components, switch power off, remove the PCB completely from the instrument, and desolder from both sides. Use a vacuum desoldering tool. The traces on the Emax circuit boards are very thin. Use extreme care and work carefully.
Remember: Heat the pin, not the pad.

Keyboard Emax

THE SERVICE POSITION

Before taking Emax apart we recommend providing a soft work surface. A carpeted or rubber covered workbench is ideal. Place the Emax upside-down on the padded workbench so that the keyboard is toward you. This will allow you to play the keyboard and have the jacks toward the rear of your bench. We realize that this position is a bit awkward, but it's about the only way to work on the machine, save standing it on it's end! Audio jacks that are L-shaped will allow you to tilt the unit back so that you can see the controls. Be careful when doing this so that you don't break any of the plastic jacks!

NOTES ON EMAX SCREWS

Particular care must be exercised when removing and replacing screws on the Emax. Many screws are the self-tapping type and will strip out the plastic if they are tightened down too hard. Other screws mate with Pem-serts, which are easily pulled out from the plastic housing. Make sure that the Pem-serted screws go in smoothly.
If a screw is crossthreaded, simply replace it with a new screw.

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If the Pem-sert is pulled out from the plastic case, don't worry. It can be "welded" back in place by heating it up with the tip of your trusty soldering iron.
If a self-tapping screw strips out the plastic, either insert a Pem-sert, or fill with a strong glue, such as Black Max or Epoxy, and re-insert the original screw.

REMOVING THE BOTTOM PANEL

Remove the (10) 8-32 x 1/4" bottom panel screws (E-mu P/N HS 327) from the perimeter of the bottom panel, then lift off the aluminum panel (see diagram). When replacing the bottom panel screws be very careful not to crossthread the screws into the brass Pem-serts.

REMOVING THE FLOPPY DISK DRIVE

To remove the Floppy disk drive, the drive bracket must be removed first. The drive bracket is mounted to the plastic housing by (4) 8 x 1/2" self-tapping phillips screws (E-mu P/N HS 340). The disk drive itself is secured to the bracket by (4) 4-40 x 1/4" machine screws (E-mu P/N HS 352). These can be removed after first removing the power and data cables from the floppy drive.

REMOVING THE POWER SUPPLY

The switching power supply is mounted directly to the plastic housing by (4) 6 x 3/8 self-tapping screws. Remove the 5 electrical connectors to the supply before removing the screws. One of these connectors is an in-line type and carries 110 V. Make sure that there is no exposed metal on this connector. If there is, heatshrink it!

REMOVING THE CPU AND OUTPUT BOARDS

The CPU board is mounted to the housing with (6) 6-32 x 1/4" machine screws (E-mu P/N HS 353). These screws mate with Pem-serts molded into the plastic housing. The 6 connectors to the CPU board should be disconnected before the screws are removed.
The Output board has only (4) mounting screws (HS 353) and one connector. When removing either board, be careful not to lose any of the jack washers.

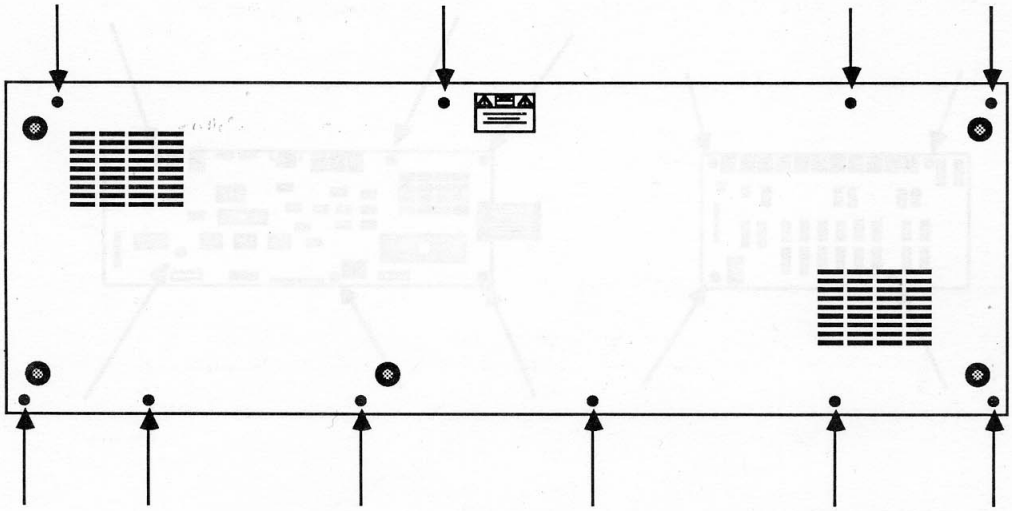
REMOVING THE KEYBOARD

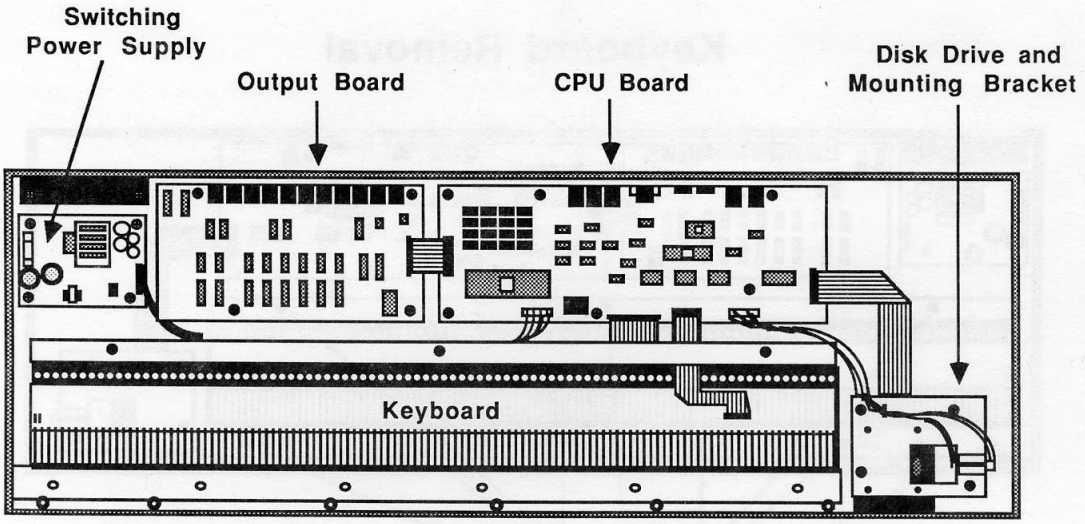
Removal of Emax's keyboard will not be necessary for most repair jobs. The Bad News is: to remove the front panel board, you must first remove the keyboard assembly. Moan, groan, assorted curses,%#&!¥. The Good News is that it's not that hard to remove it!
To remove the keyboard: First, disconnect the power plug from the CPU board and the flat ribbon cable from the keyboard circuit board. Next, remove the (3) keyboard bracket screws (E-mu P/N HS 327) and the (5) or (6) screws (E-mu P/N HS354) from the front of the keyboard. The keyboard assembly can now be carefully lifted out from the housing and set aside. When re-installing the keyboard, our assembly department recommends installing the second screw from the left first. This makes the screw holes line up better. If the end keys rub, a shim is glued to the end of the keyboard to center it correctly. Rubbing can sometimes be corrected by simply loosening the mounting screws and re-adjusting the keyboard.

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Bottom Panel Screw Locations

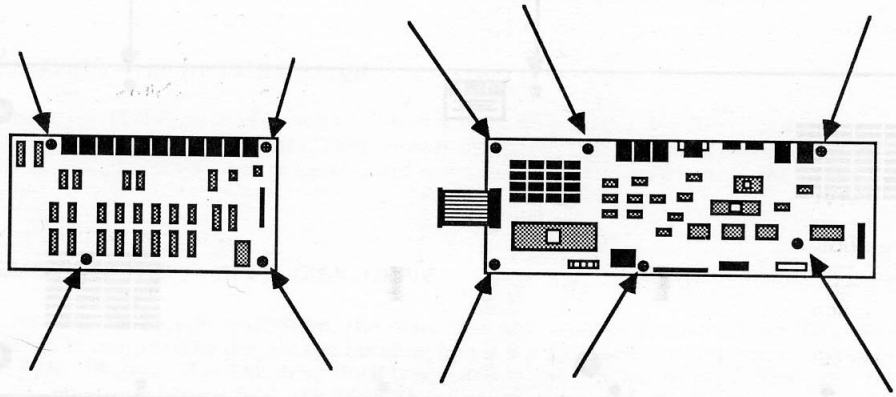




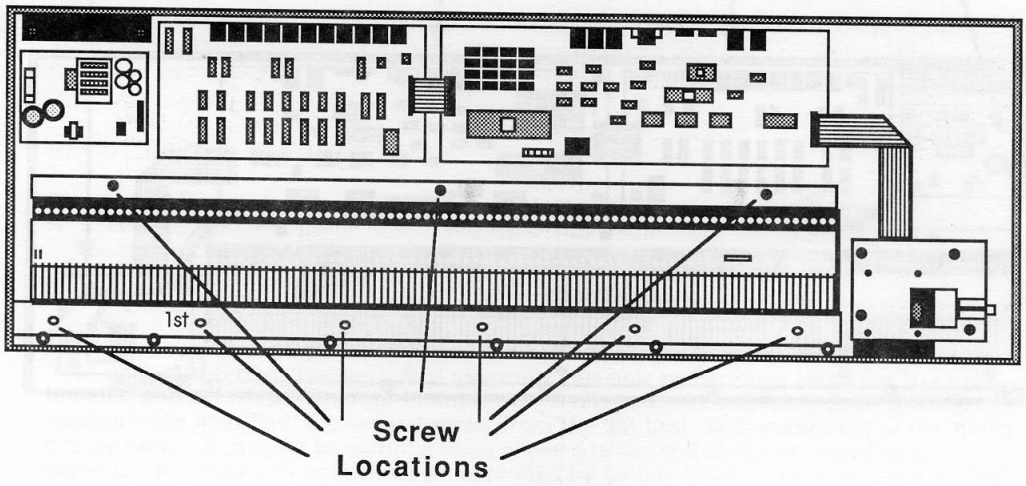
Emax Service Position

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CPU and Output Board Screw Locations



Keyboard Removal



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REMOVING THE FRONT PANEL BOARD

To remove the front panel board, simply remove the (12) 6 x 3/8 self-tapping screws, (E-mu P/N HS 357) and lift out the board. The rubber buttons will be left in the housing. When re-installing the panel, make sure that the LED's are straight and that the rubber buttons are fully seated before you start screwing!

Rack Mount Emax

THE SERVICE POSITION

Before taking Emax apart we recommend providing a soft work surface. A carpeted or rubber covered workbench is ideal. Place the Emax rack upside-down on the padded workbench so that the front panel is toward you. You should also have a MIDI keyboard within reach so that Emax can be played.

REMOVING THE BOTTOM PANEL

Remove the (10) 6-32 x 1/4" bottom panel screws (E-mu P/N HS 368) from the perimeter of the bottom panel, then lift off the metal panel and place next to the main unit (see diagram) taking care not to pull the output board ribbon cable. Note: Four of the bottom panel screws may also attach the rubber feet to the case. The bottom panel may be simply laid diagonally, resting on the edge of the rack case; or may be placed on top of some other object such as a box or large book to bring it up to the height of the rack case. With the Emax in this position, most of the circuitry can be easily accessed. Do be careful when first removing the panel that you do not rip the output board cable out from the circuit board.

REMOVING THE FRONT PANEL BOARD

The front panel board is secured to the rack chassis by means of (7) 6-32 x 1/4" machine screws (E-mu P/N HS 336). The front panel needs to be removed in order to replace the slider pots or to clean the front panel buttons.

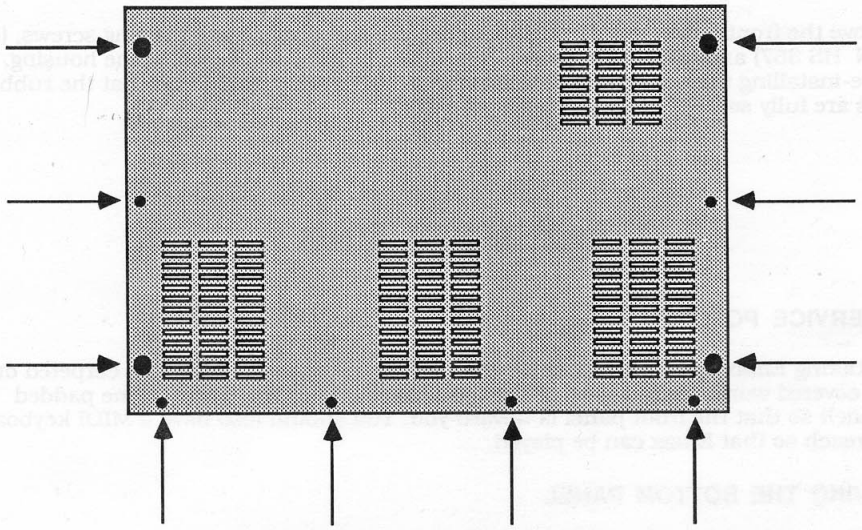
REMOVING THE POWER SUPPLY

The switching power supply is mounted directly to the side of the steel chassis by (4) 6-32 x 1/4" machine screws (E-mu P/N HS 353). Remove the 5 electrical connectors to the supply before removing the screws. One of these connectors is an in-line type and carries 110 V. Make sure that there is no exposed metal on this connector. If there is, heatshrink it!

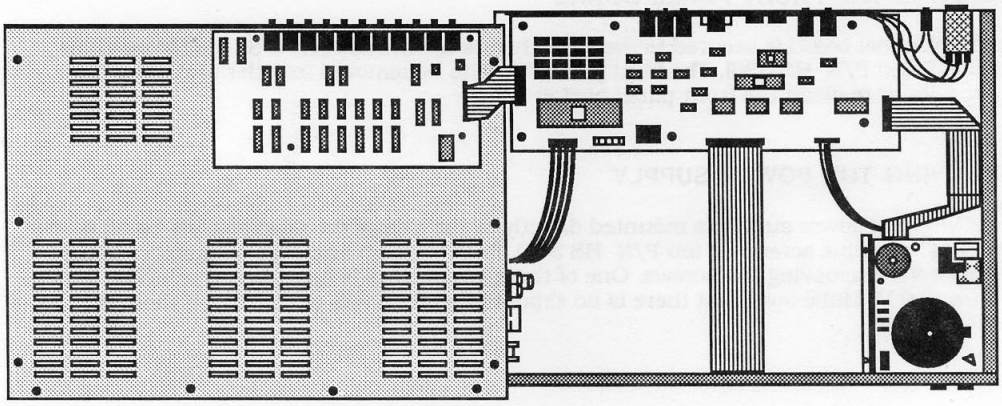
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Emax Rack Bottom Panel Screw Locations



Emax Rack Service Position



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REMOVING THE CPU AND OUTPUT BOARDS

The CPU board is mounted to the housing with (6) 6-32 x 1/4" machine screws (E-mu P/N HS 336). On early board revisions, the CPU board is mounted to the chassis with nylon screws (E-mu P/N HS 366). If the board is secured with nylon screws, be sure to replace with nylon to avoid ground shorts! The rear panel jack nuts should be removed and the 6 connectors to the CPU board disconnected before the screws are removed.
The Output board has only (4) mounting screws (E-mu P/N HS 336) and one connector. Again, the rear panel jack nuts should be removed before the board mounting screws are taken out.

REMOVING THE FLOPPY DISK DRIVE

Early Units (approx. SN 1-300)
Removal of the floppy disk drive on early Emax rack units requires that the front panel board be removed first to avoid damage to the traces. After the front panel has been removed, the (4) nuts on the disk drive mounting brackets can be removed. The cables to the drive should now be removed so as not to damage them. The drive mounts to the brackets by means of (4) 4-40 x 1/4" machine screws (E-mu P/N HS 352).

Later Model Units (approx. SN >300)
Later model Emax rack units have an improved floppy disk mounting scheme. These units no longer require removal of the front panel to remove the drive (although care should still be taken not to harm the delicate traces on the front panel). The drive brackets mount to the chassis by means of (4) 6-32 x 1/4" machine screws (E-mu P/N HS 353). The drive mounts to the brackets by means of (4) 4-40 x 1/4" machine screws (E-mu P/N HS 352).

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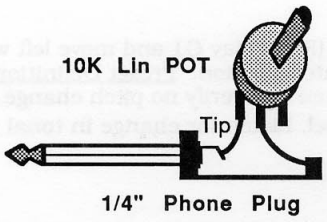
E-MAX
FUNCTIONAL TEST PROCEDURE

This functional test procedure is very similar to the E-mu factory final test for a new Emax. A functional test can be performed to verify that a problem exists or as a final test to verify that the unit is working perfectly before you return it to your customer. Instruments to be serviced should be thoroughly tested beforehand. This will verify that a malfunction has indeed occured, perhaps reveal related or unrelated malfunctions and provide a basis for troubleshooting. When performing these tests, remember to play all 8 channels. Most of the tests are performed by ear, so you will need at least one of these in addition to the equipment listed below.

Equipment needed: Amp and Headphones
2 mono audio cables
MIDI cable
Sample source
Sync source
Footpedal Simulator
Footswitch
MUST disk (v. 2.3 or higher)
Scratch diskette

CONSTRUCTION OF THE FOOTPEDAL SIMULATOR

To test and calibrate Emax's footpedal input, either a footpedal (voltage or resistance type; see Interface Specification), or a footpedal simulator is required. The construction of a footpedal simulator is described below.



CONSTRUCTION OF THE FOOTPEDAL SIMULATOR

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NOTES

1) "Slider" refers to data slider.
2) Underlined words and numbers indicate a button to be pressed.
3) "(PXX")" indicates a preset number needed for a particular test.
4) C1 refers to lowest key, C6 is highest key.
5) Watch the Emax display when executing panel functions; it often tells you helpful things or gives you instructions.

SET-UP

Plug audio cables into left and right output jacks. Verify 110/220 V switch is in 110 V position. Boot MUST disk. (P13) Verify output by playing first 2 octaves. Play C2 eight times.

FUNCTIONAL PROCEDURE

Step 1 Recalibrate Wheels, Pressure, Footpedal, and Sliders

Master, 8, 4, 1. Move left wheel for minimum post value in display. Enter. Rotate left wheel for maximum value. Enter. Return left wheel to center position. Enter, Yes, Enter. Position right wheel for minimum value. Enter. Rotate right wheel to maximum value. Enter, Yes, Enter. Press key hard and hold. Enter. Press key softly. Enter. Release key. Yes, Enter. Plug in footpedal simulator. Move simulator to minimum value. Enter. Move to maximum value. Enter, Yes, Enter. Move data slider to minimum position. Enter. Move data slider to maximum position. Enter, Yes, Enter. Move volume slider to minimum position. Enter. Move volume slider to maximum position. Yes, Master. Note: Pressure is not implemented, but pretend that it is.

Step 2 Function Check

(P13) Play keyboard and check volume fader. (P00) Play G1 and move left wheel. Verify pitch change. Return pitch wheel to center position. Preset Definition, 9. Play G1 repeatedly while pushing 1, 0 and 1, 1. Listen and verify no pitch change. Preset Definition, (P01). Play G1 and move right wheel. Listen for change in tonal quality.

Step 3 Pan, Mono Out, Channel Outputs, and Stereo Output Check

(P11) Play G2 and verify sound moving left and right. Remove left audio plug. Verify constant output on right side. Play G1 thru G2 to check all eight channels. Remove right audio plug and check each channel output jack. Remove right audio plug. Plug headphones into Left/Stereo jack. Play C1 thru B1 to silence all but one channel.

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Listen for panning. Remove headphones and reconnect audio cables. Play C2 to silence all channels.

Step 4 Loop Check

(P06) Play B1 eight times. (P07) Play B1 eight times. (P08) Play B1 eight times. (P09) Play chromatic scale across entire keyboard.

Step 5 Truncate and Loop Check

(P06) Digital Processing, Enter, 1. Play G1. Move slider until start number is around 5000. Play G1 and listen to verify "loop" changed to "oop". Press cursor ≥ . Move slider to bottom position and verify no sound. Play G1 repeatedly and slowly move slider up. Notice click sound changes to "uh", then "ou", and then "oop". Leave slider at max. Enter, Yes, 2. Play G1 and listen for "loop". Move slider until length is about 5000. Play G1 and listen for rapid "ou" loop. Press cursor ≤. Play G1 while moving slider up and listen to the loop starting point. Verify that the starting point advances. Digital Processing.

Step 6 MIDI Check

(P01) Connect MIDI cable between MIDI In and Out jacks. Play G2 and hold it down. Unplug one end of MIDI cable and release G2. Verify the note is still playing.

Step 7 Sync Check

Play. Verify sequence plays. Turn amp volume down. Briefly insert one audio cable into Clock Out jack and listen for buzzing sound. Press Stop twice. Manage, 2. Move slider up to select click 24 - external sync. Play. E-Max is waiting for sync input. Connect Clock Out (from Drum Box or signal generator, see Interface Specifications) to Clock In on E-Max. Sequence should start. Vary external clock tempo thru full range. Verify sequencer follows tempo changes perfectly thru full range. Unplug sync input. Sequence should stop. Press Stop twice.

Step 8 Panel and Footswitch Check

Master, 8, 6, Yes, 6. While watching display and LED's, check all buttons except Enter and Transpose. Plug in footswitch and check both Footswitch jack inputs. Push Enter twice.

Step 9 Memory, RS422, and Disk Test

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Master, 8, 8, Yes. Perform the following diagnostic tests:

1. RAM Test
2. ERAM Test.
3. RS422 check. Use RS-422 test plug.
4. Write and Read Disk Test. Be sure to use scratch diskette for test disk. Eject disk after 8 seconds to stop test. Verify no errors indicated in display.
5. Floppy Verify Test. Perform after Write and Read Disk Test. Watch display for errors.

Step 10 Sample Check

Press Master, 4 to erase memory. Sample, 3. Move slider to max to select 42kHz. 4. Use slider to select 12.4 seconds. 1. Select +40dB. Connect sample source and check display for no overload. Push 7 to sample. Play sample for entire duration and listen for distortion and noise. Note: a 0 dB gain setting should be used when sample quality is in question.

Step 11 Final Check

Boot E-Max. Insert Piano disk. Select a preset without velocity control and listen to each key using soft touch. Verify uniformity across keyboard.

Step 12 Shake test. Reassemble and verify no loose parts.

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M.U.S.T. DISK

The M.U.S.T. disk (Max Universal Sound Test Disk)is provided to facilitate easier and more thorough functional tests and troubleshooting. The disk contains various presets which have Emax parameter set-ups programmed into them. When used in conjunction with the Functional Test Procedure, the M.U.S.T. disk provides a very complete test of Emax functions. We recommend that you play other disks (such as the Piano) in addition to the M.U.S.T. disk after performing your functional test in order to make certain that the unit is problem free.
Note: It is a good idea to keep your M.U.S.T. disk updated with the most recent version of software so that you won't have to worry about software problems while doing your functional test.

M.U.S.T. PRESETS and SEQUENCES

PRESET	TITLE	FUNCTION	PLAY
P00	PITCH WHEEL	Tests operation of Spring Wheel	Low Octave
P01	MOD WL	Tests operation of Right Wheel	Low Octave
P02	FILTER Fc	Filter Fc on Right Wheel	Low Octave
P03	FILTER Hi Q	Filter in full Resonance	Low Octave
P04	FILTER Mid Q	Filter in mid Resonance	Low Octave
P05	PANNER Mid Q	Tests Panning function	Low Octave
P06	LOOP	Tests Loop function	Low Octave
P07	BACKWARD	Tests Backward Loop function	Low Octave
P08	CHORUS	Tests Chorus function	Low Octave
P09	FULL /	Test to make sure a Key plays before it reaches bottom of travel.	Full KYBD
P10	PEDAL	Tests Control Pedal Input	Low Octave
P11	CHANNEL Chek	Play 8 notes and check individual outputs.	4 Octaves
P12	Q & Fc Trim	Simplifies Q & Fc Trim.	4 Octaves
P13	sine.997.44s	1kHz Sine wave	Middle C
P14	sine 50.27sh	50 hz Sine wave	Middle C
P15	sine 8k 44sh	8kHz Sine wave	Middle C

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P17	Sample Now!	Sample Test	Low Octave
P18	Ambiant Vibe	Vibe Sample	Full KYBD

SEQUENCE	TITLE	DESCRIPTION
S01	Theo's Mood	Tech Tune
S02	Down the River	Tech Tune
S03	E-Circuz	Tech Tune
S04	Silent Temple	Tech Tune
S05	Scale	Automatic Scales
S06	Channel Check	Holds Keys down
S07	Pan Test	Automatic Pan Test
S08	LOOP Test	Automatic Loop Test
S09	Backtest	Auto. Backwards Loop Test
S10	Chorus Test	Auto. Chorus Test

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EMAX THEORY OF OPERATION

OVERVIEW

Emax represents a great leap forward in sampling technology developed by Emu Systems. Unlike it's predecessors, the Emulator 1 and the Emulator 2, Emax makes use of VLSI (very large scale integration) as well as the use of a 32 bit (internal) microprocessor and the use of PAL's (programmable logic array) for reduced chip count and increased power. Other specialized chips such as disk controllers are also used. The E-chip represents the most dramatic chip (and hence cost) reduction by handling all the memory addressing and data distribution for the sound channels. The E-chip contains about 50,000 transistors. If all these transistors were laid end to end it would not work nearly as well!!

The simplified block diagram (fig. 2) shows the entire Emax. Starting at the top we see that all the user controls (Buttons, Keyboard, Sliders, Wheels,and Footswitches) are read by the Scanner CPU. The Scanner interrupts the Main CPU when it has user data to transfer.

The LEDs are treated as a write only port. They are connected to a latch which the Main CPU writes to when an LED needs to be turned on or off.

The Liquid Crystal Display is connected to the data bus and treated as a read/write port. All information for the user is written to this port in ASCII except for a few graphic symbols.

The National 32008 is the Main CPU that runs the machine. It is coupled with a 32201 Timing Control Unit (TCU) which generates clocks, reset, read/write signals and allows bus cycle timing control. The Main CPU operating system is loaded into two 4464 Dynamic RAM's on boot up from the Floppy Disk. However, since Emax's operating system is larger than the 64K of RAM, an "overlay" system is used. As different processing modules on the Emax front panel are accessed, different sections of the program are loaded into RAM from the Floppy Disk. This accounts for the slight delay encountered when entering certain modules. A 2732 EPROM holds the bootstrap routines and system self-diagnostics that are invoked on power up. The Main CPU generates the digital envelopes that are sent to the output channels. It's high processing speed also allows it to perform Digital Signal Processing (DSP) functions on the sound data.

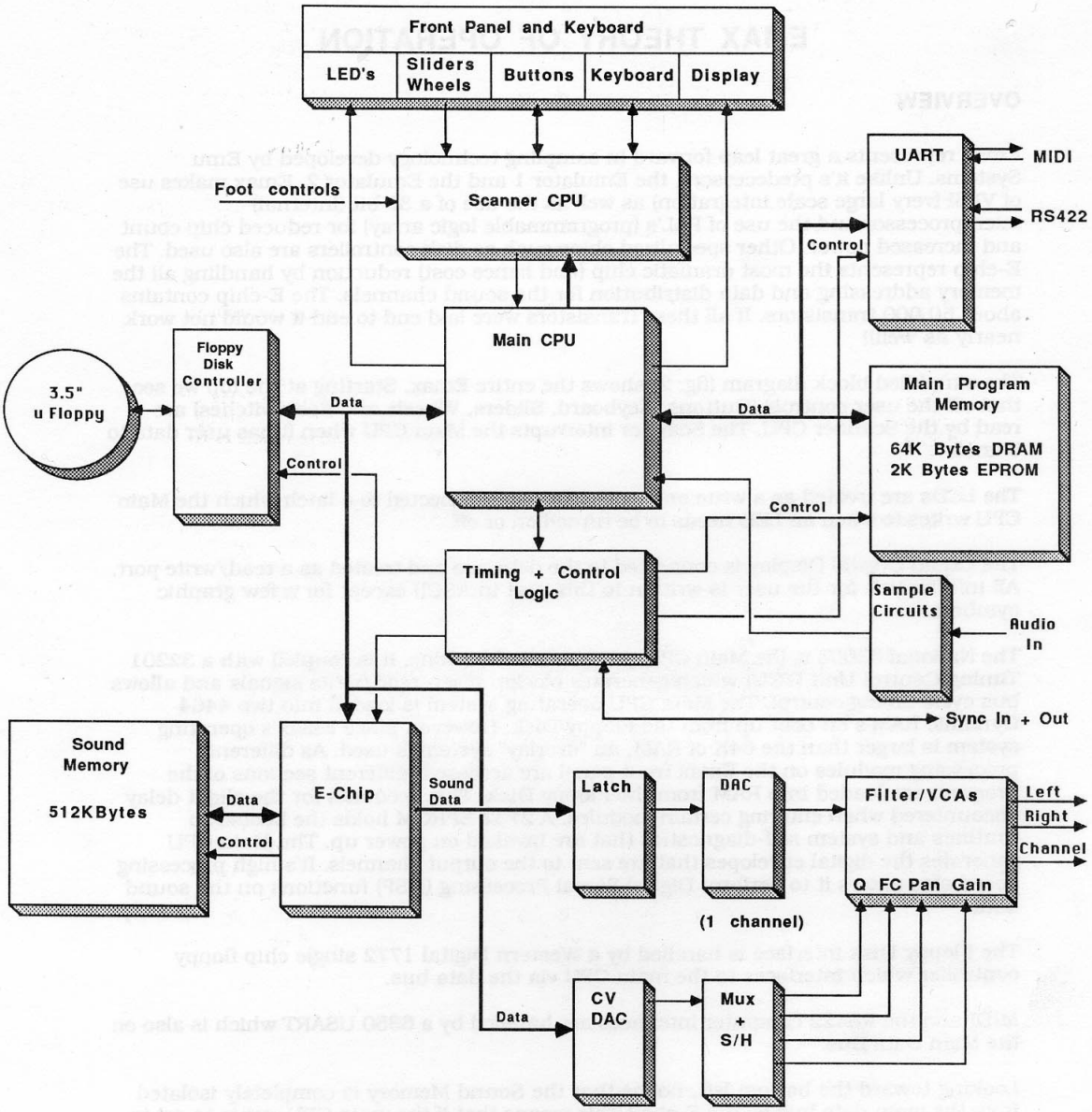
The Floppy Disk interface is handled by a Western Digital 1772 single chip floppy controller which interfaces to the main CPU via the data bus.

MIDI and the RS422 computer interfaces are handled by a 6850 USART which is also on the Main Data Bus.

Looking toward the bottom left, notice that the Sound Memory is completely isolated from the main data bus by the E-chip! This means that if the main CPU wants to get to the sound memory, it must request it from the E-chip. The E-chip has a special mode for this. The E-chip performs three main functions; 1) Low distortion pitch shifting, 2) Data expansion, 3) Volume contouring. It also keeps track of which channel is playing which sound. The Sound Memory consists of (16) 41256 dynamic RAM chips. Their addressing and refreshing is handled by the E-chip and a PAL.

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EMAX Simplified Block Diagram

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In the lower right corner we see the sound generation circuitry. Data is latched into a 12 bit DAC and the resulting sound is processed through an SSM 2047, which is a filter/VCA combination. The dynamic control voltages for the SSM 2047 are supplied by an 8 bit DAC and distributed by SSM 2300's, which are 8 channel Sample and Holds.

NOTICE

The Emax was designed to use 74HCT series logic instead of 74LS. We did this to lower the power requirements and use a smaller power supply. We do NOT recommend using 74LS chips as replacements for HCT as they overtax the power supply. There are a few locations where LS is used because of circuit loading, however the majority of the TTL ICs are HCT.

CPU AND CLOCKS

The CPU is a 32008 8 bit bus processor, controlled with a 32201 timing control unit (TCU). For timing details, see the 32008 and 32201 data sheets.

The 32008 produces a 24 bit address, latching the low order 8 bits from the multiplexed address/data bus. The TCU acts as a crystal oscillator producing 8 and 16 MHz clocks, and additional CPU signals: -RD, -WR, and -TSO (used for dynamic RAM timing). It also generates a clean -RESET signal for the rest of the system. The 8 MHz clock is further divided down, (by IC 4) to 4 MHz for the Scanner MPU and 500 KHz for use by the USART.

The "wait state" timing of the 32008 is determined by the 32201, which in turn is determined by the address bus of the 32008. Hence the port address of memory and I/O ports will declare their timing, through the feedback from A18-19 into the 74HCT139. Signal +FAST. D forces a no-wait-state cycle.
Additional clocks C10 (10MHz), C2M, and C500K (500 KHz) are developed here as well.

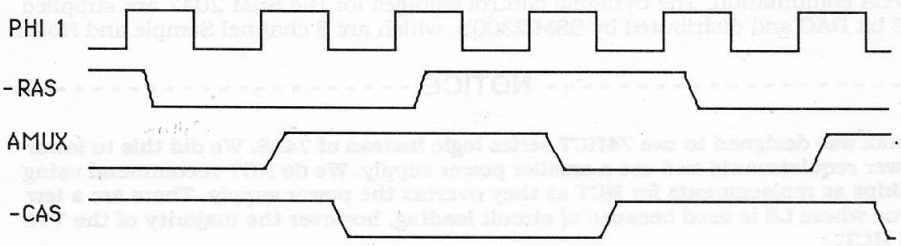
RAM AND FLOPPY DISK

On each processor cycle, -RAS is brought low by the TCU -TSO output. The DRAM begins at address space 008000 and holds 64 K Bytes. The address is decoded by data selectors IC 28 and IC 29. The signal AMUX is produced by a PAL. This produces AMUX changing on the 16 MHz clock edge following that which produced -RAS, thus allowing address hold time. CAS follows AMUX by 1/2 16 MHz cycle, thus allowing address mux propagation delays. -WR will be set up by the TCU approximately syncronously with RAS, hence allowing "early write" cycles. Refresh is done by the CPU in a periodic interrupt routine.

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TIMING:



The floppy disk controller is based on the Western Digital 1772 single chip floppy controller. This chip supplies most of the floppy disk control signals and directly interfaces with the main CPU. The DMA request is routed to NMI to allow interrupt driven FDC data transfers. However, the programmers decided not to use NMI and it stands ready but unused. Note: This has been deleted on the latest board revisions.

The input signals are terminated by R-pack networks, and the output signals are driven by inverting drivers. Two additional signals, side select and motor on, are driven by an external latch (IC 22) because they are not correctly supplied by the 1772.

EPROM, EEPROM, TIMER, MIDI

The processor address, data and control busses interface directly to the EPROM which is mapped to decode from address 0 (boot address). The EPROM contains the routines necessary to load the operating system from the floppy disk and also minimal system self-diagnostic routines which are run on power up.

The EEPROM is a National 9306 which is packaged in an 8 pin DIP. The 9306 will hold 256 bits of data and is used in Emax to store slider and wheel calibrations as well as channel filter calibrations. When writing to the 9306 activity will be seen on CE, SK (clock), and the Din pins. The same holds true for the read operation except that the Dout pin will also be active. For more information on this chip, consult the data sheet.

The Emax timer is an 8254 programmable timer. The timer's three sections control five separate functions:
Timer 1 supplies the clock that determines the cutoff frequency of the switched-capacitor anti-alias filter.
Timer 2 supplies the TG interrupt to the CPU. This will generally be the periodic interrupt that refreshes the dynamic RAM and updates the analog parameters. Each TG interrupt updates two output channels with envelope and pitch information and occurs approximately every 2 mS. Timer 2 also supplies the analog-to-digital converter clock to the successive approximation register during sampling operations.
Timer 3 is the general purpose software interrupt timer. It is switched by a PAL and an LED latch bit from the sync input to the timer. It also supplies the sample rate clock to the sample and hold and the SAR during sampling operations.

The MIDI interface is a simple 6850 serial interface chip, using the usual MIDI optoisolator (iso-optolator?) circuitry. The 6850 contains various command and mode registers which are initialized during power-on boot. The output circuitry has been slightly modified to give the same output current loop as the midi spec while not using an open collector inverter, hence reducing package count.

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The RS-422 interface shares the serial port with the MIDI circuitry. The RS-422 is designed to operate at 500 K baud, and sends the tx data (pins 8 and 9) and a 500 K AC coupled clock (pin7). Data is received at pins 4 and 5. MIDI is prevented from interfering with RS-422 by the use of a -MIDIOF. D signal controlling an AND gate.

CHIP SELECTS AND INTERRUPT VECTORING

The chip select decoding for the Emax is accomplished using the hi order address lines, a PAL, a '42 decoder, and a '139 decoder. There are 8 types of chip selects of interest:

1) EPROM
2) DRAM
3) Interrupt Vector Port
4) LCD
5) Other 6800-like peripherals
6) R/W strobed peripherals
7) Address decoded peripherals
8) Timer interrupt reset

The EPROM chip select is decoded by A15 and A16 being low.
The DRAM is decoded by the PAL (IC 26). This enables AMUX/CAS.
The Interrupt Vector Port is decoded by the PAL (IC 26).
The LCD "E" chip select is decoded by the PAL (IC 26).
The other 6800 peripherals "E" is decoded by the PAL (IC 26). They are further decoded off the low order address.
The R/W strobe peripherals are decoded by the PAL (IC 26) and are further decoded by the '42 and '139 decoders.
The address decoded peripherals are decoded by the PAL (IC 26) and are further decoded by the '42 decoder.
The timer interrupt reset is decoded by the PAL (IC 26) and is further decoded by the '42 decoder.
The 32008 CPU obtains an interrupt vector via a control table indexed by the value read upon interrupt from memory location fffe00. This value is supplied by a '244 decoded by a PAL (IC 26) to this address. The value itself is simply the state of all interrupt sources, hence prioritization can be done in the interrupt table.
-INT is supplied as the NOR function of all interrupt sources

SCANNER MPU

For the scanner MPU, we are using the Rockwell 6500/11 which is a single-chip microcomputer containing a 6502 microprocessor, 3 K of ROM, 192 bytes of RAM, 2 counter/timers and built-in I/O ports and clock.
The scanner MPU handles all of the user interfacing. It reads the keyboard, calculates the velocities, reads the panel buttons and footswitches and performs the analog to digital conversion on the wheels, sliders and footpedal.
The scanner interface is a parallel read port to the 32008 (IC 16). The scanner MPU requests attention by bringing the scanner interrupt line SCNINT active (high). The 32008 will respond by reading the parallel scanner data port. On reading this port, an NMI (-CSRSCN. D) is returned to the scanner MPU, thus completing a handshake. The scanner MPU can receive data from the 32008 by means of a serial link (+SCNDTA.D). The data and clock lines are part of a parallel LED latch.
To perform an analog to digital conversion, the 6500 first selects X7 on the 4051 multiplexer. This line is connected to 5 volts and so charges capacitor C53. Next, the pot

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to be measured is selected, and an internal counter is started. Since the pot to be measured is now essentially across the capacitor to ground, the cap now begins to discharge. When the voltage across the capacitor drops below the threshold of the digital inverter, the output of the inverter goes high and is sensed by the -NMI pin of the 6500 which stops the counter. The count directly corresponds to the position of the pot that was measured. It's simple, but it works!

LED LATCHES

The LED latches are strobed on address decode and WR. They latch a new 8 bit value, which directly drives the LED's through a current limiting resistor. A few miscelleneous bits of latch 2 are used for other purposes, such as motor on and side selection for the floppy disk drive and clock out. Note that the LED latches are write only ports.

E-CHIP INTERFACE AND SYNC

The E-chip is a 16 channel, fully pipelined sampled data audio signal processor. It implements 16 independent variable sample rate audio channels, each with independent level control. The chip contains facilities for sample memory refresh, and DMA read and write operations, both during audio operation at nominal rates and at very high bus bandwidth when audio operation has been suspended. (More: See The E-mu Systems E-chip: A Functional Perspective)

WARNING: THE E-CHIP IS EXTREMELY STATIC SENSITIVE AND EXPENSIVE ! USE STATIC CONTROL PROCEDURES WHEN REMOVING OR HANDLING THE E-CHIP.

The E-chip is interfaced to the main CPU by a simple interface using address lines A10 and A11 and a chip select (CS ECHIP). It is also on the main CPU data bus. The 8 MHz clock has it's duty cycle changed by the circuitry near IC 54 to be high for 77 nS and low for 48 nS which is necessary for proper operation.

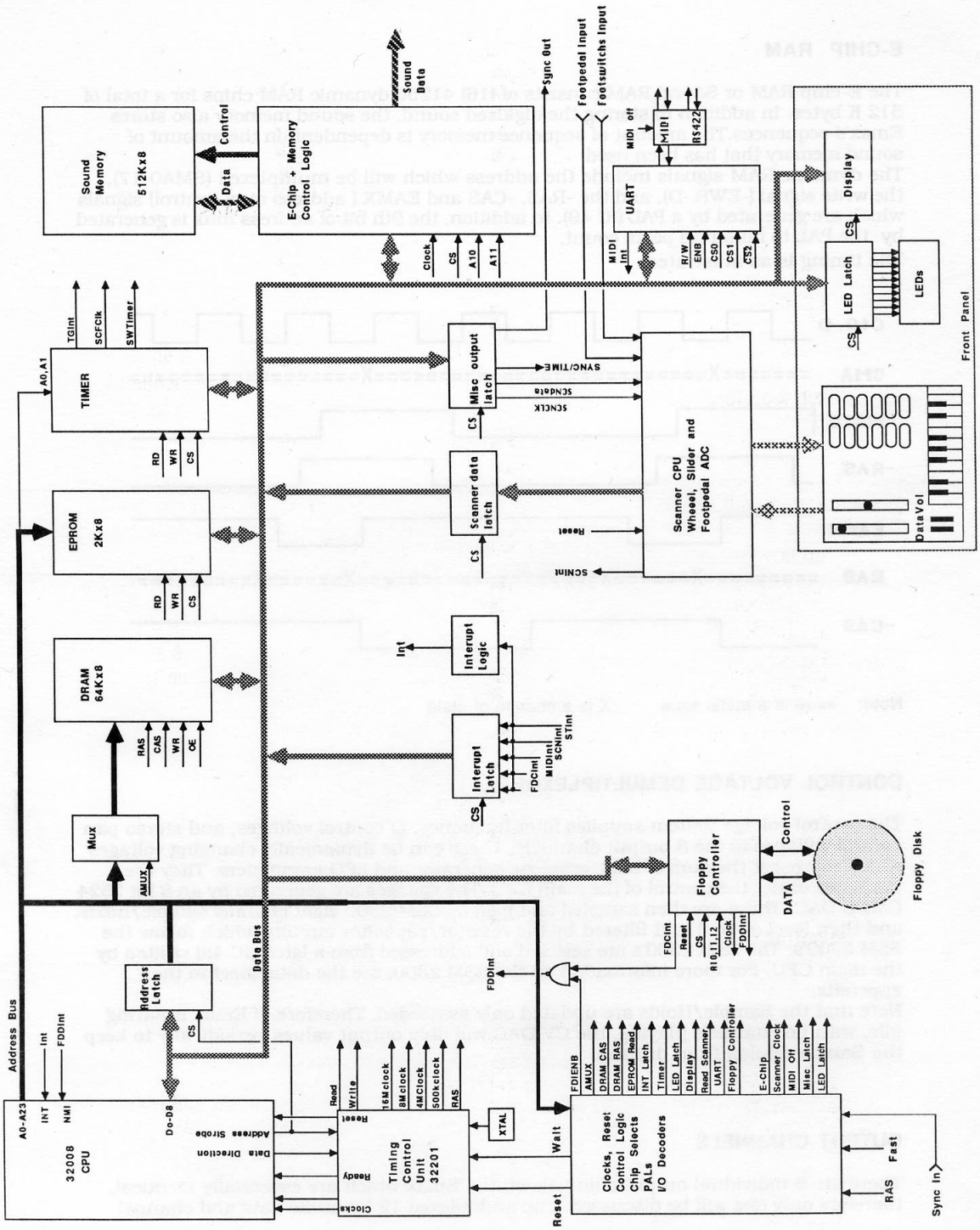
The data output is split into two groups. OL14-16 represent a channel number from 0 to 7. This, along with SHSTB (sample/hold strobe), generates the data latch signal on the analog board. The D flip-flop (IC 56) adds a 1/2 clock delay to SHSTB to provide proper timing to the output board data latches. OL2-13 are the 12 bit digital audio data, which feeds the DAC latches on the analog board.

The sync input is performed by a uA9637 differential line receiver. It's internal bias voltage is filtered by a cap to provide a stable reference. An RC network provides hysteresis. The sync input is AC coupled to the other input. The output represents a signal conditioned sync signal. There should be 35 mV hysteresis and 500 mV sensitivity, and input protection to +/- 15 V.

The conditioned signal is applied to a PAL input which generates an interrupt. The PAL generates a latched interrupt on a timer pulse in timer mode, or a sync edge transition in sync mode. The interrupt is unlatched (acknowledged) by a read or write of the RSTSTI port (IC 27). The interrupt can then be "routed" to the 8254 timer to provide a programmably divided count. Internal or external clock can be selected by the PAL input SYNC/-TIME.

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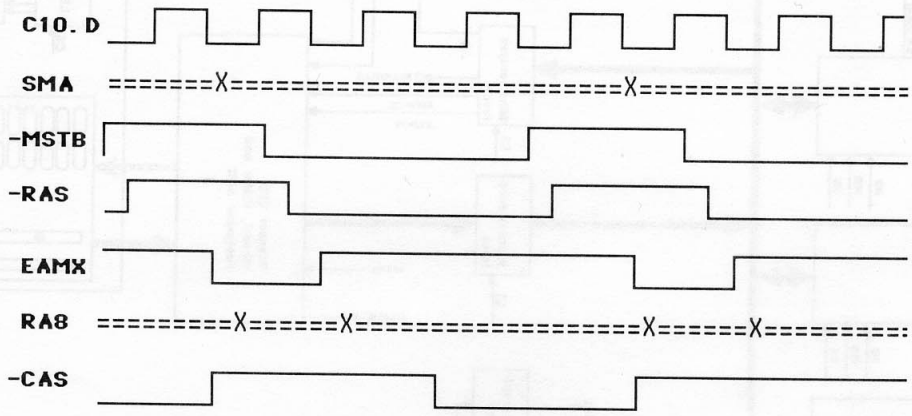


EMAX Digital Board

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E-CHIP RAM

The E-chip RAM or Sound RAM consists of (16) 41256 dynamic RAM chips for a total of 512 K bytes. In addition to storing the digitized sound, the sound memory also stores Emax's sequences.The amount of sequence memory is dependent on the amount of sound memory that has been used.
The dynamic RAM signals include the address which will be multiplexed (SMA0-17), the write signal (-EWR. D), and the -RAS, -CAS and EAMX (address mux control) signals which are generated by a PAL (IC 49). In addition, the 9th bit of address mux is generated by the PAL to minimize parts count.
The timing is as illustrated:



Note: ==== is a static state X is a change of state

CONTROL VOLTAGE DEMULTIPLEXOR

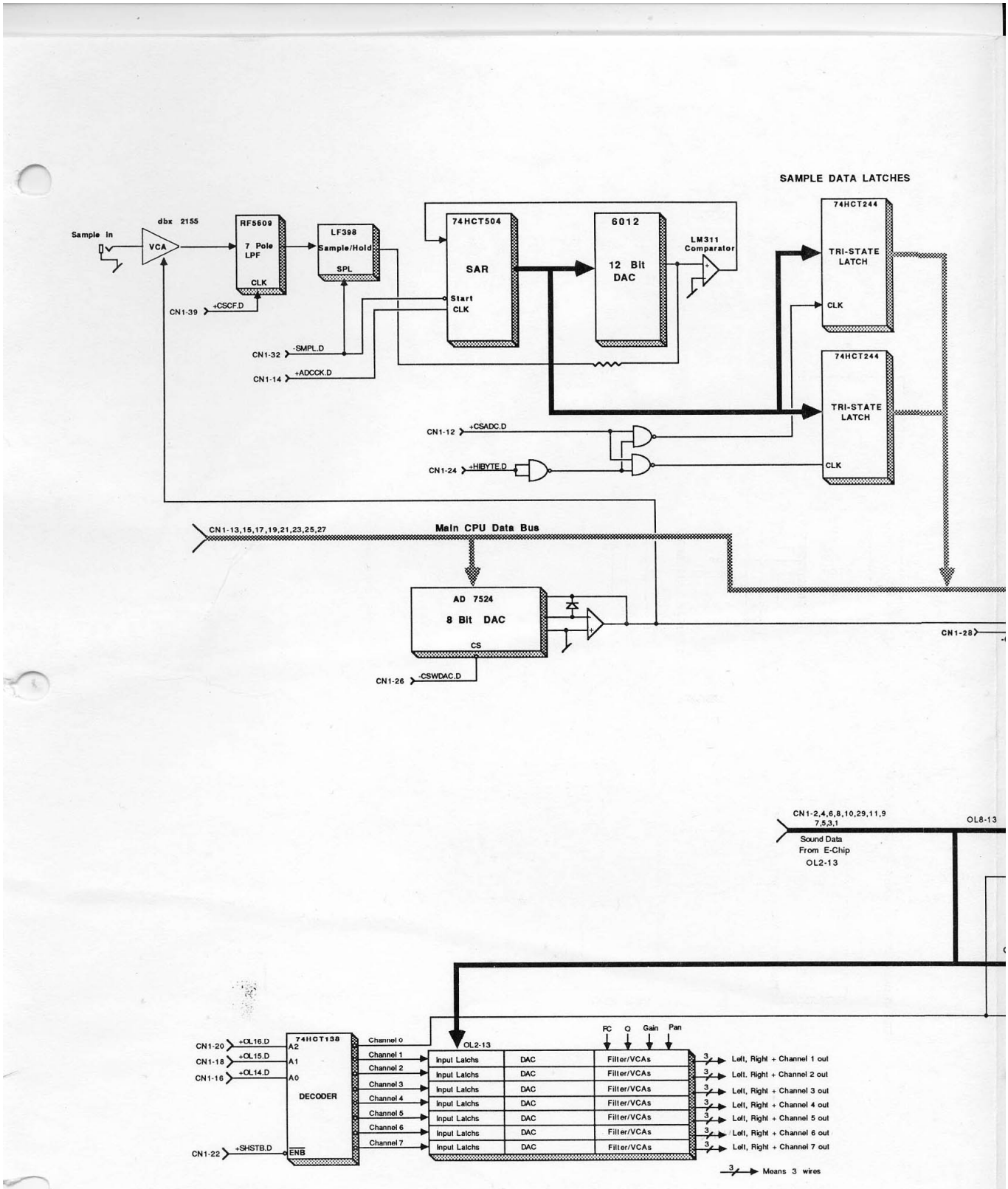
The control voltage system supplies filter frequency, Q control voltages, and stereo pan control voltages to the 8 output channels. These can be dynamically changing voltages which represent the sum of bias, envelope generator and LFO parameters. They are produced under the control of the main CPU. The voltages are generated by an 8 bit 7524 CMOS DAC. These are then sampled and held by SSM 2300 eight channel sample/holds, and then level shifted and filtered by the resistor/capacitor circuits which follow the SSM 2300's. The SSM 2300's are selected and addressed from a latch (IC 48) written by the main CPU. For more information on the SSM 2300, see the data sheet in the appendix.
Note that the Sample/Holds are updated only as needed. Therefore, if Emax is sitting idle, with no channels playing, the CV DAC will only output values periodically to keep the Sample/Holds from drifting.

OUTPUT CHANNELS

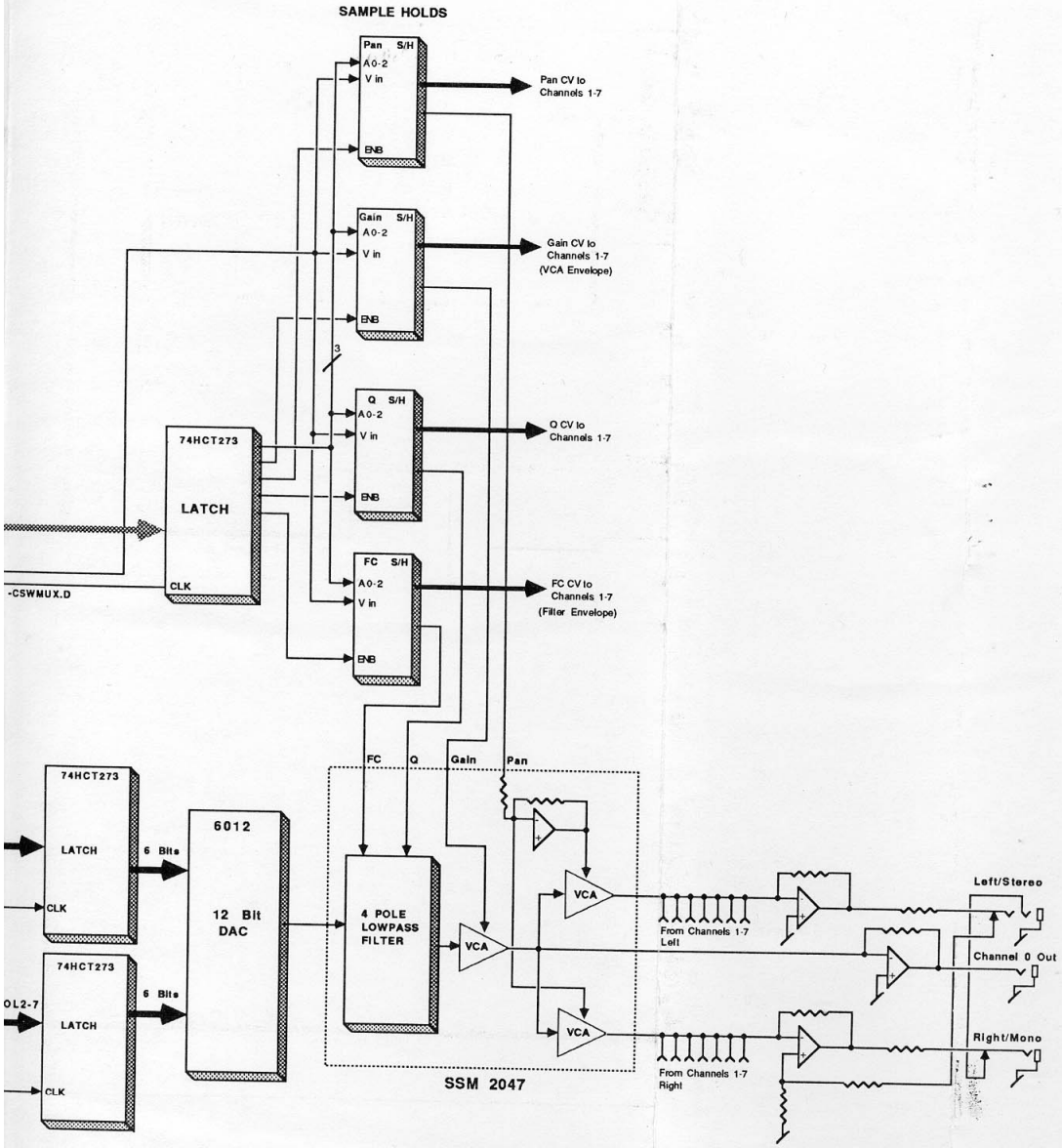
There are 8 individual output channels on the Emax which are essentially identical, therefore only one will be discussed. The multiplexed 12 bit audio data and channel

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EMAX ANALOG BOARD BLOCK DIAGRAM

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strobes from the E-chip are used to latch the individual channel data into two 74HCT174's. The clock for these latches is generated by a 74HCT138 (IC 18) from the E-chip's SHSTB output and the encoded channel number on the high order OL outputs from the E-chip (OL14-16). The 74HCT174's hold the data for a 6012 12 bit linear DAC, whose output is applied to the input of the SSM 2047. The SSM 2047 is a filter/ VCA combination which includes 24dB/octave low pass filter, gain VCA ,and stereo panning network. Each channel's 4 control voltages (Fc, Q, gain, and pan) are supplied from the control voltage demultiplexer. Each SSM 2047 has three audio current outputs. The main output is fed into 1/4 of a TL084 op-amp the output of which drives the individual channel output. The other two outputs (left and right),drive the inputs of the left and right channel summers (IC 40) which have a clever switching scheme to allow stereo and mono operation.
Note that the front panel volume slider affects the volume of the machine via the E-chip and not through analog means. This means that the best possible signal to noise level will be attained with the volume control at maximum.
Also note that the SSM 2047 is the *only* filter after the DAC. In addition to synthesiser effects, it's function is that of a reconstruction filter to remove the little steps (also called clock noise) in the DAC output. This must be done manually by the user.

SAMPLE INPUT

From the sample input jack on the rear panel, the audio signal to be sampled is capacitively coupled via C113 into a dbx 2155 which is a low noise VCA. The control voltage input to the VCA is supplied directly by the CV DAC (IC 49). During sampling operations the CV DAC is loaded with the gain value and supplies only the sample VCA. It does not update the channel sample and holds during sampling since the channels are silent during this time. The audio signal from the VCA is now a current and is converted back to a voltage by a TL084 (IC 41). This signal is then applied to a switched capacitor 7 pole elliptical anti-alias filter, whose cutoff is programmed by a timer (IC 17) on the CPU board. The output of the switched capacitor filter (SCF) is lowpass filtered to remove the SCF clock frequency, and AC coupled,then applied to the ADC sample/hold. The signal is held whenever the ADC is converting. The conversion rate is set by the 8254 timer under control of the main CPU. The conversion is accomplished using a 12 bit DAC together with a Successive Approximation Register (SAR), and an LM 311 comparator.
At this point, a basic explanation of successive approximation is in order. Referring to fig. 5 the three most basic elements of an 8 bit system can be seen. A few details such as the CPU and the sample/hold were left out in order to simplify the drawing. To start the process, the timer would send a start conversion signal and the successive approximation would begin. The SAR starts by setting bit 7 and looking at the output of the comparator. The output of the comparator tells the SAR whether the DAC's output is higher or lower than the input signal. If the DAC output is higher, the input bit will be set to 0. If the DAC output is lower, the input bit will be set to a 1. In fig. 5 the SAR set bit 7 which represents .500 volts and tested the comparator output. Since the + input was .600 V and the - was .500 V, the comparator's output was high which says the DAC is less than the input. The SAR will now set bit 7 high for the remainder of the test. As can be seen at the bottom of fig. 5, each bit is exactly half of the previous one. When the SAR sets bit 6 high, the DAC's output is the sum of bit 7 and bit 6 or .750 V. This is higher than the .600 V on the input and so the comparator output will be 0. Bit 6 is reset to 0. This process continues until all 8 bits are tested and set to 0 or 1. After all the bits are tested, the End of Conversion (EOC) line goes low to signal the main CPU that the data is ready to be stored in memory.
The EOC signals the main CPU via the wait line, taking the CPU out of the wait state that it was placed in at the start of the conversion process. The CPU now reads in the data. Since the data bus is only eight bits wide and the sample data is twelve bits, the

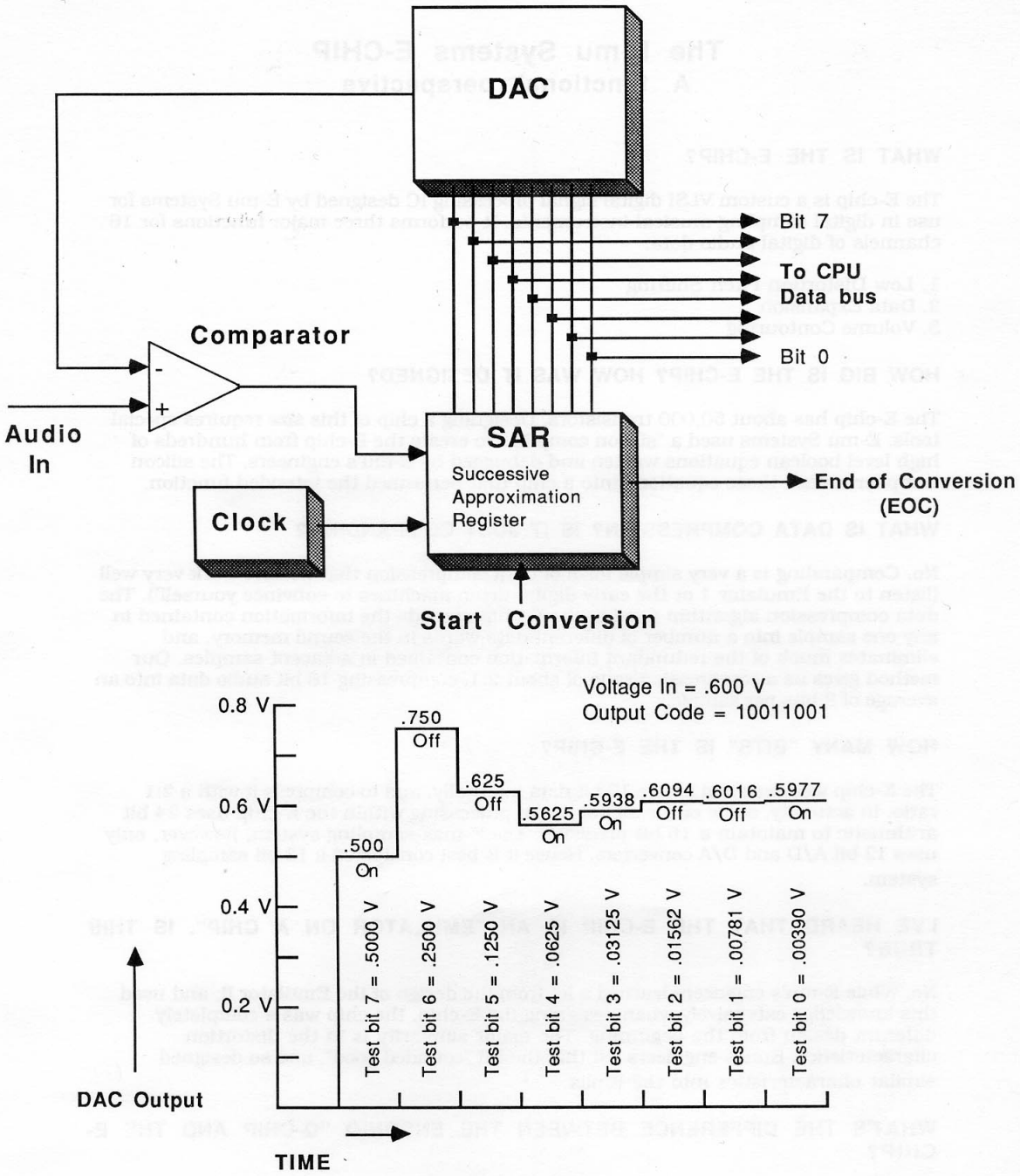
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main CPU must read the ADC port twice. Address line 0 is used to select between low and high bytes. Between conversions the main CPU also performs calculations to update the LCD VU meter.

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Sample Theory
Fig. 5

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The E-mu Systems E-CHIP
A functional perspective

WHAT IS THE E-CHIP?

The E-chip is a custom VLSI digital signal processing IC designed by E-mu Systems for use in digital sampling musical instruments. It performs three major functions for 16 channels of digital audio data:

1. Low Distortion Pitch Shifting
2. Data Expansion
3. Volume Contouring

HOW BIG IS THE E-CHIP? HOW WAS IT DESIGNED?

The E-chip has about 50,000 transistors. Designing a chip of this size requires special tools. E-mu Systems used a "silicon compiler" to create the E-chip from hundreds of high level boolean equations written and debugged by E-mu's engineers. The silicon compiler turned these equations into a chip that performed the intended function.

WHAT IS DATA COMPRESSION? IS IT JUST COMPANDING?

No. Companding is a very simple form of data compression that doesn't work very well (listen to the Emulator 1 or the early digital drum machines to convince yourself!). The data compression algorithm used in the E-chip spreads the information contained in any one sample into a number of different data words in the sound memory, and eliminates much of the redundant information contained in adjacent samples. Our method gives us a compression ratio of about 2:1, compressing 16 bit audio data into an average of 8 bits per sample.

HOW MANY "BITS" IS THE E-CHIP?

The E-chip was designed to use 16 bit data internally, and to compress it with a 2:1 ratio. In actuality, some of the digital signal processing within the E-chip uses 24 bit arithmetic to maintain a 16 bit precision. The E-max sampling system, however, only uses 12 bit A/D and D/A converters. Hence it is best considered a 12 bit sampling system.

I'VE HEARD THAT THE E-CHIP IS AN "EMULATOR ON A CHIP". IS THIS TRUE?

No. While E-mu's engineers learned a lot from the design of the Emulator II, and used this knowledge extensively when designing the E-chip, the chip was a completely differant design from the beginning. The major similarity is in the distortion characteristics. Emu's engineers felt that the EII "sounded good", and so designed similar characteristics into the Emax.

WHAT'S THE DIFFERENCE BETWEEN THE ENSONIQ "Q-CHIP AND THE E-CHIP?

The Ensoniq Q-chip is a 16 channel address generator. Because it doesn't do any DSP, it causes substantial distortion to the audio when the pitch is shifted. Also, the Ensoniq Q-chip has 8 bit D/A converters on the chip, limiting it's performance and also

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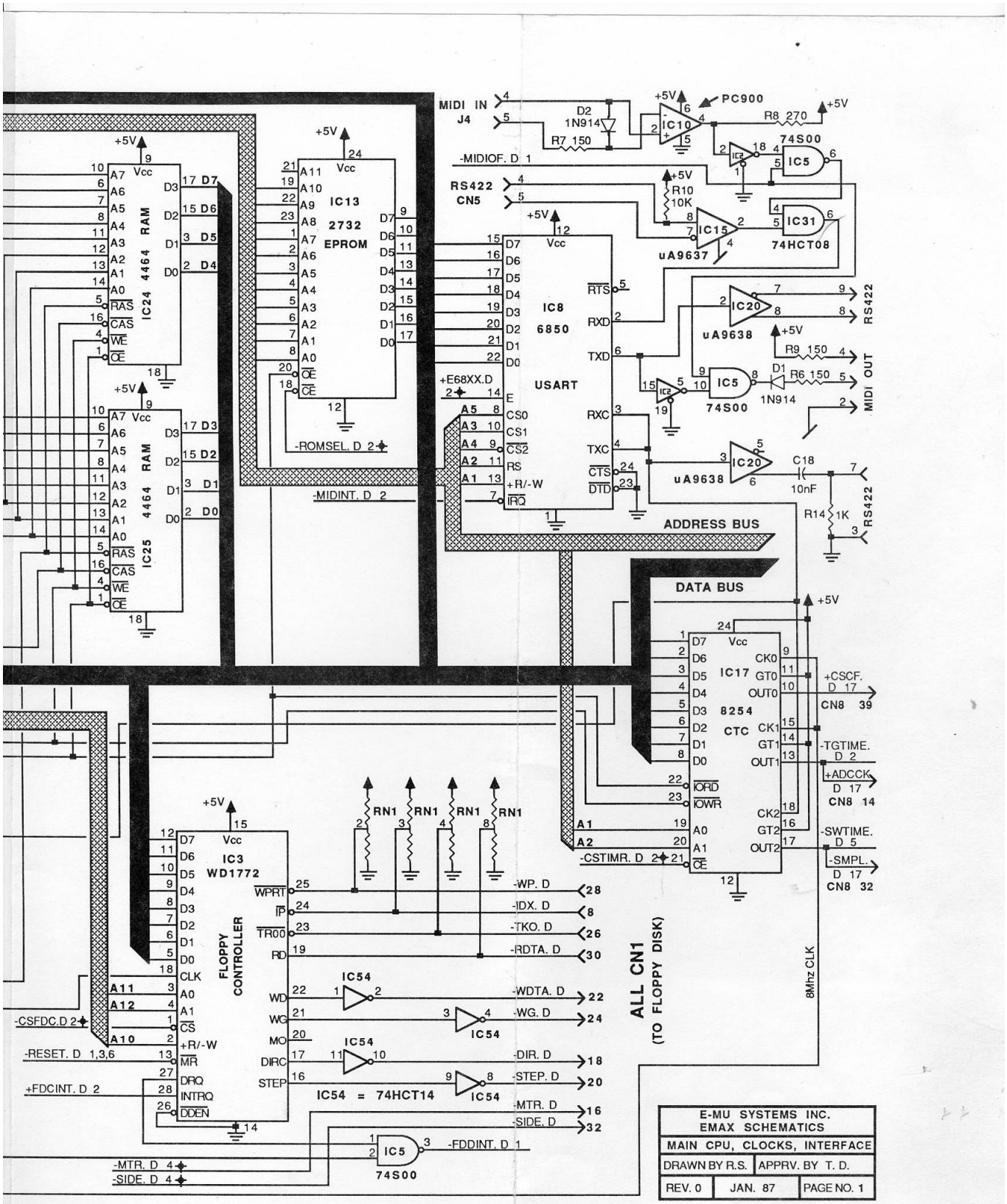
introducing analog/digital noise coupling. The E-chip is an all digital approach, allowing us to use external D/A converters and select the precision we wish to implement. The Digital Signal Processing (DSP) computations reduce the distortion involved in shifting pitch, and allow us to compress our data to allow faster loading and more memory. Yes, the E-chip does address generation like the Q-chip, but that's a small part of the functionality.

CAN I BUY AN E-CHIP?

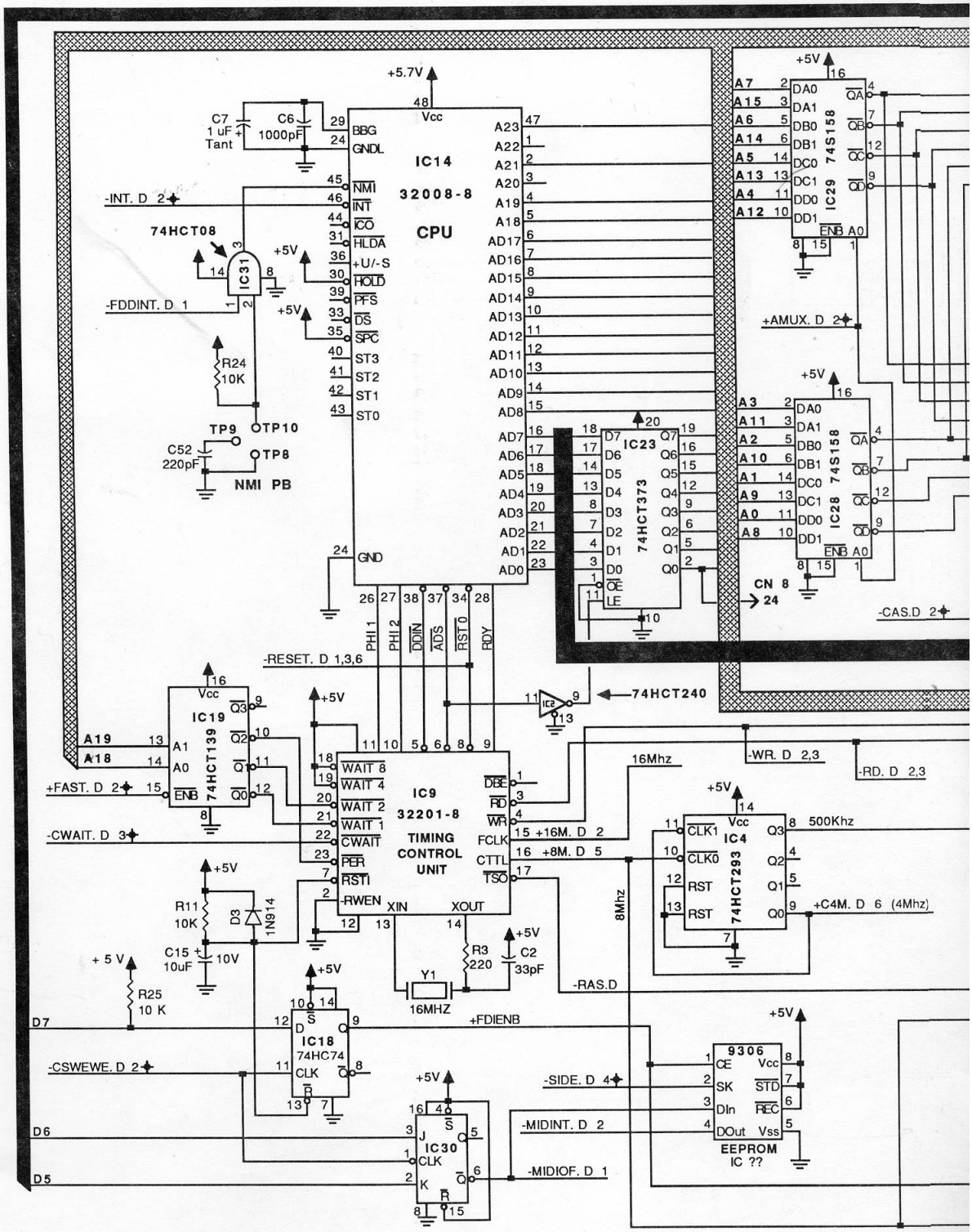
No (Except to service an Emax). Because it's a proprietary custom component, we're keeping most of the information about it confidential. Not only don't we want our competitors to get hold of a xeroxed spec. sheet, we also don't want to burden our customer service folk with answering questions about chips, applications, etc.

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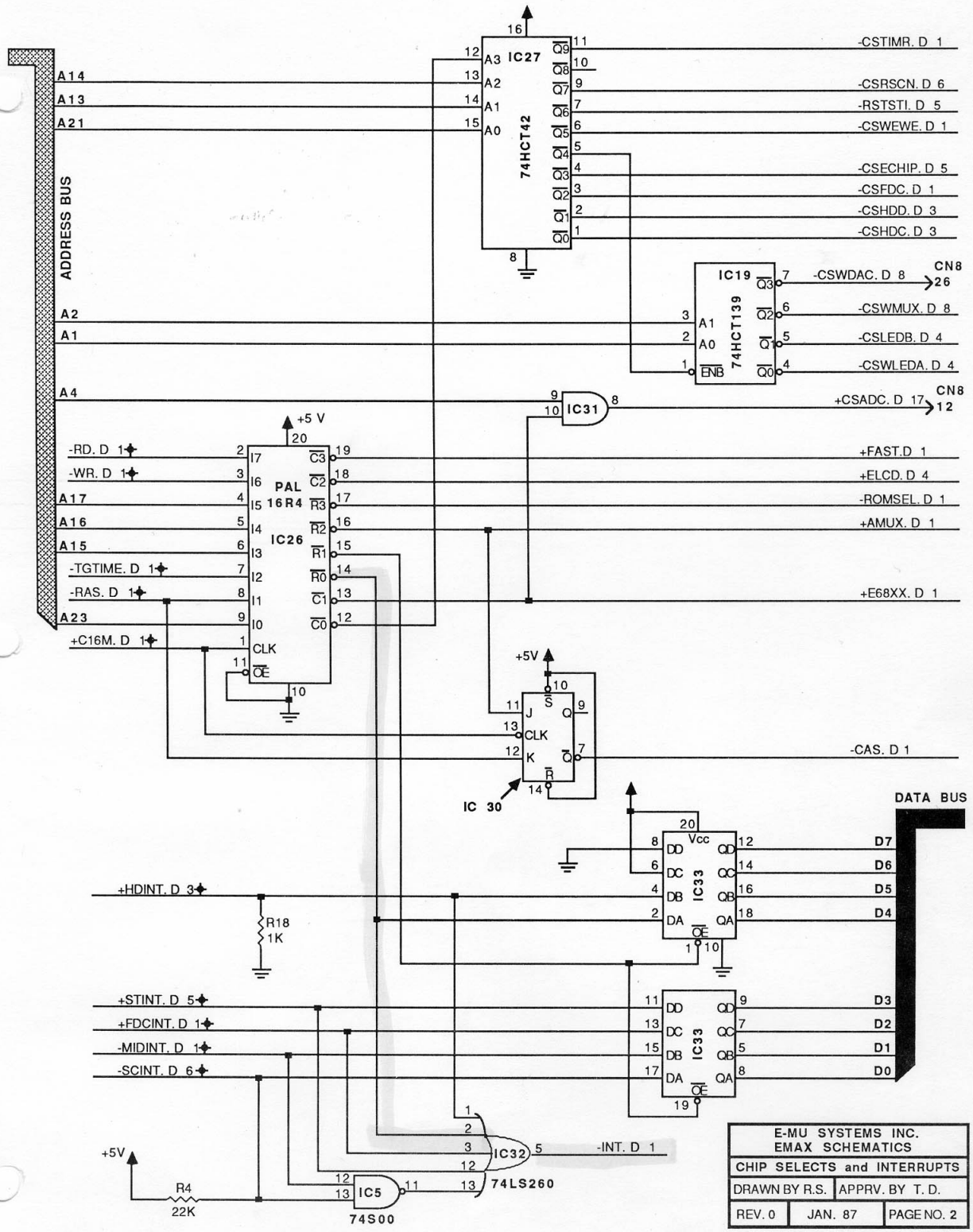
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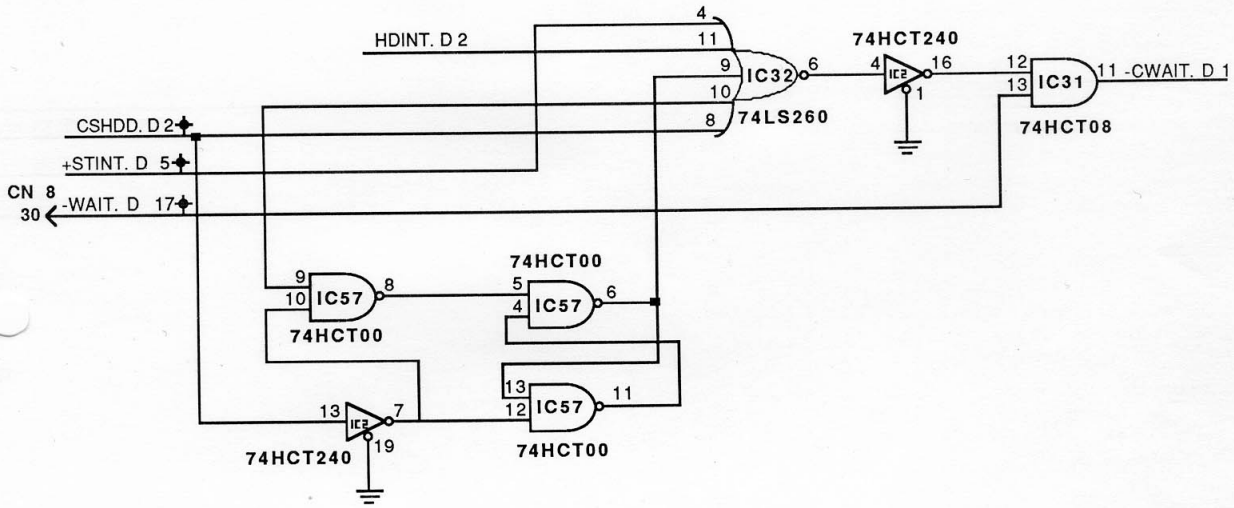
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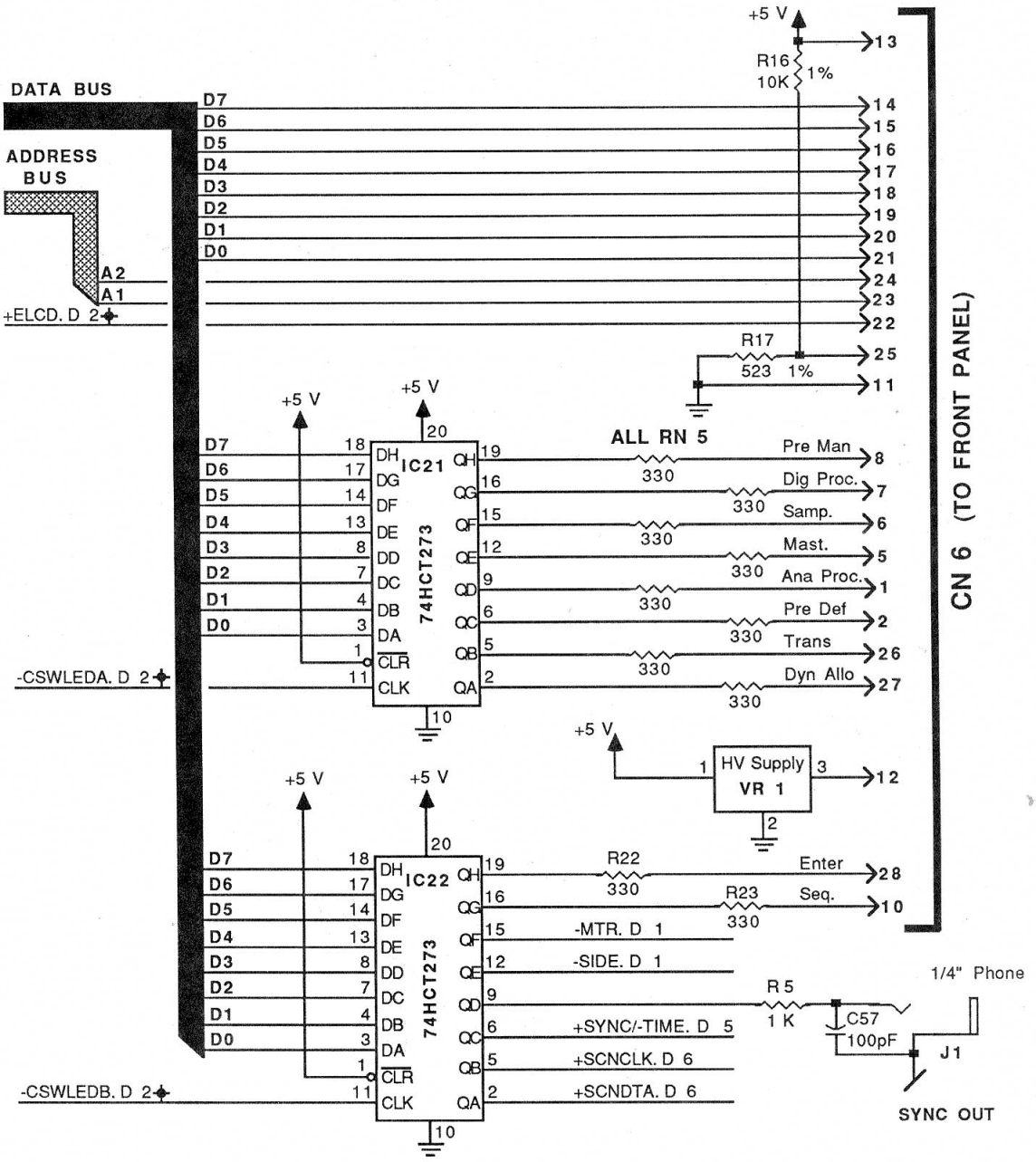


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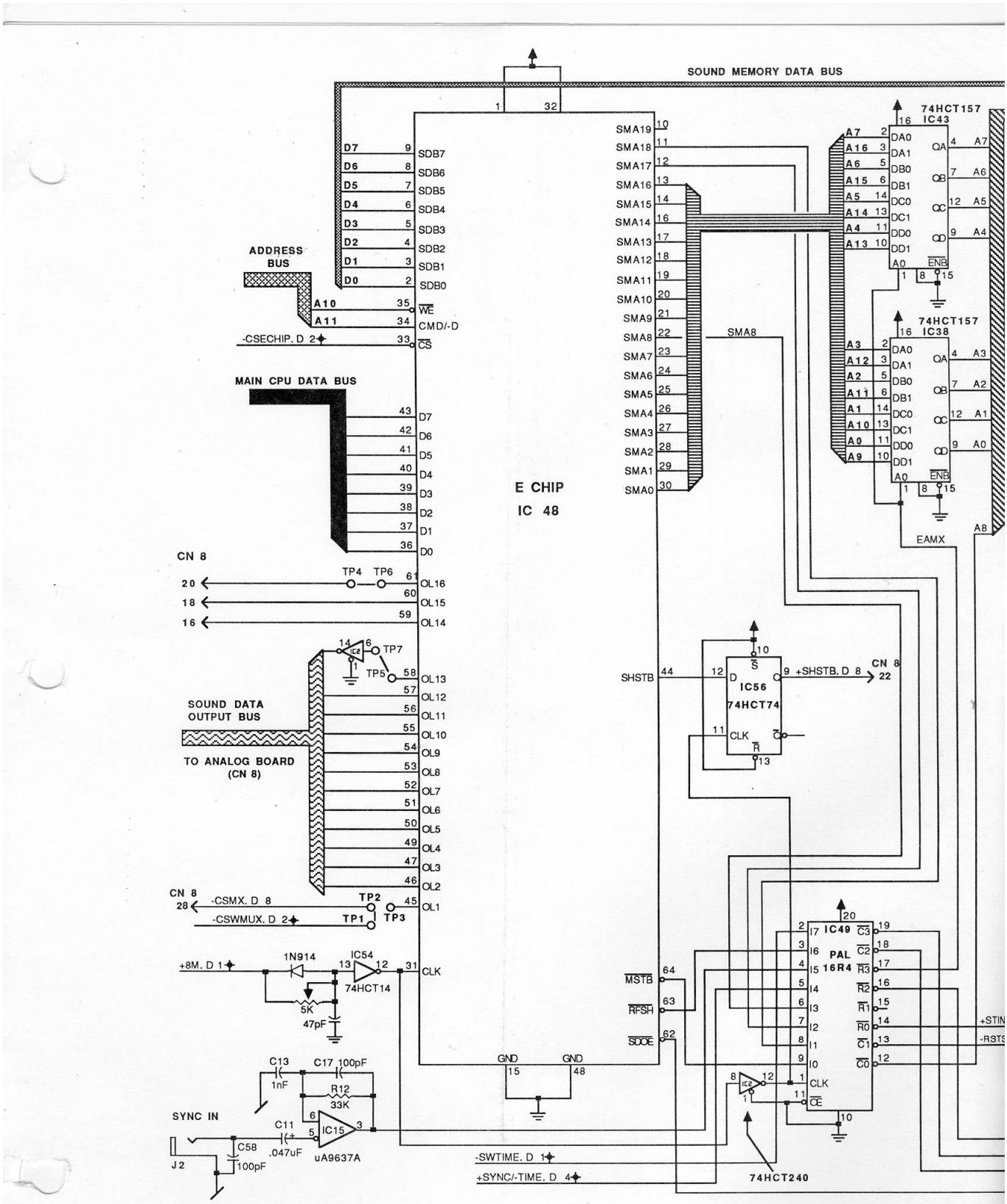
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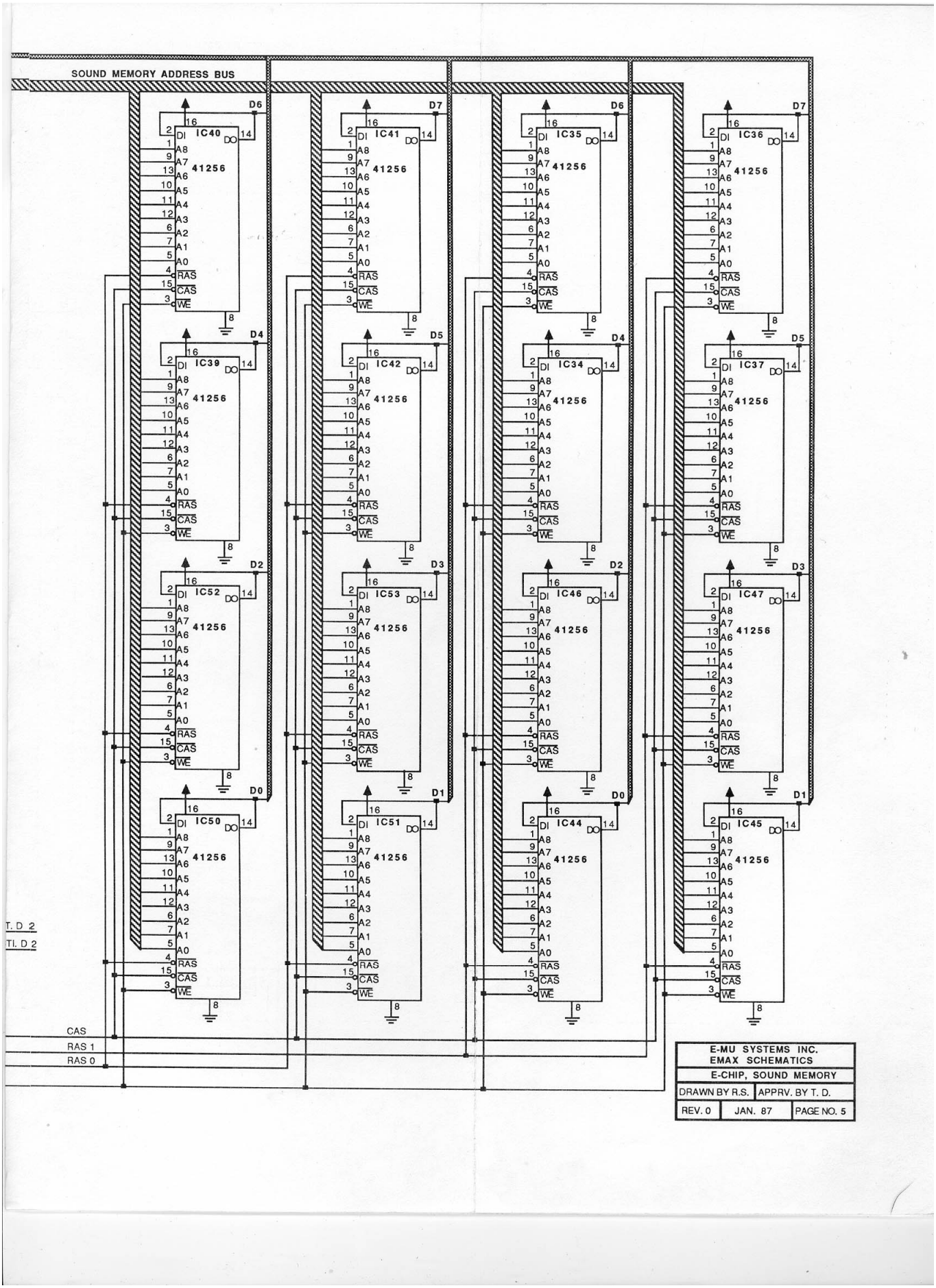


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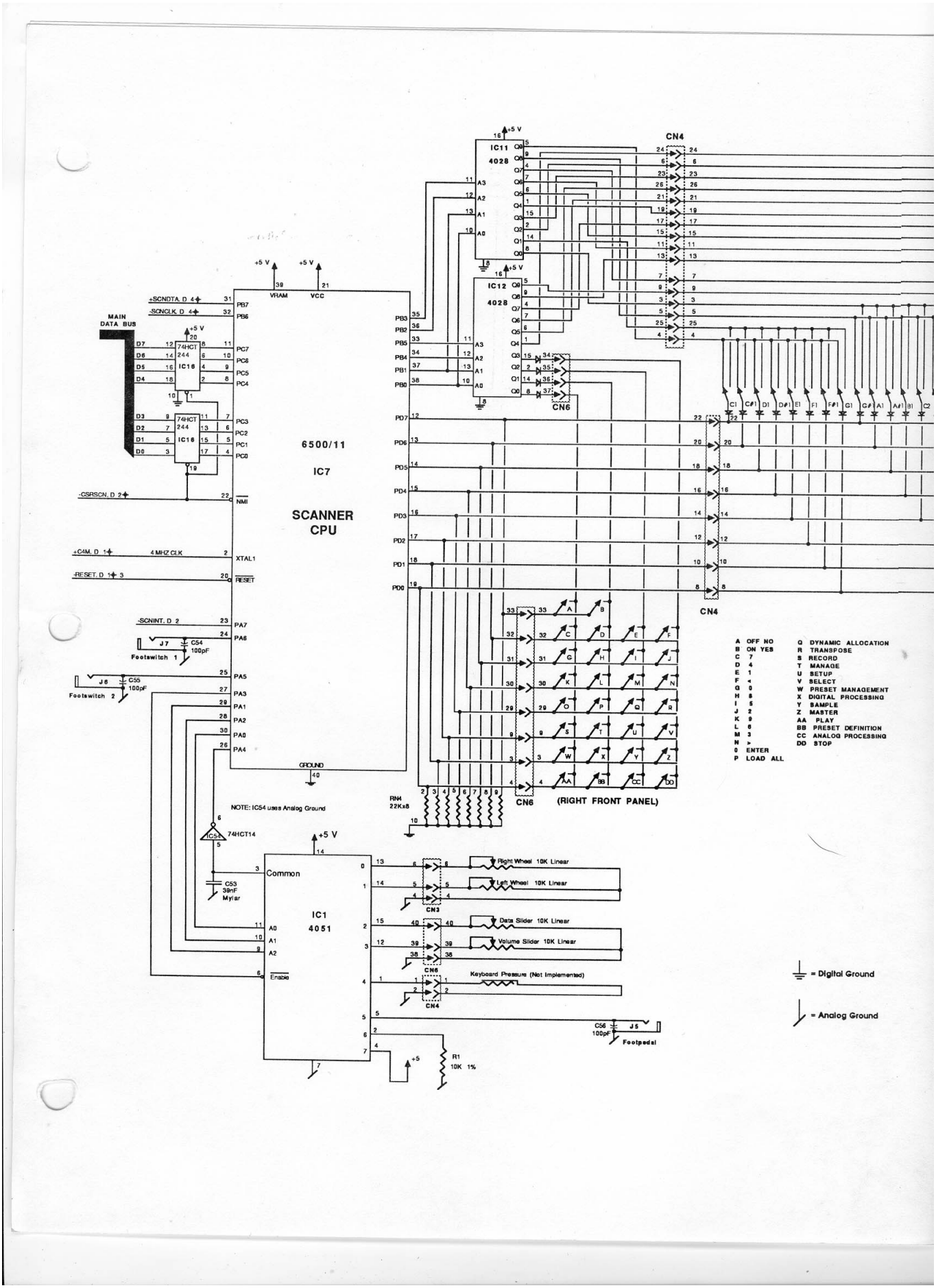
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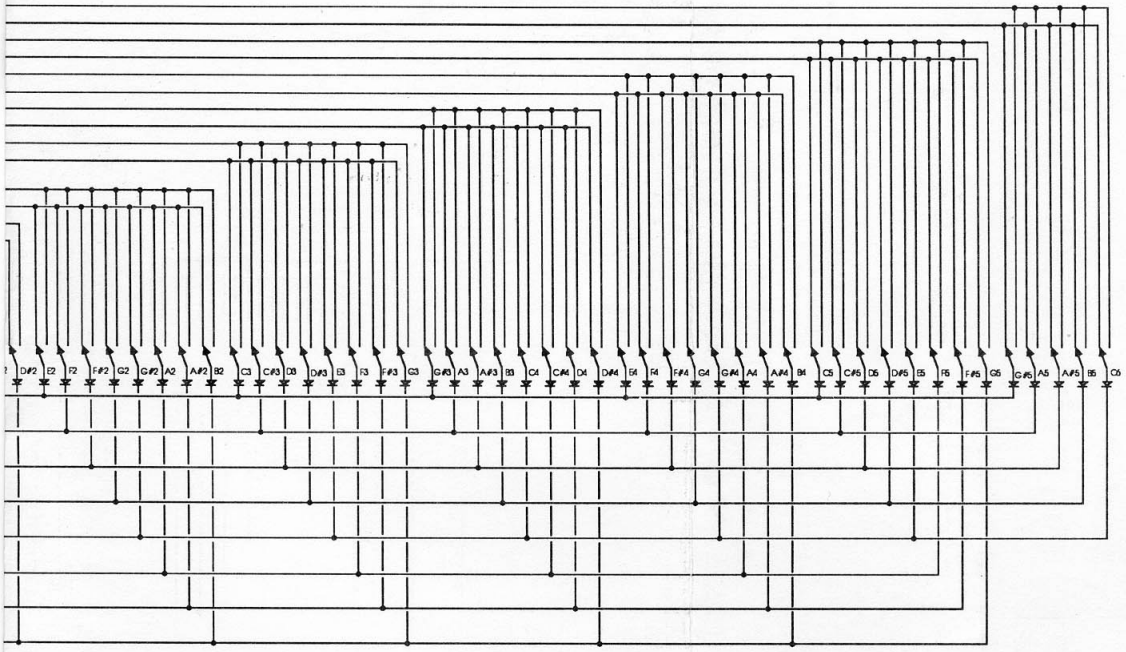
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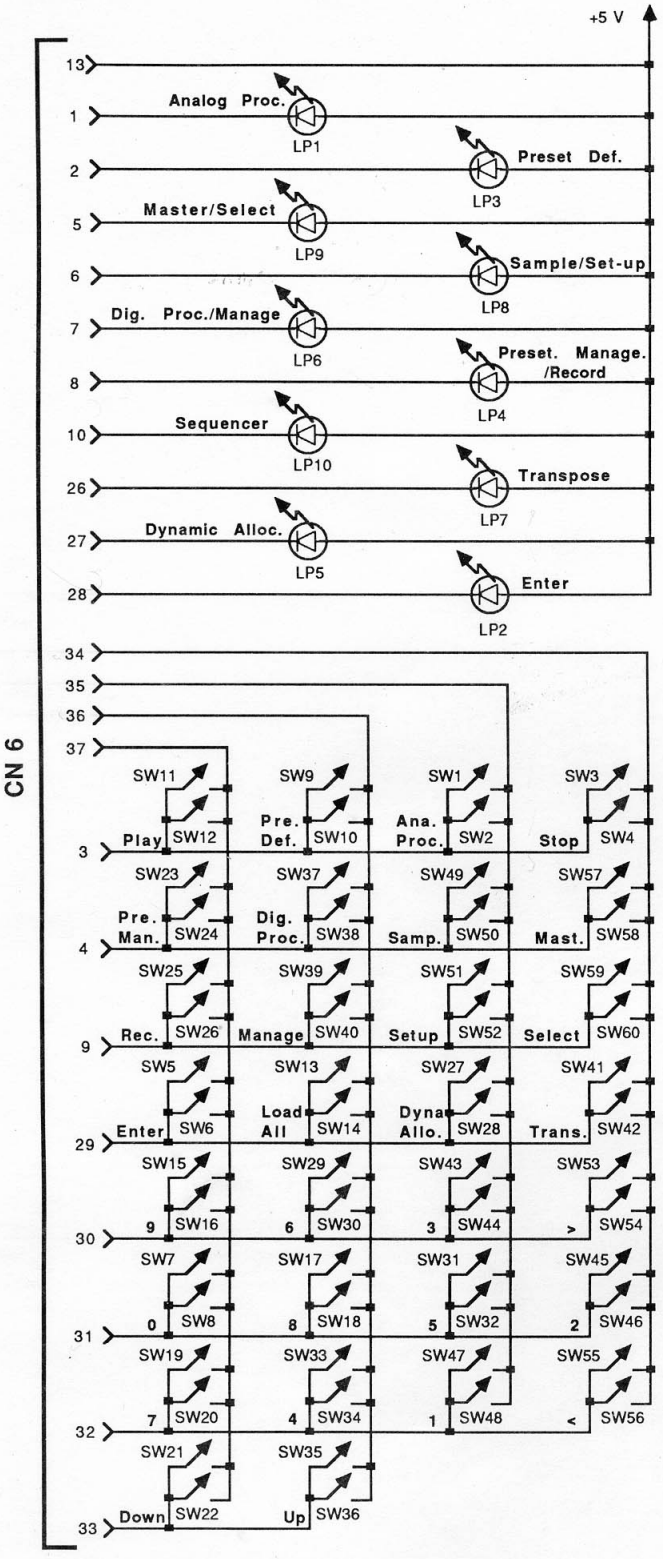
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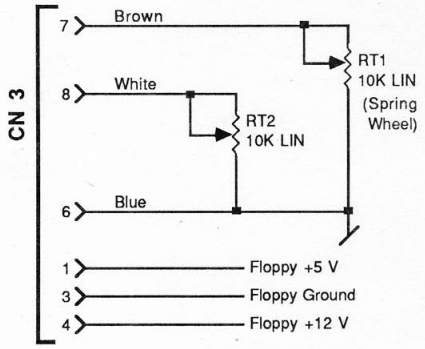


5 OCTAVE KEYBOARD

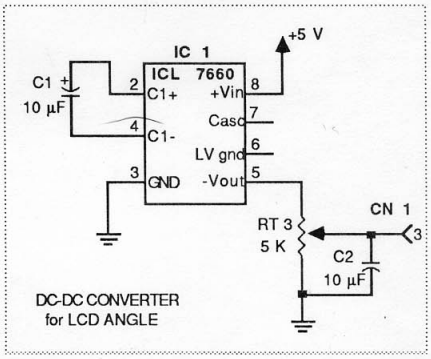
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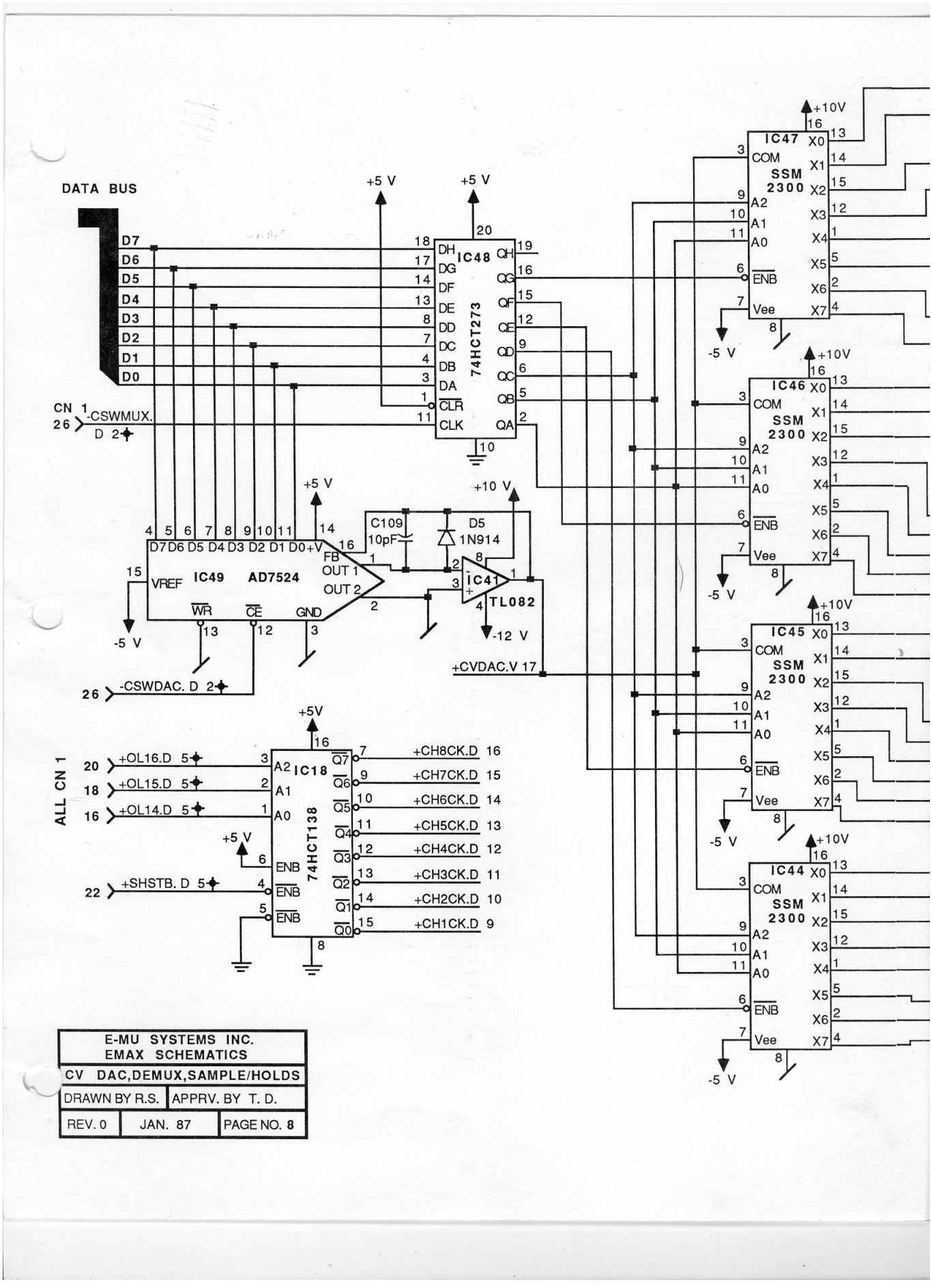


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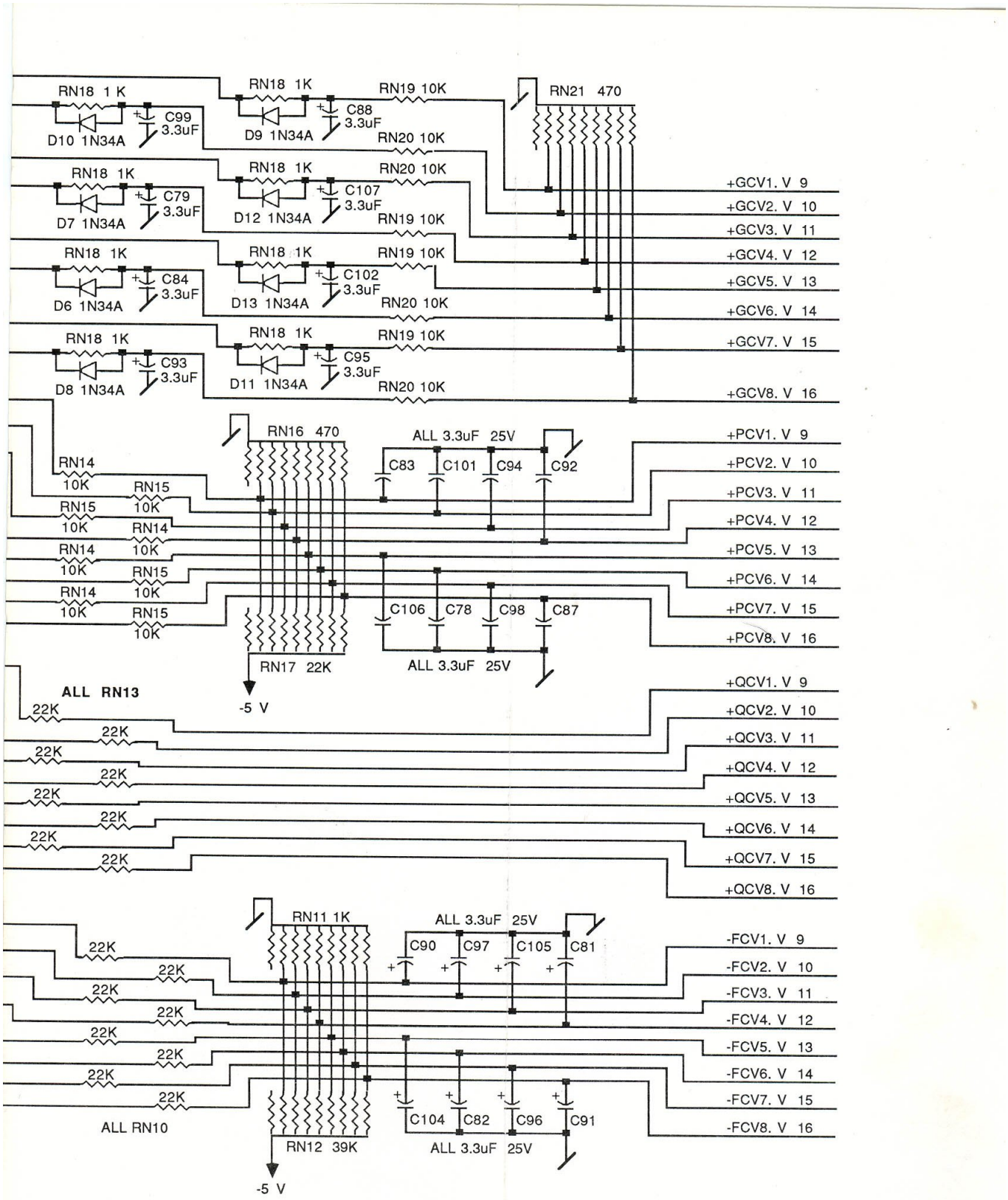
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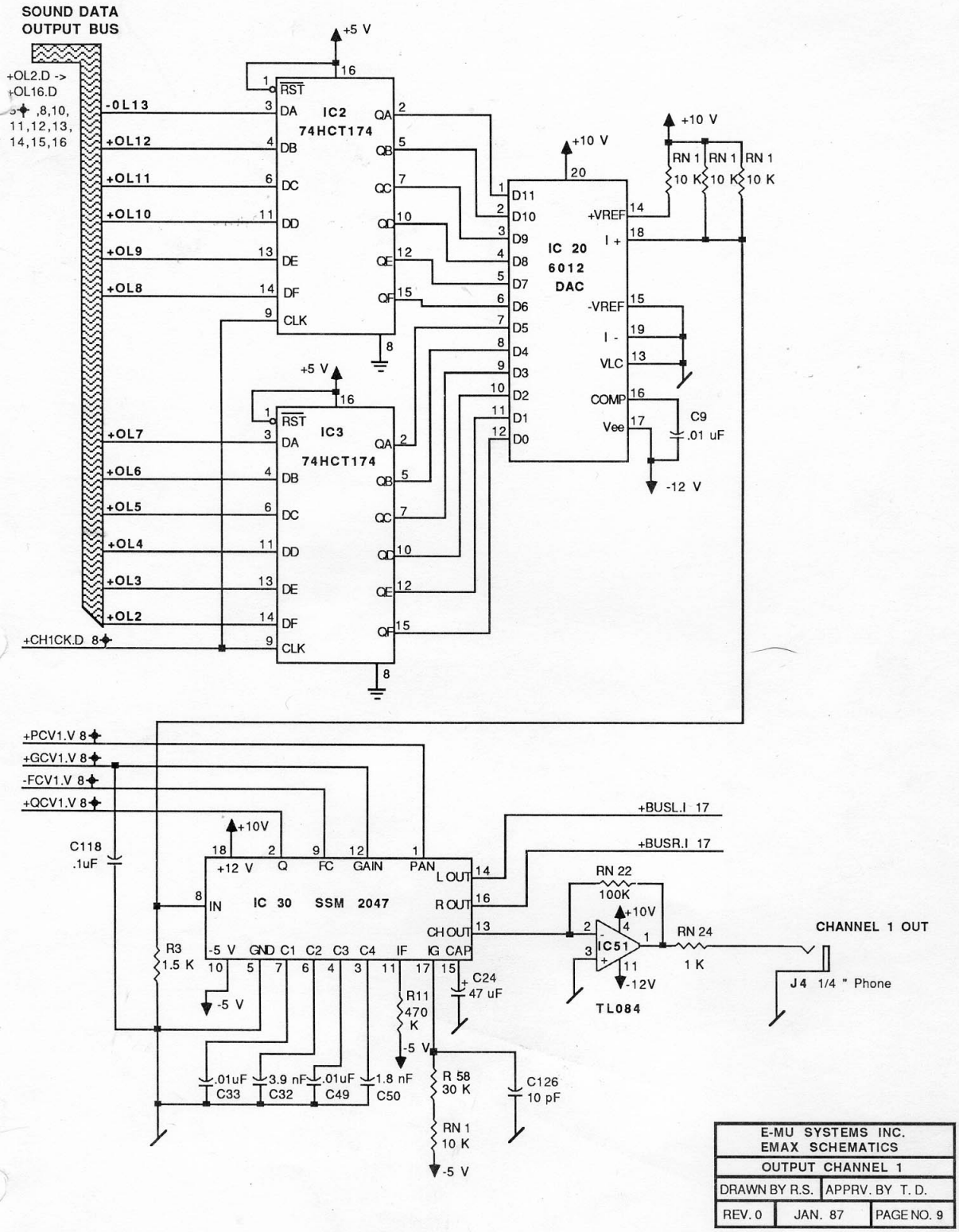


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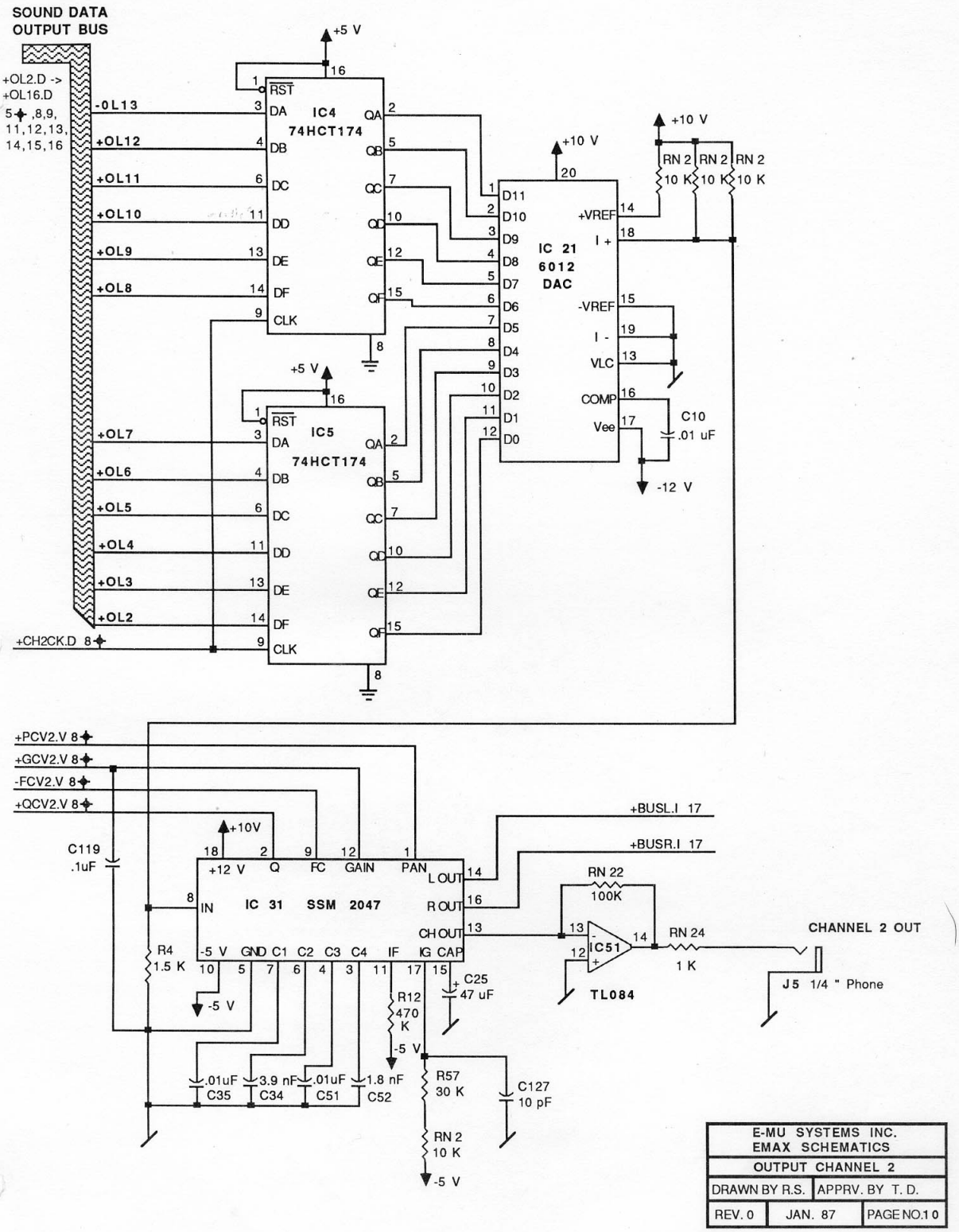


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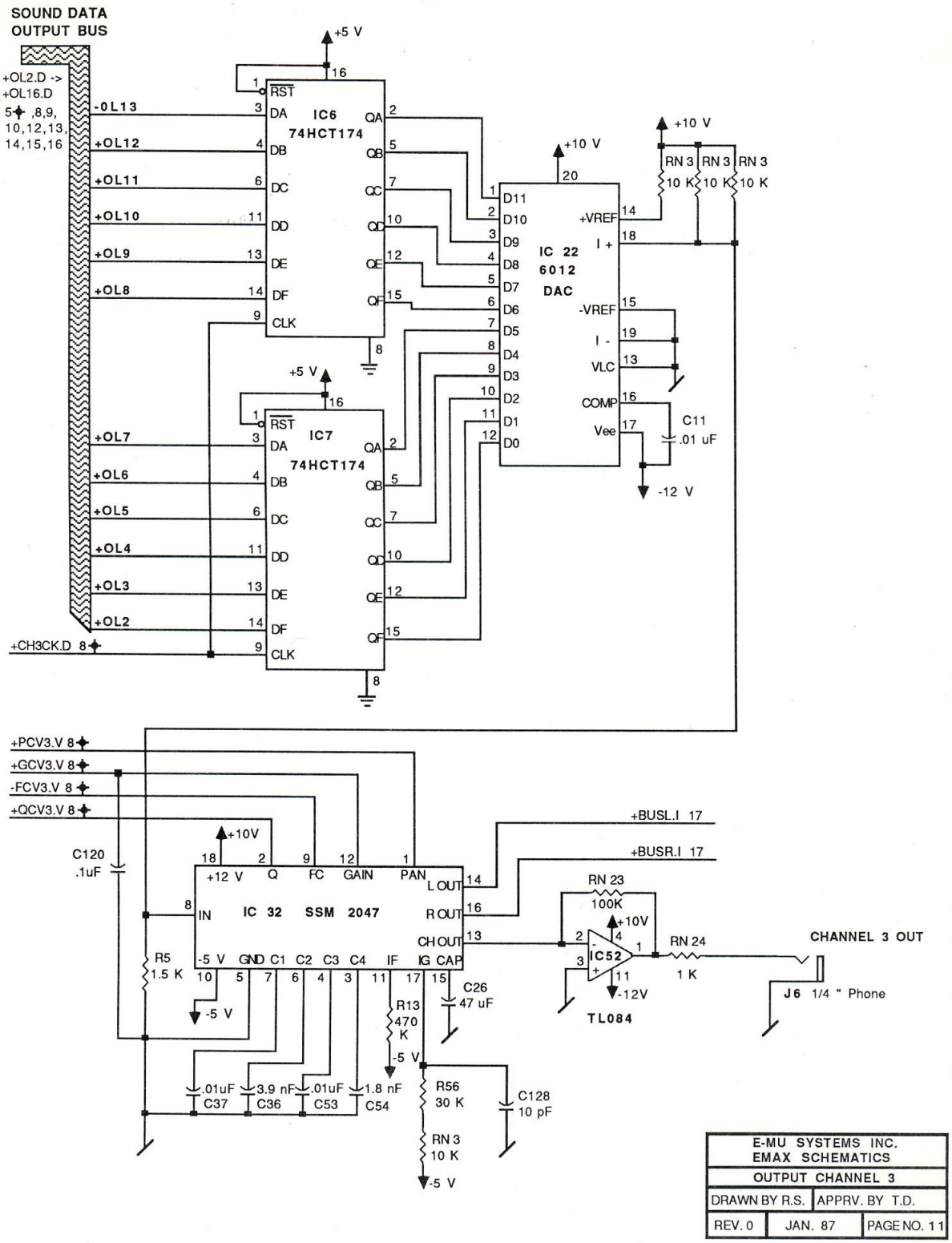
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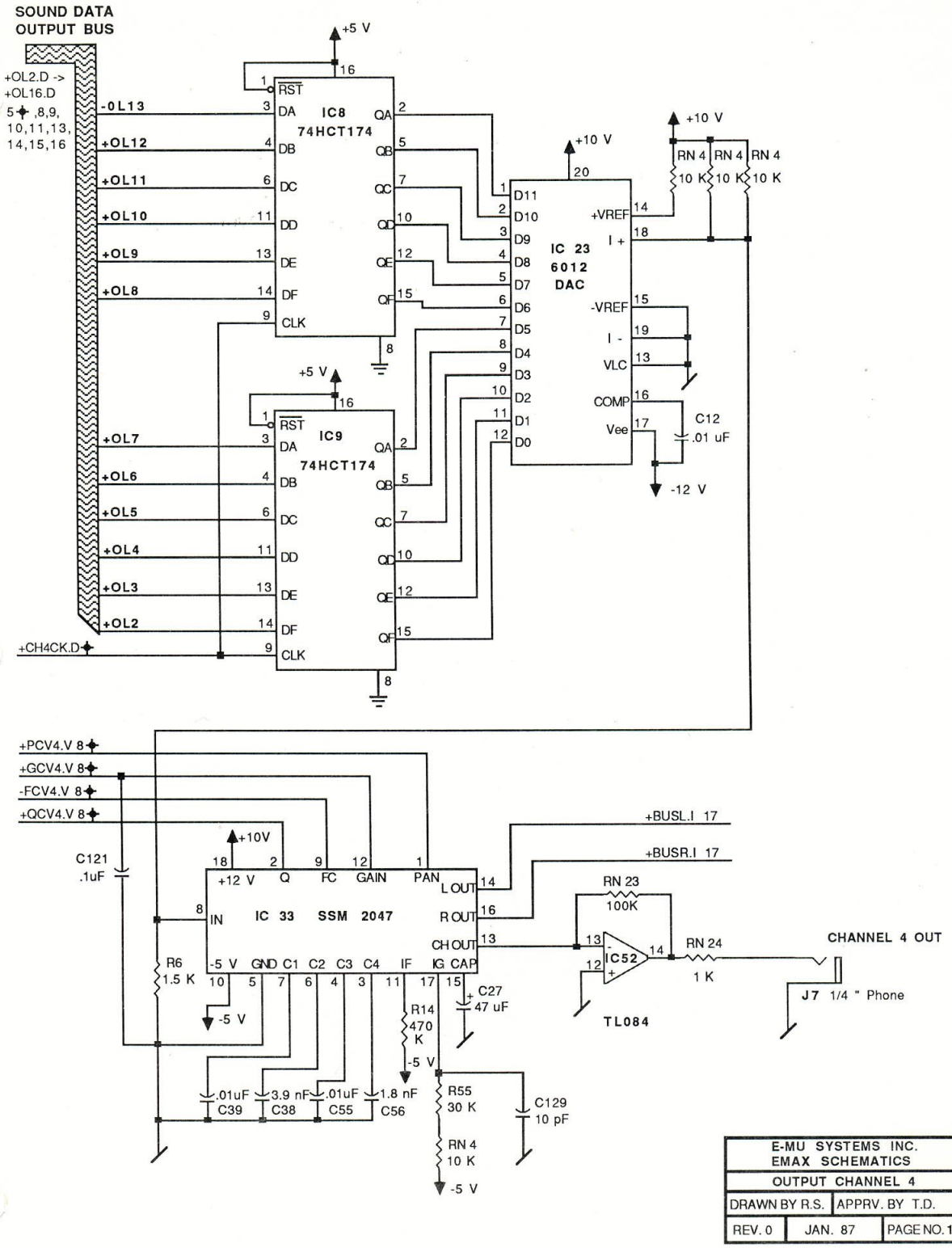
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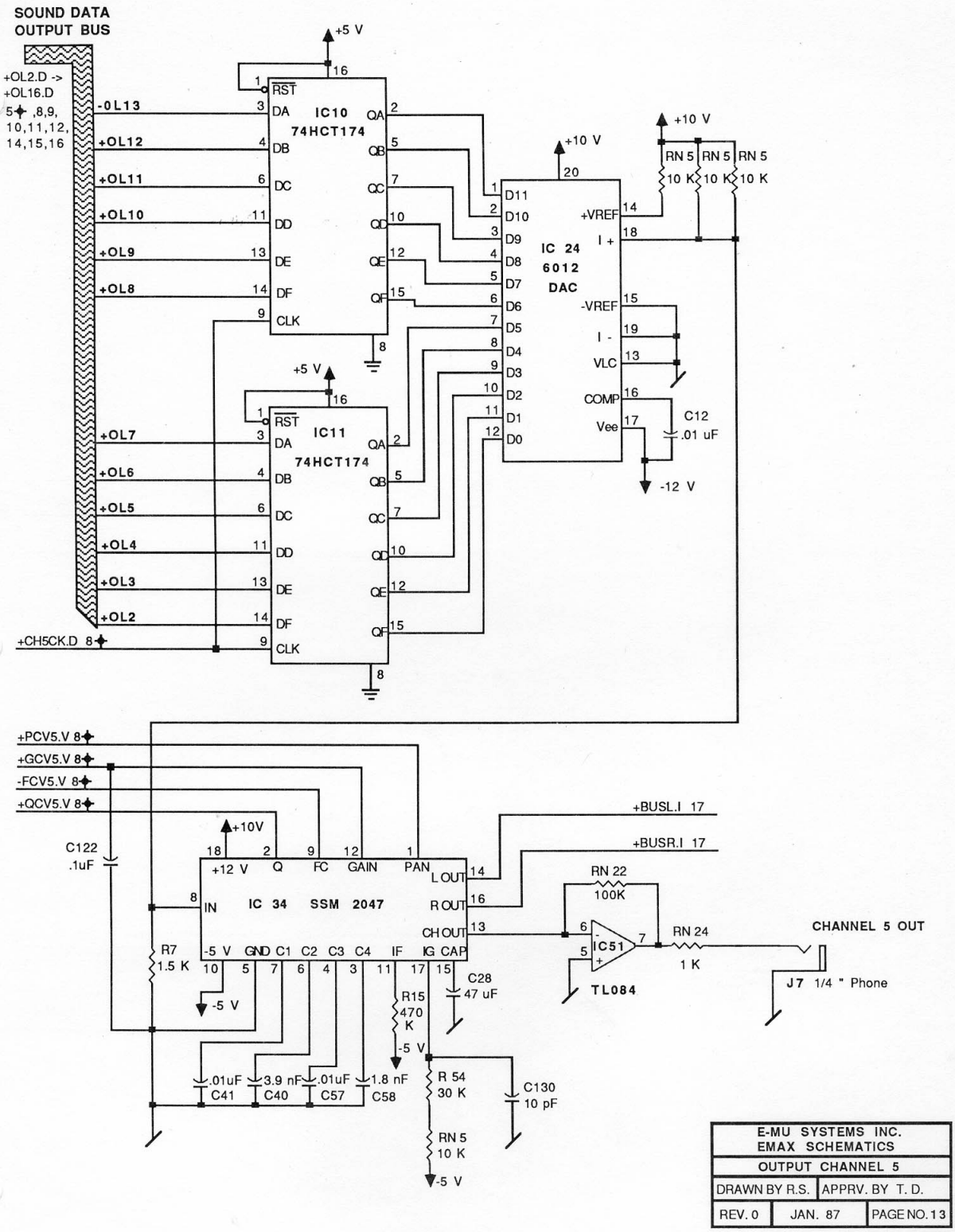
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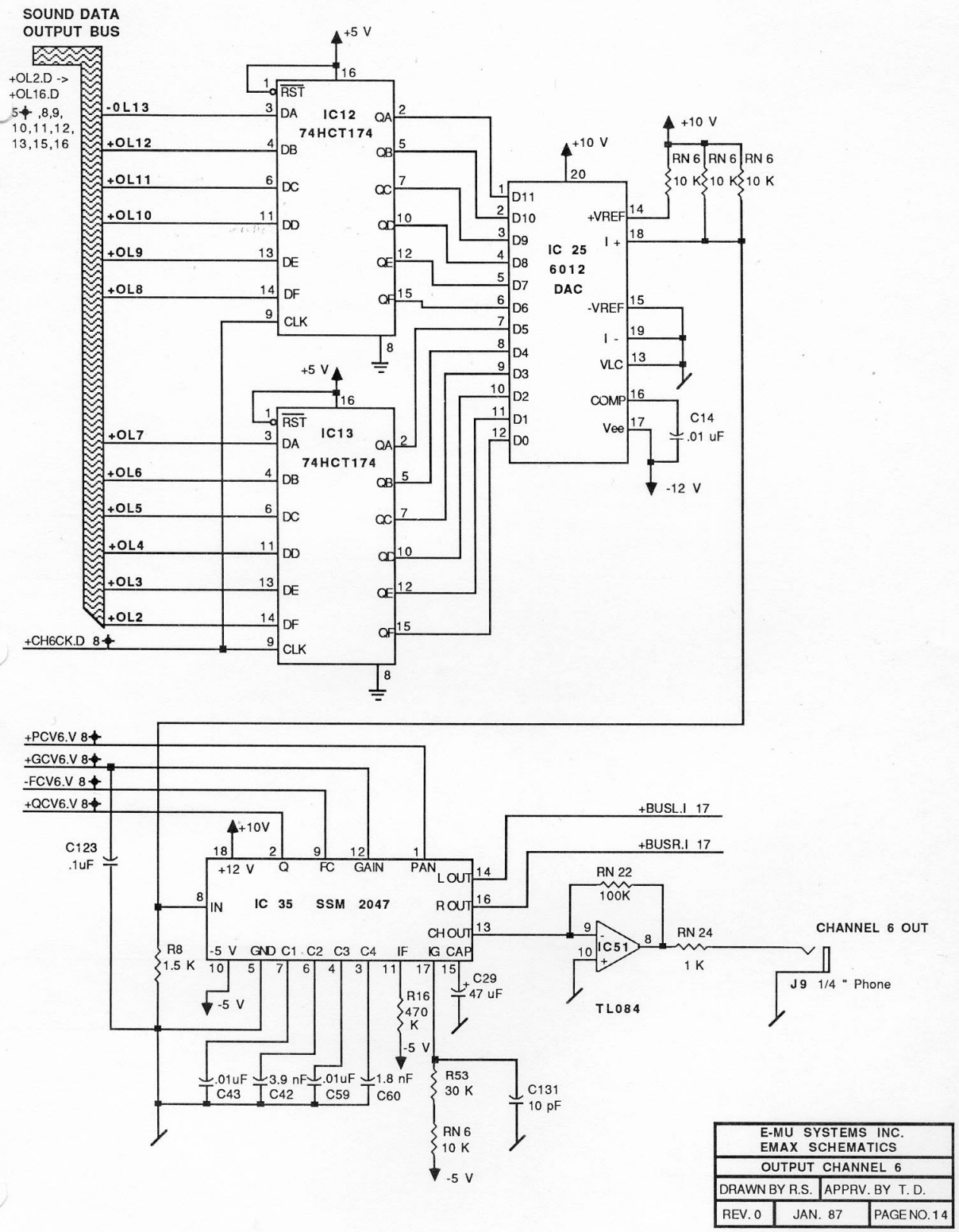
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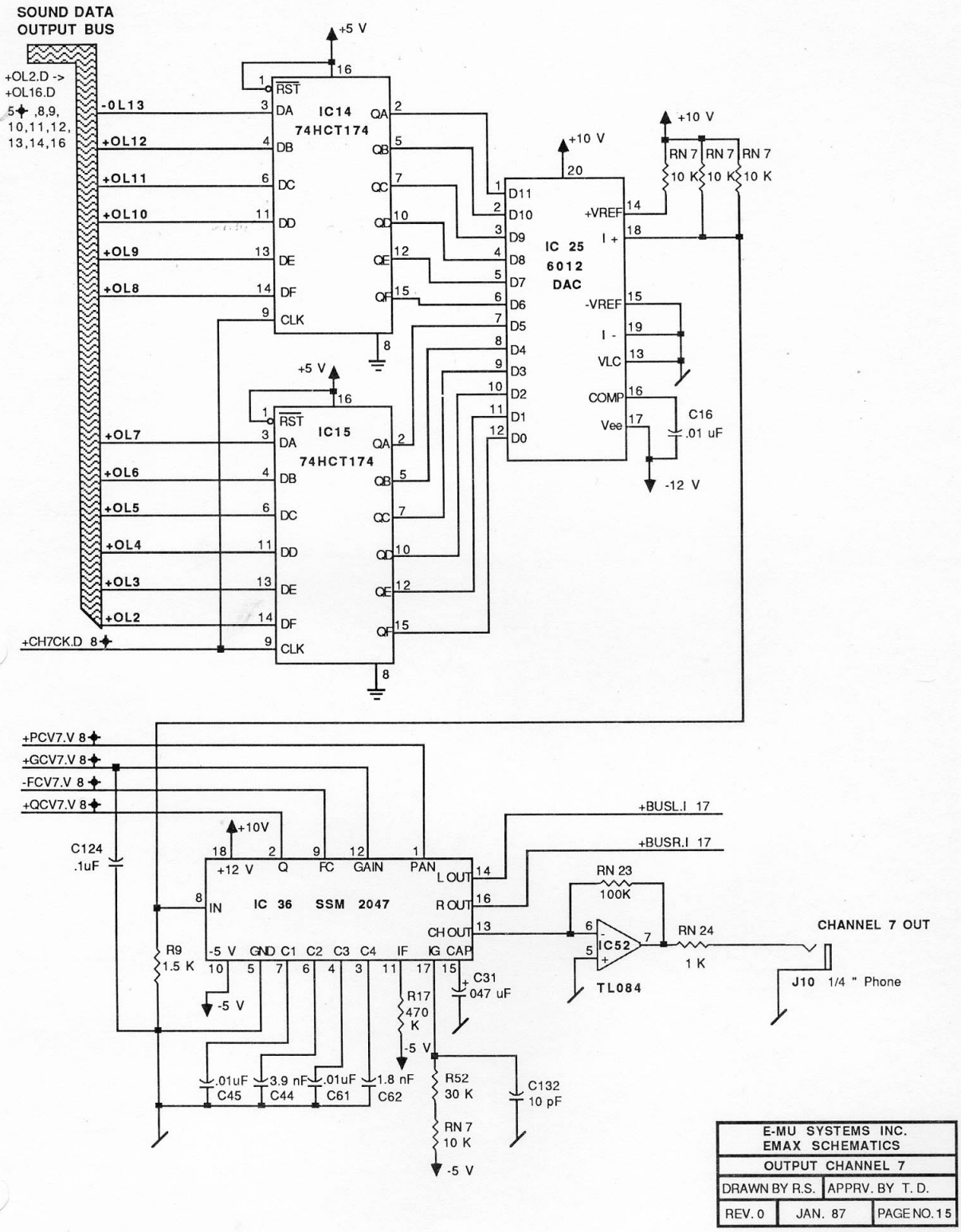
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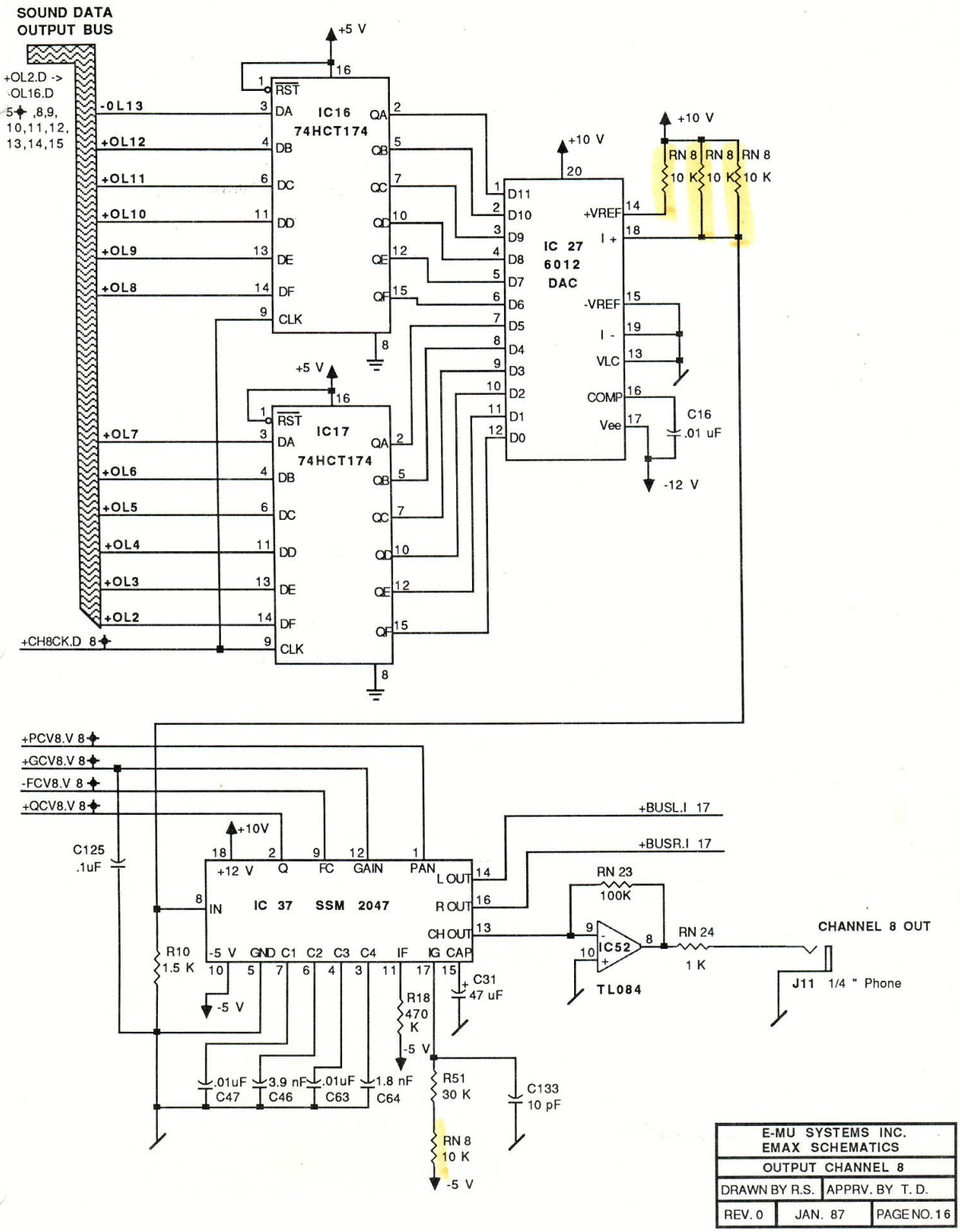
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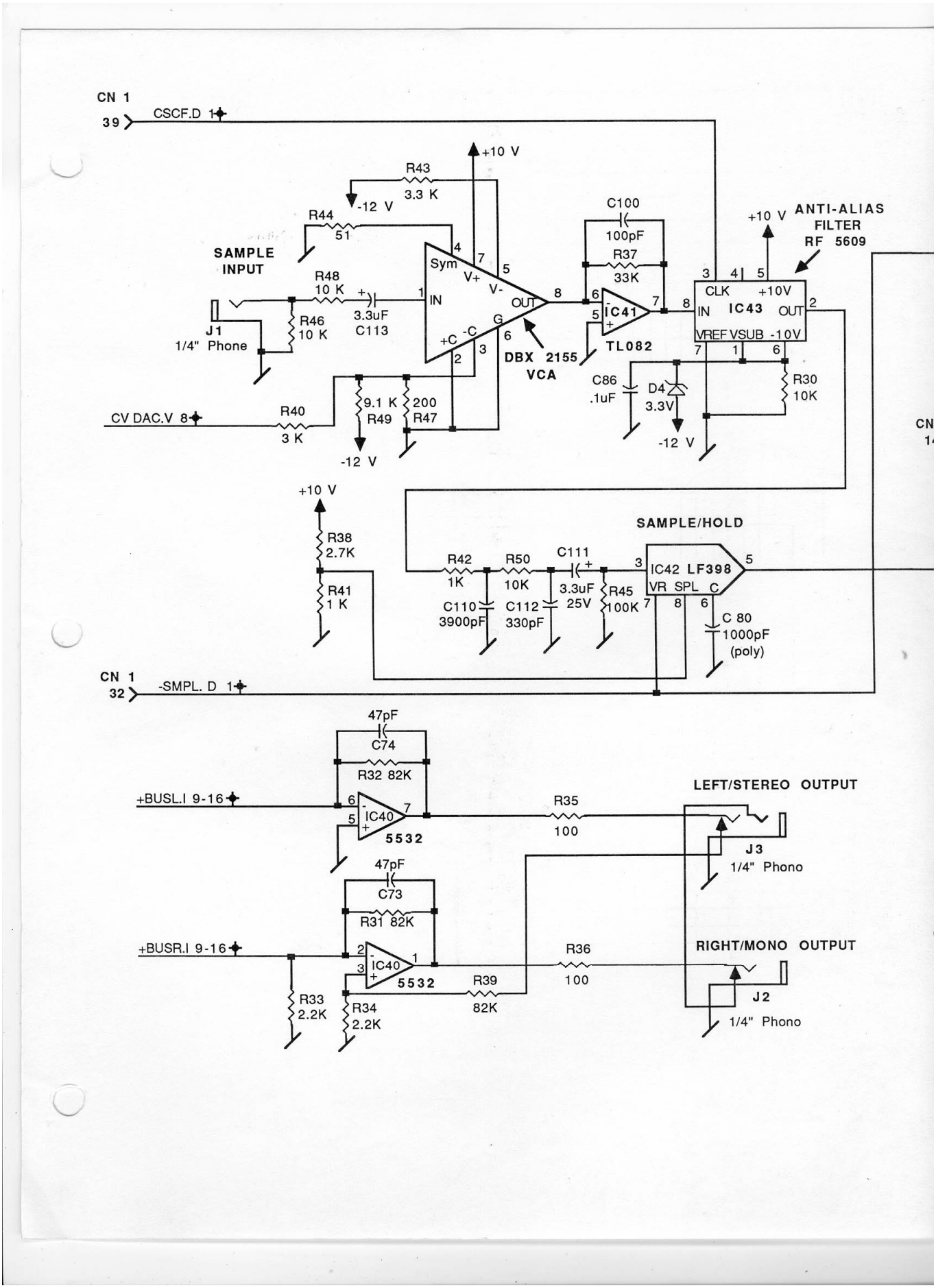
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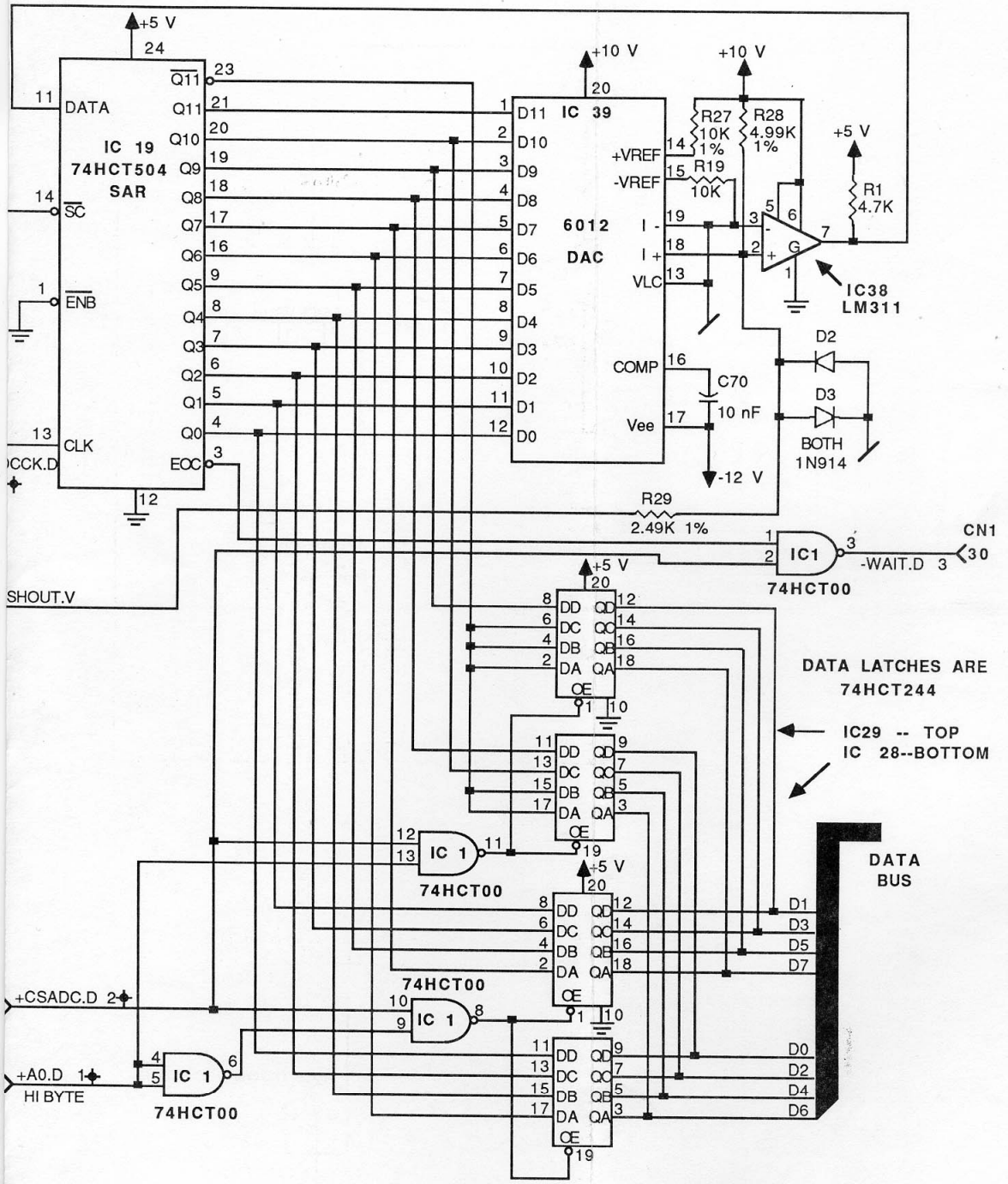


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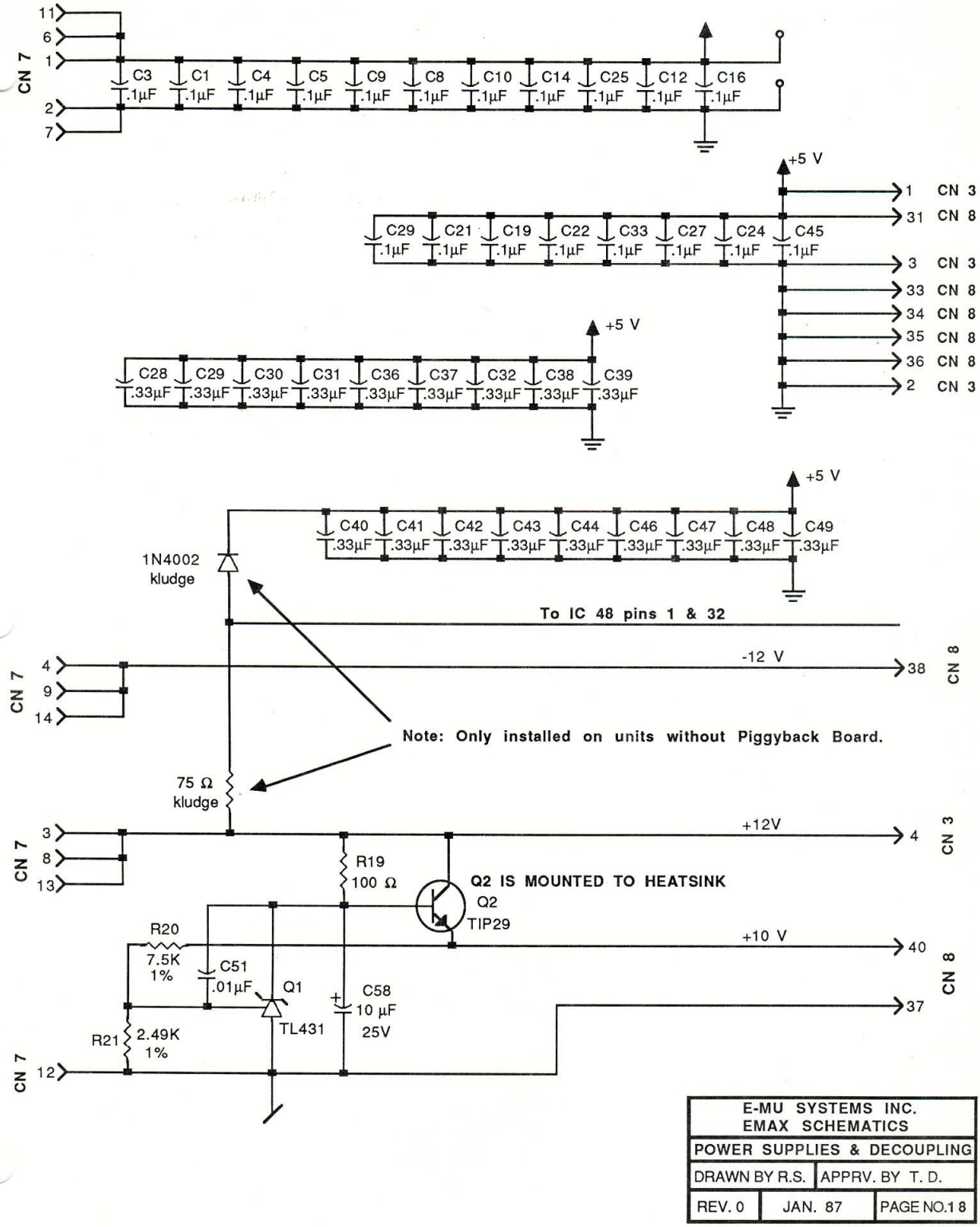
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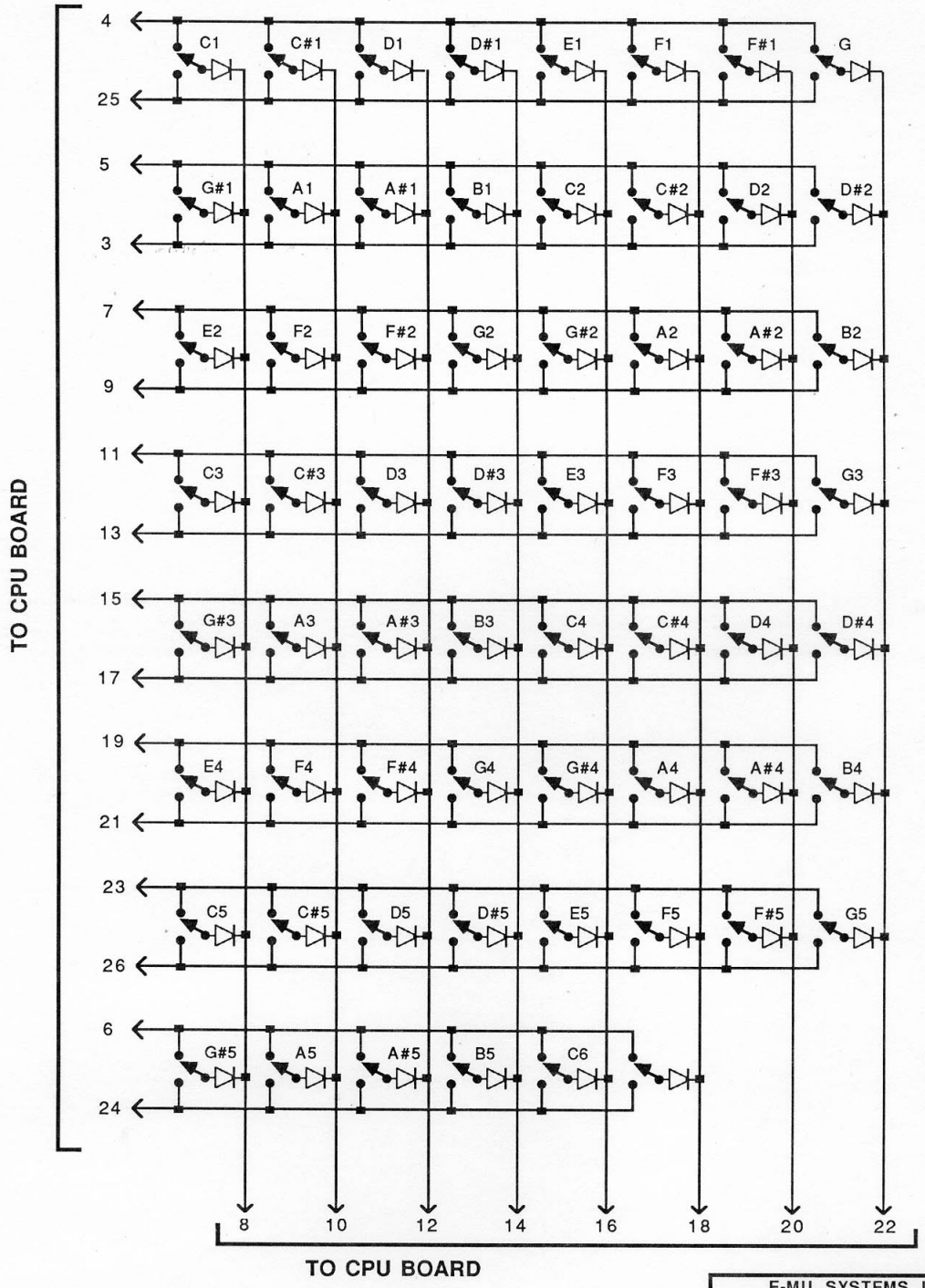


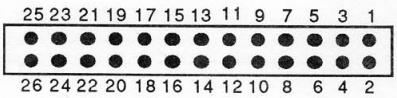
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EMAX SIGNAL NAME DEFINITIONS

The signal names are comprised of:
(a) + or - specifying active high or low.
(b) An abbreviation of the signal function.
(c) An abbreviation of the signal type.
(d) The signal's destination and source page numbers. Source page is indicated by an + following the page number. If there is no + after a page number then the present page is the source page. If the present page is listed with the destination page then the signal appears again on the same page.
There are three types of signals; **D, V** and **I**. **D** stands for digital, **V** stands for voltage or an analog signal and **I** stands for a current.

EXAMPLE:	(a)	(b)	(c)	(d)
	-	8M	.D	1+
	(Low)	8 mHz Clock	Digital	Source page 2

Emax Signal Name List

Name	Source	Destination	Type	Description
+A0.D	1	1,17	TTL	Main CPU Address Bus 0
+A1.D	1	1,2,3,4	TTL	Main CPU Address Bus 1
+A2.D	1	1,2,3,4	TTL	Main CPU Address Bus 2
+A3.D	1	1,3	TTL	Main CPU Address Bus 3
+A4.D	1	1,2	TTL	Main CPU Address Bus 4
+A5.D	1	1	TTL	Main CPU Address Bus 5
+A6.D	1	1	TTL	Main CPU Address Bus 6
+A7.D	1	1	TTL	Main CPU Address Bus 7
+A8.D	1	1	TTL	Main CPU Address Bus 8
+A9.D	1	1	TTL	Main CPU Address Bus 9
+A10.D	1	1,5	TTL	Main CPU Address Bus 10
+A11.D	1	1,5	TTL	Main CPU Address Bus 11
+A12.D	1	1	TTL	Main CPU Address Bus 12
+A13.D	1	1,2	TTL	Main CPU Address Bus 13
+A14.D	1	1,2	TTL	Main CPU Address Bus 14
+A15.D	1	1,2	TTL	Main CPU Address Bus 15
+A16.D	1	1,2	TTL	Main CPU Address Bus 16
+A17.D	1	1,2	TTL	Main CPU Address Bus 17
+A18.D	1	1	TTL	Main CPU Address Bus 18
+A19.D	1	1	TTL	Main CPU Address Bus 19
+A20.D	1	1	TTL	Main CPU Address Bus 20
+A21.D	1	1	TTL	Main CPU Address Bus 21
+A22.D	1	1	TTL	Main CPU Address Bus 22
+A23.D	1	1	TTL	Main CPU Address Bus 23

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Name	Source	Destination	Type	Description
+ADCCK.D	1	17	TTL	ADC Clock
+AMUX.D	2	1	TTL	Main CPU Address Mux.
+BUSL.I	9-16	17	Current	Left Audio Bus
+BUSR.I	9-16	17	Current	Right Audio Bus
+C16M.D	1	2	TTL	16 MHz Clock
+C8M.D	1	1	TTL	8 MHz Clock
+C4M.D	1	6	TTL	4 MHz Clock
+C500K.D	1	1	TTL	500 KHz Clock
-CAS.D	2	1	TTL	Column Address Select
+CH1CK.D	8	9	TTL	Channel 1 Clock
+CH2CK.D	8	10	TTL	Channel 2 Clock
+CH3CK.D	8	11	TTL	Channel 3 Clock
+CH4CK.D	8	12	TTL	Channel 4 Clock
+CH5CK.D	8	13	TTL	Channel 5 Clock
+CH6CK.D	8	14	TTL	Channel 6 Clock
+CH7CK.D	8	15	TTL	Channel 7 Clock
+CH8CK.D	8	16	TTL	Channel 8 Clock
+CSADC.D	2	17	TTL	ADC Chip Select
+CSCF.D	1	17	TTL	Switch Cap. Filter Chip Select
-CSECHIP.D	2	5	TTL	E-Chip Chip Select
-CSFDC.D	2	1	TTL	Floppy Disk Contr. Chip Select
-CSRSCN.D	2	6	TTL	Chip Select Read Scanner
-CSTIMR.D	2	1	TTL	Timer Chip Select
-CSWDAC.D	2	8	TTL	Write DAC Chip Select
-CSWEWE.D	2	1	TTL	Chip Select Write Enable
-CSWLEDA.D	2	4	TTL	Write LED Port A Chip Select
-CSWLEDB.D	2	4	TTL	Write LED Port B Chip Select
-CSWMUX.D	2	8	TTL	Write Demux. Chip Select
+CVDAC.V	8	8,17	Ana. Voltage	CV DAC Voltage
-CWAIT.D	3	1	TTL	Main CPU Wait
+D0.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 0
+D1.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 1
+D2.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 2
+D3.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 3
+D4.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 4
+D5.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 5
+D6.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 6
+D7.D	1	1,2,3,4,5,6,8	Tri-State	Main CPU Data Bus 7
-DIR.D	1	CN 1 (Dig.)	TTL	Floppy Disk Head Direction
+E68XX.D	2	1	TTL	USART Chip Enable
+EAMX.D	5	5	TTL	Mux. Select
+ELCD.D	2	4	TTL	LCD Chip Enable
+FAST.D	2	1	TTL	Disable Waits
-FCV1.V	8	9	Ana. Voltage	Filter Control Voltage Ch.1
-FCV2.V	8	10	Ana. Voltage	Filter Control Voltage Ch.2
-FCV3.V	8	11	Ana. Voltage	Filter Control Voltage Ch.3
-FCV4.V	8	12	Ana. Voltage	Filter Control Voltage Ch.4
-FCV5.V	8	13	Ana. Voltage	Filter Control Voltage Ch.5
-FCV6.V	8	14	Ana. Voltage	Filter Control Voltage Ch.6
-FCV7.V	8	15	Ana. Voltage	Filter Control Voltage Ch.7
-FCV8.V	8	16	Ana. Voltage	Filter Control Voltage Ch.8
+FDCINT.D	1	2	TTL	Floppy Disk Contr. Interrupt
+GCV1.V	8	9	Ana. Voltage	Gain Control Voltage Ch. 1
+GCV2.V	8	10	Ana. Voltage	Gain Control Voltage Ch. 2
+GCV3.V	8	11	Ana. Voltage	Gain Control Voltage Ch. 3

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Name	Source	Destination	Type	Description
+GCV4.V	8	12	Ana. Voltage	Gain Control Voltage Ch. 4
+GCV5.V	8	13	Ana. Voltage	Gain Control Voltage Ch. 5
+GCV6.V	8	14	Ana. Voltage	Gain Control Voltage Ch. 6
+GCV7.V	8	15	Ana. Voltage	Gain Control Voltage Ch. 7
+GCV8.V	8	16	Ana. Voltage	Gain Control Voltage Ch. 8
+HIBYTE.D	1 (+A0.D)	17	TTL	ADC Hi Byte Select
-IDX.D	1	CN 1 (Dig.)	TTL	Floppy Disk Index Signal
-INT.D	2	1	TTL	Main CPU Maskable Interrupt
-MIDINT.D	1	2	TTL	MIDI Interrupt
-MIDIOF.D	1	1	TTL	MIDI Off Control
-MTR.D	4	CN 1 (Dig.)	TTL	Floppy Disk Motor Control
+OL1.D	5	Not Used	TTL	Sound Data Output 1
+OL2.D	5	9-16	TTL	Sound Data Output 2
+OL3.D	5	9-16	TTL	Sound Data Output 3
+OL4.D	5	9-16	TTL	Sound Data Output 4
+OL5.D	5	9-16	TTL	Sound Data Output 5
+OL6.D	5	9-16	TTL	Sound Data Output 6
+OL7.D	5	9-16	TTL	Sound Data Output 7
+OL8.D	5	9-16	TTL	Sound Data Output 8
+OL9.D	5	9-16	TTL	Sound Data Output 9
+OL10.D	5	9-16	TTL	Sound Data Output 10
+OL11.D	5	9-16	TTL	Sound Data Output 11
+OL12.D	5	9-16	TTL	Sound Data Output 12
+OL13.D	5	9-16	TTL	Sound Data Output 13
+OL14.D	5	8	TTL	Sound Data Output 14
+OL15.D	5	8	TTL	Sound Data Output 15
+OL16.D	5	8	TTL	Sound Data Output 16
+PCV1.V	8	9	Ana. Voltage	Pan Control Voltage Ch.1
+PCV2.V	8	10	Ana. Voltage	Pan Control Voltage Ch.2
+PCV3.V	8	11	Ana. Voltage	Pan Control Voltage Ch.3
+PCV4.V	8	12	Ana. Voltage	Pan Control Voltage Ch.4
+PCV5.V	8	13	Ana. Voltage	Pan Control Voltage Ch.5
+PCV6.V	8	14	Ana. Voltage	Pan Control Voltage Ch.6
+PCV7.V	8	15	Ana. Voltage	Pan Control Voltage Ch.7
+PCV8.V	8	16	Ana. Voltage	Pan Control Voltage Ch.8
+QCV1.V	8	9	Ana. Voltage	Q Control Voltage Ch. 1
+QCV2.V	8	10	Ana. Voltage	Q Control Voltage Ch. 2
+QCV3.V	8	11	Ana. Voltage	Q Control Voltage Ch. 3
+QCV4.V	8	12	Ana. Voltage	Q Control Voltage Ch. 4
+QCV5.V	8	13	Ana. Voltage	Q Control Voltage Ch. 5
+QCV6.V	8	14	Ana. Voltage	Q Control Voltage Ch. 6
+QCV7.V	8	15	Ana. Voltage	Q Control Voltage Ch. 7
+QCV8.V	8	16	Ana. Voltage	Q Control Voltage Ch. 8
-RAS.D	1	1	TTL	Column Address Select
-RD.D	1	1	TTL	Main CPU Read Line
-RDTA.D	1	CN 1 (Dig.)	TTL	Floppy Disk Read Data
-RESET.D	1	3,6	TTL	System Reset
-ROMSEL.D	2	1	TTL	Read Only Memory Select
-RSTSTI.D	2	5	TTL	Reset Software Timer Interrupt
+SCNCLK.D	4	6	TTL	Scanner CPU Data Clock
+SCNDTA.D	4	6	TTL	Scanner CPU Data Line
-SCNINT.D	6	2	TTL	Scanner CPU Interrupt
+SDB0.D	5	5	Tri-State	Sound Data Bus 0
+SDB1.D	5	5	Tri-State	Sound Data Bus 1
+SDB2.D	5	5	Tri-State	Sound Data Bus 2

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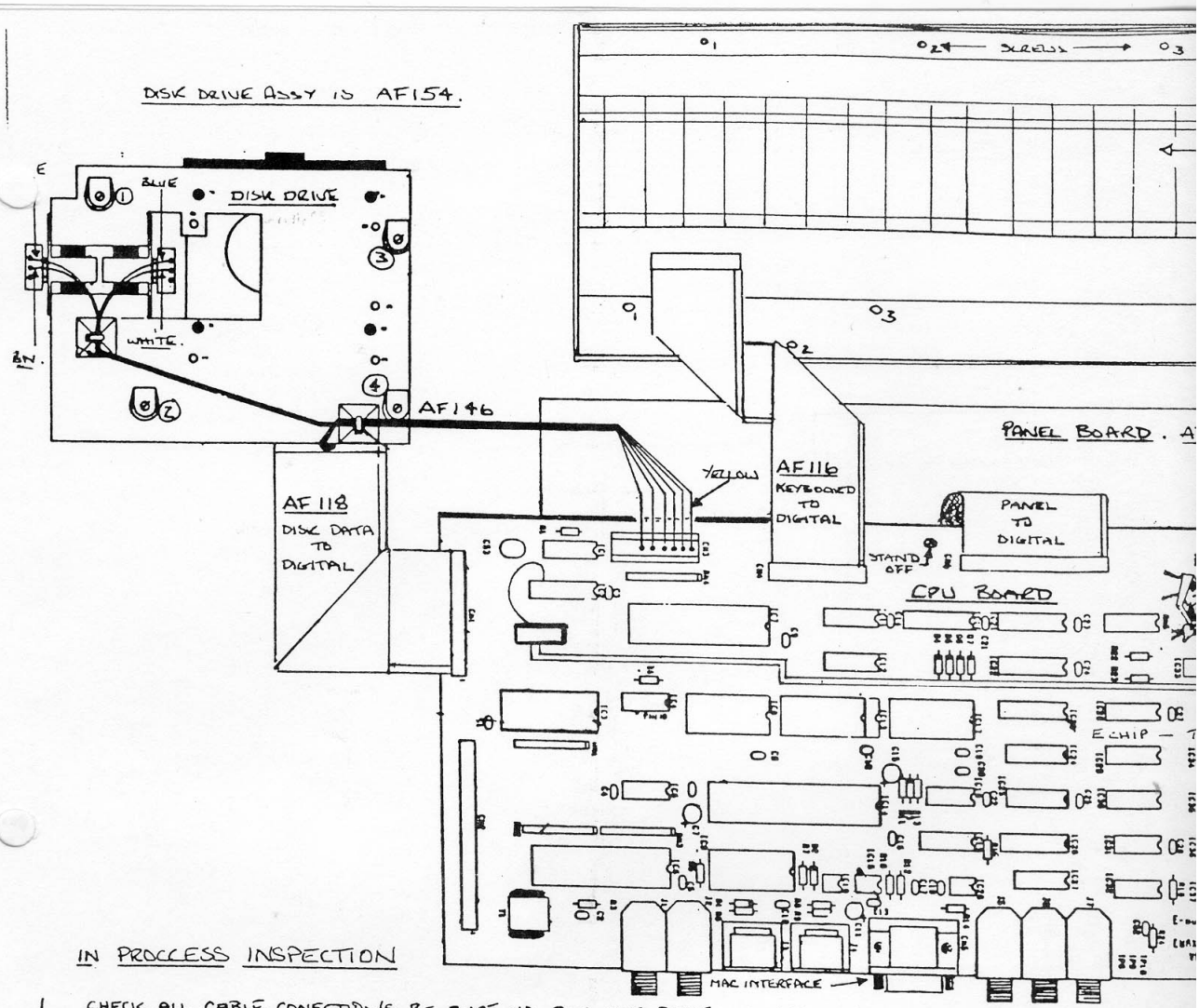
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Name	Source	Destination	Type	Description
+SDB3.D	5	5	Tri-State	Sound Data Bus 3
+SDB4.D	5	5	Tri-State	Sound Data Bus 4
+SDB5.D	5	5	Tri-State	Sound Data Bus 5
+SDB6.D	5	5	Tri-State	Sound Data Bus 6
+SDB7.D	5	5	Tri-State	Sound Data Bus 7
+SHOUT.V	17	17	Ana. Voltage	Input Sample/Hold Out
+SHSTB.D	5	8	TTL	Sample/Hold Strobe
-SIDE.D	4	CN 1 (Dig.)	TTL	Floppy Disk Side Select
+SMA0.D	5	5	TTL	Sound Memory Address 0
+SMA1.D	5	5	TTL	Sound Memory Address 1
+SMA2.D	5	5	TTL	Sound Memory Address 2
+SMA3.D	5	5	TTL	Sound Memory Address 3
+SMA4.D	5	5	TTL	Sound Memory Address 4
+SMA5.D	5	5	TTL	Sound Memory Address 5
+SMA6.D	5	5	TTL	Sound Memory Address 6
+SMA7.D	5	5	TTL	Sound Memory Address 7
+SMA8.D	5	5	TTL	Sound Memory Address 8
+SMA9.D	5	5	TTL	Sound Memory Address 9
+SMA10.D	5	5	TTL	Sound Memory Address 10
+SMA11.D	5	5	TTL	Sound Memory Address 11
+SMA12.D	5	5	TTL	Sound Memory Address 12
+SMA13.D	5	5	TTL	Sound Memory Address 13
+SMA14.D	5	5	TTL	Sound Memory Address 14
+SMA15.D	5	5	TTL	Sound Memory Address 15
+SMA16.D	5	5	TTL	Sound Memory Address 16
-SMPL.D	1	17	TTL	Sample Clock
-STEP.D	1	CN 1 (Dig.)	TTL	Floppy Disk Head Step
+STINT.D	5	2	TTL	Software Timer Interrupt
-SWTIME.D	1	5	TTL	Software Timer Clock
+SYNC/-TIME.D	4	5	TTL	External Sync/Timer Select
-TGTIME.D	1	2	TTL	Transient Generator Timer
-WDTA.D	1	CN 1 (Dig.)	TTL	Floppy Disk Write Data
-WG.D	1	CN 1 (Dig.)	TTL	Floppy Disk Write Gate
-WP.D	1	CN 1 (Dig.)	TTL	Floppy Disk Write Protect
-WR.D	1	1	TTL	Main CPU Write Line

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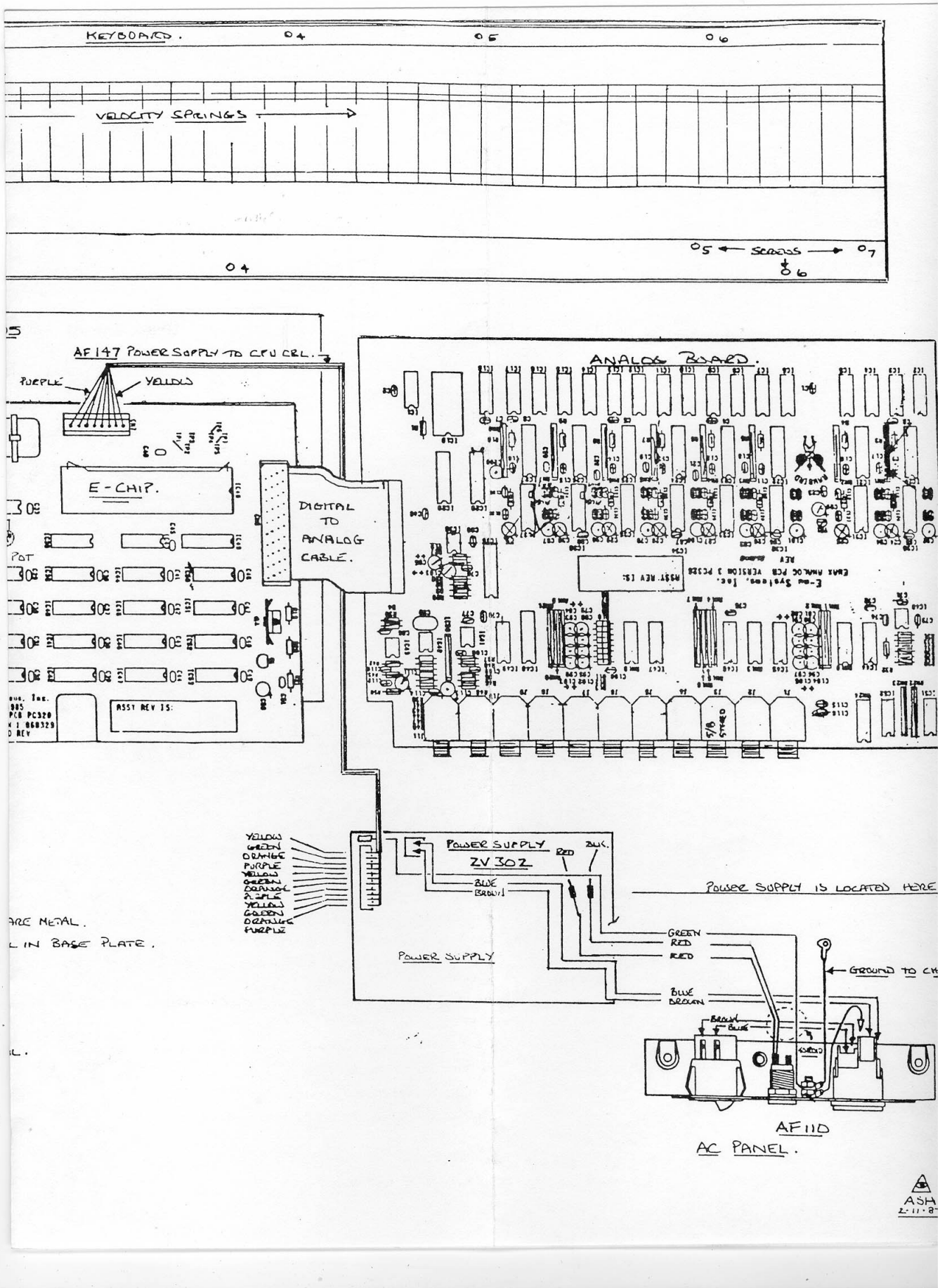
DISK DRIVE ASSY IS AF154.



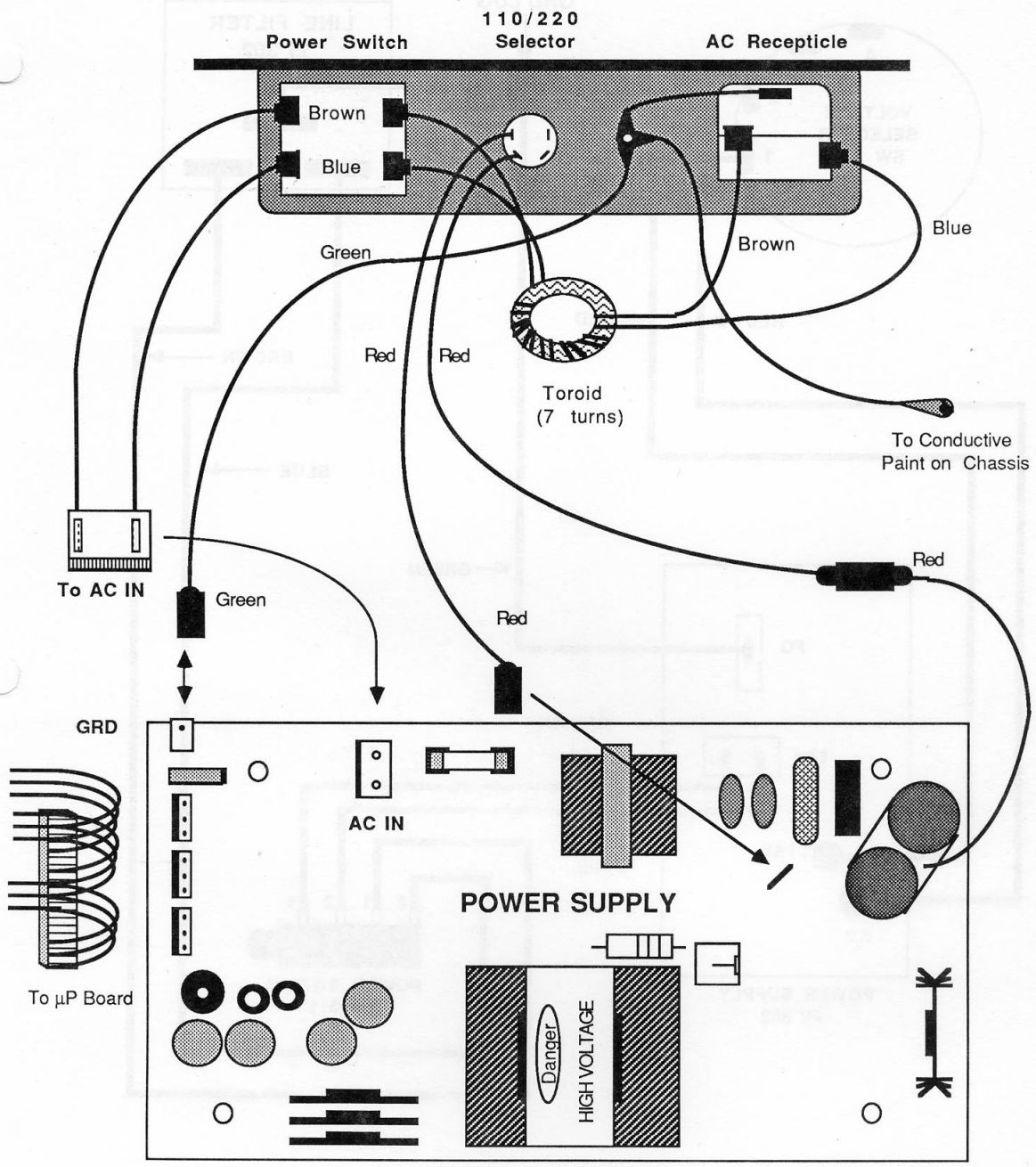
IN PROCESS INSPECTION

1 CHECK ALL CABLE CONECTIONS. BE SURE NO PINS ARE BENT OUT THE SIDE OF CONECTOR (COMMON PROBLEM)
2 CHECK ORIENTATION OF CABLES: RED STRIPE INDICATES PIN 1.
3 CHECK ALL CABLES ARE IN MACHINE
4 CHECK THAT WIRES ARE NOT INTEFERING WITH OPERATION OF PITCH WHEELS.
5 MAKE SURE ALL SIX SCREWS ARE IN FRONT OF KEYBOARD, & 7 ARE IN REAR BRACKET.
6 SEE THAT ALL FOUR MOUNTING SCREWS ARE IN DISK DRIVE
7 CHECK GROUND WIRE FROM AC PANEL IS SECURED TO HOUSING.
8 CHECK THAT HEAT SHRINK ON THE CONECTORS OF RED WIRES FROM AC PANEL TO POWER SUPPLY, ARE COVERIN
9 CHECK THAT SAME RED WIRES ARE SECURED WITH A TIE WRAP SO THEY DO NOT PROTRUDE THROUGH G
10 LOOK FOR WHITE PCB STANDOFF IS INSTALLED BETWEEN AF116 & PANEL TO DIGITAL CABLE.
11 INSPECT VELOCITY SPRINGS & ADJUST AS NECESSARY.
12 SEE THAT LP1 & LP2 LED SOCKETS ARE BENT AT 45° (PANEL BOARD UNDER KEYBOARD)
13 CHECK THAT E-CHIP TRIM POT HAS GLYPT ON IT.
14 MAKE AN OVER ALL INSPECTION OF INSIDE TO BE SURE NO LOOSE DEBRIS IS INSIDE. LOOK FOR ANYTHING UNU
15 SEE THAT COPPER WASHERS ARE INSTALLED ON OUT-PUT JACKS.
16 MAKE SURE ALL LABELS ON BACK OF MACHINE ARE PRESENT & CORRECT.
17 TURN MACHINE OVER, LISTEN FOR ANY LOOSE OBJECTS FALLING AROUND INSIDE.
18 CHECK THAT PITCH WHEELS MOVE FREELY
19 MAKE SURE BUTTONS ARE INSTALLED CORRECT WAY AROUND
20 GIVE AN OVERALL COSMETIC INSPECTION OF HOUSING & KEYBOARD.
21 CHECK MAC INTERFACE CONECTOR IS TIGHT.

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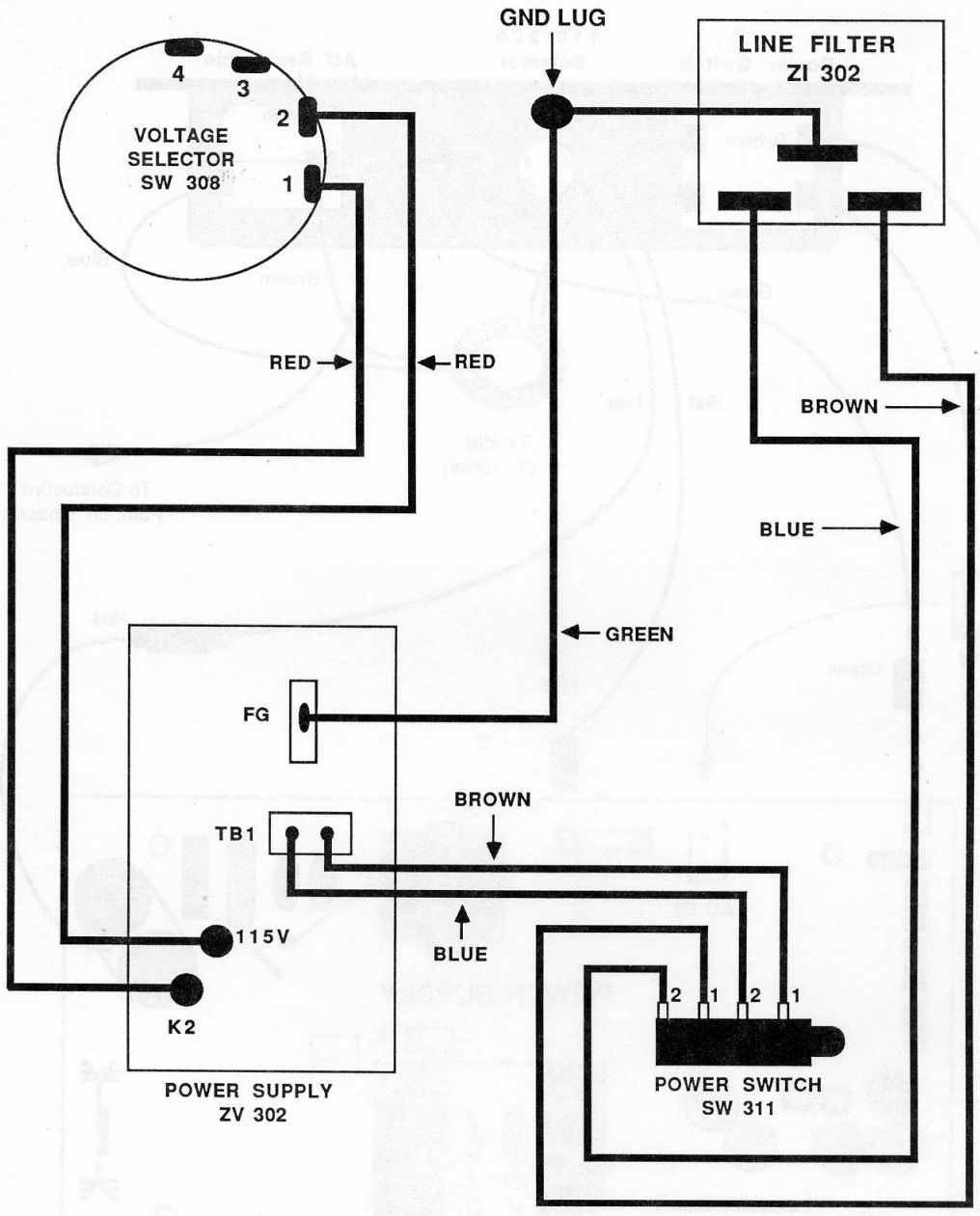


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Emax Keyboard AC Wiring Diagram

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Emax Rack AC Wiring Diagram

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EMAX PARTS LIST

ORDERING PARTS: Parts can be ordered by written order or by phone. When ordering parts, you MUST order by E-mu part number. The minimum parts order is $15.00. Emergency rush orders can usually be sent out the same day if the order is received by 11:00 PST. Parts orders can be placed between the hours of 8:30 am and 5:30 pm PST Monday through Friday. E-mu Customer Service Department (408) 438-1921.

CPU BOARD

CAPACITORS	E-MU P/N	QUANTITY
33 pF	CC 329	1
47 pF 50V	CC 326	2
100 pF	CC 103	1
220 pF	CC 104	1
1000 pF	CC 324	2
.039 µF Plas.	CP 315	1
.047 µF 50V	CC 332	1
.01 µF 50V	CC 312	2
.1 µF 50V	CC 314	19
.33 µF 50V	CC 334	19
1 µF 25V	CT 315	1
10 µF 25V Tant.	CT 317	1
10 µF 25V Alum.	CA 325	2

COMPONANT	E-MU P/N	QUANTITY
5 Pin DIN Socket	JI 302	2
1/4" Audio Jack Mono	JA 301	5
RS422 Conn.	JI 309	1
40 pin Conn.	JR 309	1
40 pin Ribbon Socket	JR 310	1
Ribbon Header	JR 311	1
Ribbon Header	JR 307	1
Ribbon Header	JR 308	1
Ribbon Header	JR 312	1
Pwr. Conn. 8 Pos. Male	JP 325	2
16 pin DIP Socket	JC 311	16
18 pin DIP Socket	JC 105	2
20 pin DIP Socket	JC 106	2
24 pin DIP Socket	JC 107	3
28 pin DIP Socket	JC 308	1
40 pin DIP Socket	JC 309	2
48 pin DIP Socket	JC 329	1
64 pin DIP Socket	JC 326	1

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INTEGRATED CIRCUITS	E-MU P/N	QUANTITY
Analog and Hybrid ICs		
4051 Analog Mux	IC 208	1
TL 431 Adust.Lin Reg.	IL 328	1
PC 900 Optoisolator	OE 302	1
Memory ICs		
241256 Dyna. RAM 256K	IM 360	16
4464 64K x 4 RAM	IM 373	2
732 Mainboot EPROM	IP 349	1
Digital ICs		
4028 Decoder	IC 129	2
32201 TCU	IC 348	1
8254-2 Int. Timer	IM 341	1
R6500/11 µComputer	IM 368	1
32008 µProcessor	IM 370	1
6850 Adapt. Interface	IM 372	1
E-Chip	IM 374	1
265 bit EEPROM	IM 376	1
WD1772 Floppy Controller	II 341	1
9637 Diff. Line Recv.	II 348	1
Emax "TIM" PAL	IP 344	1
Emax "CS" PAL	IP 345	1
74LS260 Dual NOR	IT 120	1
74S00 Quad NAND	IT 342	1
74HCT244 Octal Buffer	IT 360	2
74HCT273 Octal Flip-Flop	IT 361	2
74HCT08 Quad 2-in AND	IT 363	1
74HCT42 Decoder	IT 366	1
74HCT240 Octal Decoder	IT 374	1
74HCT157 Quad Mux	IT 379	2
74HCT112 Dual Flip-Flop	IT 385	1
74HCT139 Dual Decoder	IT 387	1
74HCT373 Octal Latch	IT 391	1
74HC74 Dual D Flip-Flop	IT 397	1
74HCT14 Hex Inverter	IT 398	1
74LS293 4 bit Counter	IT 399	1
UA9638 Dual Line Driver	IT 400	1
74S158 Multiplexer	IT 401	2

RESISTORS	E-MU P/N	QUANTITY
220 Ω Res. Network SIP	RN 322	3
330 Ω x8 Res. Network DIP	RN 320	1
22K Ω x9 Res. Network SIP	RN 323	1
523 Ω 1/4 W 1%	RP 308	1
2.49K Ω 1/4 W 1%	RP 301	1
7.5K Ω 1/4 W 1%	RP 351	1
10K Ω 1/4 W 1%	RP 106	2
100 Ω 1/4 W	RR 301	2
150 Ω 1/4 W	RR 102	3
220 Ω 1/4 W	RR 339	1

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270 Ω 1/4 W	RR 347	1
330 Ω 1/4 W	RR 303	2
1K Ω 1/4 W	RR 305	3
2.7K Ω 1/4 W	RR 360	1
10K Ω 1/4 W	RR 309	4
22K Ω 1/4 W	RR 313	1
33K Ω 1/4 W	RR 316	1
1M Ω 1/4 W	RR 325	1
5K Ω Trim 1 turn	RT 306	1
75 Ω 1 W	RW 304	1

MISCELLANEOUS	E-MU P/N	QUANTITY	
Short Digital-> Analog Cable	AF 125	1	Note: There are 2 types.
Long Digital-> Analog Cable	AF 140	1	" " "
1N914 Signal Diode	DD301	9	
1N4002 Rect. Diode	DD 302	1	
TIP29 NPN Power Trans.	QQ 306	1	
TO-220 Heatsink	ZE 323	1	
LCD Volt. Supply	ZV 300	1	
16 MHz Crystal	ZX 305	1	

OUTPUT BOARD

CAPACITORS	E-MU P/N	QUANTITY
10 pF 50V	CC 301	9
47 pF 50V	CC 326	2
100 pF 50V Plas.	CP 107	1
330 pF 50V	CC 304	1
1800 pF 100V	CC 330	8
3900 pF 50V	CC325	9
.01 µF 50V	CC 312	25
.1 µF 50V	CC 103	48
1 µF 25V Tant.	CT 315	2
3.3 µF 25V Alum. Radial	CA 324	26
47 µF 16V Alum.	CA 326	8
10 µF 25V Tant.	CT 317	1
10 µF 25V Alum. Radial	CA 325	1

CONNECTORS	E-MU P/N	QUANTITY
1/4" Audio Jack Mono	JA 301	9
1/4" Audio Jack Mono Clo	JA 307	1
1/4" Audio Jack Stereo	JA 309	1
16 pin DIP Socket	JC 311	5
18 pin DIP Socket	JC 105	8
20 pin DIP Socket	JC 106	9
Straight Ribbon Header	JR 312	1

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INTEGRATED CIRCUITS	E-MU P/N	QUANTITY
Analog and Hybrid ICs		
SSM2300 Sample/Hold-Mux	IC 347	4
TL084 Quad OpAmp	IL 302	2
5532 Dual OpAmp	IL 326	1
LM320L -5V Reg.	IL 327	1
TL082 Dual OpAmp	IL 329	1
dbx 2155 VCA	IL 330	1
SSM2047 Filt-Amp	IL 331	8
Interface ICs		
LM311 Comparator	II 102	1
7524 8 bit MDAC	II 331	1
LF398 Sample/Hold	II 338	1
RF5609 Lowpass Filter	II 342	1
AD6012 12 bit DAC	II 350	9
Digital ICs		
74HCT138 3-8 Decoder	IT 357	1
74HCT175 Hex D Flip-Flop	IT 359	16
74HCT244 Octal Buffer	IT 360	2
74HCT273 Octal Flip-Flop	IT 361	1
74HCT00 2-In Quad NAND	IT 369	1
74HCT504 SAR	IT 381	1

RESISTORS	E-MU P/N	QUANTITY
470 Ω x9 Res. Network SIP	RN 330	2
1K Ω x9 Res. Network SIP	RN 327	1
1K Ω x8 Res. Network DIP	RN 331	2
10K Ω x5 Res. Network SIP	RN 328	12
22K Ω x8 Res. Network DIP	RN 313	2
22K Ω x9 Res. Network SIP	RN 323	1
56K Ω x9 Res. Network SIP	RN 333	1
51 Ω 1/4 W	RR 361	1
2.49K Ω 1/4 W 1%	RP 301	1
4.99K Ω 1/4 W 0.1%	RP 352	1
10K Ω 1/4 W 0.1%	RP 353	1
100 Ω 1/4 W	RR 301	2
200 Ω 1/4 W	RR 302	1
1K Ω 1/4 W	RR 305	3
1.5K Ω 1/4 W	RR 348	8
2.2K Ω 1/4 W	RR 337	2
2.7K Ω 1/4 W	RR 360	1
3K Ω 1/4 W	RR 327	1
3.3K Ω 1/4 W	RR 110	1
4.7K Ω 1/4 W	RR 307	1
9.1K Ω 1/4 W	RR 321	1
10K Ω 1/4 W	RR 309	5
20K Ω 1/4 W	RR 323	8
33K Ω 1/4 W	RR 316	1
82K Ω 1/4 W	RR 362	3
100K Ω 1/4 W	RR 318	1

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470K Ω 1/4 W	RR 329	8

MISCELLANEOUS	E-MU P/N	QUANTITY
1N914 Signal Diode	DD 301	4
1N34A Germanium Diode	DD 304	8
1N746 -3.3V Zener Diode	DD 313	1

FRONT PANEL
(Keyboard)

COMPONANT	E-MU P/N	QUANTITY
Ribbon Cable/Conn.	AF 124	1
Connector	JC 328	2
Connector 2 Pos.	JC 321	10
Connector 3 Pos.	JC 324	1
Connector 7 Pos.	JC 325	2
LED T1-3/4 Red	LP 302	9
LED T1-3/4 Green	LP 308	1
LCD 16 Char x 2	LP 309	1
10K Ω Lin Slide Pot	RC 312	2
Rubber Keypad Set	ZR 322	1

MISCELLANEOUS
Keyboard

ASSEMBLIES	E-MU P/N	QUANTITY
Keyboard Ribbon Cable	AF 116	1
Floppy Drive Power Cable	AF 118	1
Power Cable	AF 147	1
CPU->Disk Drive Rib. Cable	AF 132	1
5 Octave Keyboard	ZK 308	1
3.5" Floppy Disk Drive	ZM 329	1
Switching Power Supply	ZV 302	1

PLASTIC	E-MU P/N	QUANTITY
Emax Plastic Housing	EP 322	1
Plastic Control Wheels	EP 323	2
Slider Knobs	HK 323	2
Control Panel Label	ZL 343	1
Back Panel Analog Label	ZL 344	1
Back Panel CPU Label	ZL 346	1
Stick-on Rubber Feet	ZR 326	5

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Snap-on Rubber Feet	ZR 330	5

HARDWARE	E-MU P/N	QUANTITY
Bottom Panel	EM 339	1
Keyboard Bracket	EM 340	1
Metal Power Panel	EM 341	1
Drive/Wheel Bracket	EM 342	1
Wheel Spring	HB 300	1
3/8/ x32 Nut	HN 311	4
8-32 x1/4" Screw	HS 327	13
8 x 1/2" Sht. Metal Screw	HS 340	4
4-40 x 1/4" Mach. Screw	HS 352	4
6-32 x 1/4" Screw	HS 353	10
Keyboard Screws M3 x 10	HS 354	6
4 x 3/8" Sht. Metal Screw	HS 357	12
6 x 3/8" Sht. Metal Screw	HS 363	4
3/8" Lock Washer	HW 312	2
Retaining Ring	HW 333	1
Power Receptacle	JP 319	1
Fuse Drawer	JP 320	1
110/220 Selector	SW 308	1
Power Switch	SW 309	1
1 Amp Slo-Blo Fuse	ZF 306	2
Ferrite Toroid	ZI 301	1

FRONT PANEL (RACK)

COMPONANT	E-MU P/N	QUANTITY
Front Panel-> CPU Cable	AF 133	1
10 µF 25V Cap. Alum.	CA 325	2
+5V to -5V Converter	IL332	1
LCD Connector	JC 327	1
LCD Connector single	JC 328	2
Red LED T1-3/4	LP 302	9
Green LED T1- 3/4	LP 308	1
LCD Assembly	LP 310	1
10K Ω Slider Pot	RC 312	2
Grey SPST Panel Switch	SW 310	30

RACK HARDWARE and MISC.

HARDWARE	E-MU P/N	QUANTITY
Power Cable Assy.	AF 130	1

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CPU->Disk Drive Rib. Cable	AF 132	1
Disk Drive Power Cable	AF 145	1
Metal S-Bracket	EM 348	1
Disk Drive Bracket	EM 350	1
Rack Bottom Panel	EM 351	1
Rack Chassis	EM 352	1
6-32 Kepf. Nut	HN 121	5
3/8/-32 Nut	HN 135	16
4-40 x3/8 Screw	HS 117	2
6-32 x 3/8 Screw	HS 336	13
110/220 Selector Switch	SW 308	1
Pushbutton Power Switch	SW 311	1
1 Amp Slo-Blo Fuse	ZF 306	2
AC Line Filter w/ Socket	ZI 302	1
Front Panel Label	ZL 359	1

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