EMULATOR SERVICE MANUAL

REVISION OF
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SERIAL NUMBER ______________

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I. INTRODUCTION

This service manual is intended specifically for E-mu Systems Emulator owners and service centers with qualified electronic technicians wishing to be able to repair and maintain E-mu Systems Emulators. It contains proprietary technical information on the Emulator. The entire contents are copyrighted by E-mu Systems, Inc. Any duplication of the material herein, including the machine readable information contained on the service diskettes, without the prior written authorization of E-mu Systems, Inc., is forbidden.

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Leasing of this service manual entitles you to quarterly updates of the information and service programs for a period of one year. You may subscribe to additional updates for a nominal fee. Be sure to send in your registration card and keep us informed of any address changes to insure you get the updates.

We at E-mu are interested in improving the quality of our services to you. We would appreciate any suggestions you might have, and would also be pleased if you could report any errors or discrepancies in the manual to us.

Thanks,

--- The Emuons

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II. EMULATOR SERVICE - AN OVERVIEW OF PROCEDURES

The Emulator is a complex computer-based musical instrument. Much of its functionality is based on high speed bidirectional busses and software control that is beyond the experience of many technicians. Furthermore, the debugging of such systems requires expensive capital equipment such as CPU in-circuit emulation systems and logic analyzers. Hence it is unreasonable to expect service centers to be capable of complete field service of Emulator systems.

This manual is intended to instruct technicians in the various options they have at their disposal to correct field failures of Emulators.

Emulator failures can be broken down into several major categories. Each of these categories can be handled most efficiently by a different service procedure:

1. Mechanical failures. Such failures include broken or disattached connectors, broken controls, broken or pinched wires, etc. In general the problem can be found by visual inspection or continuity testing, and easily repaired by a service center. A mechanical failure should be the first suspect in any case when an Emulator has failed after shipment. In general, a thorough mechanical inspection should be an early step before any repairs are attempted.

2. Disk Drive Misalignment. Mechanical mistreatment of the disk drive can shift the drive read/write head, track 00 sense switch, or index LED out of proper position. A service center outfitted with an alignment diskette and a alignment control PROM can realign disk drive. Alternatively, the disk drive can be exchanged.

3. Analog subsystem electronic failure. Certain subsystems of the Emulator contain conventional analog electronic circuitry that can be easily repaired by a competent technician. These areas include the front panel, power supply, and certain portions of the output circuit boards.

4. Digital subsystem electronic failure. The digital subsystems of the Emulator are most easily analyzed for failure by exchange of circuit boards. Actual repairs can generally be done by exchange of IC's. All digital IC's in the Emulator are socketed.

5. Obscure failures. These include hairline cracks on PC boards, intermittent mechanical problems, and anything else that defies analysis as above. These are best handled by complete circuit board exchange or return of the instrument to the factory.

Thus, depending upon the type of failure, the technician can make a choice of method of analysis ranging from visual observation through electronic analysis to return of the instrument or circuit board to the factory.

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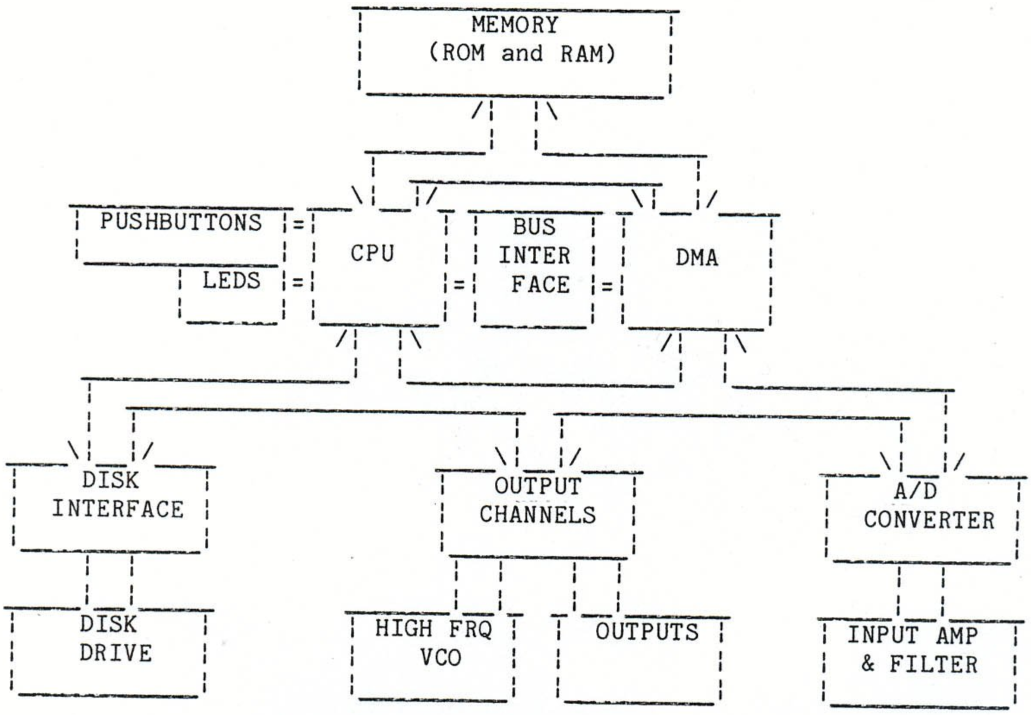
III. THE EMULATOR SYSTEM

The Emulator is a digitally based electronic musical instrument. It is important that the technician understand the proper functionality of the instrument BEFORE attempting repairs. If you do not own an Emulator, or are not familiar with its function and use, please refer to the appendix containing the Emulator Owner's Manual. Anyone servicing Emulators should have read this manual in its entirety before continuing reading the Service Manual.

The Emulator performs its function by digitizing a sampled waveform, storing the waveform in memory or on diskette, and then playing back the recorded waveform at an appropriate sample rate when a key is depressed. The entire system block diagram and communication paths can be diagrammed:



The details and a few additional sections will be discussed in detail in section IV of this manual. The important features to realize now are:

1. The CPU and DMA systems control access to the memory.
2. Through the control of the CPU and DMA, data may be transfered to and from the disk interface, output channels, and input analog/digital converter.
3. The CPU controls the data read from the pushbuttons and keys, and the data to the LED's.
4. The high frequency voltage controlled oscillator directs data flow rate in the output channels.
5. Software contained on the diskette and loaded into the instrument at the time of power-up determines the functions and sequence of functions performed.

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IV. EMULATOR SOFTWARE AND ALGORITHMS

The Emulator is a software controlled instrument. To accurately understand the nature of malfunctions and their isolation, a substantial understanding of the software and alogrithms used in the computer programming is required.

1. The bootstrap ROM. The EMULATOR.PROM contains only sufficient information to load a program from disk into the RAM memory space of the Emulator. The PROM initializes and loads the first track from the diskette, and then jumps to execute the program thus loaded. Hence the Emulator function is entirely determined by information on the disk drive.

Emulator software programs are initialized to the instruments in which they were first executed. If an incorrect diskette is inserted into an Emulator during power up, the GET LOWER and GET UPPER lites will be turned on, and the SAVE and SWAP lites turned off after the program is loaded. If a diskette has not yet been initialized in an instrument, it must be inserted with the write protect tab removed. If this is not done, the SAVE lite will be turned on, and the GET and SWAP lites left off. Thus if either of these situations occur, you should be aware that the instrument is operating correctly, and either the software for the wrong instrument is being used or the disk must have its write protect tab removed.

Note: The EMULATOR.PROM should not be switched from one unit to another. Contact the factory if the PROM is suspected bad, or if a CPU board must be exchanged.

The following descriptions refer to the EMULATOR.PROM 810928. If the instrument you are servicing does not have this PROM, please contact the factory. As far as we know, all instruments that have the RELEASE PEDAL jacks have this PROM. This includes all instruments in the United States. The PROM is IC #132 on the large CPU circuit board.

When the Emulator is first powered up, it turns on all the panel LEDs. It then attempts to read the operating program from the diskette. If any error occurs during this process, certain panel LEDs will be extinguished among the group of GET, SAVE, SWAP, VIBRATO, SAMPLE and OVERLORD. This may occur so quickly that it will appear that certain LEDs did not light at all. However, if any LED's outside this group - ie. DYNAMIC, SUSTAIN, T/F, or any of the optional sequencer LEDs fail to light, this is an indication of a bad LED or CPU board failure.

Normally, all the LEDs will light and the disk drive will begin to run. At this time, the head of the disk drive will seek inward 5 tracks, then outward to track 00. If this does not occur, it is indicative of a RAM memory or interrupt system problem on the CPU board.

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Assuming the head moves correctly, the CPU will attempt to load the program from the disk. At this time, several disk errors are possible:

a. If the diskette is not in place, not turning, or if an index pulse is not detected through the disk interface, a NOT READY error will occur. If this happens, the head will restep after 5 seconds. A restep after 5 seconds is a sure indication of a NOT READY error. After the first 5 seconds have elapsed, the front panel LEDs will indicate a NOT READY error by extinguishing the SWAP, SAMPLE, and OVERLOAD LEDs. If the Emulator has a failed disk drive or disk power supply, the disk drive will often not rotate, and a NOT READY error will be indicated.

b. If the diskette is poorly aligned, or some failure in the disk interface gives poor data reliability, a CRC error will occur. If this happens, the head will restep after 10 revolutions of the diskette, which takes 2 seconds. A restep after 2 seconds is a sure indication of a CRC error. After the 2 seconds have elapsed, the front panel LEDs will indicate a CRC error by extinguishing the GET LOWER, SWAP, SAMPLE and OVERLOAD LEDs.

c. If the diskette is very poorly aligned, or if the track 00 detect switch is misaligned or broken, a WRONG TRACK error will occur. If this happens, the head will restep every third revolution, or about 2 times a second. After each restep, the front panel LEDs will indicate a WRONG TRACK error by extinguishing the SAVE, GET LOWER, SAMPLE, and OVERLORD LEDs.

d. If the diskette is very poorly aligned or some failure of the drive or interface gives completely erroneous data, the disk interface program will never find a synchronization mark in the data. In this case, the head will only seek once, but the disk drive will remain on. This symptom is highly indicative of bad data. The front panel LEDs will all stay in the same state they were in before the diskette was inserted. If a NOT READY error is indicated when no diskette is inserted, but no LEDs extinguish when one is inserted during power-up, very poor alignment is indicated and the disk drive should be repaired or replaced.

If the disk drive turns off after a few seconds, it is a sure indication that the program has been read correctly from the disk. In this case, the above described LED combinations of GET LOWER and GET UPPER on and SAVE and SWAP off or GET LOWER, GET UPPER, and SWAP off with SAVE on (in both cases, both VIBRATO, the SAMPLE and OVERLOAD LEDs will be off) indicate disk initialization problems.

If all LED's are extinguished after disk activity, it indicates both segments of the program have been read correctly. The program then 'automatically' presses GET LOWER and GET UPPER to load the initial sounds. Errors in these GETs will behave exactly like errors had the buttons been pressed.

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The program for the Emulator is written onto tracks 00 and 01 of the diskette. If for some reason the track 1 portion of the program cannot be read, the instrument will start over again after the failed read. This is nearly always due to a damaged diskette, and subtituting a new diskette will remedy the problem. If this problem occurs, it can be identified by the head seek pattern. If a beginning seek (in 5 tracks, out to track 00), followed by a single inward head step after about a second, then either 3 resteps at 0.2 second intervals or a beginning seek after about 2 seconds occurs, the track 01 read is failing and a new diskette should be tried. If a track 01 read error is suspected and a new diskette does not fix it, it will nearly always be caused by failure of the stepper motor in the disk drive. Verify the motor is stepping. If it is, it is unlikely the problem is track 01 read.

In summary:

At powerup, the CPU turns ON all LED's.

During program read attempts, the CPU can only extinguish among the group of GET, SAVE, SWAP, VIBRATO, SAMPLE, and OVERLOAD.

If program load is unsuccessful, the code indicated by extinguished LED's will indicate the problem.

If all LED's are extinguished, the program has been loaded correctly.

2. The Emulator software has six major sections: SCAN controls the scanning of keyboard and controls. CONTROL contains the routines executed for control pushbuttons. SUSTAIN handles the effects of the sustain sliders. KEYBOARD controls the assignment and data sent to output channels. SAMPLE controls the sampling of data. SEQUENCER controls the sequencer buttons and timing.

SCAN primarily scans the pushbuttons and keys. The result of scan is a pulse waveform on each bus output. Any pressed button or key will then give a high level on the data input line while its corresponding bus is high. The CPU calls CONTROL or KEYBOARD routines whenever an appropriate transition occurs in the scanned buttons and keys.

SCAN scans the keys at a rate of 100 Hz. This is accomplished by the Z-80 CTC channel 1. A 100 Hz pulse can be observed at the CTC ZC/TO output for channel 1.

CONTROL is composed of a series of subroutines called by the depression of a corresponding button. The following algorithm details may be useful:

GENERAL: Each routine separately turns on any associated LED and performs the function. If neither the function nor the LED happen, it indicates a bad connection to the pushbutton or a failed pushbutton. If the function happens but the LED doesn't work, it indicates a bad connection to the LED or a failed LED. If the LED works but the function doesn't, it indicates that there is a hardware problem in executing the function.

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GET LOWER, GET UPPER: Inititially calls the EMULATOR.PROM disk routines to read the first sector of the sound. The actual data transfer is accomplished by the DMA circuitry for output channel 0, hence channel 0 should not make sound during data transfers. After each transfer, the CPU directs another track read from the disk until all 16 tracks comprising the sound data have been read. The data for loop and truncation is contained in the first track, hence if this track is read, the loop and truncation will change to those of the new sound.

If any disk error occurs, the LED on the associated button will remain lit. This can occur due to a damaged disk or a misaligned disk drive. The usual errors will be CRC or WRONG TRACK.

As each track read alternates the status of the pushbutton's LED, the number of re-reads required for each track can be observed from the rhythm of the LED blink. A smooth, quickly blinking LED indicates good reads, a hesitating LED indicates a damaged diskette or a misaligned drive.

SAVE: Save disables the entire Emulator including the pushbutton and keyboard scan while it occurs. It is slower than GET because it writes the data onto a track and then re-reads it to verify correct transfer. Again, the quality of the write process can be judged by the rhythm of the LED. If when SAVE is pressed the LED lites with no drive action, the write protect indication is at a logical 0. This normally occurs when the write protect tab is present on the diskette, but could also occur if the disk interface was misreading the flag due to failed electronics.

SWAP: Swap exchanges sets of 32 bytes from lower to upper memory and vice-versa. Each set of 32 bytes occurs as controlled by the Z-80 CTC channel 0. When the process is complete, the LED is extinguished.

Successful swap is indicative of the CPU's control of the two memory sections and good data read and write of the entire memory. If the sounds have changed after swapping, it is indicative of bad memory and a memory test should be run.

DYNAMIC ALLOCATION: Simply sets two flags in the keyboard routine. There is no hardware other than the LED and button associated with it.

MODULATION: The upper and lower modulation buttons turn on and off bits in the Z-80 PIO channel B. These bits control 4053 analog switches on the front panel that enable or disable the routing of the Mod Wheel signal to the high frequency VCO control voltage.

SUSTAIN and TRUNCATE/FILTER: These buttons simply set flags. The hardware associated with their function is described under SUSTAIN software.

SAMPLE: Calls the SAMPLE software as discussed below.

SEQUENCER AND MODE: These buttons simply perform entirely software based functions.

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SUSTAIN software is called every scan cycle regardless of the software sustain state. There are four alternating phases, two for each slider. The first selects which of the two sliders is to provide a number by setting a bit in the Z-80 PIO which selects the slider through a 4053 analog switch on the front panel board. The second phase triggers a one-shot whose time is determined by the resistance of the selected slider. This pulse gates an oscillator to provide a string of pulses to the Z-80 CTC. The CTC counts the pulses to give a number proportional to the slider setting. This number is used by the SUSTAIN routine to determine loop, filter, and truncate coefficients.

SAMPLE software is called when the sample button is pressed. It terminates any playing notes and stops the keyboard and control scan. SAMPLE monitors data directly through the CPU during the overload test phases, but transfers the final data to memory via output channel 0. Sample sets the loop pointers in the sampled sound to a 'percussive' sound. This means the sound will play through the entire sample period if held down, with no apparent loop. However, a loop is always present in any Emulator sound. In a percussive sound, the loop is maintained at the end of the sound in two bytes of zero data at the highest locations of memory. If the keys are continuously held, the DMA's will repeatedly fetch data from locations 0FFFC-0FFFD (hex) in memory. The data at these locations will be 00 (hex).

KEYBOARD assigns the channels to the sounds. The sound assignment algorithms deserve attention because they enable the technician to determine which channel is producing a particular symptom.

Emulator output channels are numbered 0-7. In an eight voice, channels 0-4 are routed to the LOWER output and 5-7 to the UPPER output. As the output boards are virtually identical, channels 0 and 4 are board channel 'A', 1 and 5 'B', 2 and 6 'C' and 3 and 7 'D' on the lower and upper boards respectively.

In FIXED assignment (DYNAMIC ALLOCATION OFF), the assignment algorithm works as follows for the lower keyboard in software versions EPX.03XX:

When the first key is pressed, it is assigned to channel 4. When a new key is pressed, the channels are checked starting at 4 and working down to channel 0 looking for a channel no longer producing sound (either from a key pressed and held or from a decaying channel [which could even be inaudible]). If all 5 channels are producing sound, a new search is done starting from 4 towards 0 looking for a channel that is not assigned to a pressed key. If all 5 channels are pressed, a 'rip-off' occurs to a random channel among the 5.

In FIXED assignment for the upper keyboard, the same rules are used but the search is from channel 7 towards channel 5.

In dynamic assignment, the rules are basically the same, except that in the lower keyboard, the search goes 4-3-2-1-0-7-6-5 and the upper goes 7-6-5-4-3-2-1-0. 'Rip-off' always occurs from channel 0-4 in the lower section and 5-7 in the upper section.

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Note that it is necessary to continue to hold the keys down to insure a new channel is assigned. Once a channel has been assigned, it may be held and the others released if you want to listen to just that channel.

The DISABLE CHANNEL feature of software versions 0305 and above software gives the technician the capability of isolating single channels for test purposes, and can be used for isolating distorting or non-functional channels as well as its intended purpose of muting failed channels. However, certain intermittent problems only occur when many channels are played at once. These problems are generally of a nature of an extraneous "hiss", "squack", or "bleep" occuring due to the channel reading unassigned memory accidentally, or the instrument re-booting during playing, and are caused by very obscure failures in the channel interface IC's. If board swapping is impossible, the following procedure can be used to isolate the offending channel:

1. Set the instrument in FIXED ALLOCATION.

2. Wait well after all sound has stopped from previous key depressions (at least 5 seconds).

3. Carefully press 3 keys in the upper keyboard one at a time. These will be assigned to channels 7, 6, and 5 respectively. Hold the keys by inserting wads of paper between the key cracks without releasing the keys.

4. Carefully press 5 keys on the lower keyboard one at a time. These will be assigned to channels 4,3,2,1 and 0 respectively. Again hold the keys as above.

5. Release the key coresponding to the suspected channel.

6. Wait a sufficient time for the problem to occur. If the problem does occur, it is not associated with your suspected channel. Guess again. If it does not occur, you have probably identified the offending channel.

7. If you have tried all 8 channels during this test and the problem occurs when each of the 8 are inactive, the problem is not associated with a specific channel.

Another method of hearing the sound from just the channel desired is to use a sound whose loop is 'percussive'. This is done by setting the sustain loop start point at the end of the sound. You must still hold the keys down to force new channel assignment, but they will not be making noise as their loops will be in '00' data.

When a channel is assigned, the 'attack' portion of the sound is first transferred by the low order DMA section assigned to the channel. When this is complete, the upper order DMA section transfers the loop portion of the sound. When the key is released, the low order DMA section then transfers the decay portion of the sound.

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The keyboard program also sets the data ports of the output channel for an appropriate pitch and filter setting.

The sequencer is entirely software based on existing hardware, and should exhibit no failures except those associated with other failures, and of course LED and pushbutton failures. We recommend ignoring the sequencer entirely during debugging whenever possible.

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V. EMULATOR SUBSYSTEMS

The Emulator may be divided into a number of subsystems. These may be further classified by circuit board. The sections will each be discussed in detail in this section:

POWER SUPPLY CIRCUIT BOARD:
Power Supplies - +15, -15, -12, -5, +12 Disk, +12 CPU, +5 OL, +5 OM, +5 Disk, +5 CPU.

FRONT PANEL CIRCUIT BOARD:

RIGHT PANEL:
Input Amplifier, Input Filter, Input A/D converter.

LEFT PANEL:
Modulation LFO, Mod switches, Sliders & slider switch, High Frequency VCOs, Mix output buffer.

MAIN OUTPUT CIRCUIT BOARD:
Output channels 4-7.

LOWER OUTPUT CIRCUIT BOARD:
Output channels 0-3.

CPU CIRCUIT BOARD:
RAM memory & interface, I/O selects, Bus Interface, CPU, CTC, ROM memory, Clock & Reset circuits, Keyboard interface, LED interface, DMA interface, Disk interface, Misc Bit Control (PIO), A/D control.

SEQUENCER BOARD:
Sequencer buttons & LEDs, footswitch interface.

DISK DRIVE

MODULATION WHEELS

RIBBON HARNESSING

INPUT/OUTPUT HARNESSING

POWER HARNESSING

OPENING THE EMULATOR: To open the Emulator, unscrew the two 7/16" hex head captive fasteners on the bottom left and right of the instrument. Lift upward on the front of the instrument to hinge it open. Lock the top open lock on the left side. This will give you access to the CPU and Output circuit boards, the power supply, the keyboard, the disk drive, and most of the harnessing.

To close the instrument, be sure all cables are clear, then release the top open lock and close the front. Screw the captive fasteners in, being careful not to overtighten them.

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POWER SUPPLY: The power supply is a group of conventional 3 terminal regulators mounted on a common heatsink. A schematic is included in the appendix. The power supply is easily removed by the 4 screws mounting it to the case accessible from the outside rear of the instrument. Removing the 10 regulator mounting screws and the 4 circuit board mounting screws will give access to the foil side of the circuit board. The most common failures in the power supply will be inadequade soldering on the regulators or regulator failure.

FRONT PANEL ACCESS: The Emulator front panel boards are more difficult to service. Open the Emulator. Remove the keyboard by first loosening the four 5/16" nuts holding the rear keyboard channel to the frame, then removing the two screws from the keyboard to the rear channel. Then remove the three front screws holding the keyboard. Unplug the DIP plug, and remove the keyboard through the front of the instrument. Set it carefully down to prevent bending of the "J" wire contacts. The front panel circuit boards are now accessable.

On certain Emulators, the keyboard has been spaced upward by washers on the three front channel screws. The best way to reassemble if these are present is to glue them in place.

RIGHT FRONT PANEL: The right front panel contains largely conventional analog circuitry. A schematic is included in the appendix. Problems in sampling an input signal could be associated with the right panel. The signal should be traced through the input amplifier, analog anti-aliasing filter, and sample/hold amplifier. If the signal can be traced without distortion to this point and no obvious mechanical damage has been done to the board, the E-mu CALIBRATION diskette should be used with factory assistance to determine the nature of an input sampling problem from this point on in the circuitry.

LEFT FRONT PANEL: The left front panel contains largely conventional analog circuitry. A schematic is included in the appendix. Problems with modulation, sustain controls, pitch bend, tune controls, and mix output may be found on this circuit board.

The modulation LFO is a conventional triangle LFO circuit. The LFO output is routed through the Modulation Wheel and returned to the circuit board. The attenuated signal can be switched into the control input of either the lower or upper HFVCO by means of 4053 analog switches.

The Pitch Wheel is continuously connected to the control inputs of both HFVCOs, and each Tune control goes to the corresponding control input. The circuitry generates an exponential control voltage which is used to tune a varactor diode oscillator. The oscillators output is buffered and sent to the output boards. The nominal oscillator frequency is 11.55 MHz. The oscillators should be calibrated using the E-mu CALIBRATION diskette.

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Pushbuttons and LEDs on the front panel are connected and controlled by the CPU. Failed pushbuttons can be identified by the fact that when pressed the diode end does not go high when the other button terminal (connected to a scan bus) goes high. A failed diode may be similarly detected. A failed LED is best identified by activating the LED, and measuring its voltage drop. An LED should have approximately 1.4V drop.

The sustain controls are active only when the sustain buttons are pressed. In this case, a 50% duty cycle square wave should be observed on the 4053 switch associated with the sliders, and a one-shot signal should occur alternately on the two sliders, varying in duty cycle with the setting.

OUTPUT BOARDS:

Each output board consists of four identical sections. A schematic of each section is provided in the appendix. Output sections are most easily debugged in the field by IC swaps. As there are many identical output sections, this is easily accomplished in the instrument. Determine the failing channel by reference to the keyboard algorithms above, or by using the CHANNEL.TEST software diskette described in the appendix. You can verify that you have identified the correct channel by removing the SSM 2044 filter IC from the suspected channel, which will prevent it from producing any sound. If the problem becomes a mute channel, you have found the suspected channel.

Channels 0-3 are located on the output board nearest the CPU board. Channel 0 is nearest the front of the instrument, channel 3 nearest the rear. Channels 4-7 are located on the output board nearest the disk drive. Channel 4 is nearest the front of the instrument, channel 7 nearest the rear. Note that the schematics refer to channels A thru D. As mentioned above, A-D correspond to channels 0-3 and 4-7 on the lower and upper boards.

The 3 74LS163 counters form the time base counter. They should be suspected if one channel exhibits bizarre pitches or no sound at all. The 3 74LS273 latches should be suspected if the bizarre pitches, no sound, or distorted audio occurs. The 74LS32, 2 74LS00's, and 1/2 74LS221 all are involved in system control. They should be suspected if no sound occurs, or bizarre distortions. The 74LS74 is involved in loop control. It should be suspected if sound loop sequencing is incorrect, or bizarre sounds show up.

The 2812 should be suspected if data distortion or no sound occurs. The 6072 should be suspected if sound distortion occurs.

The 2812 is a complex part and should be suspected in highly interrmittent problems associated with the channel. In particular, we have observed occasional bizarre noises eminating from a held channel to be associated with a failed 2812, and re-booting of the instrument when the channel is held to also be associated with the 2812.

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The SSM 2044 filter should be suspected if distorted or no sound occurs, or if filtering differences occur between channels.

The 5534 amplifiers should be suspected if groups of channels are distorted or soundless. The 5534 on the lower output board will affect channels 0-3 as a group. IC 89 on the main board will affect 0-4, IC 90 affects 5-7.

The 74LS125 (IC 1) affects the lower/upper sound selection for each channel.

SEQUENCER BOARD ACCESS: The Sequencer Board is mounted on a bracket below the left end cap. On most units, it can be removed by peeling back the label on the end cap to expose 3 holes that give access to the sequencer board mounting screws. If these holes are not present, drill 5/16 holes according to the sequencer ECO (see appendix). The sequencer board can be probed in place in the instrument for many purposes.

SEQUENCER BOARD: The sequencer board will be associated with broken switch and LED problems in the sequencer. Also, a failure to sense the release or accessory footswitch may occur in this board.

MODULATION WHEEL ACCESS: The Modulation Wheels are mounted on a bracket below the left end cap. DO NOT attempt to remove this bracket, it is virtually impossible. To replace a mod pot, loosen the bracket and the wheel associated with the pot (you will have to remove the pitch bend pot to replace the vibrato pot), unscrew the pot using a 1/2" wrench, and replace.

MODULATION WHEELS: The modulation wheels directly control the pitch offset and modulation level into the HFVCOs setting the pitch of both channels. Any problem will affect both channels equally. The Vibrato pedal jack switches the vibrato wheel out of the circuit.

RIBBON HARNESSING: The ribbon cables will occasionally come loose during transit. If replaced into connectors, it is very easy to insert them misaligned or to break pins. Be careful.

INPUT/OUTPUT and POWER HARNESSING: These cables occasionally have loose pins.

CPU CIRCUIT BOARD: The CPU circuit board contains a number of complex digital subsystems. The only reasonable technical approaches to repair in many cases are IC substitution and computerized testing.

RAM memory can be tested comprehensively using an E-mu GALPAT diskette. This program will indicate bad chips and bad drivers. However, failures in RAM that affect program memory will prevent the program and sometimes even the PROM program from operating correctly. This can only be checked in the field by using a MEMORY.CHECK PROM.

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The I/O selects select the I/O ports. Any problems in this subsystem will prevent the associated I/O ports from operating properly.

The Bus interface converts various control signals into other control signals. The CPU will not operate at all if the bus interface is not functioning.

The CPU is a single chip that seldom fails. The CTC is also a single chip, seldom failing. The CTC system relies heavily on the interrupt system, and problems in the interrupt system will manifest themselves in CTC functions.

The ROM memory is very simple and seldom fails.

The Clock circuit is a crystal based 5 MHz oscillator. The reset circuit is based on a 74LS14 trigger and a 10 uF cap. Both seldom fail.

The keyboard interface involves a bus decoder and data input port. The LED interface is simply 2 8 bit latches and one 4 bit latch.

The Release mode interface is one 8 bit latch and 2 40109 CMOS drivers.

The DMA interface consists of 4 DMA chips and a prioritizing DMA. The prioritizing DMA is identical to the four other chips but programmed differently by the CPU. Hence a failed DMA can often be substituted to the prioritizing position to fix a minor malfunction. The DMA's are in charge of loop control, and non-functional settings of the loop controls can indicate bad DMA's.

The Disk interface is largely based on a Z-80 SIO interface chip. If disks cannot be read but the disk stepper seems to be working, disk drive alignment should be checked. If the disk is in line, the interface should be suspected.

The Z-80 PIO channel B is used for a number of miscellaneous control functions. These include CPU upper/lower sound control, Mod on/off, disk stepping and track 0 sense, and DMA 0 function selection.

The Z-80 PIO channel A is used for A/D data input. This system is best checked using the E-mu CALIBRATE diskette.

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VI. EMULATOR SERVICE CHECKLIST

A standard procedure should be followed in sevicing a failed Emulator. The following checklist will enable the technician to locate many common problems in a few minutes. The checklist should always be your first step.

I. VERIFYING POWER SUPPLY - PERFORM FOR ALL SERVICE:

A. Note Emulator Model and Serial Number on service checklist.
B. Note Diskette Software Version on service checklist.
C. Open the instrument.
D. Note EMULATOR.PROM Version (ie 810928) and number (ie #002D) on service checklist.
E. Examine the wiring to find pinched, damaged, or loose connectors:
   1. Check the power cables: Disk, Front Panel, Main Output, Lower Output, CPU.
   2. Check the other cables: Input, Output, Pitch Wheel, Footswitch.
   3. Check the Disk Data Cable
   4. Check the DIP Harnesses - 6 connections on each Output Board, 2 on Sequencer Board, 7 on Front Panel, 17 (14 on 4 voice) on CPU.
F. Turn on the Emulator.
G. Verify Power Supplies:
   1. Disk +12 V at the pin nearest the corner of the disk drive.
   2. Disk +5 V at the pin furthest from the corner of the drive.
   3. Main output +5 V at IC 1 pin 14 of the main output board.
   4. Lower output +5 V at IC 1 pin 14 of the main output board.
   5. -12V at IC 67 pin 2 of either output board.
   6. +15V at IC 89 pin 7 of either output board.
   7. -15V at IC 89 pin 4 of either output board.
   8. CPU +5 V at IC 201 pin 9 of the CPU board
   9. -5V at IC 201 pin 1 of the CPU board.
   10. CPU +12 V at IC 201 pin 8 of the CPU board.
H. If any supply is not within 10% of its rated voltage, disconnect all power connectors from the supply and test the supply. Replace or repair if the supply is still bad. If the supply tests good, test with a dummy load - 1A for all 5V supplies, 500 mA for all others. If the supply tests good, suspect a bad part connected to the supply.
I. If all supplies test good, the power supply subsection is not at fault. Be aware, however, that connectors may still not take the supply to all locations. Continue to test for the supply as the problem is further isolated.

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II. CPU FUNCTIONALITY - VERIFY FOR ALL GROSS FUNCTIONALITY PROBLEMS:

A. If most of the front panel LEDs lite when power is applied, it is likely that the CPU is functional. Note which LED's are extinguished and review prior chapters of this manual for more information, or call E-mu service department.

B. If the disk drive turns on, it is certain the CPU is generally functional. Skip to II-D.

C. If any of the following LEDs fail to lite: DYNAMIC, SUSTAIN LOWER, SUSTAIN UPPER, TRUNCATE/FILTER, the problem does not appear to be a failed LED, and the EMULATOR.PROM version is 810928 or greater, the CPU board is probably bad. Remove the CPU board and examine for mechanical damage. Exchange it if practical.

D. If the disk drive starts but the head does not move, an interrupt system problem or memory test problem is indicated. Exchange CPU boards if practical, or run the MEMORY.CHECK PROM.

E. If the disk drive head steps, the memory and interrupt systems are generally functional. With no diskette in the Emulator, the head should re-seek every 5 seconds, and the SWAP, SAMPLE, and OVERLORD lites should extinguish after the second seek.

F. Insert a diskette. Observe for a disk error as described above. If any error occurs, identify it and note it on the service checklist. Exchange the disk drive. Realign a misaligned drive if practical. If exchanging the drive does not change the problem, suspect the disk interface on the CPU board. Examine for mechanical damage, exchange CPU boards, or swap interface IC's as appropriate.

G. If the disk loads and stops, suspect improperly initialized diskette.

H. If the disk begins loading the lower and upper sounds, observe the rhythm of the lites during load. Uneven rhythm indicates disk errors. Exhange the drive. Realign a poorly aligned drive.

I. If the disk loads properly, the Emulator CPU is generally functional.

III. SPECIFIC FUNCTION FAILURES - CHECK FOR SPECIFIC SYMPTOMS:

A. GET LOWER and GET UPPER - poor rhythm or disk errors. Run the DISK EXERCISER and DISK.COMPATABILITY programs. Either the user's diskettes are damaged from improper handling or the drive needs alignment.

B. SAVE - no action. Check write protect.

C. SAVE - errors. Same as III-A above.

D. SWAP - sounds are altered. Probably bad RAM. Run GALPAT.

E. VIBRATO enable. Check 4053, LFO, pitch wheels and pedal jack.

F. SUSTAIN controls. Check sliders, 4053, and one-shot.

G. SAMPLE. Verify signal path to A/D converter. Run CALIBRATION.

H. RELEASE footswitch. Check footswitch wires and sequencer board.

I. PITCH BEND. Check front panel & wheels.

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IV. CHANNEL FAILURES:

A. Determine the channel(s) failing:
   1. A group of 4 channels (0-3 or 4-7) indicates a bad board, a bad 5534, or a chip select IC failure.
   2. A pair of channels (0-1, 2-3, 4-5, 6-7) indicates a DMA chip, or a connector problem.
   3. A single bad channel indicates a DMA chip or an IC within a single channel.
   4. Bad channels can be found using the disable channel feature.

B. If the problem is associated with certain loop settings, it is a bad DMA chip. IC 31, the prioritizing DMA, is not used in the same mode as the other DMA's, IC21-24. Hence if no exchange DMA's are available, exchanging IC31 with the failed IC and writing 'BAD' on the failed IC in location 31 will often fix the problem.

C. If the problem is distortion, incorrect pitch, or no sound, and is repeatable, use the disable channel feature and IC exchange to fix the problem. Also check for damaged connectors.

D. If the problem is intermittent, suspect the 2812 or 9517A associated with the channel. IC exchange is the only way to find such problems. A mechanical intermittent might also be possible.

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VII. REPAIR BY BOARD EXCHANGE

The simplest form of problem analysis and repair is circuit board exchange. If a problem is observed in a unit, use the checklist to determine which subsystem is at fault. The board containing that subsystem is then removed and a known working board substituted. If the problem is no longer observed, board has been determined to contain the malfunctioning subsystem. If the problem still occurs, it is known to not be involved in a subsystem contained on the board.

We highly recommend board exchange as the first step in debugging a difficult problem. If it is not immediately obvious and unambiguous as to the subsystem that is causing the problem, board exchange is by far the quickest method for determining the subsystem.

Repair by board exchange is also recommanded for many problems. E-mu keeps a stock of boards, and boards are available for purchase by service centers to enable repair by exchange.

The following boards or subsystems can be stocked by service centers:

1. Disk Drive - highly recommended.
2. Output Board - A Main output board can easily be converted to a Lower.
3. CPU Board - recommended as CPU's are difficult to repair
4. Front Panel Board
5. Power Supply
6. Spare Cabling
7. Sequencer Board

The following subsystem guide may help in board exchange problems:

PROBLEM	POSSIBLE BOARDS
No CPU	Power Supply, CPU
No Disk Rd	Power Supply, CPU
No Program	Power Supply, CPU, Lower Output
No Output	CPU, Lower Output, Main Output, Front Panel
No Mod	Front Panel
No Bend	Front Panel
Distortion	Lower Output, Main Output
No Sample	Front Panel, CPU
No Footswitch	Sequencer

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VIII. REPAIR BY COMPONENT EXCHANGE

When a problem has been isolated to a subsection, and it is suspected that the problem involves field failure of a component, analysis of the problem and repair by component exchange is often the best solution.

An example is a failed output channel. If it can be determined that, say, channel 4 has a problem that channel 3 does not exhibit, parts can be swapped between channels 3 and 4. When the problem moves to channel 3, it is known that the failed IC has been exchanged. This IC can then be replaced. If all the IC's associated with channel 4 have been exchanged, it has been determined that the failure is in a passive component (unlikely) or a mechanical connection (more likely).

The following guides indicate to which subsystem an IC belongs:

Right Panel: IC 1-4 - A/D. IC 5-10 Input Amp & Filter.

Left Panel: IC 1 - Mod switching & sustain pot switching.
IC 2 - LFO. IC 3 - Mix Output.
IC 4-7 HFVCO CV processing
IC 8 - Lower HFVCO, IC 9 - Upper HFVCO, IC 10 HFVCO buffer.

Output Boards (note - Channels 0-3 on lower board and 4-7 on main board correspond to channels A-D respectively.)

IC 1 - Lower/Upper sound selection
IC 2-4 - Channel D pitch counters
IC 5-7 - Channel C "
IC 8-10 - Channel B "
IC 11-13 - Channel A "
IC 22-24 - Channel D Sound/pitch/filter data
IC 25-27 - Channel C "
IC 28-30 - Channel B "
IC 31-33 - Channel A "
IC 42-44 - Channel D control
IC 45 - Channel C-D "
IC 46-48 - Channel C "
IC 49-51 - Channel B "
IC 52 - Channel B-A "
IC 53-55 - Channel A "

Continued next page........

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Output Boards, continued

IC 61 - Channel D data
IC 62 - Channel D loop & control
IC 63 - Channel C data
IC 64 - Channel C loop & control
IC 65 - Channel B data
IC 66 - Channel B loop & control
IC 67 - Channel A data
IC 68 - Channel A loop & control
IC 81 - Channel D D/A
IC 82 - Channel D filter
IC 83 - Channel C D/A
IC 84 - Channel C filter
IC 85 - Channel B D/A
IC 86 - Channel B filter
IC 87 - Channel A D/A
IC 88 - Channel A filter
IC 89 - Lower Output
IC 90 - Upper Output

CPU Board:

IC 12 - Channels 4-7 control
IC 15 - Channels 0-3 control
IC 21 - Channels 6-7 control
IC 22 - Channels 4-5 control
IC 23 - Channels 2-3 control
IC 24 - Channels 0-1 control
IC 31-34 - DMA control
IC 44 - Disk control
IC 51 - Disk & sustain
IC 52 - Disk control buffer
IC 53 - Disk & A/D
IC 54-55 - Disk timing
IC 62 - A/D, Disk, Mod select, Misc.
IC 71-74 A/D
IC 76 - Misc gate
IC 81-85 - Data buffer
IC 102-103 - Channel on/off (release modification)
IC 104-114 - LED interface
IC 121-126 - Keyboard and pushbutton interface
IC 131 - CPU
IC 132 - ROM
IC 133 - CTC
IC 134-135 - Clock Generator
IC 141-146 - Bus interface
IC 151-157 - Chip Selects
IC 161-195 - RAM interface and drivers
IC 201-276 - RAM memory

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IX. EMULATOR SERVICE AIDS

Various programs and aids are available to the Emulator service center:

INCLUDED WITH SERVICE MANUAL:

DISK EXERCISER DISKETTE: Used to verify functionality of an Emulator disk drive. Will test several thousand track reads per hour, tabulating number, type, and location of errors. Used at the factory to verify functionality.

DISK COMPATIBLITY DISKETTE: Similar to above, but verifies instrument compatibility from one Emulator to another.

CALIBRATION DISKETTE: Used to calibrate the Emulator and to verify function of the High Frequency VCO's and the A/D subsystem. No other tools besides this diskette are required to accurately calibrate an Emulator.

EP8S.0305 DISKETTE: Software with channel disable feature used to isolate channel problems. Also useful as standardized software for the technician to use if the instrument has unusual software.

GALPAT DISKETTE: Used in the case of subtle failures in the RAM. Thoroughly checks the RAM memory for all possible errors including soft errors.

ADDITIONAL OPTIONAL AIDS:

DISK ALIGNMENT KIT: Required tools are a phillips-head screwdriver, and oscilloscope, an E-mu DISK ALIGNMENT PROM, and a Dysan Analog Alignment Disk. This enables the service center to perform head radial alignment and track 00 switch alignment for minifloppy drives.

MEMORY.CHECK PROM: Used in the case of gross failure of the RAM. Isolates common problems with the RAM and distinguishes these problems from other CPU failures.

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APPENDIX I GLOSSARY OF TERMS

A/D [converter] Analog to Digital converter. A part or process that converts an analog (voltage) level into a digital (numeric) quantity.

algorithm A way of doing something. Usually the method by which a computer program goes about its task.

alignment Mechanical matching of tolerances. In the Emulator disk subsystem, the disk drive head must be properly aligned, as must the track 00 sense switch and the index mark sensor.

COMDAC Companding D/A converter. A D/A converter that uses a non-linear encoding scheme. Such a converter produces the same distortion level for a variety of signal levels, and has a much greater dynamic range than a linear encoding converter.

CPU Central Processing Unit. The 'brains' of the computer system. The CPU is in charge of fetching and executing stored program steps from the memory.

CRC Cyclic Redundancy Check. When data is stored on the Emulator disk subsystem, each string of data includes 16 extra bits of information computed depending on the entire data string. When the data is retrieved from the disk, this computation is done again, and the result verified against the retrieved 16 bits. If the data agrees, the chances are about 1 in 60,000 that there could be an error in the retrieved data.

CTC Counter Timer Circuit - An IC computer peripheral containing four programmable counters. These counters can be programmed by the CPU to count events, or divide the system clock to generate timing intervals.

D/A [converter] Digital to Analog. A part or process that converts digital or numeric information into an analog or voltage level. In the Emulator, the output channels convert the digital sound information into analog signals for the final output.

Disk A system of storing information magnetically. A disk of magnetic medium similar to recording tape (called a diskette) spins under a recording read/write head. The head can write and recall data from the diskette. Data is stored in circular patterns called tracks, and the head can be stepped from one track to another. The Emulator uses a 'minifloppy' disk.

Diskette The physical medium used by a disk drive. It is a 5 1/4" square paper envelope containing a disk of magnetic medium like recording tape. Diskettes require careful handling, like you would give studio quality recording tape.

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[disk] drive — The device that reads and writes diskettes. The disk drive consists of a spindle and motor that hold and rotate the diskette, a read/write magnetic head and associated electronics that transfers data to and from the diskette, and a head stepper system that moves the read/write head from one track to another. The Emulator can use any 'Shugart Compatible' 5 1/4" minifloppy disk drive.

DMA — Direct Memory Access. A process or peripheral IC by which the memory of a computer can be accessed to read or write data without intervention of the CPU. In the Emulator, the data sent to the output channels is done by DMA, as is the disk data transfer and the input sampling data.

flag — A software term used to indicate a number in memory whose value indicates a particular condition. For example, the DYNAMIC ALLOCATION button on the Emulator sets and resets a dynamic allocation flag. The KEYBOARD software routine tests the state of this flag to decide to which channels it is allowed to assign key depressions.

hardware — The portion of the Emulator composed of physical parts - IC's, switches, disk drives, etc. This is in contrast to software, which is the portion of the machine that is simply information accessed by the CPU to tell it what to do to make the instrument operate properly. Hardware problems can be fixed at service centers, software problems must be handled at the factory.

head — A component designed to create and detect magnetic domains on magnetic medium, for example a tape recorder head. The head of the disk drive in the Emulator is the site at which data is written to and read from the diskette. The head is positioned at a particular track, and the accuracy of this position is called the head alignment.

hex — hexadecimal. A method of representing numeric information in base 16. The numbers 0-9 are represented as usual, but 10 is represented as 'A' , 11 as 'B' and so on up to 15 as 'F'. The next digit to the left has a value of 16 times its value and so on. For example, 1C hex is equivalent to 28, that is 1 x 16 + 12.

HFVCO — High Frequency Voltage Controlled Oscillator. The Emulator creates accurate pitches by precisely dividing an 11 MHz signal to an appropriate rate to produce the desired pitch. The 11 MHz signal is changed in frequency to produce vibrato and pitch bend by way of voltage control. The two oscillators (one each for lower and upper keyboard sections) that produce the 11 MHz signals are the HFVCO's, and are located on the front panel circuit board.

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index	The small hole near the central spindle hole on a floppy diskette is called an index hole. Each time the diskette rotates in the drive, the index hole passes under an optical detector in the drive. This event indicates to the disk interface that the data is about to begin. The event is called an index mark.
LED	Light Emitting Diode. These are used in the Emulator instead of incandescent lights as indicators.
LFO	Low Frequency Oscillator. The vibrato oscillator in the Emulator, located on the front panel circuit board.
PIO	Parallel Input/Output circuit. A computer peripheral IC that allows two 8 bit data interfaces to or from the CPU.
program	A collection of instructions for the CPU to allow it to complete a given task. The bootstrap program for the Emulator, for example, instructs the CPU to turn on all the LED's, seek track 00, and attempt to read the data there. The programs for the Emulator are written in assembly language and involve thousands of operations for each key you press.
PROM	Programmable Read Only Memory. A type of memory that can be programmed at the E-mu factory and that will remember the data indefinitely. The PROM in a production Emulator contains the bootstrap program.
RAM	Random Access Memory. The portion of memory in the Emulator that is read/write memory.
ROM	Read Only Memory. The portion of memory in the Emulator that can only be read, not written. It is actually PROM, and is programmed with the bootstrap program.
sample	The process of dividing an analog signal into individual units of time and converting the signal level at each of these instants to a numeric value. This process is performed by the Emulator whenever a new sound is input through microphone or tape. The sample rate, or number of conversions per second is 27.778 KHz.
seek	To search for a certain track on the disk drive. This involves stepping the head from one track to another.
sector	A segment of data. In the Emulator, a sector is identical to a track.

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software — Information. In the Emulator, the entire instrument is controlled by a CPU whose instructions are software. This information is stored on the diskette, and represents thousands of man hours of work. The Emulator is a 'soft' instrument in that the actual function of the instrument can be changed by inserting a different diskette and giving it new programs.

synchronization — After an index mark is detected by the disk drive, the disk interface searches for a particular bit pattern on the diskette that indicates the start of the actual data stored on the track. This bit pattern is called a synchronization mark.

track — A diskette has data stored on it in concentric circles called tracks. The outermost track is numbered track 00, the innermost is track 34. To access a track, the disk drive steps the head to the appropriate location. A switch in the drive tells the interface the head is at track 00.

VCO — Voltage Controlled Oscillator. An oscillator whose frequency is controlled by a voltage input to the oscillator. The two master oscillators for the Emulator are VCO's whose control voltages are determined by the settings of the pitch bend, tune, and vibrato controls.

Write Protect — A small notch on the edge of a diskette allows a switch to close, allowing the disk drive to write on the diskette. When a piece of tape covers this notch the switch is left open, and the disk drive is prevented from writing on the diskette.

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EMULATOR CALIBRATION PROGRAM INSTRUCTIONS - REVISION OF 12 AUGUST 1981

The Emulator has 4 trimmers to be calibrated. One, the pitch wheel center, must be done using a DVM. The others can be done using the Emulator CPU as a test instrument and the calibration program.

To calibrate the pitch wheel center, plug the pitch wheel cable extender between the pitch wheel and the front panel circuit board on an assembled Emulator. Measure the voltage between ground (green wire) and pitch CV (blue wire). When the pitch wheel is centered, trim the wheel center trimmer to 0 volts within 50 mV. Note that this voltage will vary slightly depending on where within the center detent the wheel is set.

To calibrate the other trimmers. insert the CALIBRATE diskette and power up the instrument. Center the TUNE controls, center or disconnect the pitch wheel, and turn the GAIN switch to 0 and the ATTEN off.

To calibrate the input offset, press the SAVE button. The 8 leftmost LEDs now indicate the input data, GET LOWER indicating sign. Adjust the input offset trimmer such that the GET LOWER LED occasionally flashes, and all others (besides SAMPLE) are off.

To calibrate the lower frequency, press GET LOWER. The 8 leftmost LEDs now indicate the difference between the current and the correct frequency. Trim the lower frequency trimmer until all 8 LEDs are flashing, i.e. alternating between 0 and -1 difference.

To calibrate the upper frequency, press GET UPPER and adjust the upper frequency trimmer as above.

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EMULATOR DISK EXERCISER PROGRAM INSTRUCTIONS - REVISION OF 7 OCTOBER 1981

The Emulator Disk Exerciser tests the read and write capability of the Emulator minifloppy subsystem. It is designed to be run on an Emulator in burn-in, and will find all errors hard and soft that the system gets.

To run the exerciser, insert a DISK.EXER diskette into the Emulator and power up the instrument. The disk lite should lite continuously, and the head do a seek. After several seconds the SAMPLE lite will begin to blink. The program tests about 100 tracks per minute, and indicates resulting errors in the following manner:

NORMAL DISPLAY: When no buttons are pressed, the Disk Exerciser displays the total number of errors encountered since power-up in binary on the 8 leftmost LEDs. For example, if VIB LOWER and VIB UPPER were lit, 2**2+2**1=6 errors have occured.

GET LOWER DISPLAY: If GET LOWER is depressed and held, the display will indicate 256 times the total number of tracks read thus far. The display is in binary on the 8 leftmost LEDs. For example, if SAVE and DYNAMIC were lit, 256*(2**5+2**3)=10240 tracks have been read since power-up.

GET UPPER DISPLAY: If GET UPPER is depressed and held, the display will indicate the types of errors encountered since power-up. Each of the 8 leftmost LED's has a particular meaning:

GET LOWER - no errors have occured yet.
GET UPPER - write protect error. The disk cannot be write protected during the test!
SAVE - NOT READY error. Somebody took out the disk?
SWAP - has no meaning yet.
DYNAMIC - data verify error. The data read was not what should be there.
VIB LOWER - WRONG TRACK error. The formatting information was incorrectly read. This may mean the disk was not properly formatted.
VIB UPPER - CRC error. The SIO found a data error in the data string. This should occur, according to CDC specs, about 1 bit in 10**8. If the program is run for 100 minutes (10,000 tracks), no more than 3 CRC errors should occur.
SUS LOWER - write verify error. A CRC error occured immediately after a write operation. This is unacceptable.

SAVE DISPLAY: If SAVE is depressed and held, the display will indicate the track number on which the most recent error occured. The number is in binary on the 8 leftmost LED's. If no errors have occured, all 8 LED's will lite. This is useful for determining if sector address errors are all occuring on the same track (bad formatting) or if a particular track is causing CRC errors.

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INTERPRETING THE DISK EXERCISER

The Disk Exerciser program should be run for 10,000 track reads, which will take almost 2 hours. During this time, typically no errors at all should occur. A drive is within spec if 3 or fewer errors occur in 10,000 track reads and all are CRC errors. Any of the other errors or too many CRC errors indicate a systematic problem. Possible sources of error:

Numerous CRC errors: Bad one-shot or timing components. Bad drive. Damaged diskette.

WRONG TRACK Errors: Bad drive. Bad 7407 or PIO. Improperly formatted or damaged diskette.

Data Verify Error: Bad RAM. Bad SIO.

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EMULATOR DISK COMPATIBILITY TEST PROGRAM INSTRUCTIONS - REVISION OF 7 OCT 1981

The Emulator Disk Compatibility Tester tests the read compatibility of the Emulator minifloppy subsystem. It is designed to be run on an Emulator in burn-in, and will find all errors hard and soft that the system gets. It differs from the Disk Exerciser in that it is a write protected, factory written diskette. Hence it will determine if the Emulator under test will properly read factory written diskettes.

To run the tester, insert a DISK.COMPAT diskette into the Emulator and power up the instrument. The disk lite should lite continuously, and the head do a seek. After several seconds the SAMPLE lite will begin to blink. The program tests about 50 tracks per minute, and indicates resulting errors in the following manner:

NORMAL DISPLAY: When no buttons are pressed, the Disk Exerciser displays the total number of errors encountered since power-up in binary on the 8 leftmost LEDs. For example, if VIB LOWER and VIB UPPER were lit, 2**2+2**1=6 errors have occured.

GET LOWER DISPLAY: If GET LOWER is depressed and held, the display will indicate 256 times the total number of tracks read thus far. The display is in binary on the 8 leftmost LEDs. For example, if SAVE and DYNAMIC were lit, 256*(2**5+2**3)=10240 tracks have been read since power-up.

GET UPPER DISPLAY: If GET UPPER is depressed and held, the display will indicate the types of errors encountered since power-up. Each of the 8 leftmost LED's has a particular meaning:

GET LOWER - no errors have occured yet.
GET UPPER - write protect error. Not possible.
SAVE - NOT READY error. Somebody took out the disk?
SWAP - has no meaning yet.
DYNAMIC - data verify error. The data read was not what should be there.
VIB LOWER - WRONG TRACK error. The formatting information was incorrectly read. This may mean the disk was not properly formatted.
VIB UPPER - CRC error. The SIO found a data error in the data string. This should occur, according to CDC specs, about 1 bit in 10**8. If the program is run for 100 minutes (10,000 tracks), no more than 3 CRC errors should occur.
SUS LOWER - write verify error. Not possible.

SAVE DISPLAY: If SAVE is depressed and held, the display will indicate the track number on which the most recent error occured. The number is in binary on the 8 leftmost LED's. If no errors have occured, all 8 LED's will lite. This is useful for determining if sector address errors are all occuring on the same track or if a particular track is causing CRC errors.

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INTERPRETING THE DISK COMPATIBILITY TEST

The Disk Compatibility Test program should be run for 5,000 track reads, which will take almost 2 hours. During this time, typically no errors at all should occur. A drive is within spec if 2 or fewer errors occur in 5,000 track reads and all are CRC errors. Any of the other errors or too many CRC errors indicate a systematic problem. Possible sources of error:

Numerous CRC errors: Bad one-shot or timing components. Bad drive. Damaged diskette.

WRONG TRACK Errors: Bad drive. Bad 7407 or PIO. Improperly formatted or damaged diskette.

Data Verify Error: Bad RAM. Bad SIO.

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GALPAT MEMORY EXERCISER INSTRUCTIONS - REVISION OF 7 OCTOBER 1981

The GALPAT memory exerciser program exercises the entire memory of an Emulator using a standard GALPAT test. The test takes about 4 hours to run. During this time, the errors are displayed.

To run the test, insert the GALPAT disk into the Emulator under test and power up the instrument. The disk should boot and turn off (the diskette may then be removed) and the SAMPLE lite should begin to flash. When the test is complete, the SAMPLE lite will stop flashing and stay on.

While the program is running, its progress is being indicated by the LEDs. The SUSTAIN LOWER, SUSTAIN UPPER, and T/F lites show the segment under test, that is the value of A16, A15, and A14 respectively for the memory under test. These will progress from all off to all on in a binary sequence.

If a "soft" error is found, that is, if a memory error is detected which when re-read gives correct data, the UPPER VIBRATO lite will go on.

If a hard error occurs, the data bit (0-7) in which the error occured will be displayed as a binary number on the SWAP, DYNAMIC, and LOWER VIBRATO lites.

In any case, the memory segment in which the error occured will be displayed in binary on the GET LOWER, GET UPPER, and SAVE lites.

If any error has occured, the OVERLOAD lite will lite.

Pressing GET LOWER will show the low order address of the most recent error in binary on the 8 leftmost LED's. Pressing GET UPPER will show the high order address. Pressing SAVE will show the data pattern expected at the error address for the most recent error.

The particular memory IC failed for a test result can be determined from the following formula:

Convert the GET LOWER, GET UPPER and SAVE lights into a segment number:

GET LOWER	GET UPPER	SAVE	SEGMENT NUMBER
off	off	off	60
off	off	on	68
off	on	off	40
off	on	on	48
on	off	off	20
on	off	on	28
on	on	off	0
on	on	on	8

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If the UPPER VIBRATO lite is lit, the IC within the segment cannot be determined. If it is off, convert the SWAP, DYNAMIC, and LOWER VIBRATO lites into a bit number:

SWAP	DYNAMIC	LOWER VIBRATO	BIT NUMBER
off	off	off	0
off	off	on	1
off	on	off	2
off	on	on	3
on	off	off	4
on	off	on	5
on	on	off	6
on	on	on	7

The failed IC number is 201 + BIT NUMBER + SEGMENT NUMBER

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EMULATOR MEMORY CHECK PROM INSTRUCTIONS - REVISION OF 4/14/82

The Emulator Memory Check Prom is a PROM that can run in a Emulator without the use of RAM for the purposes of checking RAM. The PROM will find and display via the front panel LEDs all problems associated with the RAM. To use, insert the MEMCHECK.PROM into the Emulator and power it up. The front panel LED's should all lite for about five seconds and then the test will begin. While the test is in progress, the OVERLORD lite will blink. Any time results are obtained, the blinking will stop and SAMPLE will come on.

1. Memory OK - if the SAMPLE lite is lit, and all other lites extinguished, the memory tests good.
2. Single Chip Bad - If the Sample lite is lit, the last 2 digits of the single failed memory chip will be indicated in the leftmost 8 lites of the front panel. The leftmost 4 lites will indicate the middle digit, the next 4 the last digit:

GET LOWER	GET UPPER	SAVE	SWAP	MIDDLE DIGIT
off	off	off	off	0
off	off	off	on	1
off	off	on	off	2
off	off	on	on	3
off	on	off	off	4
off	on	off	on	5
off	on	on	off	6
off	on	on	on	7

DYNAMIC	LOWER VIBRATO	UPPER VIBRATO	LOWER SUSTAIN	LAST DIGIT
off	off	off	off	0
off	off	off	on	1
off	off	on	off	2
off	off	on	on	3
off	on	off	off	4
off	on	off	on	5
off	on	on	off	6
off	on	on	on	7
on	off	off	off	8
on	off	off	on	9
on	on	on	on	MULTI-ERROR

IC # = '2' MIDDLE LAST: For example, if GET UPPER, SWAP, UPPER VIBRATO and LOWER SUSTAIN are lit, the middle digit is 5, the last is 3, and the IC # to be replaced is IC #253.

BAD ADDRESS LINE: If an address line is bad, or two or more IC's in the same memory segment are bad, the SAMPLE lite will be on, the four leftmost LED's will indicate the memory segment, and the DYNAMIC, LOWER VIBRATO, UPPER VIBRATO and LOWER SUSTAIN lites will all be on. The segment indication is the 'middle' digit of the IC's dominating that section.

For example, if GET UPPER, SAVE, DYNAMIC, LWR VIB, UPR VIB, LWR SUS, and SAMPLE were all lit, the indication would be segment 6, multi error. This would be the segment composed of IC's 261 thru 268. The address lines should be checked.

BAD DATA LINE: If a data line is bad, an IC between 261 and 268 will show the error and replacing the IC will not fix it. A 'scope should be used to check the data in and data out lines.

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EMULATOR VERSION 0305 SOFTWARE ADDITIONAL INSTRUCTIONS - PRELIMINARY 10/14/81

Revision 0305 of the Emulator production software adds a channel disable feature to the instrument. This is useful for two purposes:

1. In case of a field failure of a specific channel, it allows the performer to disable the channel to prevent it from being assigned during normal play.

2. In the case of field service of an instrument, it allows a technician to disable channels for isolation of problems.

To activate the channel disable feature:

Press and hold SAMPLE, and press GET UPPER. Now press a key on the keyboard. Low 'C' disables channel 0, 'C#' channel 1, and so on thru 'G' for channel 7. To re-enable a channel, press and hold SAMPLE, and press GET UPPER. Press the key corresponding to that channel to re-enable it.

To determine which channel is failing, experiment with disabling channels until the problem disappears.

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EMULATOR DISK ALIGNMENT PROM INSTRUCTIONS - REVISION OF 14 OCTOBER 1981

The Emulator Disk Alignment Prom allows the technician to use the Emulator as a disk drive control fixture to calibrate disk drives. It has the following features:

TO RUN - Insert the PROM in the PROM socket (IC 132). Connect the disk drive. Turn on the power. All 8 leftmost LED's should lite, and perhaps the SAMPLE lite.

SEEK TRACK 0 - Pressing DYNAMIC will cause the drive to perform a track zero seek. All 8 leftmost LEDs should be out when this is finished, and the SAMPLE led, indicating track 00 flag, should be lit.

SEEK HIGHER TRACK - Pressing GET UPPER will step the head one track inward. The number displayed by the 8 leftmost LEDs will increase by one and the SAMPLE (=TK00) LED will go out.

SEEK LOWER TRACK - Pressing GET LOWER will step the head one track outward. The number in the 8 leftmost LEDs will decrease by one, and the SAMPLE (=TK00) LED will go on if track 00 is physically detected.

LOAD HEAD - Pressing SAVE will load the head and turn on the motor.

UNLOAD HEAD - Pressing SWAP will unload the head and turn off the motor.

PERFORM TK00 ADJUST ROUTINE - Pressing VIBRATO LOWER will turn on the track 00 switch adjustment routine required by CDC drives. The head will step between track 0 and track 4 with a 50% duty cycle. Pressing VIBRATO UPPER will end the routine.

These routines can be used to perform a disk alignment. For CDC drives, the following procedure may be followed:

1. Install and activate the DISK.ALIGN.PROM.

2. Seek track 00.

3. Step the head inward to track 1 (SUSTAIN LOWER on, all others off)

4. Insert a Dysan Analog Alignment Diskette.

5. Load the head.

6. Perform the Index to Burst Check and Ajustment

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7. Step the head to track 16 (SWAP on, all others off).

8. Perform the Actuator (head) Alignment.

9. Unload the head.

10. Step the head inward and out, load head and verify head alignment.

11. Step the head outward, then in, load head and verify head alignment.

12. Remove the alignment diskette.

13. Activate the TK00 adjustment routine.

14. Perform the Track 00 Switch Adjustment procedure.

15. Deactivate the TK00 routine.

16. Load the head and check motor speed using strobe pattern. Adjust with trimmer if necessary.

See the attached documents for drive alignment procedures.

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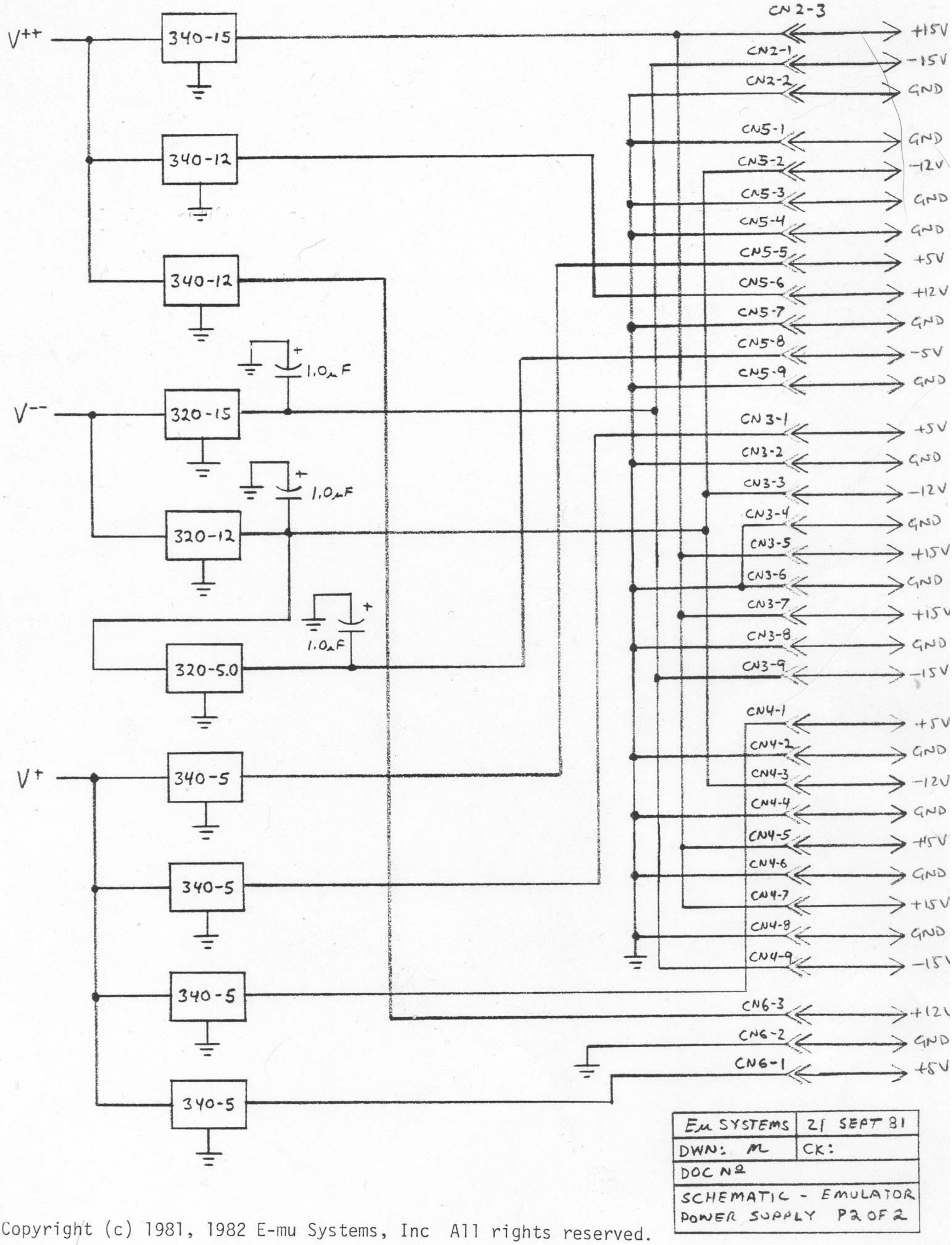

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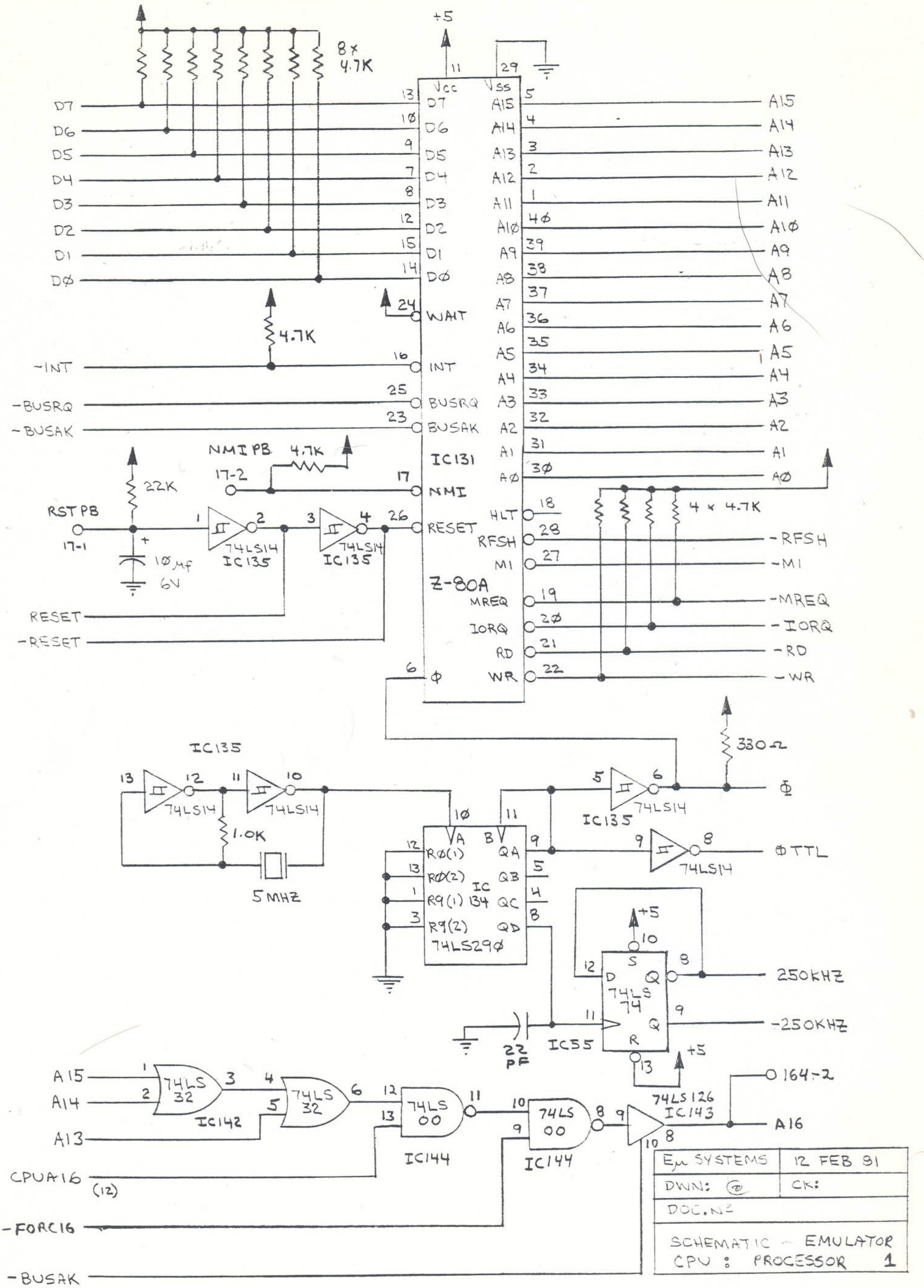

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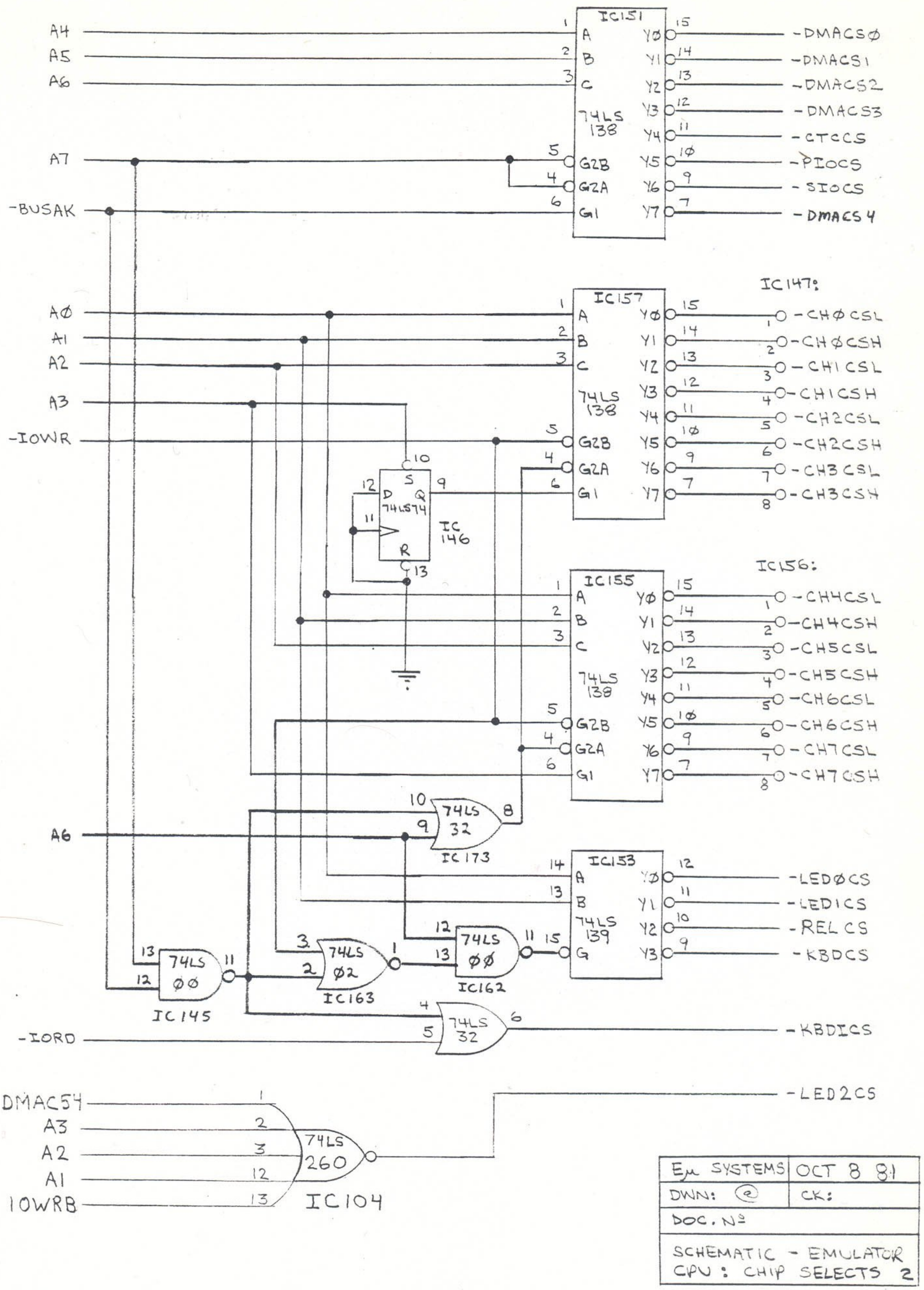

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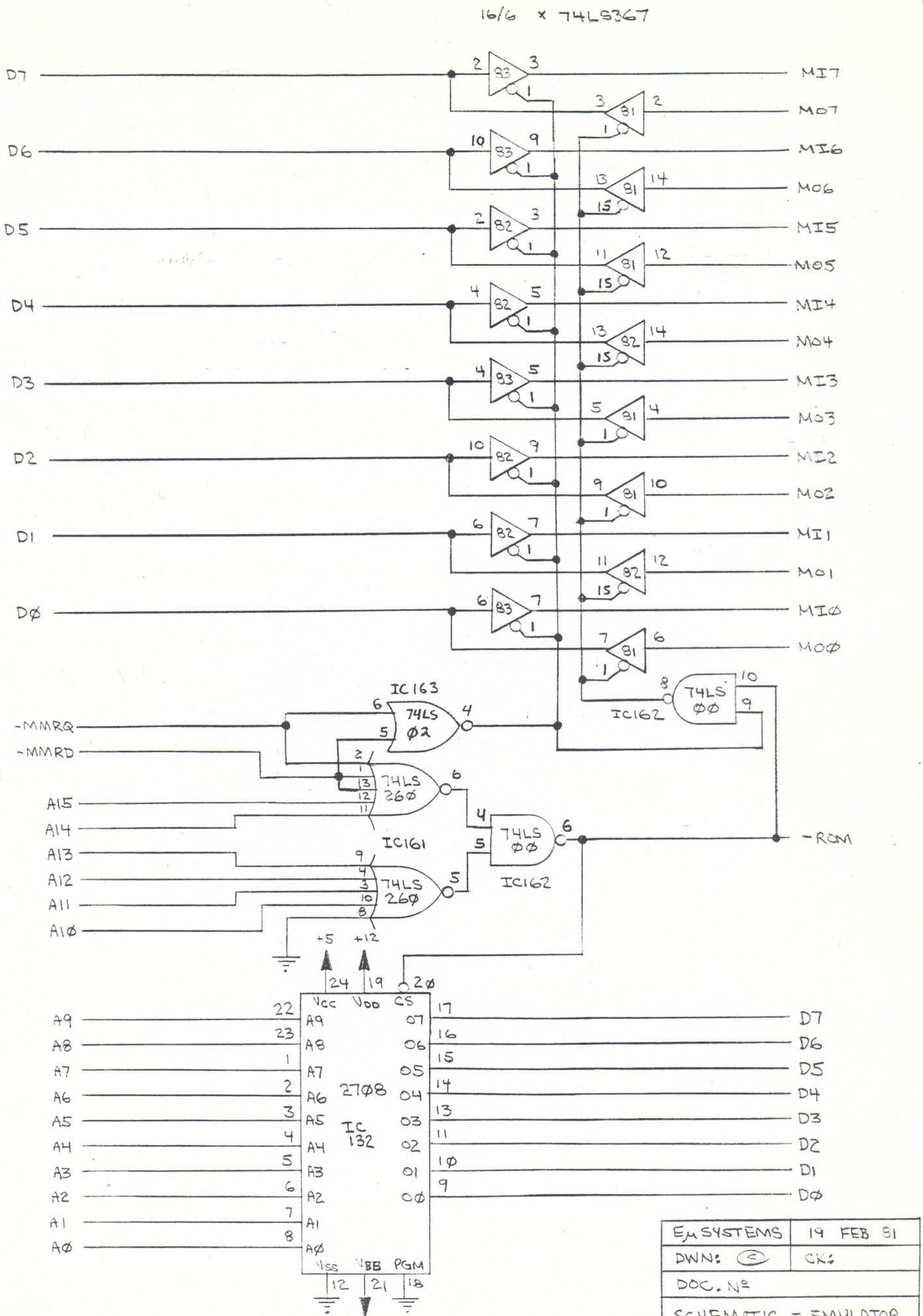

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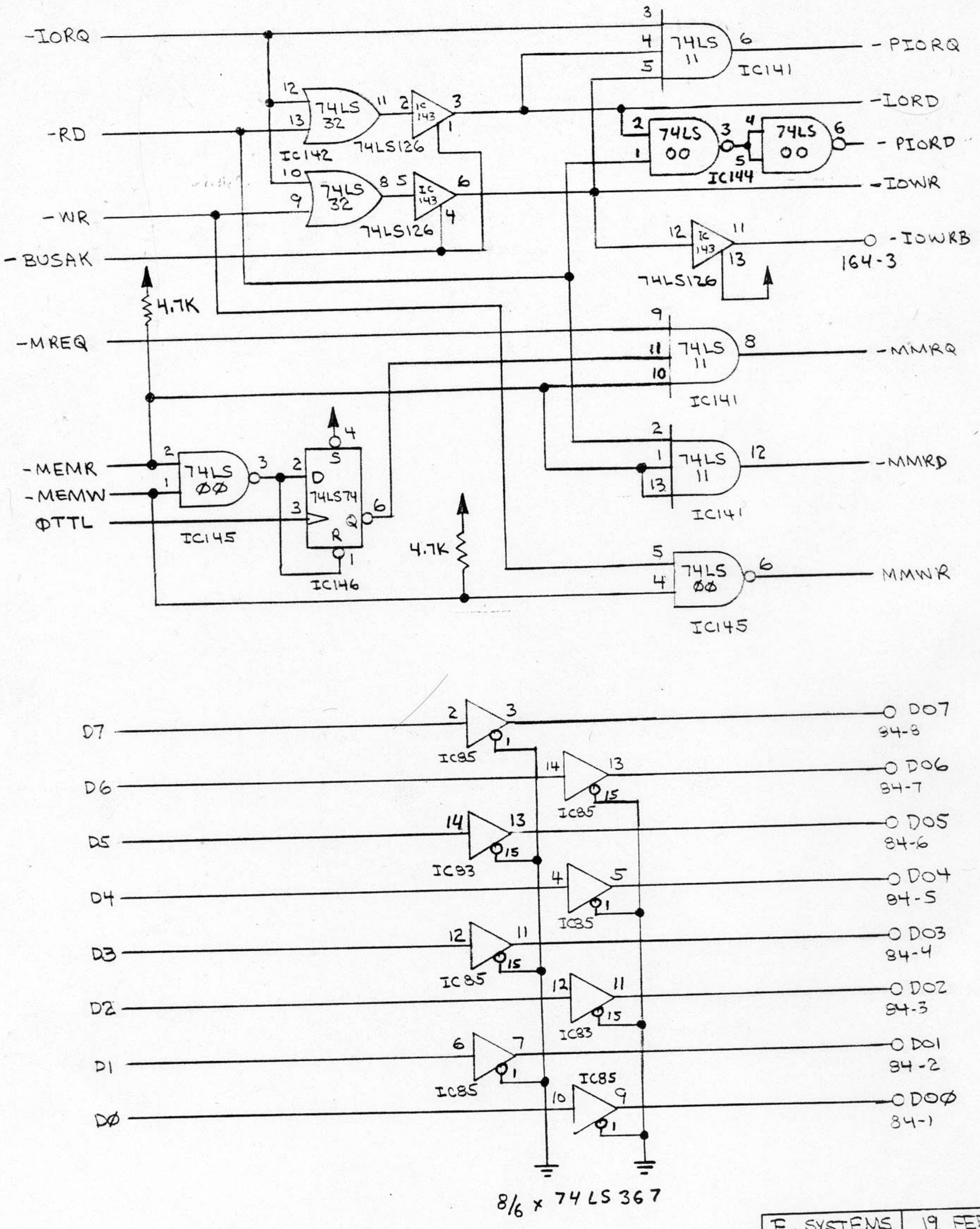

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DWN:	CK:
DOC. No	
SCHEMATIC ~ EMULATOR CPU: BUS INTERFACE 4	

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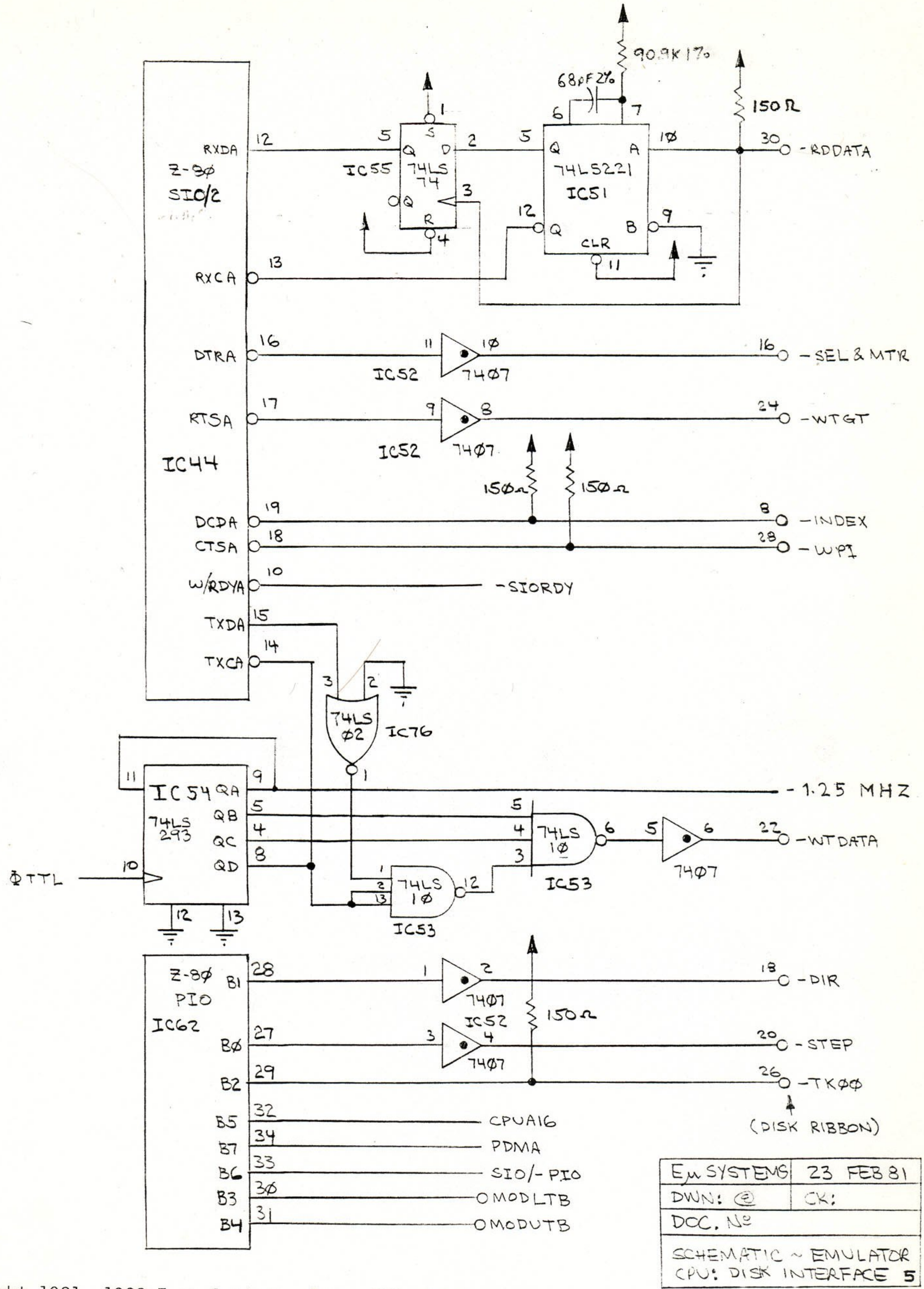

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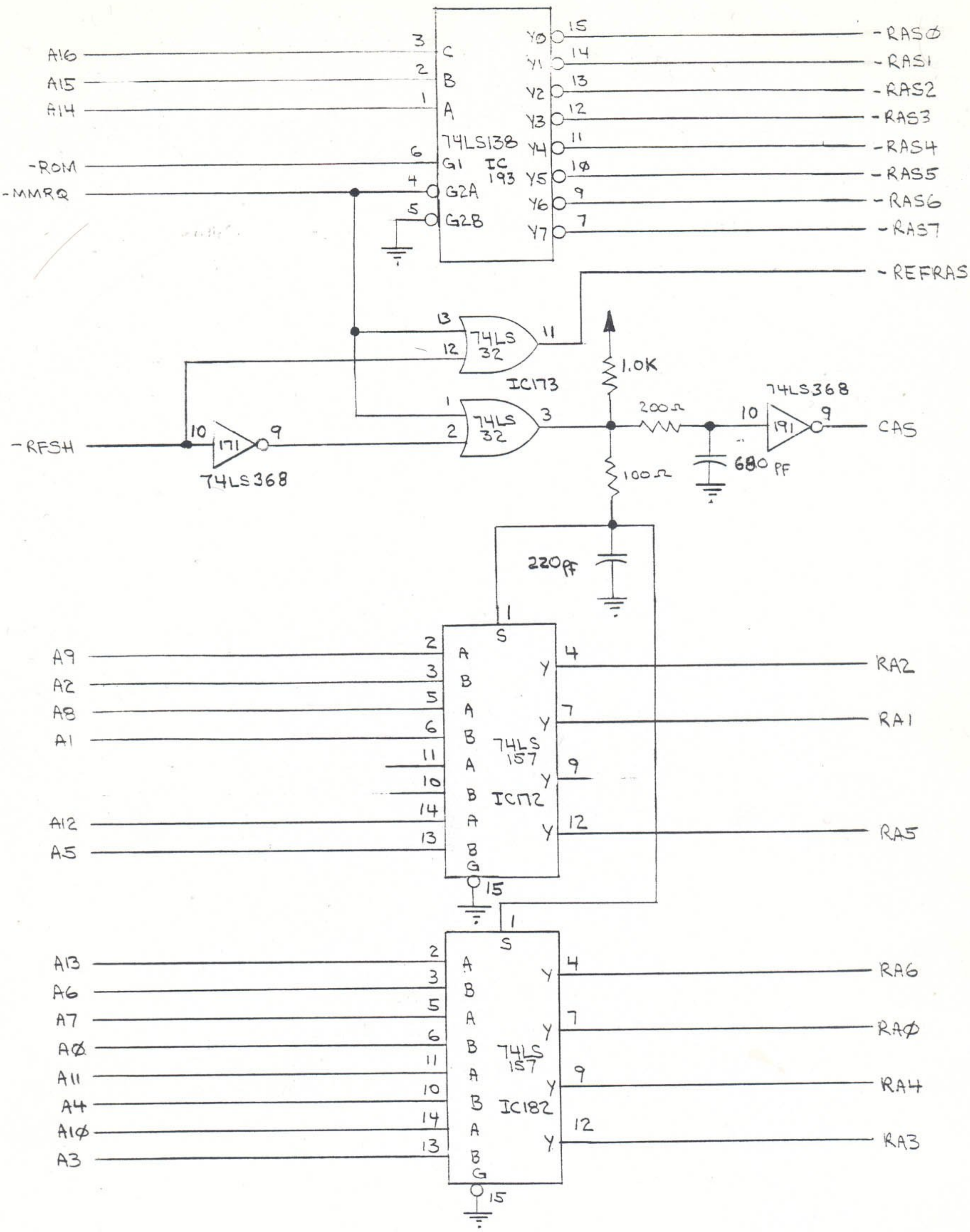

E-mu SYSTEMS	19 FEB 81
DWN: ⓢ	CK:
DOC. №	
SCHEMATIC - EMULATOR CPU: RAM INTERFACE 6	

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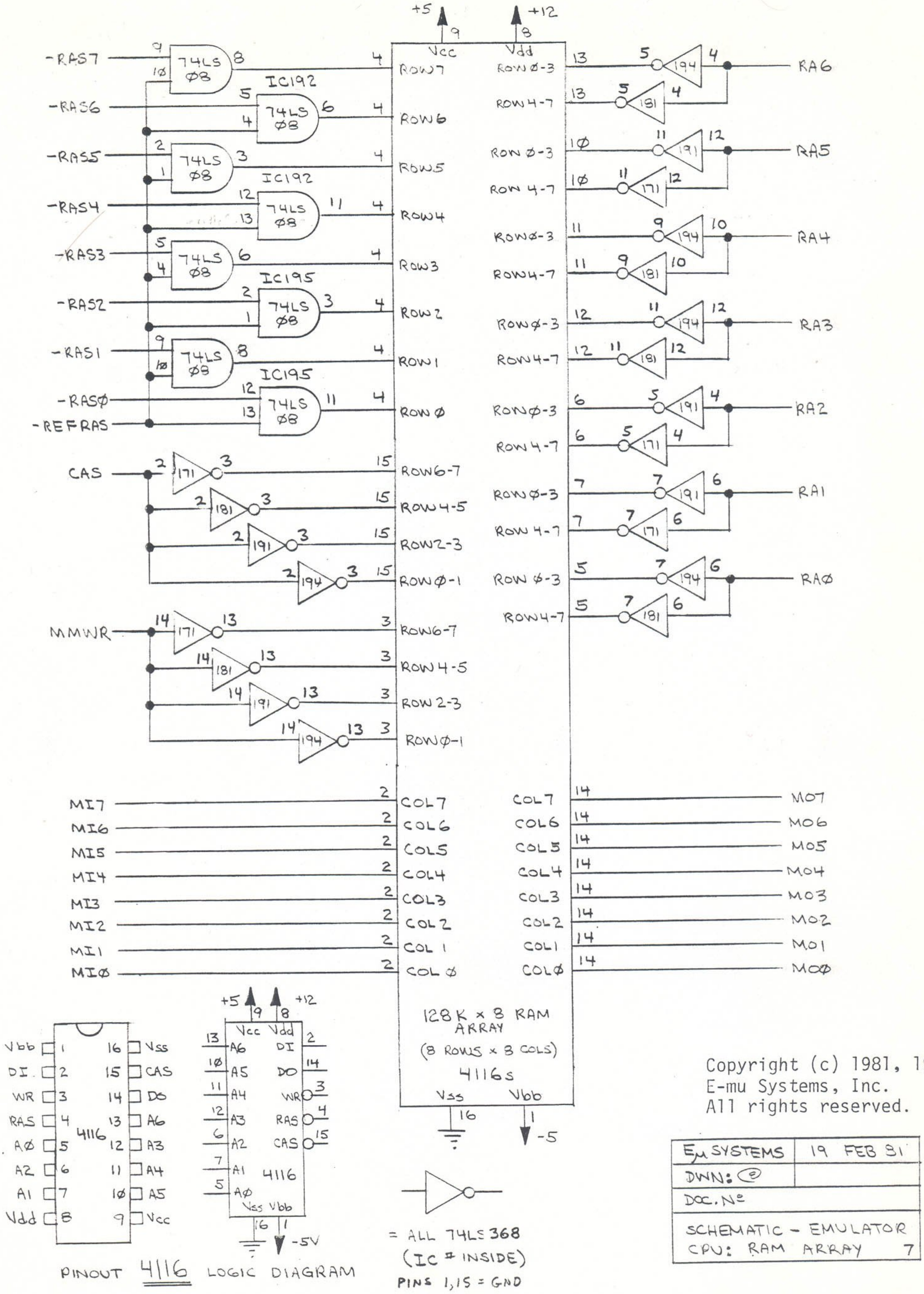

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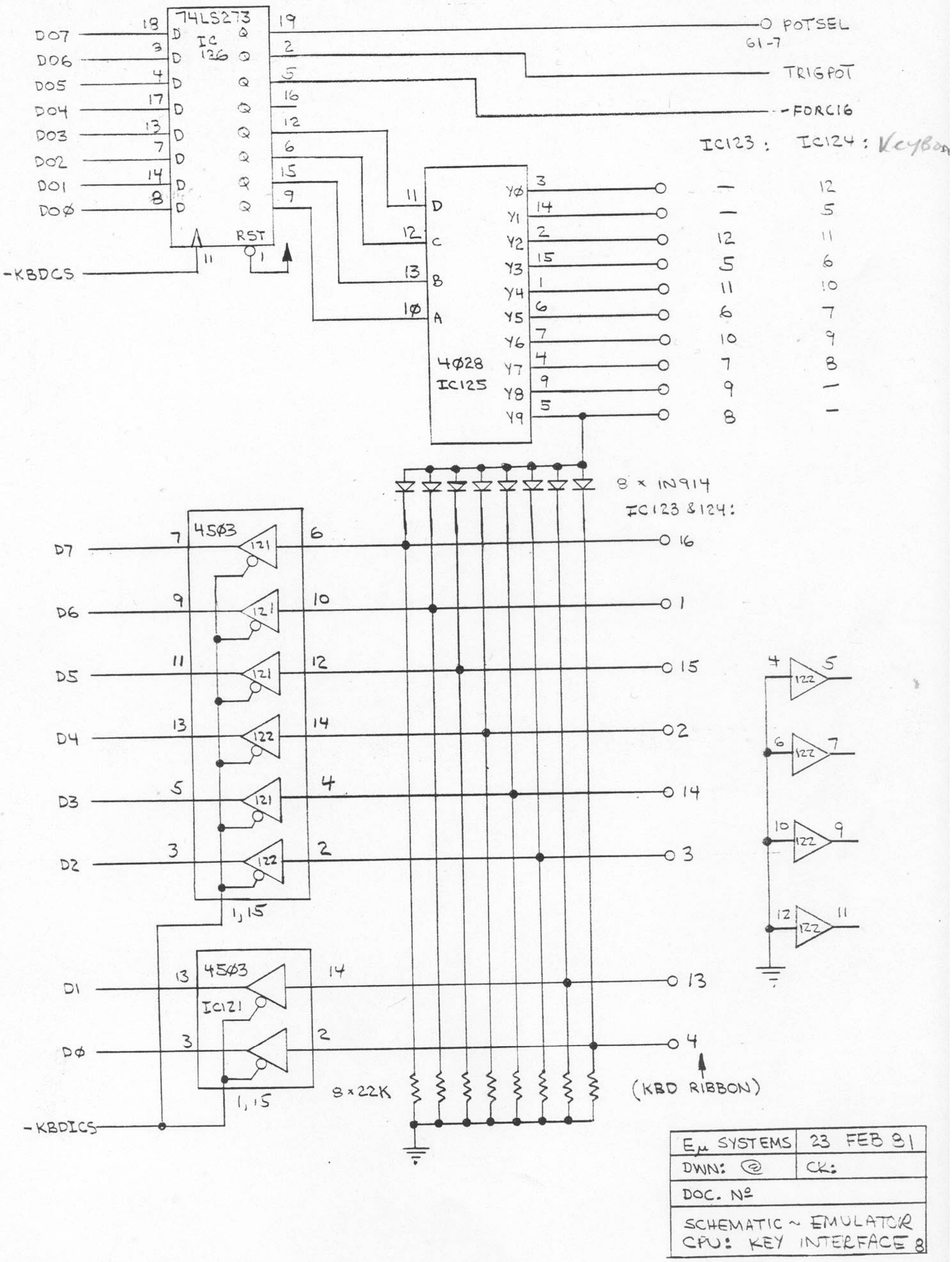

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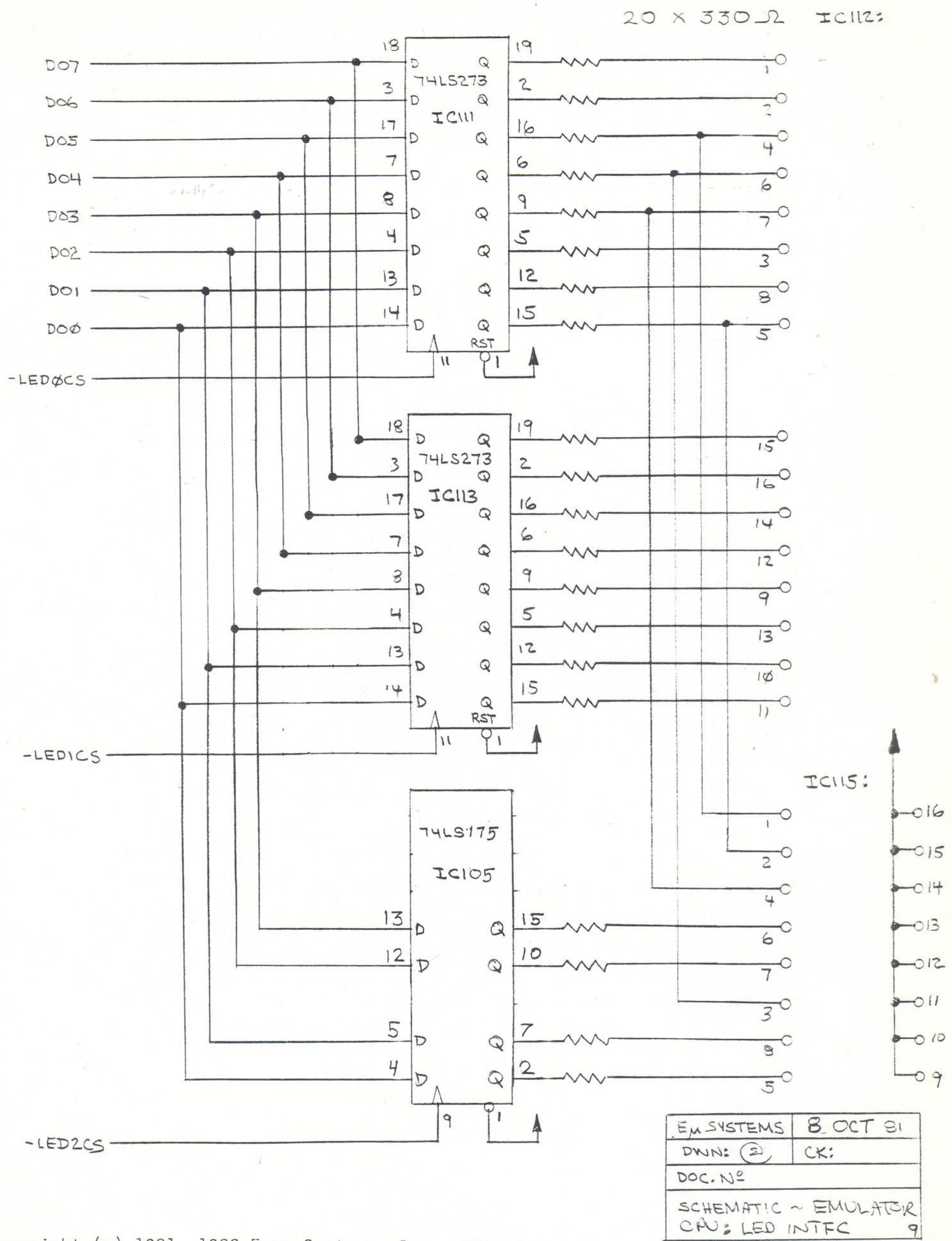

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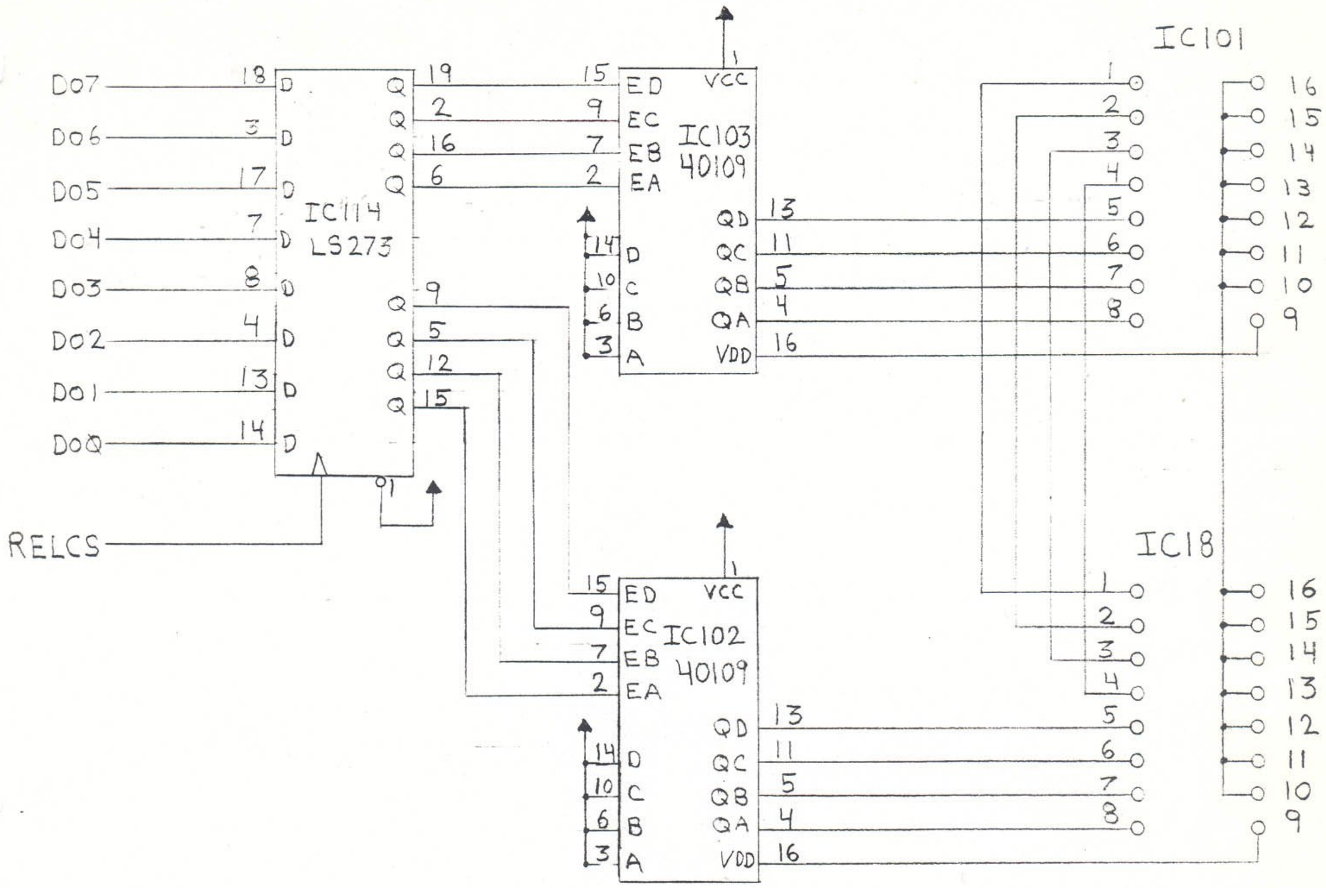

E-mu SYSTEMS	OCT 8 81
DWN: KM	CK:
DOC: Nº	
SCHEMATIC - EMULATOR CPU: RELEASE DRIVERS	

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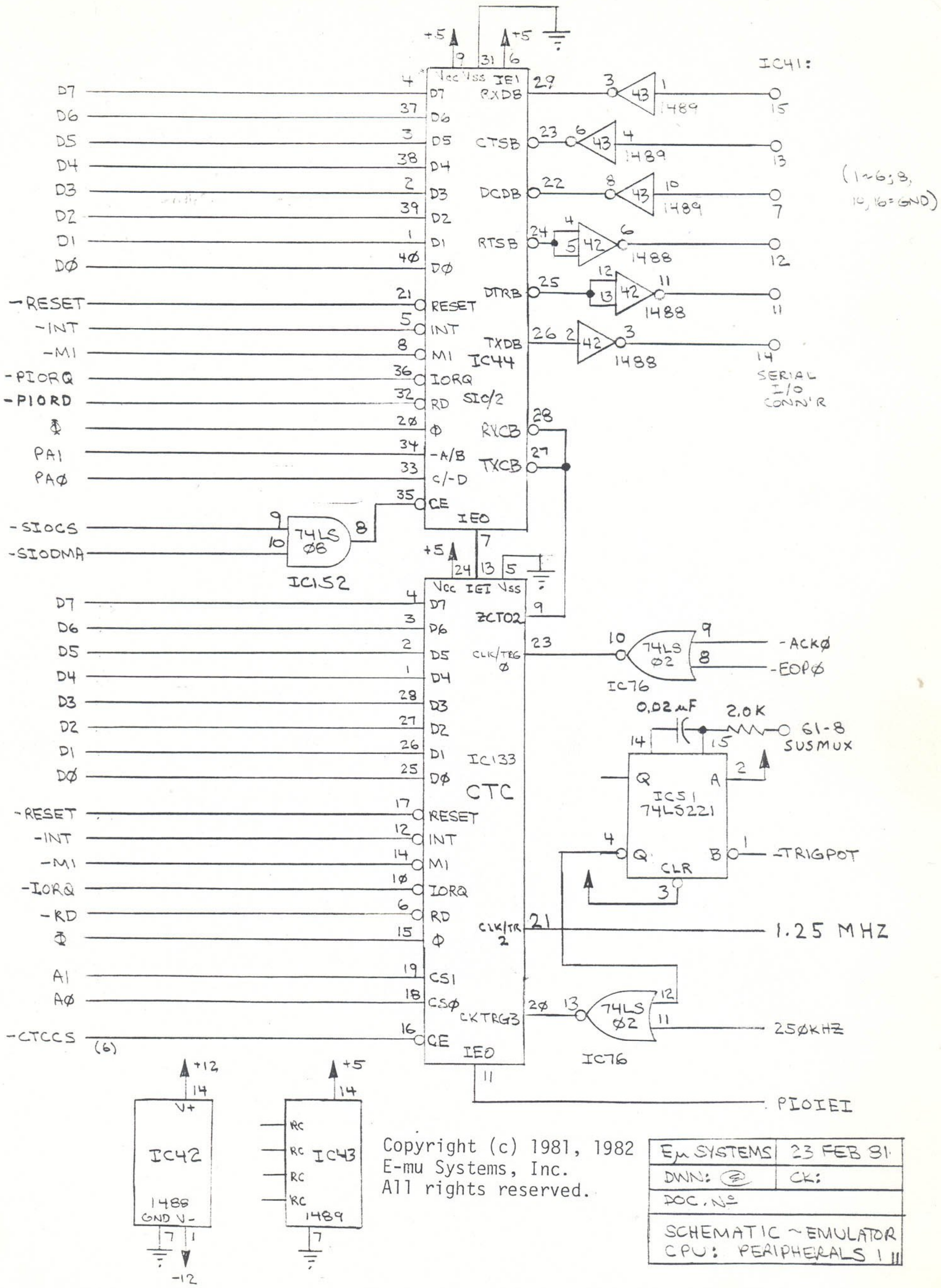

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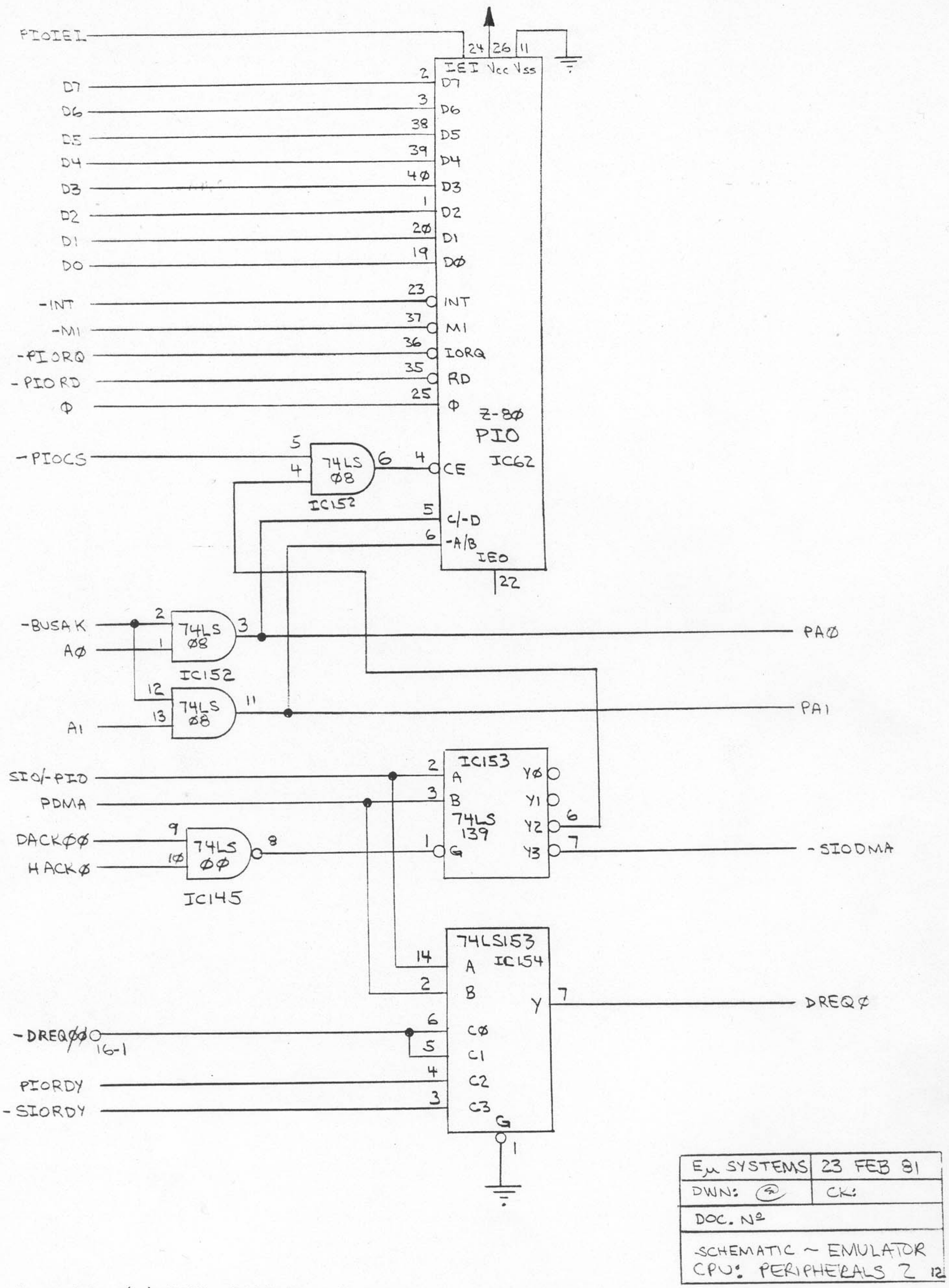

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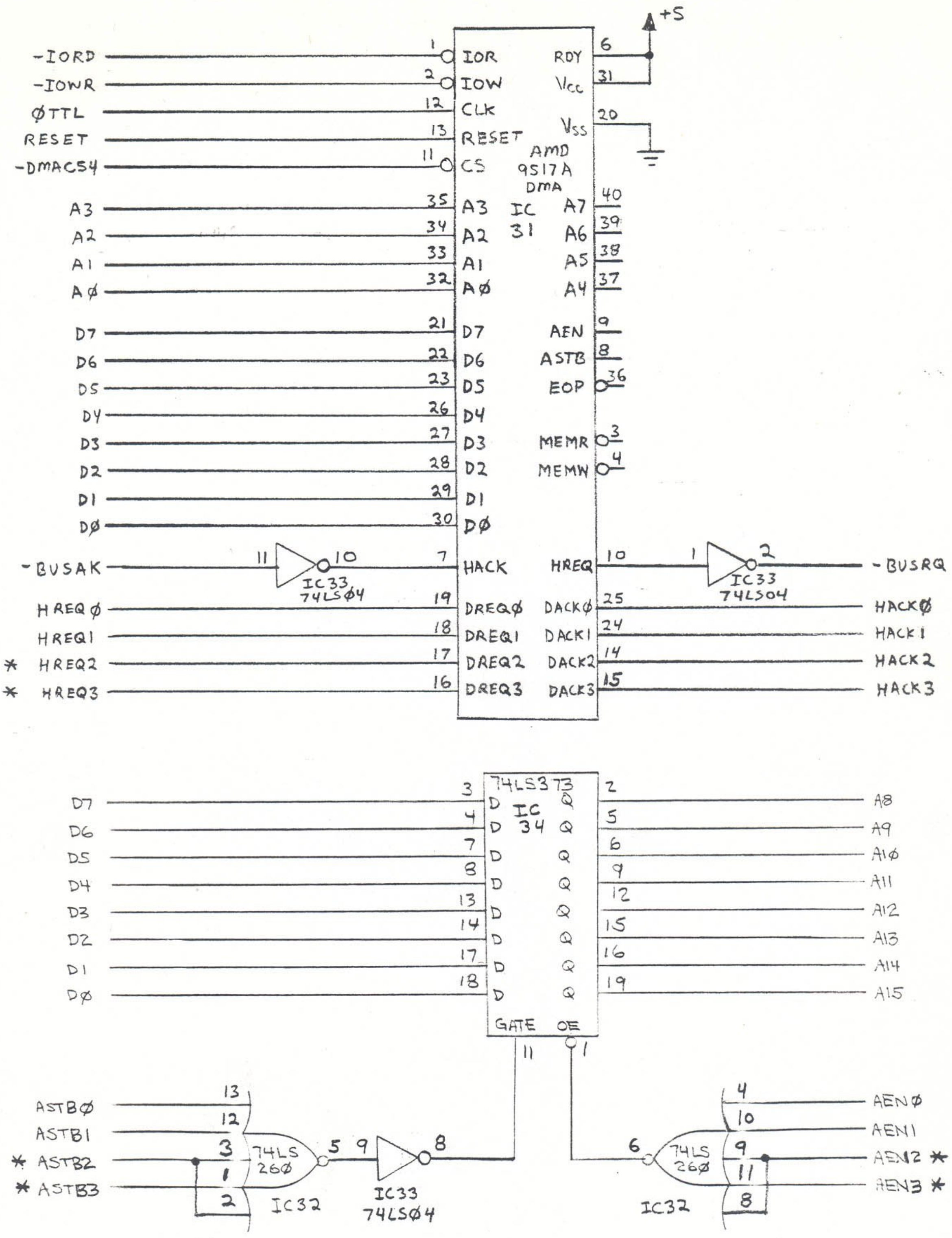

* JUMPER TO ⏚ 6 PLACES FOR 4 VOICE

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DWN: ©	CK:
DOC. Nº	
SCHEMATIC ~ EMULATOR CPU: DMA INTERFACE 13	

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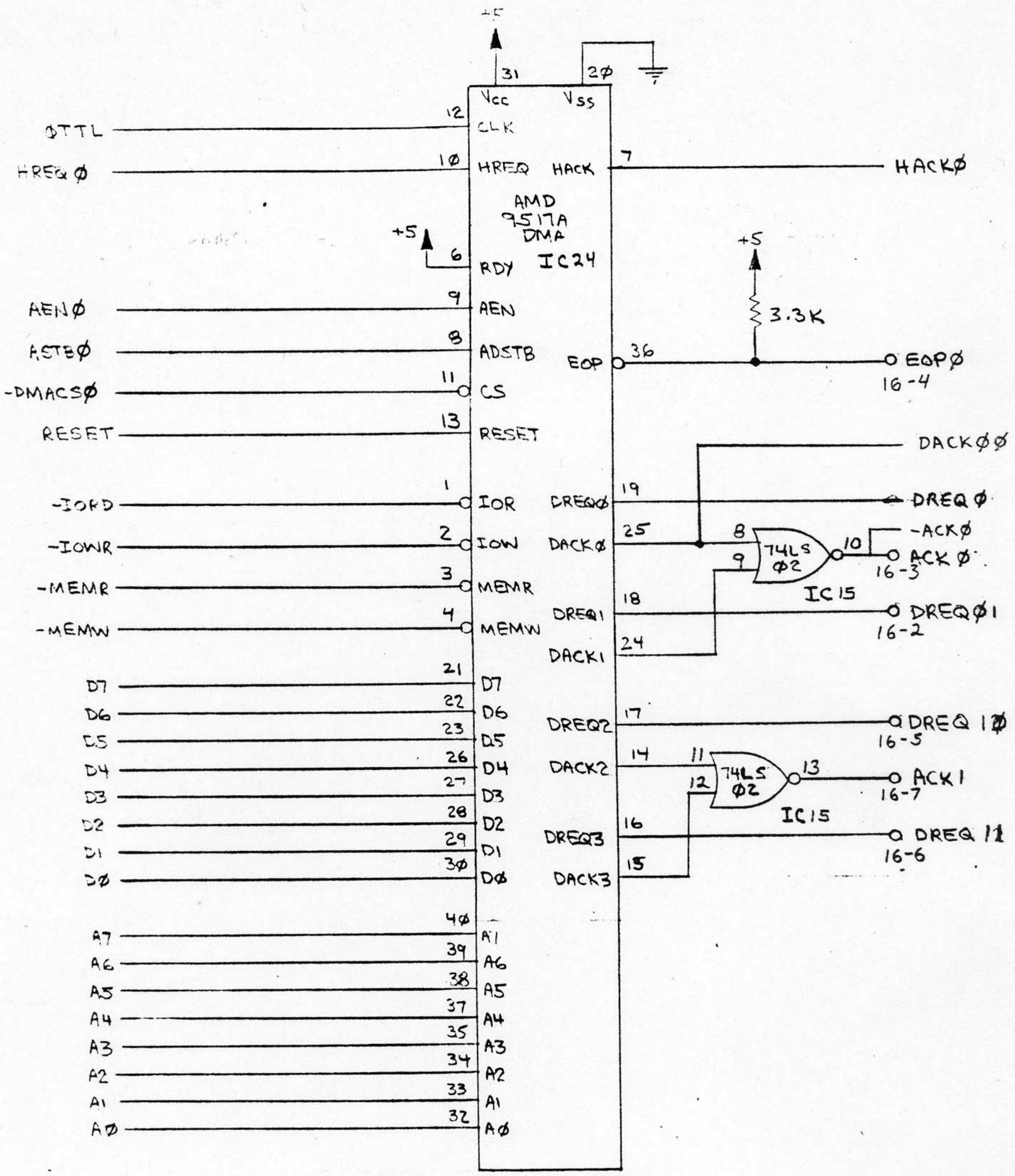

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DWN: Ⓔ	CK:
DOC. №	
SCHEMATIC ~ EMULATOR CPU: DMA Φ-1	

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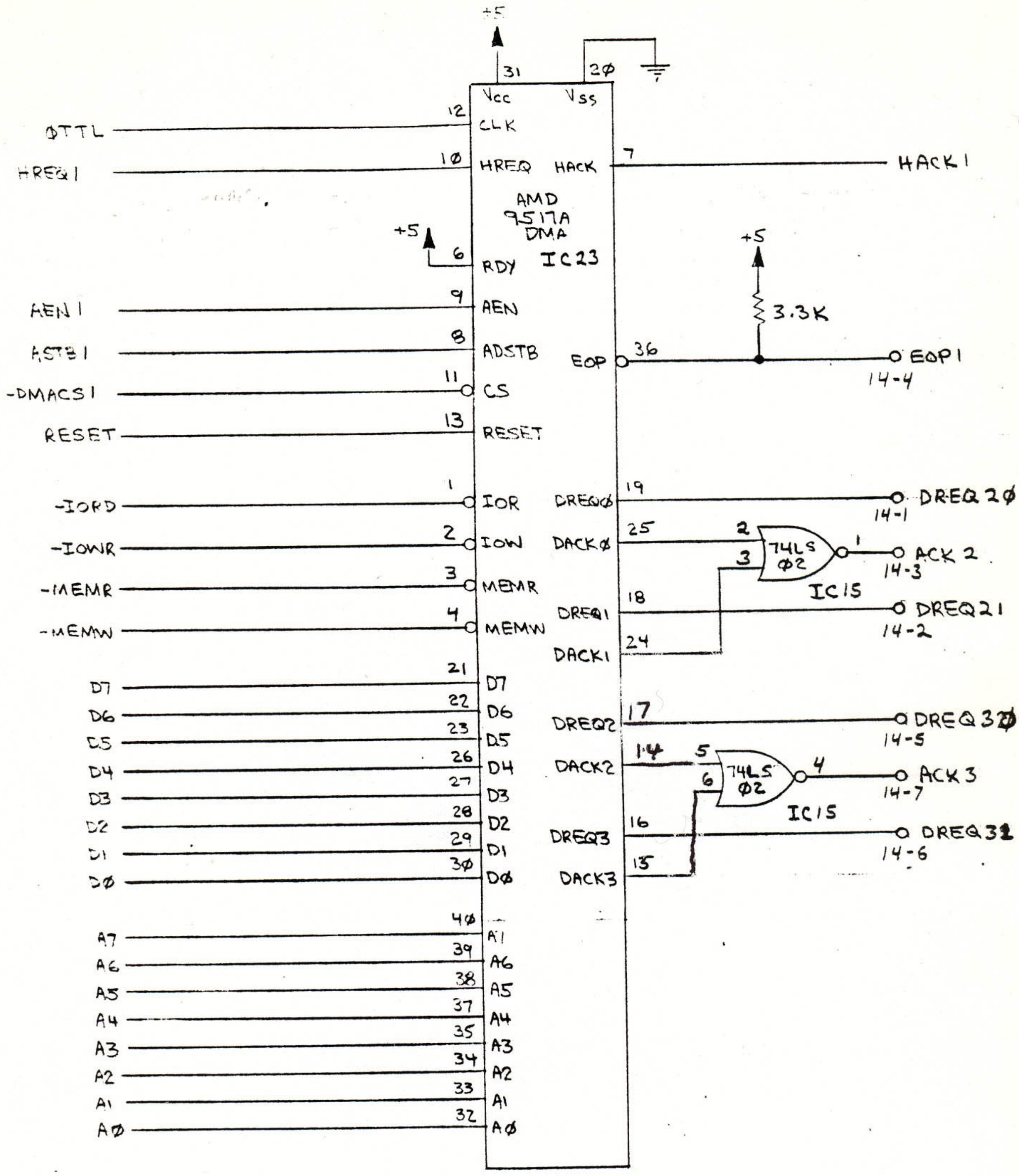

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DWN: Ⓔ	CK:
DOC. №	
SCHEMATIC ~ EMULATOR CPU: DMA 2-3	15

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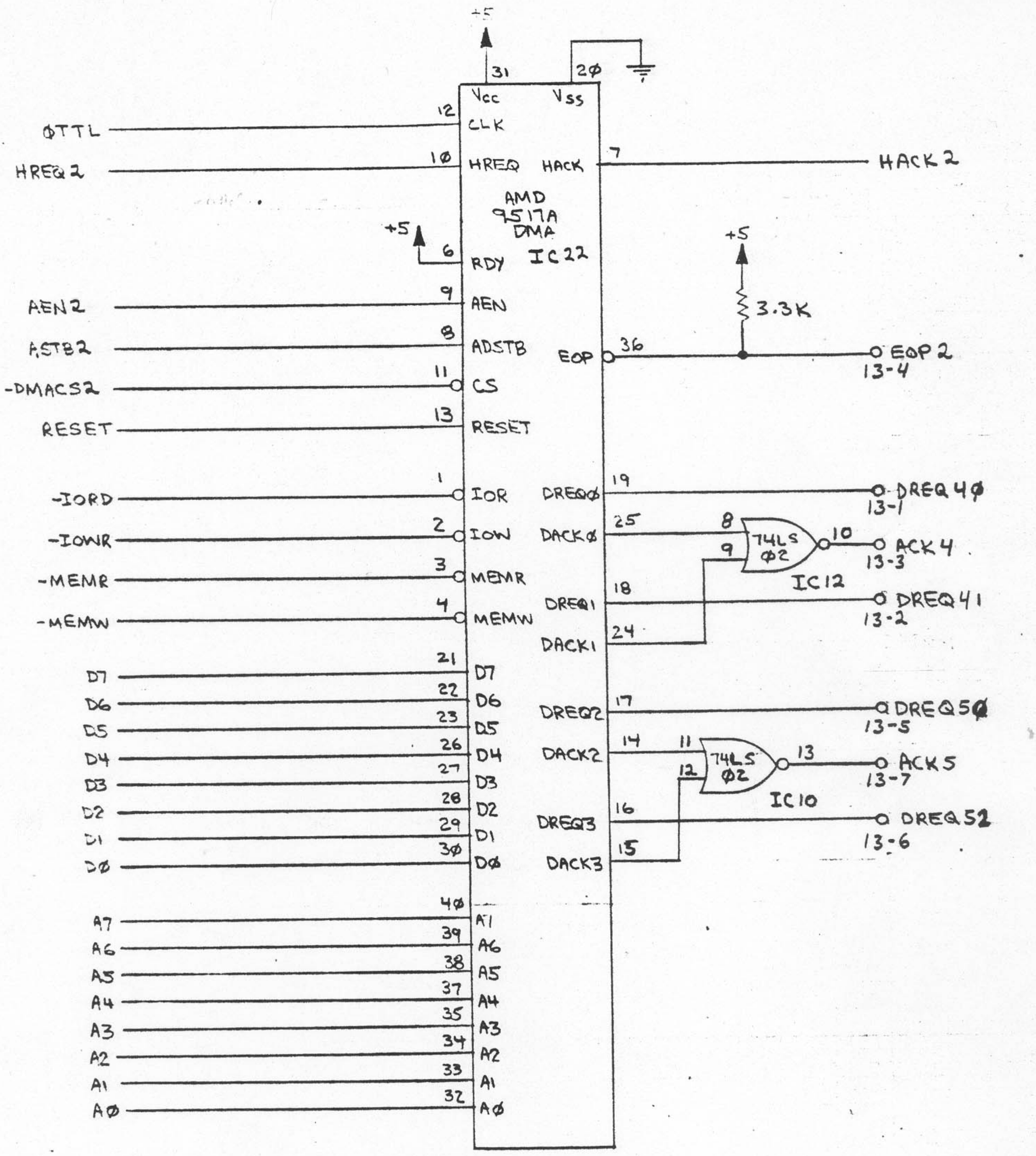

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DWN: Ⓔ	CK:
DOC. No	
SCHEMATIC ~ EMULATOR CPU: DMA 4-5	16

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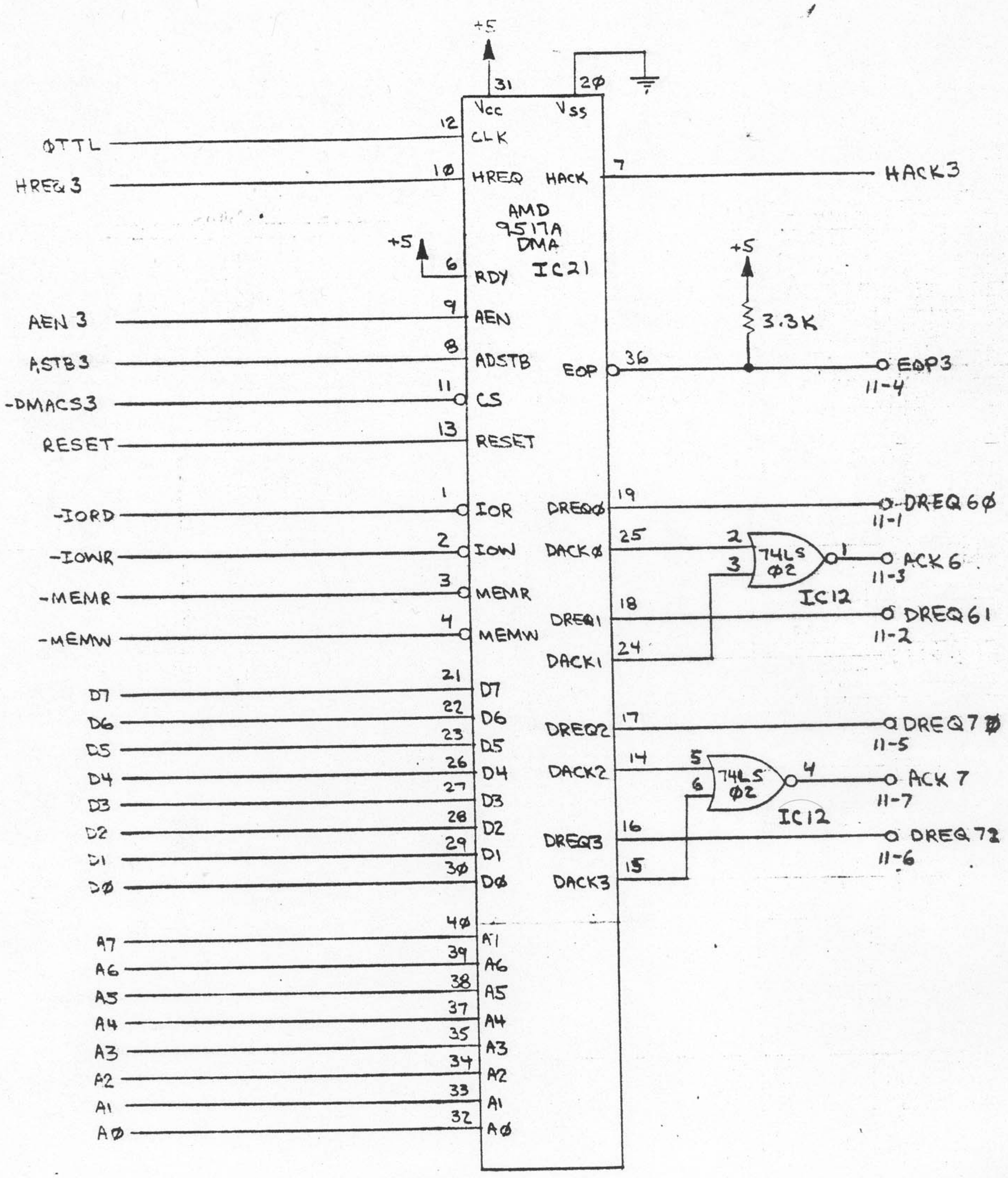

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DWN: E	CK:
DOC. №	
SCHEMATIC ~ EMULATOR CPU: DMA 6-7	17

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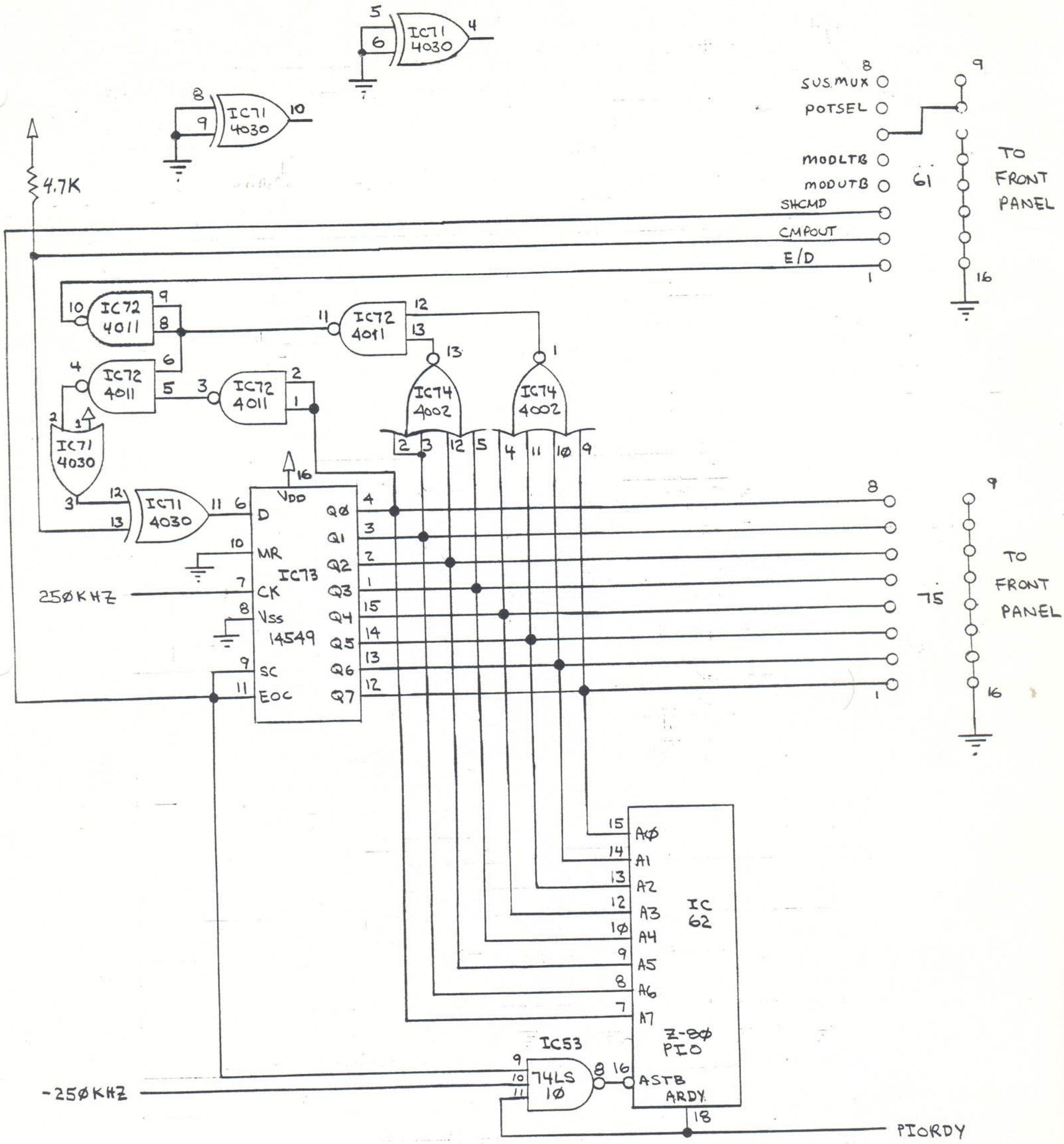

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DWN: ②	CK:
DOC N°	
SCHEMATIC – EMULATOR CPU: A/D CONVERTER	18

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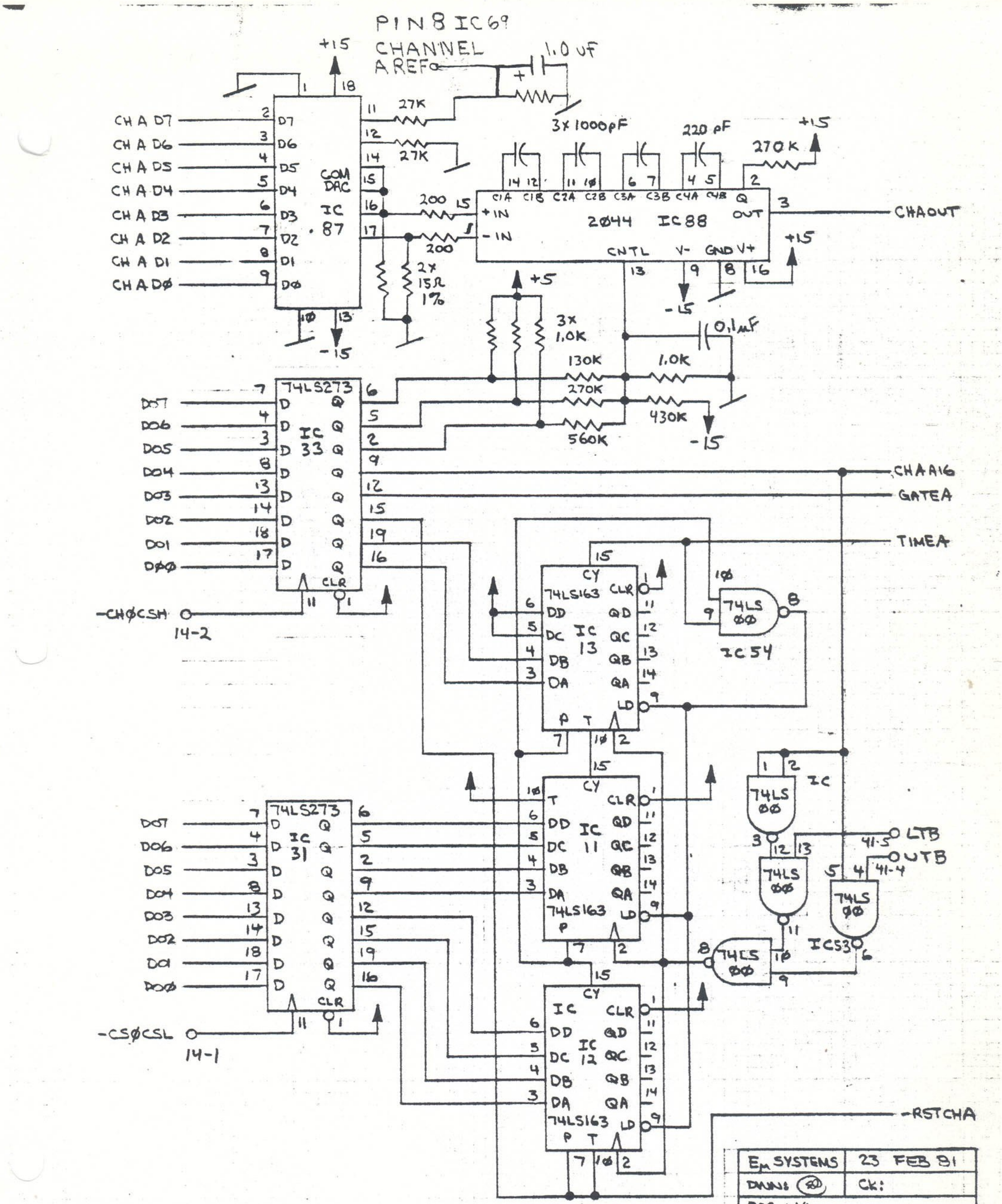

E-mu SYSTEMS 23 FEB 81
DRWN: (SD) CK:
DOC. No
SCHEMATIC ~ EMULATOR
TIME BASE : CHANNEL A

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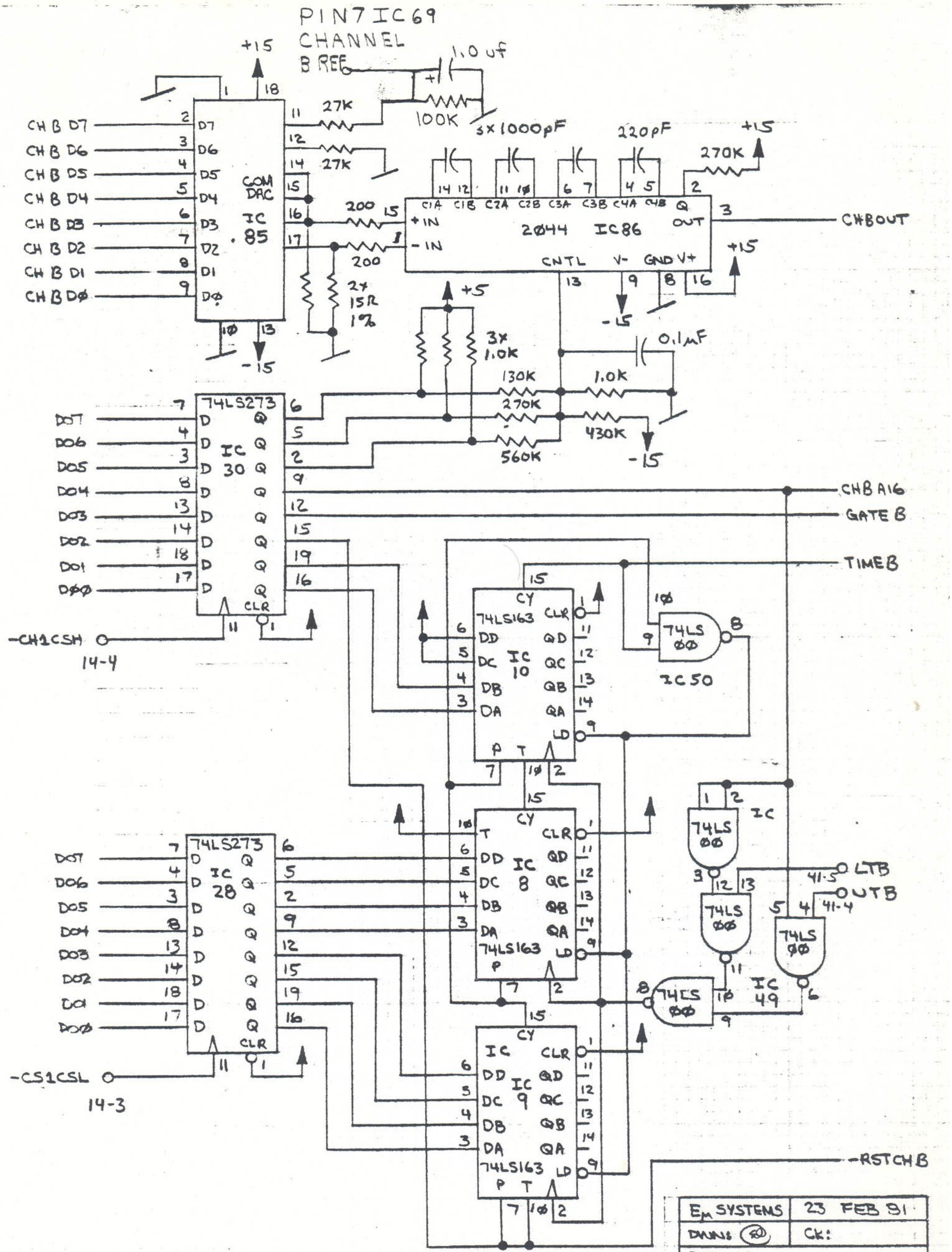

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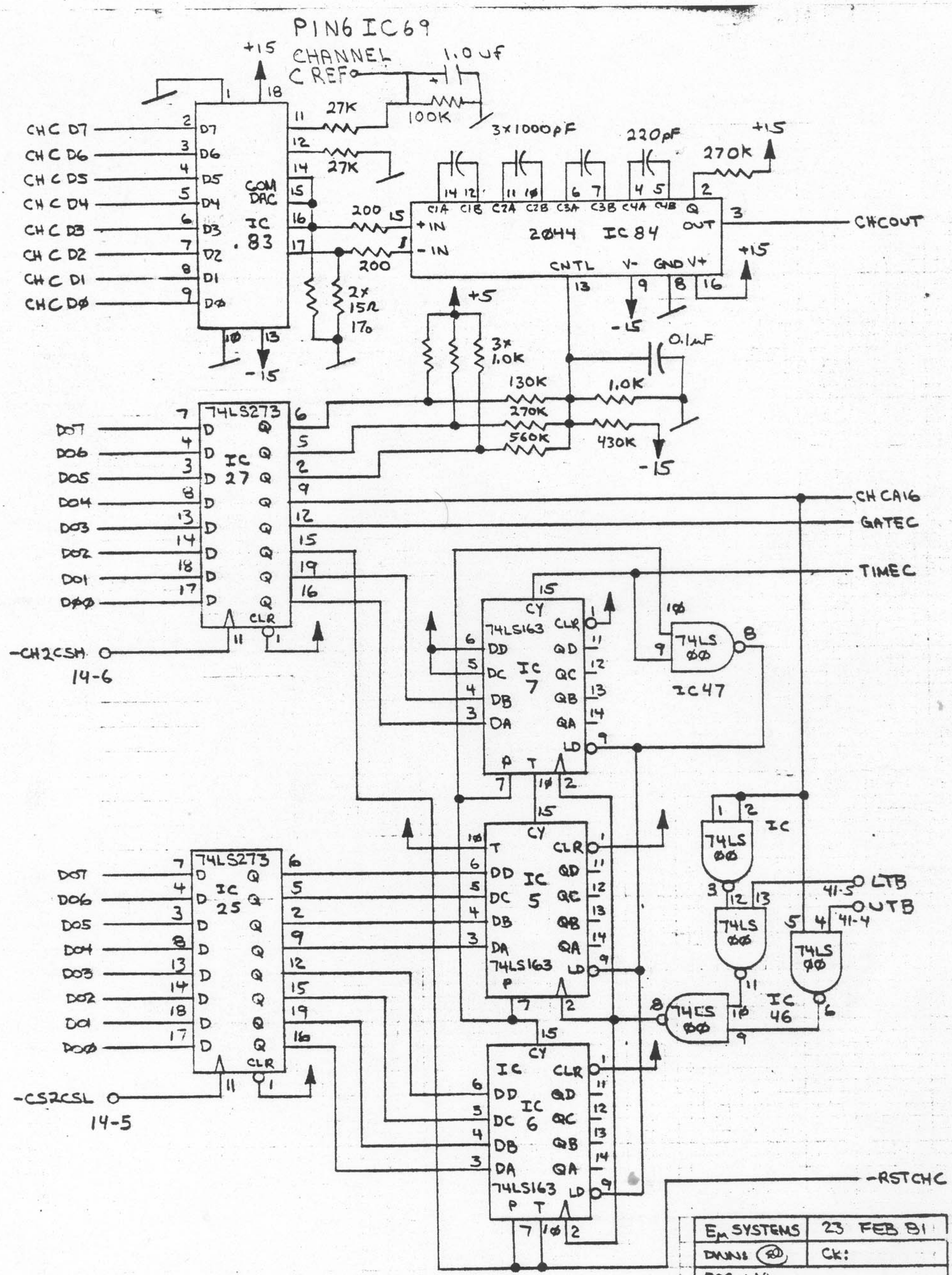
DWN: (SD)	Ck:
DOC. No	
SCHEMATIC ~ EMULATOR TIME BASE : CHANNEL B	



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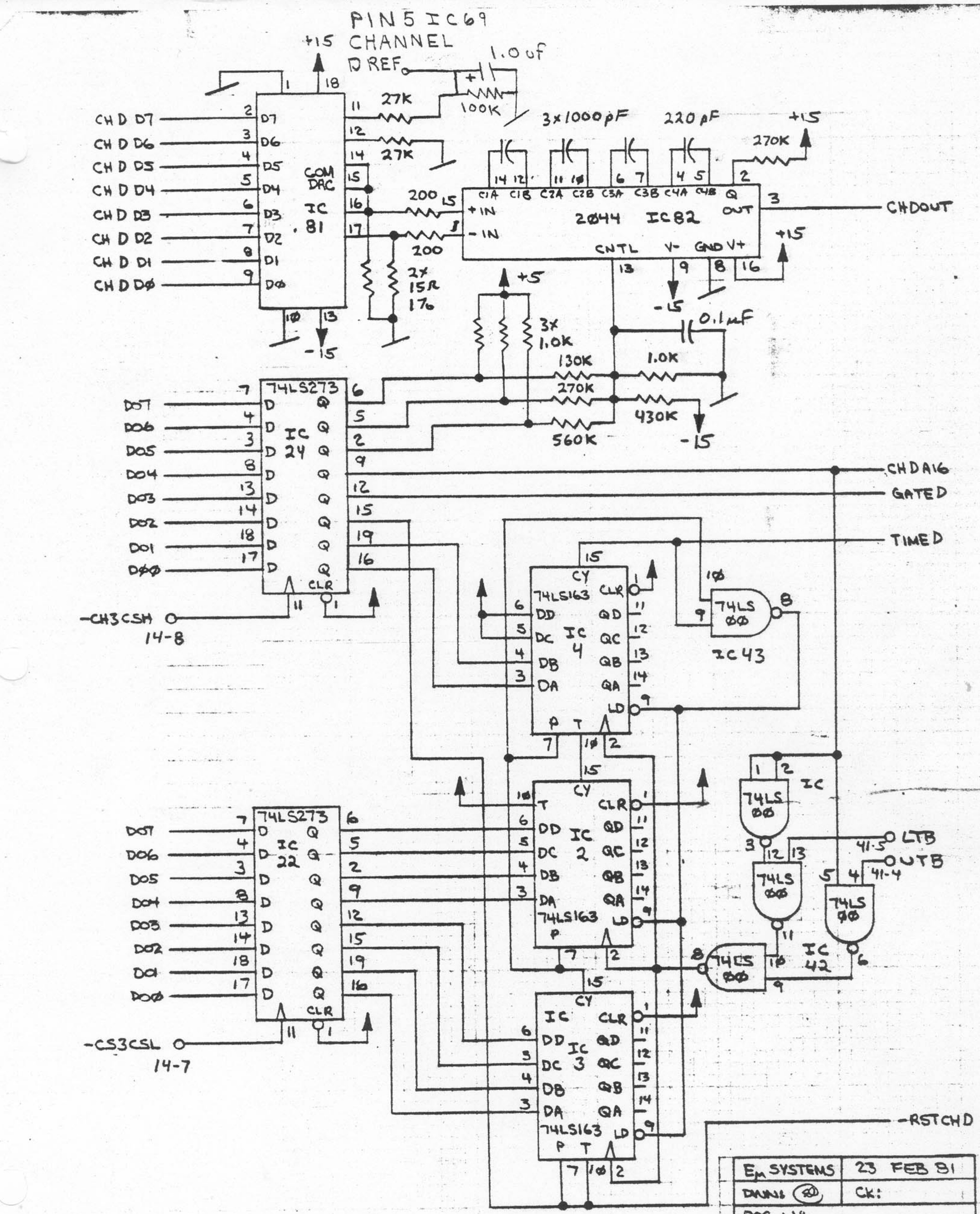
DWN:	CK:
DOC. No	
SCHEMATIC ~ EMULATOR TIME BASE : CHANNEL C	



E_M SYSTEMS	23 FEB 81
DWN	CK:
DOC. Nº	
SCHEMATIC ~ EMULATOR TIME BASE : CHANNEL D	

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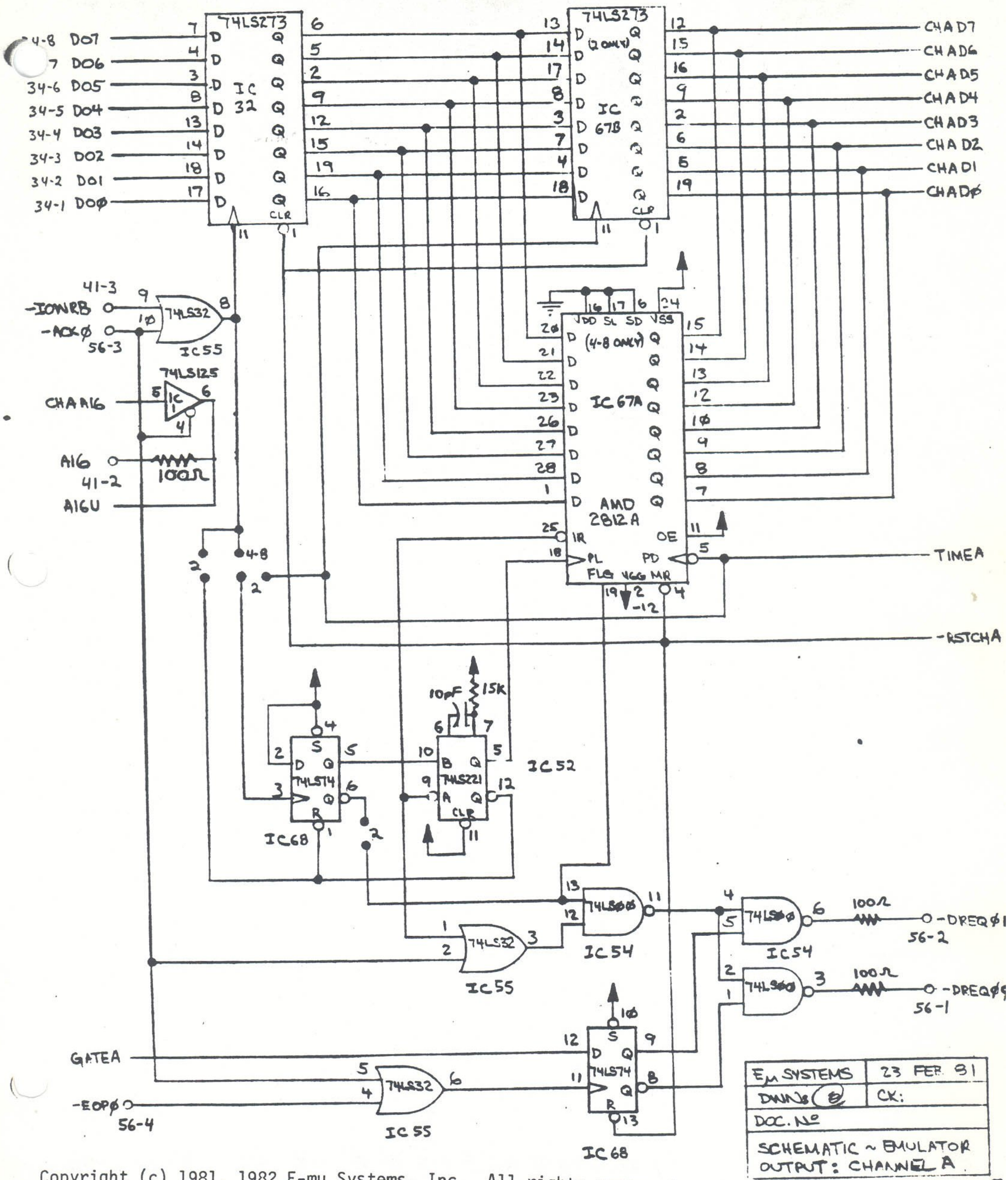

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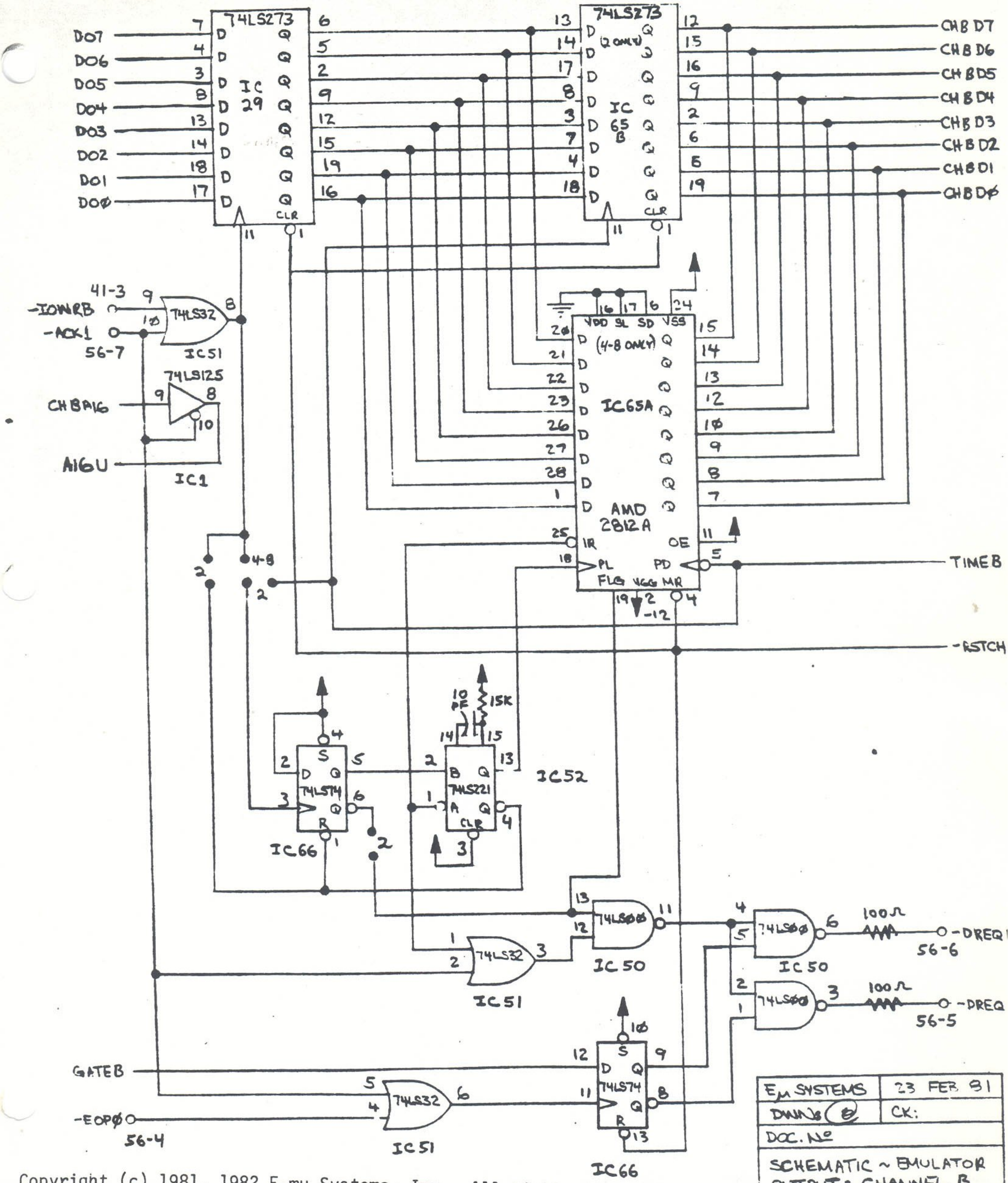

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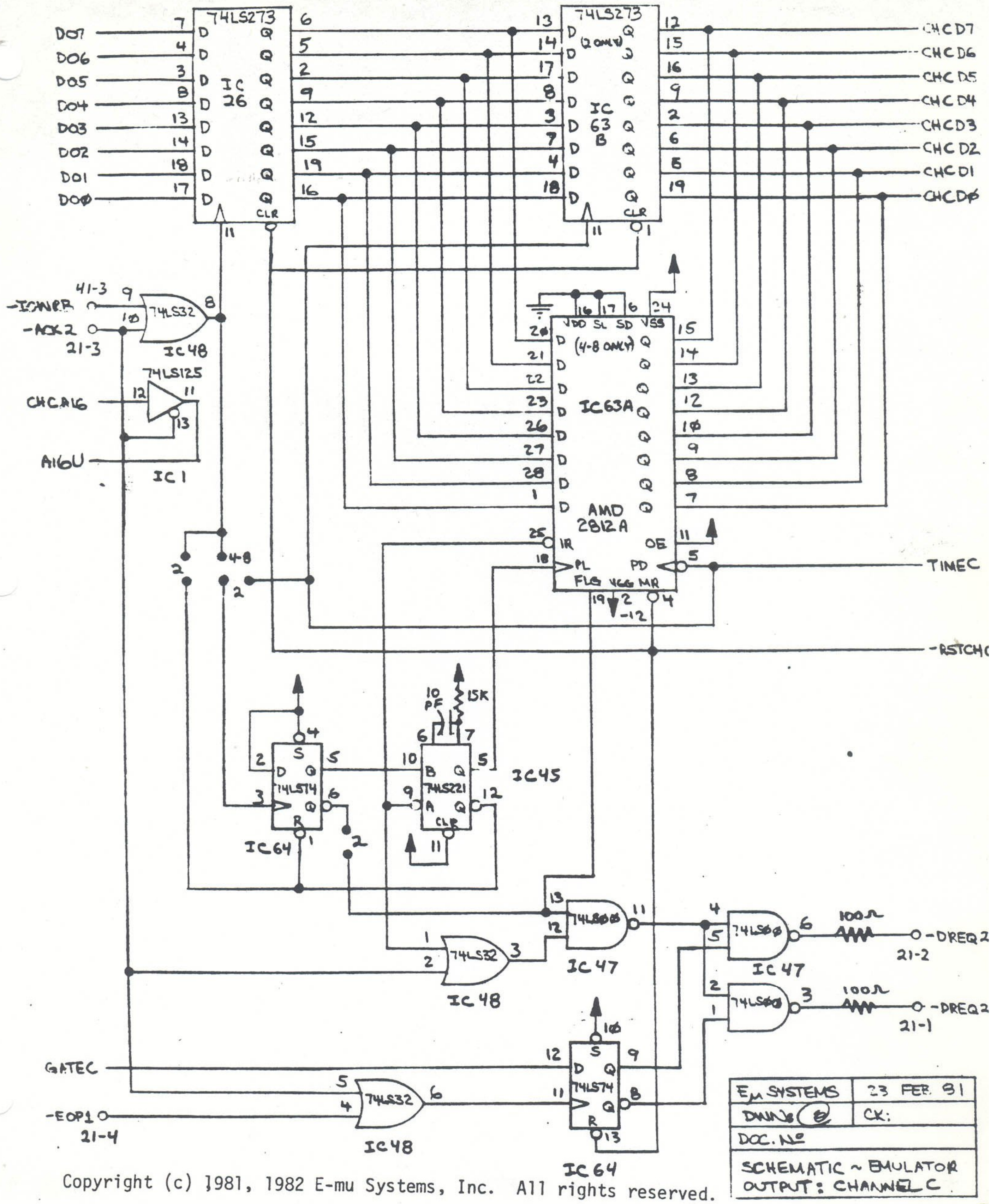

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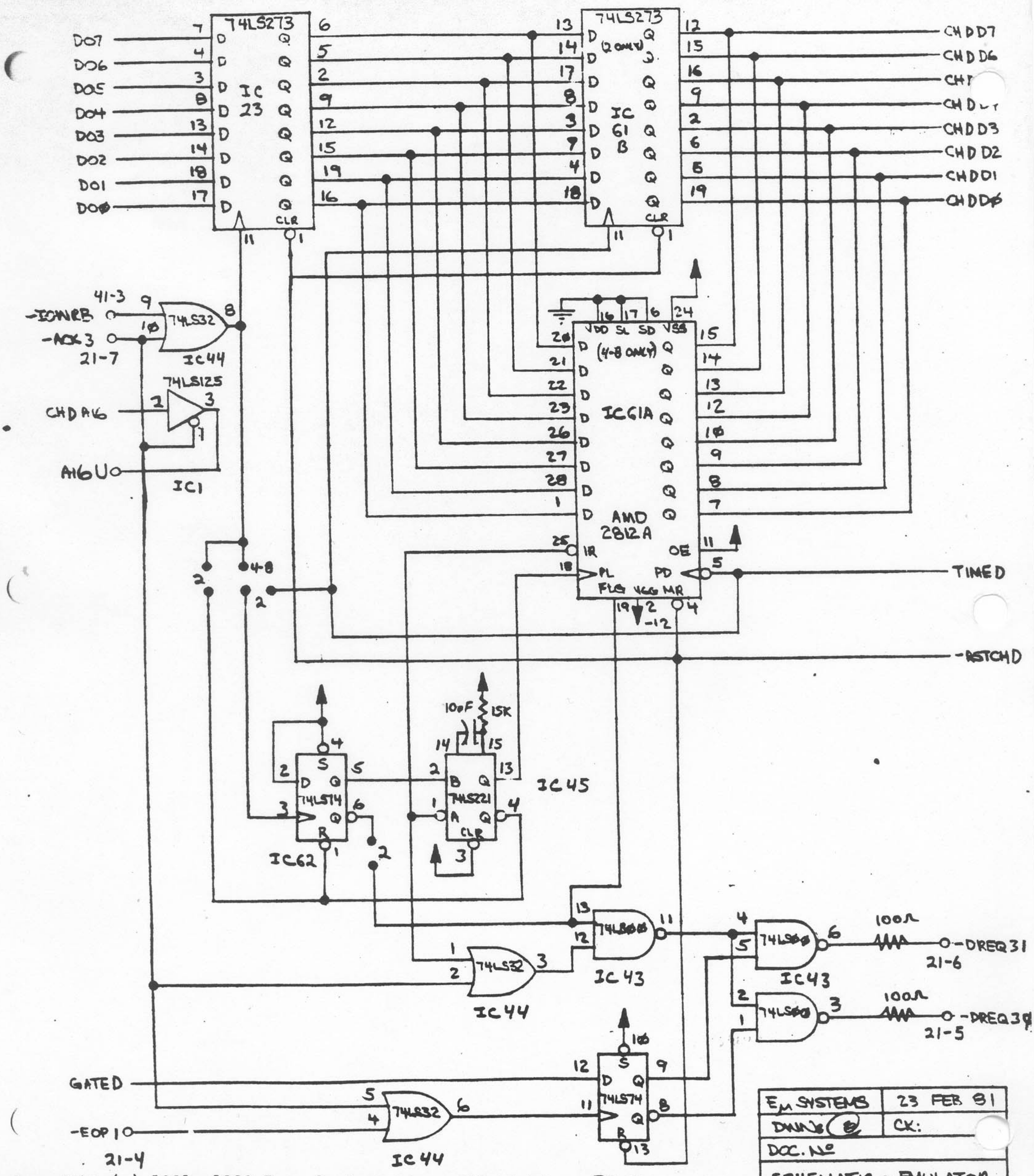

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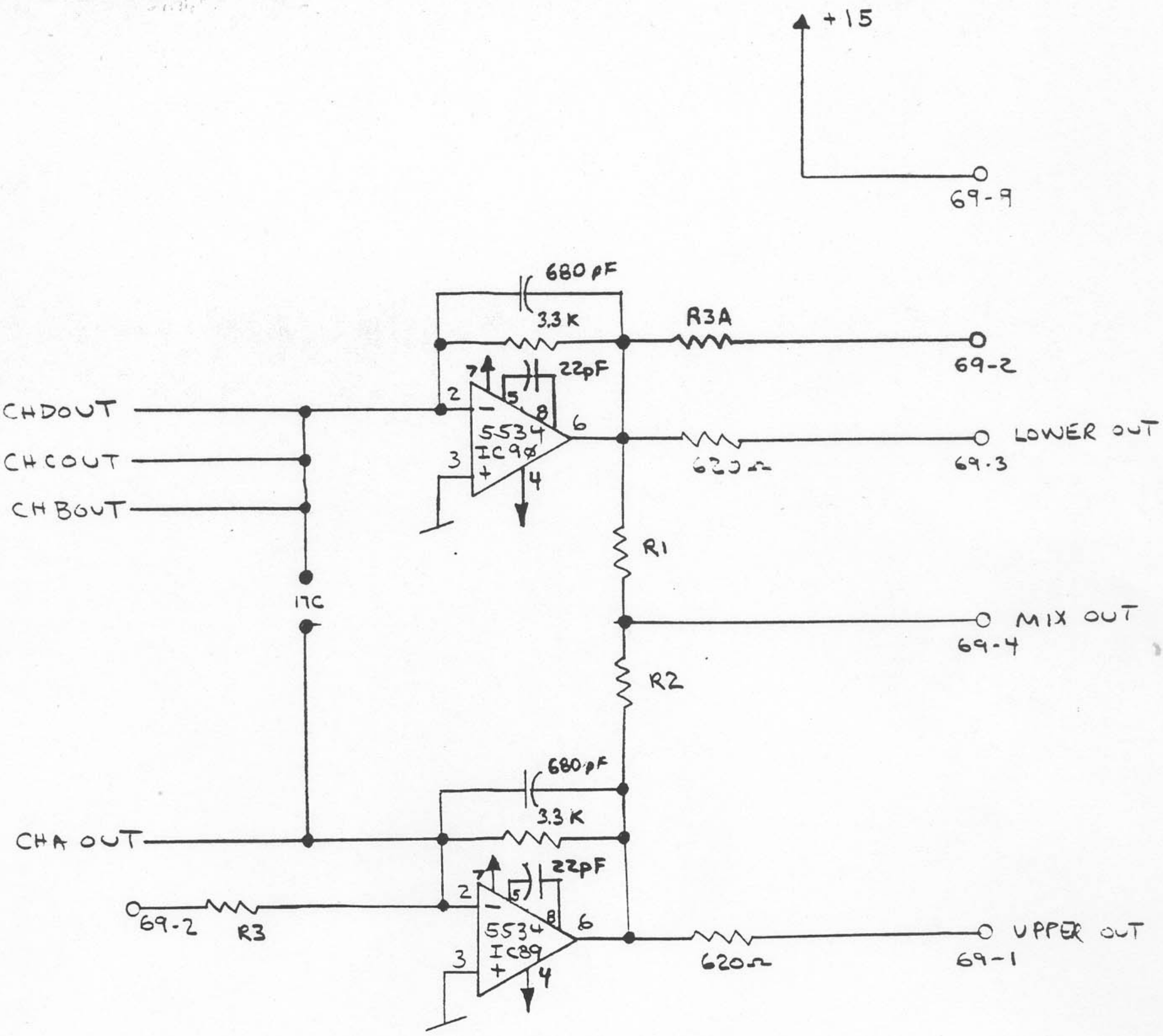
DWN:	CK:
DOC. No	
SCHEMATIC ~ EMULATOR OUTPUT: CHANNEL D.	



	4 VOICE	8 VOICE LOWER	8VOICE UPPER
JMP 17C	—	YES	—
CH A	LOWER	LOWER	LOWER
CH B	CUT & JPR TO UPPER	LOWER	UPPER
CH C	CUT & JPR TO UPPER	LOWER	UPPER
CH D	UPPER	LOWER	UPPER
R1	4.7K	—	4.7K
R2	4.7K	—	4.7K
R3	—	—	3.3K
R3A	—	100Ω	—

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Em SYSTEMS	23 FEB 81
DWN:	CK:
DOC No	
SCHEMATIC ~ EMULATOR OUTPUT AMPS	

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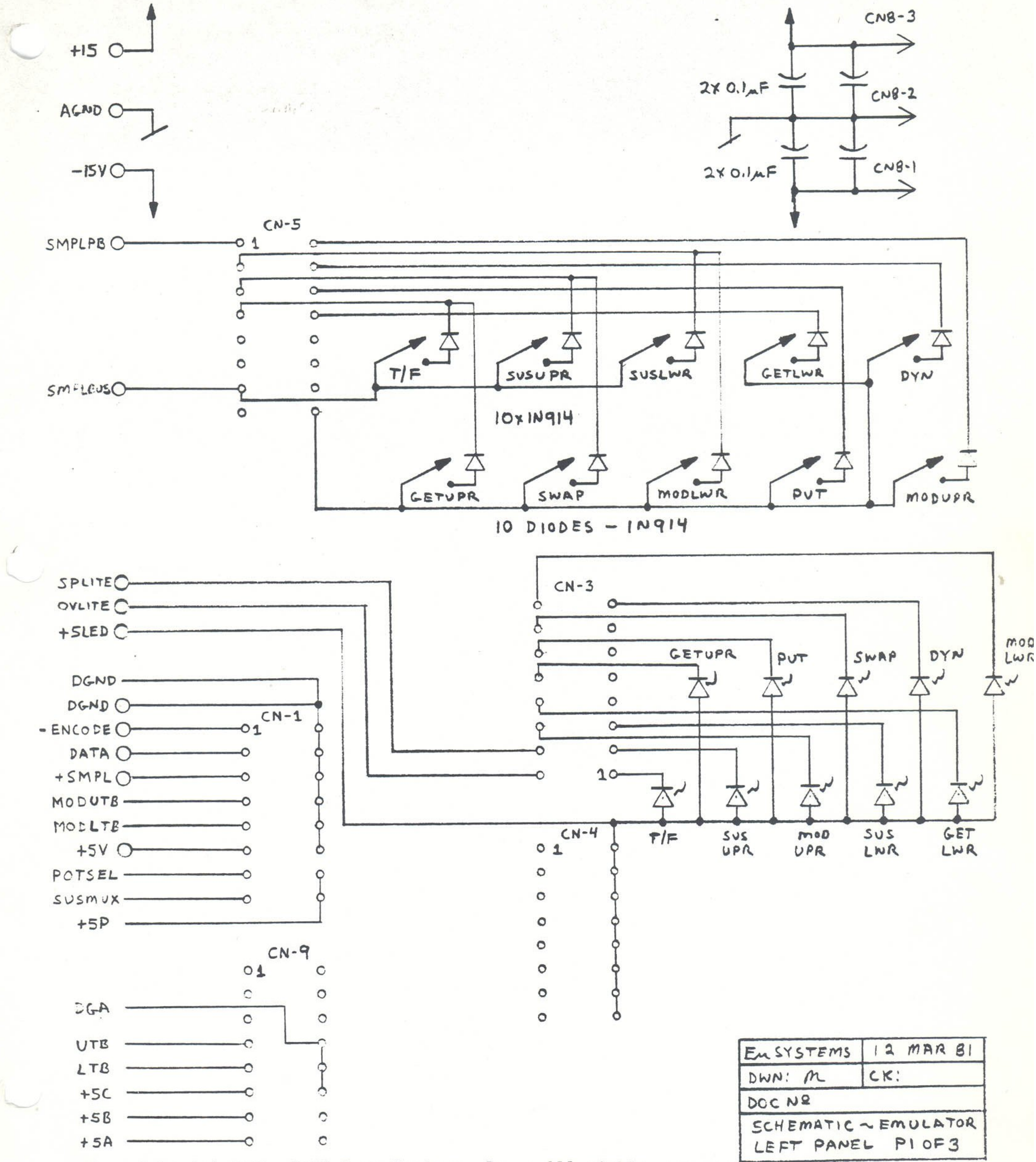

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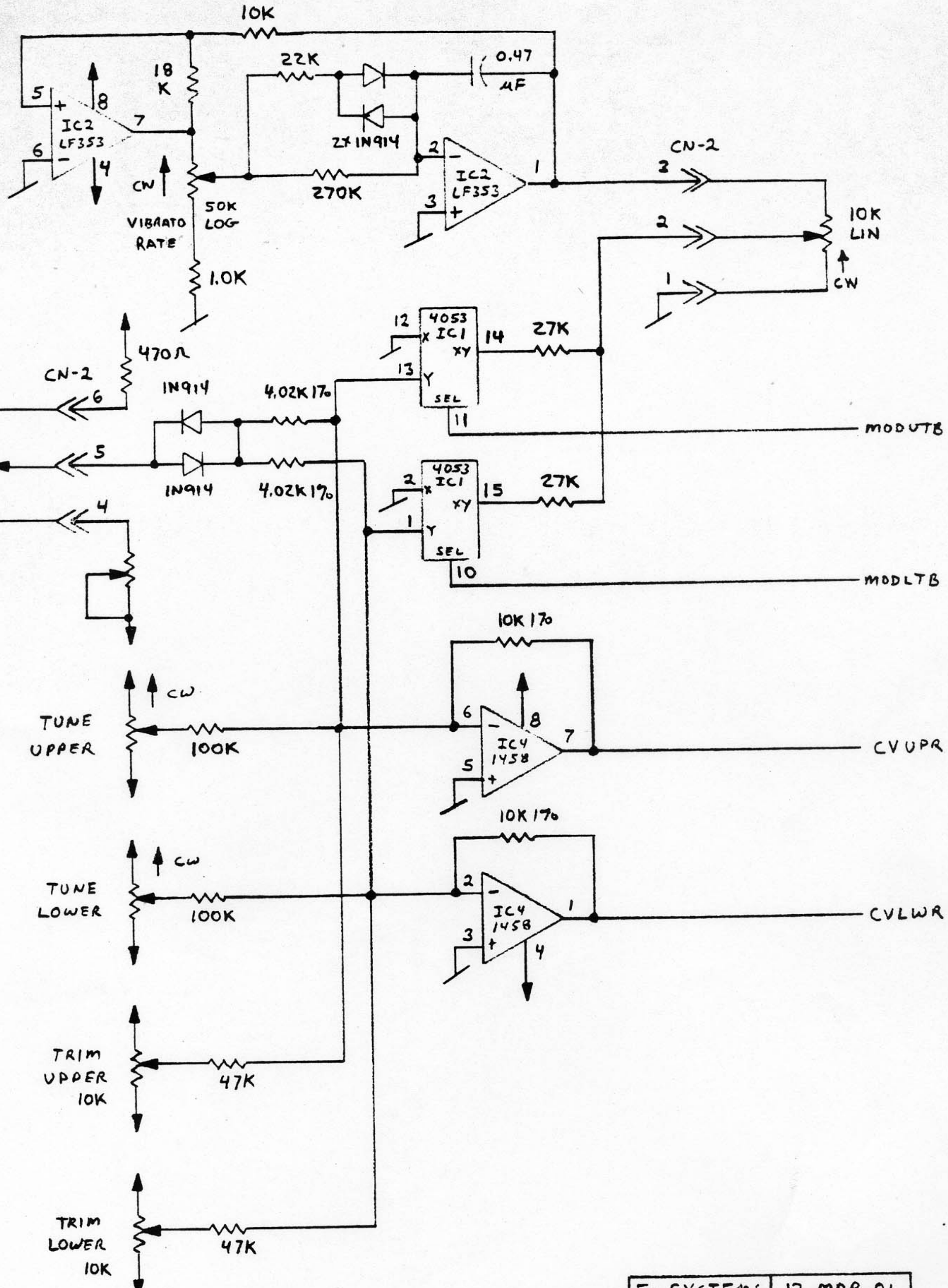

EμSYSTEMS	12 MAR 81
DWN: M	CK:
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SCHEMATIC - EMULATOR LEFT PANEL P2 OF 3	

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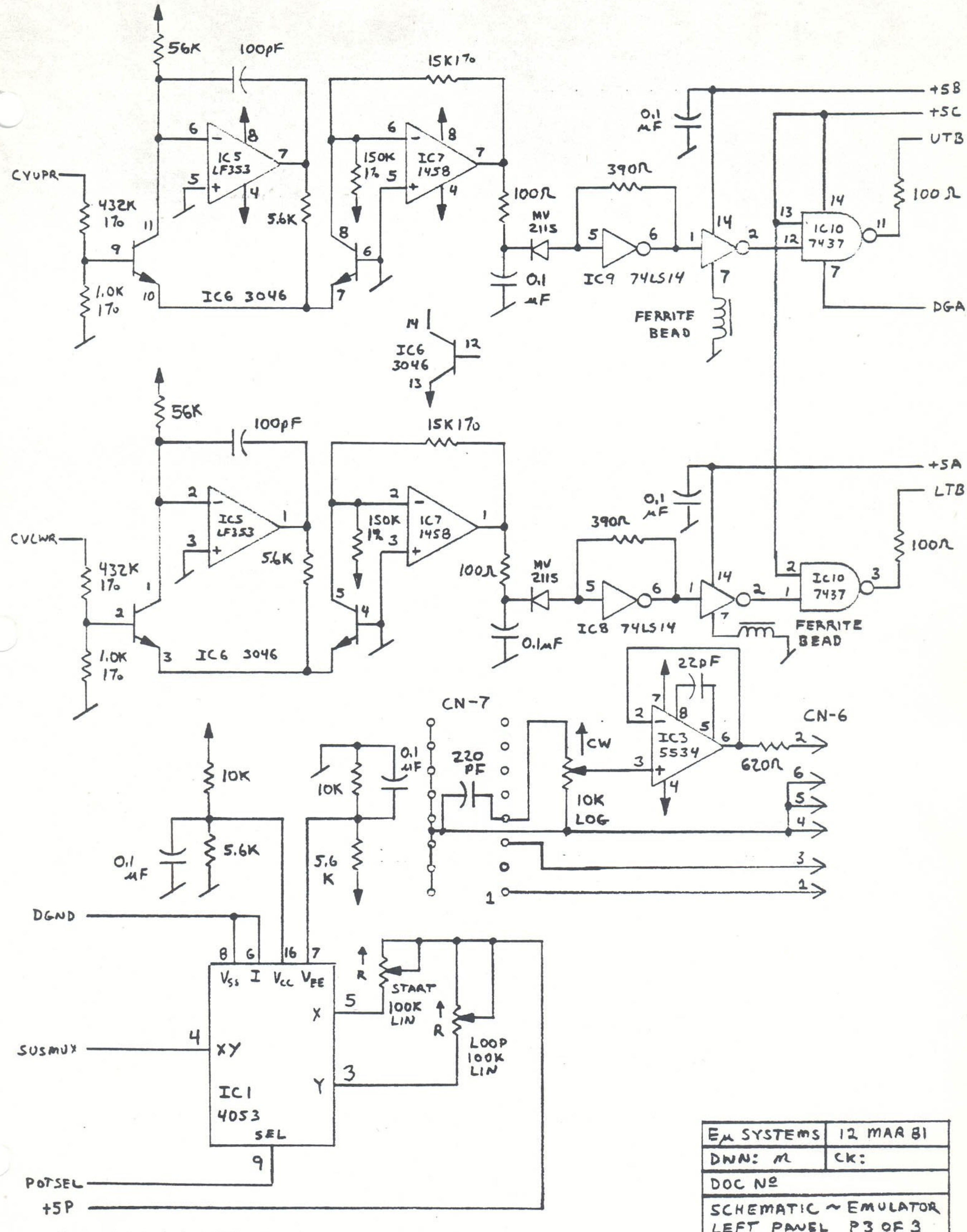

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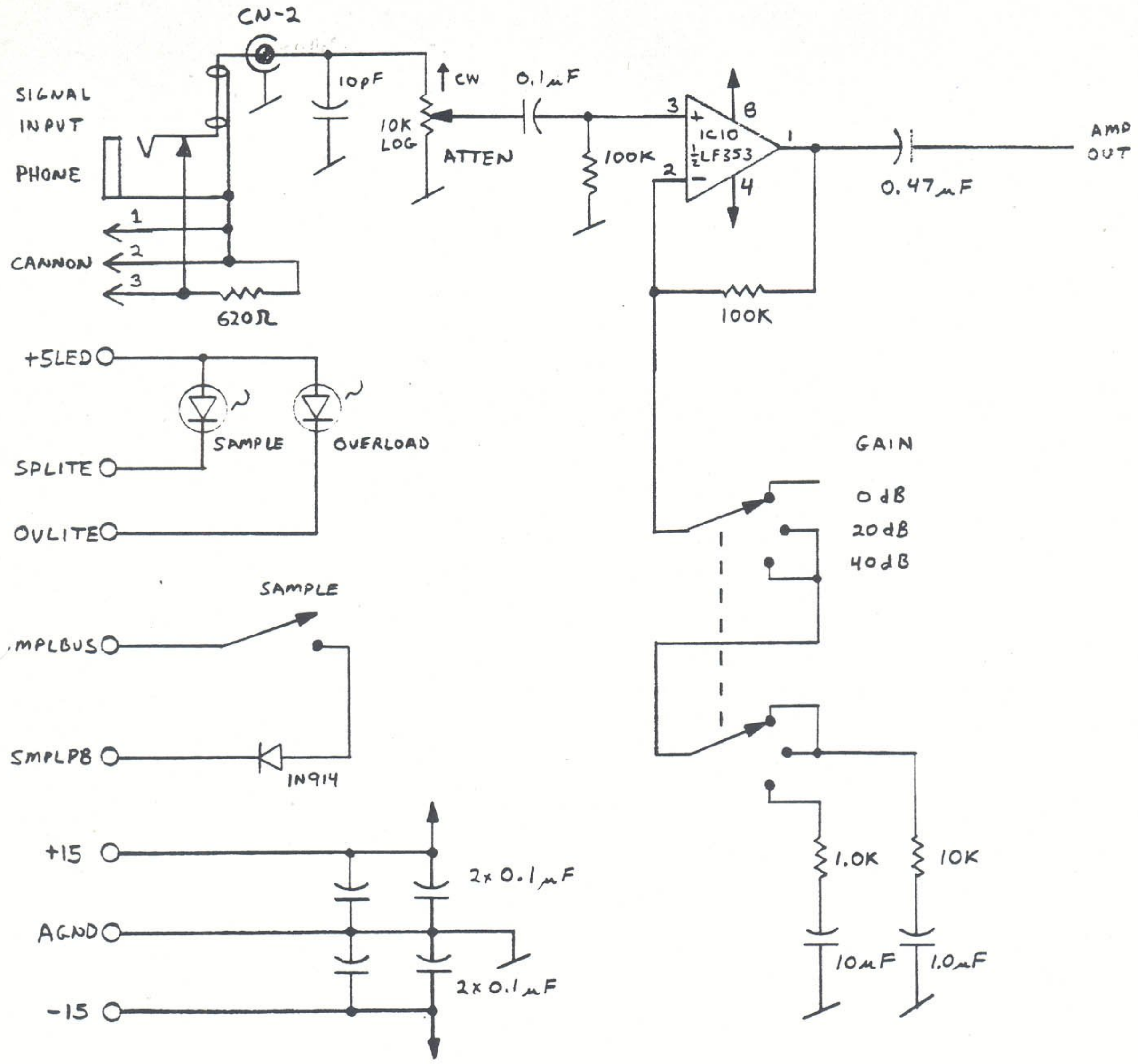

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Eµ SYSTEMS	12 MAR 81
DWN: [initials]	CK:
DOC NO	
SCHEMATIC — EMULATOR RIGHT PANEL P1 OF 3	

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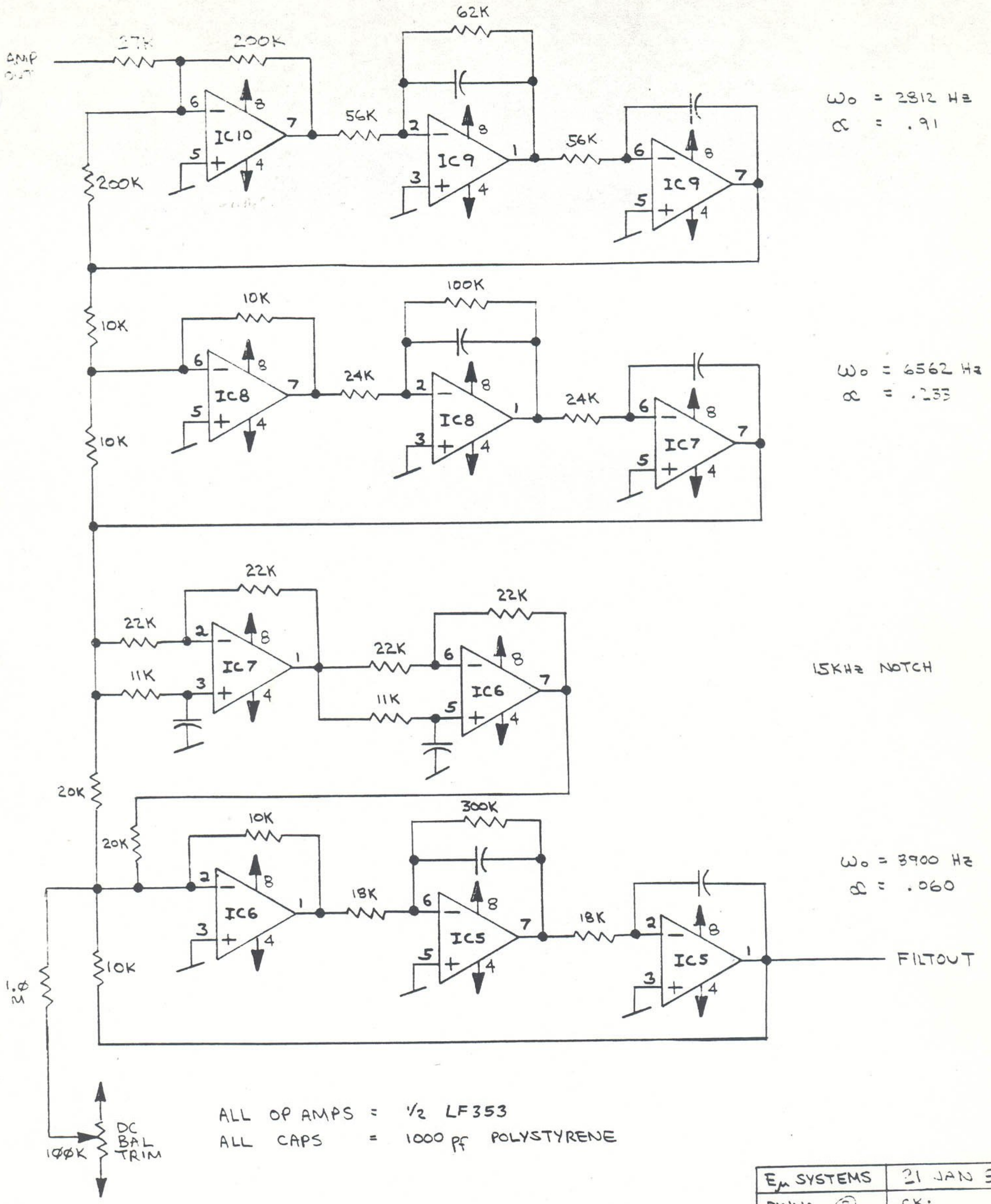

ALL OP AMPS = 1/2 LF353
ALL CAPS = 1000 pf POLYSTYRENE

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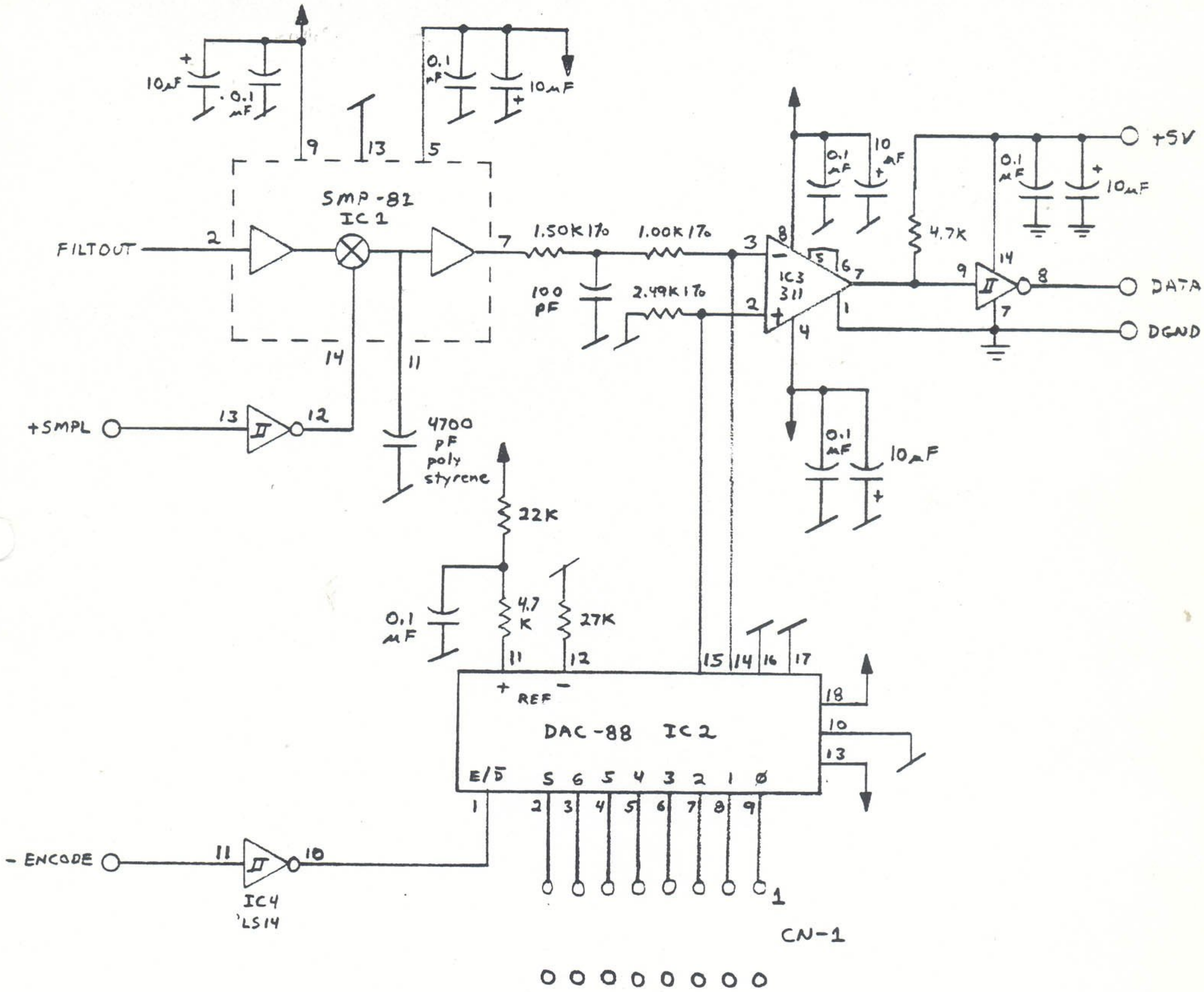

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SCHEMATIC ~ EMULATOR RIGHT PANEL	P3 OF 3

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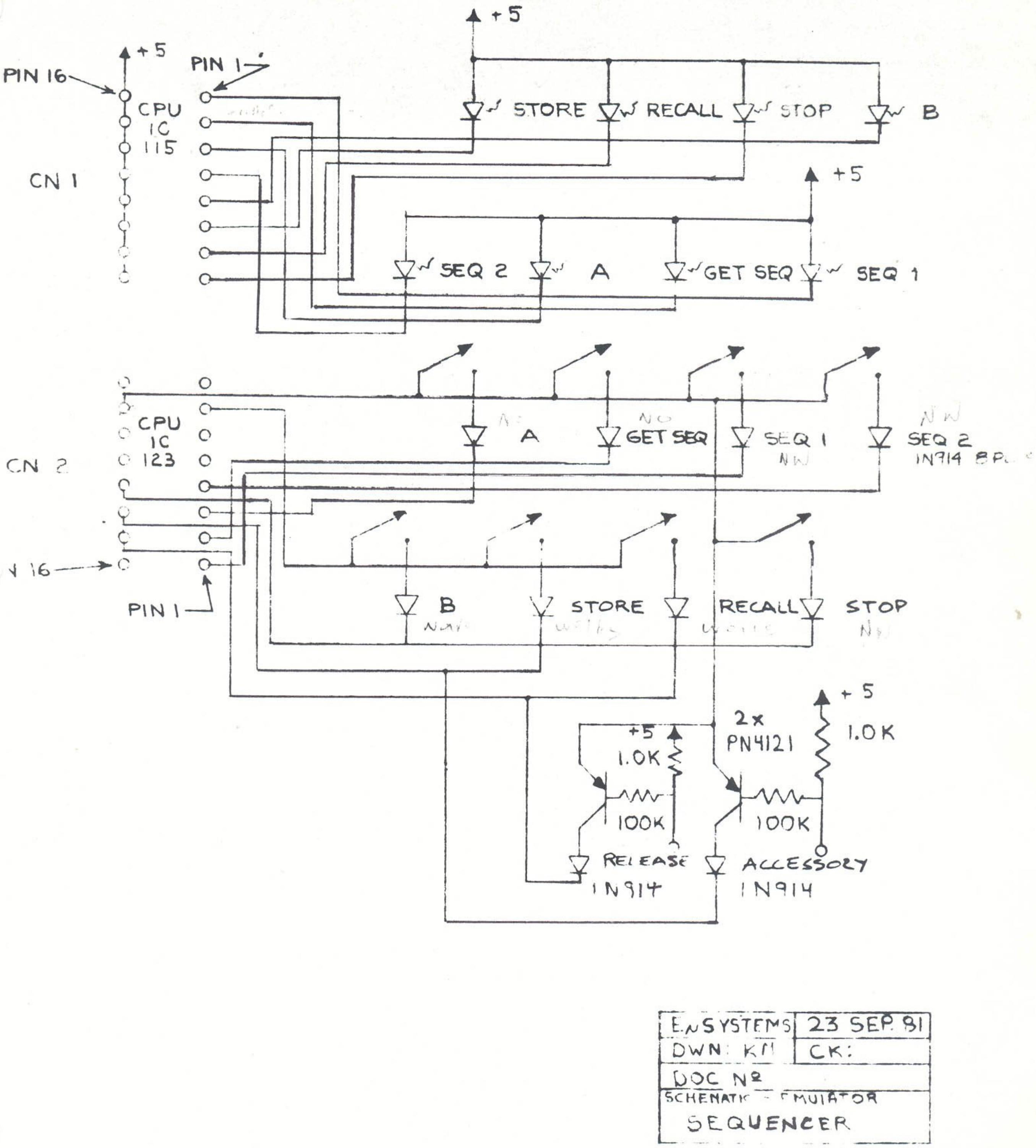

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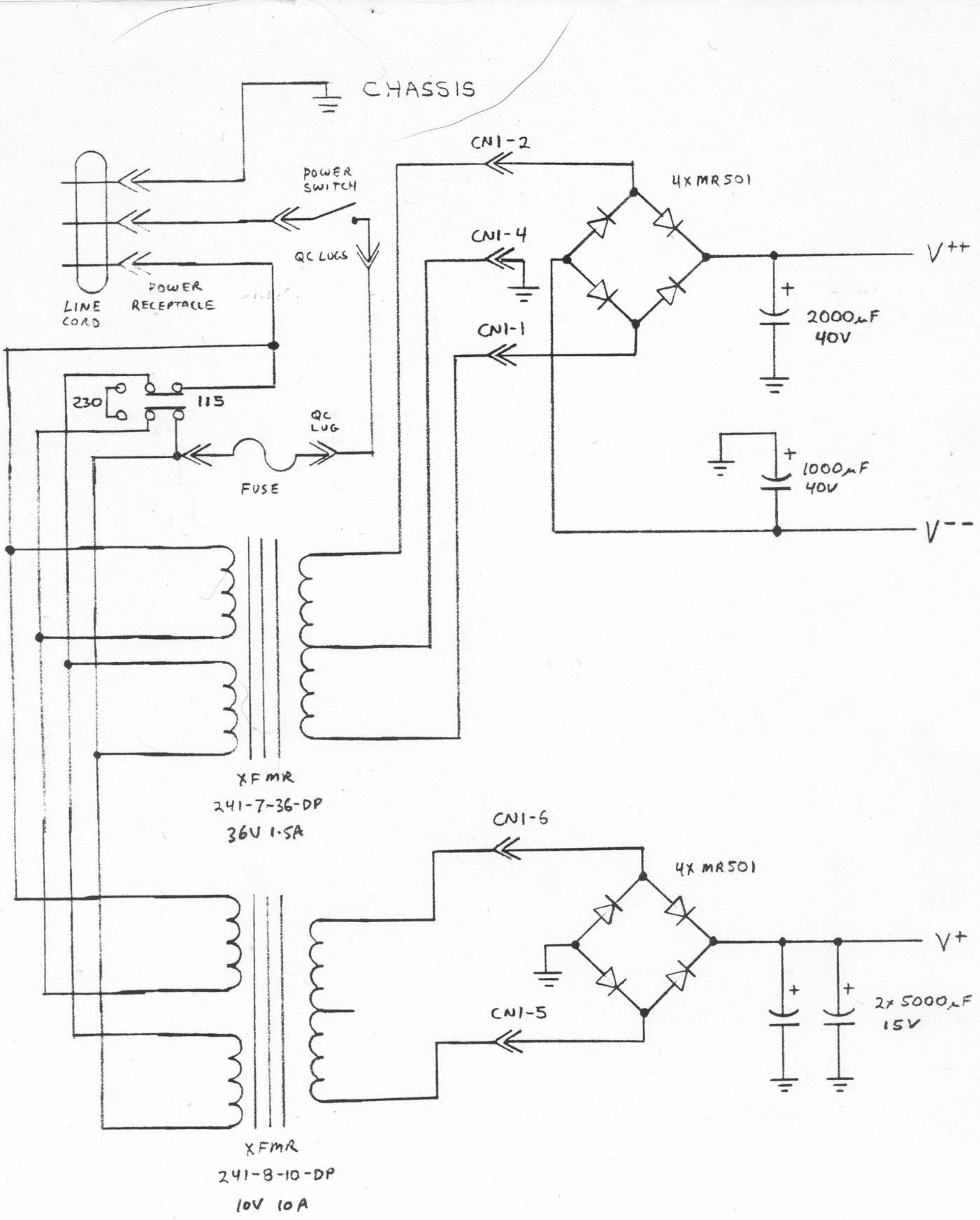

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DOC. N°	
SCHEMATIC - EMULATOR POWER SUPPLY P1 OF 2	

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