DIGITAL GROUP TV READOUT/CASSETTE INTERFACE CARD

General Design

This PC Board combines two functions needed by microprocessors, the ability to output data and messages on a low-cost TV set, and the ability to reliably store, retrieve, and exchange programs or data at low cost. The TV Readout will display 512 characters, 16 lines of 32 characters per line, with upper and lower case alpha characters, Greek alphabet, math symbols, and special characters. The characters are formed from a 7 x 13 matrix of dots, producing easy to read characters with a normal height to width aspect ratio.

The cassette section provides circuits for recording data as well as receiving data previously recorded. Frequency Shift Keying is utilized, 2125 Hz being the Mark or "1" frequency, and 2975 Hz used as the Space or "0" frequency. The frequency shift keying system gives a better signal/noise ratio and the wide spacing of the harmonically unrelated frequencies permit the use of low cost home cassette recorders in spite of their generally poor "wow" and "flutter".

Software parallel to serial conversion systems are used for record, and software serial to parallel conversion systems for data playback. These software conversion systems permit complete flexibility in Data rate (from near Ø to 1000 bits per second), Codes utilized (ASCII, Baudot, etc.), and Error checking (Parity, CRC, etc.) inclusion.

TV Readout Description

The TV Readout consists of five interacting sections. They are Memory, Character Generation, Composite Video Output, Read Clock, and Write Clock. The memory section consists of seven 2102A-2 or faster 1K memories. Only one half of each memory is used, giving a possible storage of 512 seven bit ASCII characters. The microprocessor, keyboard, or some attached circuit writes the characters one by one into the 2102's, and then the TV Readout continuously displays these characters until either more characters are entered, or the circuit is turned off.

The character generation circuit consists of two IC's, the MCM6571L character generator, and 74165 parallel to serial converting shift register. The 6571 takes the seven bit ASCII character coming from the memories and outputs 7 dots making up a character row for each of 13 potential rows making up each character. The 74165 loads these 7 dots coming out at a time into its internal memory, and then outputs these one at a time for serial transmission to a TV set. For more information on TV character generators, I would suggest reading an excellent article by Don Lancaster in June, 1974 Radio-Electronics (p. 48 - 52).

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The video output section uses a 7401 open collector NAND gate and a driver transistor to produce a low impedence composite video signal. The output is around 2 volts point-to-point with about a 1/2 volt horizontal and vertical sync and blanking pedestal.

The Read Clock is the master control of the various sections. Starting from an initial frequency of 5.990 MHz, a countdown chain of three 74193's (IC's 32, 17, &21) produce an 8µs horizontal sync when gated by 1/6 IC11, 1/2 IC20, 1/3 IC18, and 2/4 IC13. A 41 µs horizontal blanking circuit prevents loss of characters at the edges of the screen, and is produced by the gating action of IC14, 2/6 IC11, and 1/4 IC13. The resultant horizontal frequency is 15,598 Hz, somewhat lower than the standard 15,750 Hz, but usually only requires trimming horizontal hold slightly if at all.

The vertical countdown chain uses three more 74193's (IC's 24, 10, and 12) to obtain a final vertical frequency of 60 Hz, syncronous with the AC line to avoid hum roll and wobble problems on low cost TV's. 3/6 IC19 and IC25 produce an 820µs Vertical sync pulse, 1/3 IC18 and 1/6 IC19 give a ÷ 22 gating to IC's 10 and 12, and the 1/6 IC 19 produces a 3.5ms Vertical blanking pulse.

As if these operations weren't enough, various timings from the Read Clock also tell which of the 13, which make up each character, is being currently accessed, and loads the 74165 when the row of 7 dots is available from the 6571. The 5.990 MHz signal then shifts out 8 dot periods (the 8th one is a horizontal space between characters) before the next dot load command occurs. All of these timings are very critical during the design phase, but the builder should have no problems, since no adjustments are needed. The Read Clock also controls which of 512 characters is currently being inputed to the 6571 for dot encoding, except during Write Clock times.

I thought you'd never ask about the Write Clock. Well, it controls the entry of the characters from whatever external source into the 2102 memory bank. Several alternatives in character entry are possible. However, this design tries to be as simple as possible, yet give the user a very capable unit, particularly when using a microprocessor, or even mini, midi, or maxi processors.

A sequential entry system is utilized. A Home Reset control signal is developed by IC22 when it detects all of the 8 input lines high ("1"). IC's 9, 16, & 29 are then preset so that the next character to be entered will result in its being displayed as the top leftmost character on the screen. The 2nd character will be viewed to the right of the first, ... until on the 33rd character a new line appears, displaying the 33rd character. Up to 512 characters are thus sequentially entered and displayed. If a 513th and following characters are entered, an overwrite condition results, with the new page load displayed from the top leftmost, the former character overwritten "gone forever". The display may be reset at any time. Screen erase consists of either 512 or more ASCII "spaces" (Octal 240) and an ASCII ■ (all bits on), or an ASCII ■ and exactly 512 ASCII spaces, the latter being preferable.

Memory writing occurs when the MSB goes high. The 74157's then allow the 74193's IC9, 16, &29 in the Write Clock to control the memory address lines on a priority interrupt basis. 600 ns later, a 600 ns strobe pulse writes the new character into memory.

An excellent idea was suggested by Phil Mork in the Digital Group Clearinghouse to utilize a parallel logic path to step the Write Clock address without writing a character. This produces a "Pseudo Cursor" effect without the usual expense of a number of comparators, etc. A software "blink" may be easily implemented with a final result indistinguishable from a hardware cursor. The "Pseudo Cursor" logic consists of 1/6 IC19 and 1/4 IC27 which detect the presence of an LSB, toggling the Write Clock 74193's up in count without firing the 74123 Write Strobe if not simultaneously brought high (indicating character entry then, of course).

Whew!

Cassette Interface Circuit Description

The cassette record circuitry consists of a single IC (IC33), a 566 voltage controlled oscillator. A logic level input at pin 18 on the connector controls the resultant audio frequency at output pin 10. A high input ("1") produces a 2125 Hz output, and a low output ("Ø") results in 2975 Hz. The output wave shape is a symetrical triangular wave. Should the user object to using a triangular wave, a more nearly sine wave can be obtained by connecting a pair of back to back 1N914 diodes between the ground bus and the output side of the .01 condenser in the VCO.

Exact values and high quality components will result in a troublefree VCO. The 47K (R17) resistor in series with the output is a typical value to be used when coupling to the low level, low impedence external microphone inputs of most cassette recorders.

The cassette receive circuitry detects the prerecorded frequency shift keying and produces a "1" or a "Ø" output as a result of a detected 2125 Hz or 2975 Hz tone at the input. IC34 is a clamped limiter which prevents variations in amplitude from affecting the resultant detection process. The output of IC34 should be about 1.2 volts p-p, roughly a square wave of the incoming frequency, constant in amplitude regardless of tape volume setting or minor tape "dropout" problems.

Two bandpass active filters then amplify a tone 5 times when actually tuned to their respective frequencies of 2975 Hz for the top filter and 2125 Hz for the lower filter. The further off the tuned frequency the tone is, the less amplification the filter will produce. Notice that the filters are identical except for one resistor in each, R26 and R25. The actual resonance points of the filters may be easily adjusted by merely trimming this one resistor in each filter.

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Full wave active detectors produce rectified full wave pulses at the summing junction, pin 5 of IC37. The 2975 Hz tones are rectified +, and the 2125 Hz tones are rectified -. As tones depart from either exact frequency, a value less + or - is produced until approximately midway a summed voltage of Ø results.

A 3-pole lowpass active filter then removes the remaining traces of pulsating DC from the summed signal with almost no effect on the data pulses up to a speed of 1000 bits per second. If lower data rates were to be utilized, an improved signal to noise ratio could be obtained by multiplying the values of C12, C13, and C14 by the reciprocal of the data rate difference. I doubt you would notice any operational difference, however.

The final section is a slicer connected 741 (IC38). This op amp detects whether the voltage at its pin 2 is + or - with respect to the constant voltage at its pin 3. The output volatge will then swing either to nearly +5 or to nearly -12. A forward biased germanium diode prevents the actual output voltage from going less than ≈ -.2 volts, so that valid TTL levels are not exceeded. An offset adjusting pot allows the output to be placed in a "Mark Hold" condition when no tone input is being detected.

Construction

Tools: Fine tipped, low wattage soldering iron, "wire solder" (around 20 guage resin solder), small diagonal cutters

Test Equipment: Ohmeter
Audio Generator
10 MHz or better triggered sweep oscilloscope
Frequency Counter
Microprocessor, Mini, etc.

Estimated Construction Time: 5 - 10 hours

1. Insert the 24-pin socket, 6 8-pin sockets, 21 16-pin sockets, and 10 14-pin sockets into the PC Board. If the sockets have a keyway indication, orient this away from the connector. Note- the top side of the board is indicated by The Digital Group label.

2. Invert the board and carefully solder in the sockets. A special plating process is used by the Digital Group to minimize solder joint troubles. We would suggest a "warmup area" by starting with the cassette interface sections of the card.

3. Insert and solder the 11 resistors in the TV Readout section enclosed by the bus lines. Insert and solder the 28 resistors in the cassette section.

4. Insert and solder the 2 zener diodes, the germanium diode, and the 9 silicon diodes. Note - all of the diodes are oriented with their cathode or "bar" end oriented towards the right.

5. Insert and solder the output transistor in the TV Readout section.

6. Insert and solder the three 220 pfd and the 100 pfd condensers in the TV Readout section.

7. Insert and solder the thirteen condensers in the Cassette Interface section.

8. Insert and solder the three potentionmeters in the Cassette section. Note that the potentionmeter at the top right is a 50K, the others being 5K's.

9. Insert and solder the various bypass condensers in the TV Readout section. Note that the positive (+) end of the dipped tantalum condensers is indicated by the vertical marking (paint strip) along one side. Should more bypassing be required in your application, additional holes have been provided.

10. Mount the crystal flat, and carefully solder. Two methods can be used. The pins can be carefully bent and then soldered so that the crystal is held flat. Alternatively, the crystal may be epoxied to the board and short lengths of wire connected between the pins and the connection point. Either way, use a minimum amount of heat on the crystal pins.

11. At this point, measure the resistance between ground (pin 20) and the other voltage supply pins (19, 21, & 22). A very low resistance indicates a bad bypass or a solder bridge short somewhere.

12. Insert the IC's in the TV Readout section except for the memories (2102's) and the MCM6571L character generator. The notch or pin 1 end of each IC should be oriented away from the connector end of the board. Measure the resistance between pins 19 & 20, noting the value. Reverse the ohmeter leads and remeasure. A shorted reading indicates a bad IC, and near equal readings indicates a reversed IC.

13. Temporarily ground pin 1 of the TV readout and connect a TV set modified for direct video, or a commercial TV monitor, between pins 16 (video) and 20 (ground).

14. Putting a +5 voltage between pins 19 (+) and 20 (Ground) should result in 32 vertical white columns on the screen. Refer to "Troubles" section if this does not happen.

15. Connect the other ±12 supplies, and turn on power again. Measure the voltages on pins 1, 2, and 3 of the MCM6571L socket. They should measure -5, +5, and +12 respectively.

16. Plug in the 2102's and the 6571. The temporary grounding jumper to pin 1 should still be connected as well as the TV monitor. Turning on power this time should result in a random display of

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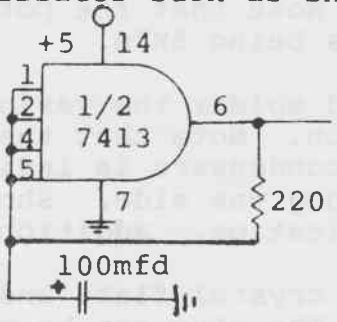
512 characters on the screen. The actual character at each location is determined by the chance bit structure at the memory locations. Remove the temporary grounding jumper from pin 1 when done with this test.

17. Complete testing of the TV Readout is best performed under microprocessor control, and sample diagnostic programs are included with the Digital Group Systems. "Breadboard diagnostic testing" may be accomplished by temporarily tieing each of pins 2 - 8 to +5 through a 1K resistor. Tie pin 1 to the output of a simple oscillator such as shown below:



Grounding pins 2 - 8 to ground should produce:

pin to ground	Character
8	~
7	}
6	{
5	w
4	o
3	
2	?

Connecting combinations of pins 2 - 8 will result in all of the various characters being entered. In case of problems, refer to "Troubles".

18. Plug in the six IC's in the Cassette section.

19. Connect a calibrated audio oscillator between pin 9 and ground. Set the oscillator to a range covering 2 KHz - 3 KHz, with a sine wave output of .1 volt or more (precise output level not important).

20. Apply +5 and ±12 voltages to the board. Measure the output at pin 6 of the 741 limiter (IC34) with an oscilloscope. The waveshape should be an approximate square wave of about .6 volts p-p.

21. Set the audio oscillator to about 2 KHz. Measure the output at pin 1 of the 5558 active banfpass limiter (IC35). Rock the oscillator's frequency, noting the exact frequency where the output at pin 1 peaks. This will generally be somewhat below

the desired frequency of 2125 Hz. A special set of pads is provided beneath, and in parallel with, the 750 ohm resistor (R25). By putting progressively lower values of resistor (starting with 22K) in parallel with the 750 ohm resistor, the resonant point of the active filter can be raised, and the final value (generally about 10K - provided) coming closest soldered in.

22. Similarly, set the oscillator to about 3 KHz and measure the output at pin 7 of the 5558 (IC35). This time tune to 2975 Hz by trying resistors below the 390 ohm resistor (R26). Generally, about 2.7K (supplied) produces a 2975 Hz resonance.

23. Measure the detected voltages at pin 5 of IC 37. When the audio oscillator approaches 2125, the output should go -. When approaching 2975, the output should go +. Trouble in this area would most likely be caused by reversed or defective diodes, or adjacent line shorts.

24. Measure the voltage at the cathode (bar) end of the output clamping germanium diode (G1). Sweeping the frequency between 2125 and 2975 Hz should result in a clean voltage jump somewhere between 2125 and 2975. Be sure that the negative-most voltage at this point is about -.2 volts.

25. Remove the audio oscillator and short input pin 9 temporarily to ground. Measure the output at pin 6 of IC34 again. A stable condition (no oscillation) should be seen. Connect the oscilloscope to the cathode of G1 again. Adjust the balance potentionmeter R42 clockwise so that the voltage is at a - level. Slowly turn the potentionmeter counterclockwise until the voltage jumps + and leave setting at this point.

26. Disconnect the temporary jumper from connector pin 9 and reconnect the audio oscillator. Perform step 24 again. If all proceeds well at this point, the cassette interface is ready to receive data.

27. Connect the oscilloscope to pin 4 of the 566 Voltage Controlled Oscillator (IC33). A triangular wave output should be seen.

28. Connect a temporary jumper between connector pin 18 and +5 (connector pin 19 is a handy +5 source). Connect a frequency counter to pin 4 of the VCO (IC33). Adjust the middle potentionmeter (R41) for a resultant output frequency of 2125 Hz.

29. Remove the jumper from +5 (pin 19), and connect to ground (connector pin 20 is fine). This time adjust R40 for 2975 Hz output.

30. Remove the jumpers and you are ready for final tune in the driving circuit. Connect the Cassette interface to the driving output port, and program the driving processor to send a + output to the cassette interface. Adjust R41 for 2125 Hz.

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Then have the processor send a Ø level. This time adjust R40 for 2975 Hz. The cassette interface is now ready for use.

Troubles - General

1. One of the more difficult troubles to find is an IC pin which was bent under the IC when it was inserted. Any unusual pressure when inserting an IC should be investigated.

2. Every pin should be soldered. The most frequent cause of trouble is an unsoldered pin, generally an end IC pin. Carefully sighting down parallel rows of pins usually finds any that are not soldered.

3. When troubleshooting with a 'scope probe, measure from the top side of the IC, not the bottom, to eliminate a bent under pin problem or defective socket from misleading.

4. Before ever plugging in any IC's, always measure the voltages at the PC board and at the pins of the more expensive IC's, like the 6571.

5. When handling IC's, avoid static charges. Run your house humidity high, and ground yourself by touching a grounded chassis before touching IC's.

6. Beware of solder splashes and drilling errors. Please inform the Digital Group of board manufacturing errors that you detect. A flashover or splash on the topside would be very difficult to find after soldering in the sockets. The black socket body of the sockets used in the Digital Group kits may be pried off after removing the IC should a hidden splash be suspected.

7. Beware of shorts in the cassette area between component leads and underlying circuitry.

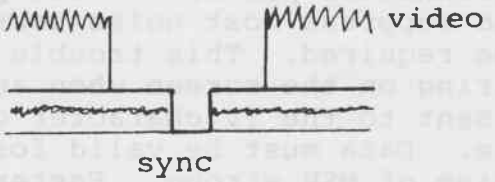
Specific Troubles

No white columns on the screen at step 14.

1. Bad connection between connector pin 16 and TV.
2. Temporary jumper from connector pin 1 to ground not connected.
3. Crystal not oscillating. Check for pulses at pin 1 of IC27.
4. Horizontal Countdown chain defective. Successively measure output at pin 3 of IC's 32, 17, and 21. Each should be progressively lower in frequency.
5. Vertical Countdown chain defective. As above #4, but measure IC's 24, 10, and 12.
6. Defective video mixer. Look for pulses at pins 1 and 13 of IC 26.

Poor or lacking syncronization at step 14.

1. TV is overloaded by the ≈ 3 volts of video. Swamp the video with a 10 ohm resistor to see if sync & video stabilizes.
2. Check for Horizontal and Vertical sync and blanking pulses at connector pin 16. A 75 ohm load should be attached. The pattern should look like:



   a. If Horizontal Sync is defective, check IC's 11, 20, 18, and 13.
   b. If Vertical Sync is defective, check IC's 19 and 25.
   c. If Horizontal Blank, check IC's 11, 13, and 14.
   d. If Vertical Blank, IC 19.

No characters at Step 16.

1. Missing voltages at the MCM6571 (IC30).
2. Defective Character generator.
3. Defective 74165 (IC31).
4. Defective logic signals to and from IC30 and IC31. All inputs and outputs should be pulsing at valid TTL levels (Ø to .8 volts = low; 2 to 5 volts = high).

Wrong character(s) in display

1. Miswired or misjumpered input.
2. Defective Memory IC. Note the bit difference between the intended character. IC1 is the memory for the Least Significant Bit (LSB) of the character ... and IC7 is the Most Significant Bit's (MSB) memory.
3. Defective 74157(s) - IC's 8, 15, and 28.

"Twinkling" character on TV

1. Slow memories. 650 nanoseconds or faster 2102's must be used.
2. Overheated memories. Access times increase with heat.
3. Wrong pulse levels at pin 1 of the 74165 (IC31). A base level of about 2.5 volts with short positive and negative going spikes should be seen.

Won't write characters

1. Missing Strobe pulse, or continuous level on MSB input (connector pin 1).
2. No Write pulse from 74123. Measure at pin 12 of IC 23, looking for an ≈ 600 ns negative going pulse. Connecting the MSB (connector pin 1) to a ≈ 50KHz TTL clock will permit viewing on lower cost oscilloscopes.

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3. Write Clock not toggling. With above temporary oscillator inputting to MSB, look for pulses at pin 3 of IC's 16, 29, and 9.
4. Defective Read/Write Multiplexers (IC's 15, 28, and 8).

Extraneous Characters

1. Noise on the input lines to the memory, particularly on the MSB (connector pin 1). A 220 pfd condenser is used on the MSB to suppress most noise sources. More or larger condensers may be required. This trouble generally shows up as an α appearing on the screen when another port is addressed.
2. Data sent to the TV character generator faster than it can handle. Data must be valid for 1.5 microseconds following the rise of MSB strobe. Faster data rates can be handled by reducing the value of the condensers in the 74123 Write strobe singleshot. Alternatively, a data hold loop consisting of NOP's can slow the data output to the readout.
3. Defective or slow memories. Look at the bit pattern of the extraneous character to determine if a single memory is bad.
4. More bypassing required. A number of unused voltage bypassing pads have been included should your particular system require them.

Defective level output from Cassette Input Limiter

1. None at all: Check for ±12 to IC34.
2. Too high output level. Diodes (S4 and S5) open or one is reversed.

Bandpass Active Filter Problems

1. Check audio oscillator for proper range.
2. Swap 5558 (IC35) with IC's 36 or 37.
3. Check for shorts or out of tolerance (5%) condensers C8, C9, C10, or C11. Disc ceramics are a no-no in tuned circuits!

Full Wave Detector

1. Diodes open, reversed or shorted.
2. Defective 5558 (IC36)

Low Pass Active Filter

1. Shorted or out of tolerance condensers.
2. Defective IC37.

Output Slicer (IC38)

1. Reversed, open, or not Germanium diode at G1.
2. Too heavily loaded output. This circuit should drive no more than one TTL load. (Standard for most I/O ports.)

TV READOUT & CASSETTE INTERFACE - PARTS LIST

IC's

IC1-7	2102-1, -2 or better
IC30	MCM6571L
IC13, 14,	7400
IC26	7401
IC11, 19	7404
IC18	7410
IC20	7420
IC22, 25	7430
IC23	74123
IC8, 15, 28	74157
IC31	74165
IC9, 10, 12, 16, 17 21, 24, 29, 32	74193
IC33	566
IC34, 38	741
IC35, 36, 37	558 or LM1458
IC27	74L00

Capacitors

C3	100 pfd mylar
C1, C2, C4	220 pfd mylar
C12	.01 mylar
C14	.015 mylar
C6	.047 mylar
C13	.0056 mylar
C8 - C11	.01 polystyrene
C7	.001 disc
C5	.033 disc

Diodes

S1 - S9	1N914 or 1N4148
G1	1N48 or eq. Germanium
Z1, Z2	5V 1 watt zener
T1	2N5129

Bypass Capacitors

15 - .01 mfd disc
7 - 1 to 3.3 mfd tantalums

Crystal

1 - 5.990 MHz

Resistors - all 1/4 watt 5% unless noted

R8	22 ohm
R3	220 ohm
R16	220 ohm 1/2 watt
R26	390 ohm
R4, 5, 6	470 ohm
R38	470 ohm 1/2 watt
R25	750 ohm
R10, 11, 37	1K
R9, 15	1.3K
R14	1.6K
R7	2.2K
Trim below R26	5.6K
R12	5.6K
R1, 2, 21, 22	6.8K
R13, 18, 19, 20 27 - 30 & trim below R25	10K
R35, 36	10K
R17, 32, 34	47K
R23, 24	68K
R31, 33, 39	100K
R40, 41	5K trimpot
R42	50K trim.

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VCO won't oscillate

1. Defective 566 (IC33).
2. Shorted condenser C6.

VCO has parasitic oscillation

1. C7 not connected.
2. Defective 566.

VCO won't tune to frequency.

1. Out of tolerance C6. You really didn't use a disc ceramic, did you?
2. Defective 566.
3. Non-TTL levels used to drive circuit.
4. Defective potentionemeters R40 or R41.
5. S1 or Z2 reversed or defective.

Warranty:

Standard Digital Group warranty applies. All Digital Group supplied parts are guaranteed on an exchange basis for 90 days. If you send the TV Readout and Cassette board back to us to fix, the following charges will apply irrespective of the warranty period:

Service charge (fix-it fee) - no final alignment of cassette interface	$20.00
Final alignment of cassette interface	$20.00
Both of above	$30.00

Parts will be charged for units outside of warranty. Service charges should be prepaid and included with the return of the kit for fastest service.

TVC CORRECTIONS

Component changes:

R23 change from 68K to 47K
R22 change from 6.8K to 4.7K
R26 change from 390 to 750
R25 change from 750 to 1K (typical values)
R12 change from 5.6K to 2.7K

IC27 should be changed from a 7400 to a 74L00

The IC was changed to avoid the problem of the crystal oscillator running at a harmonic of the correct frequency. The slower 74L00 damps this tendency out.
R23 and R22 were changed to bring the bandwidth of the 2975 bandpass filter to a more optimal range.
R26 and R25 were enlarged since the previous values were found to be too small at times.
R12 was found to be too large to tune the VCO correctly so it was reduced.

CJ3 change from .015 to .0056
R26 change from 2.2K to 5.6K
R35 , R36 change from 15K to 10K

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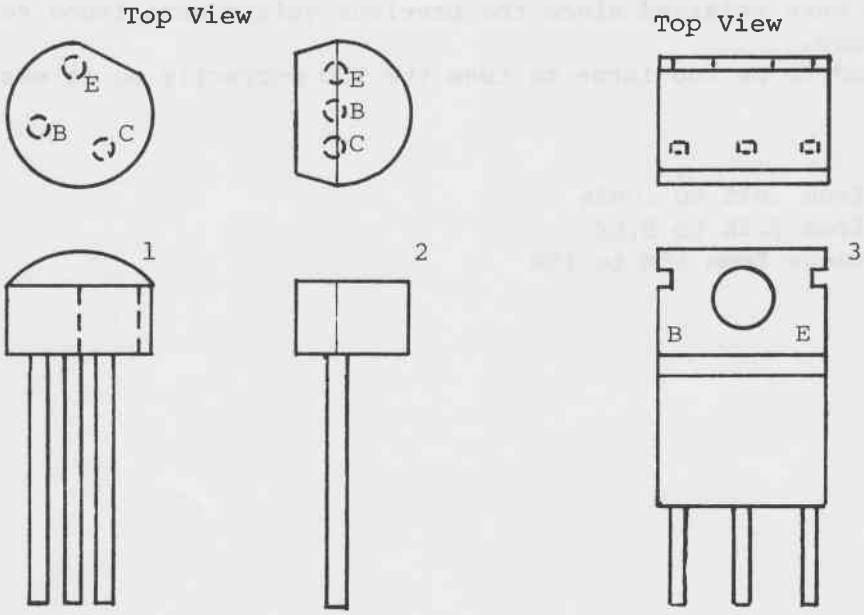
The Digital Group has received some inquiries concerning some transistors that come in different packages but have the same number we hope this effort will help if you are suffering from this problem.



The above represent two different package styles for the same transistor. (2N5129 / 2N5139)

This represents a third style. (2N6109)

The 4402 also appears as style 3.

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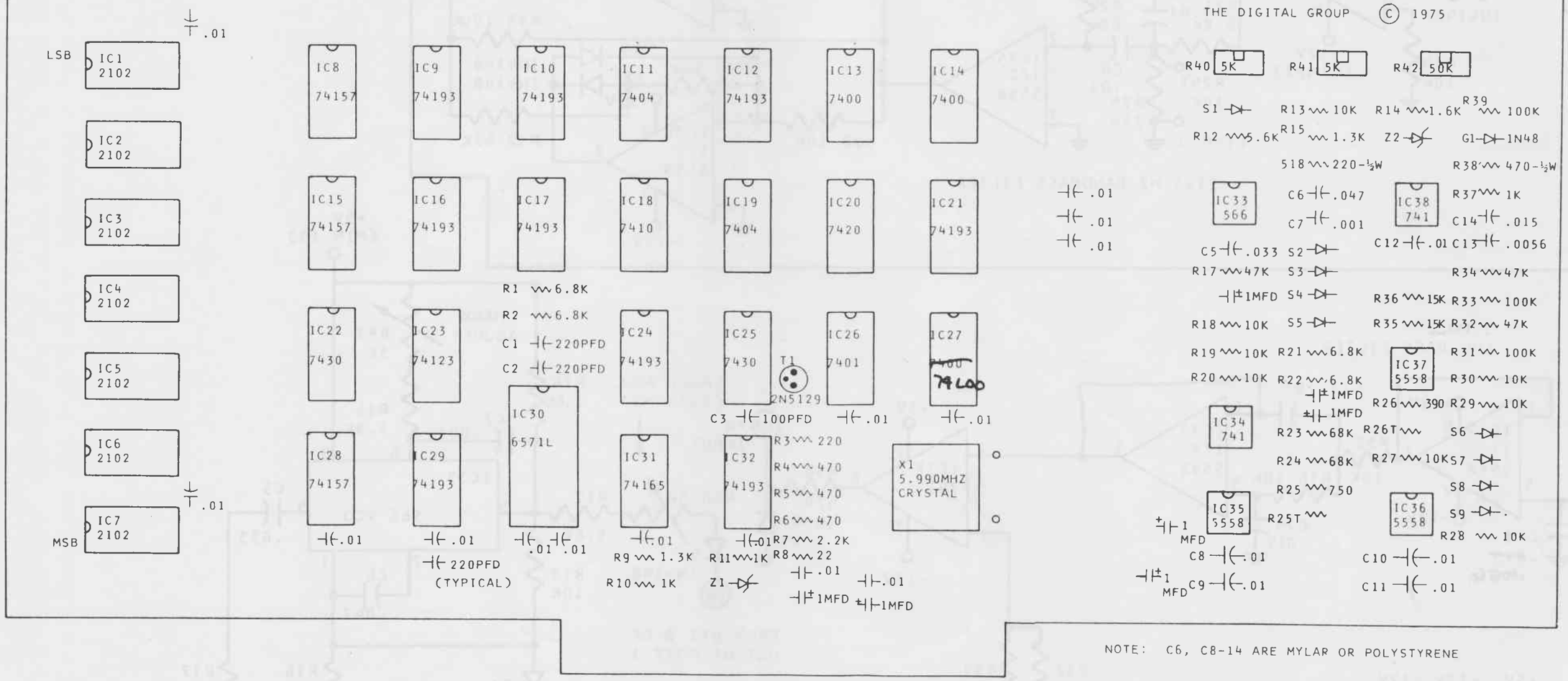
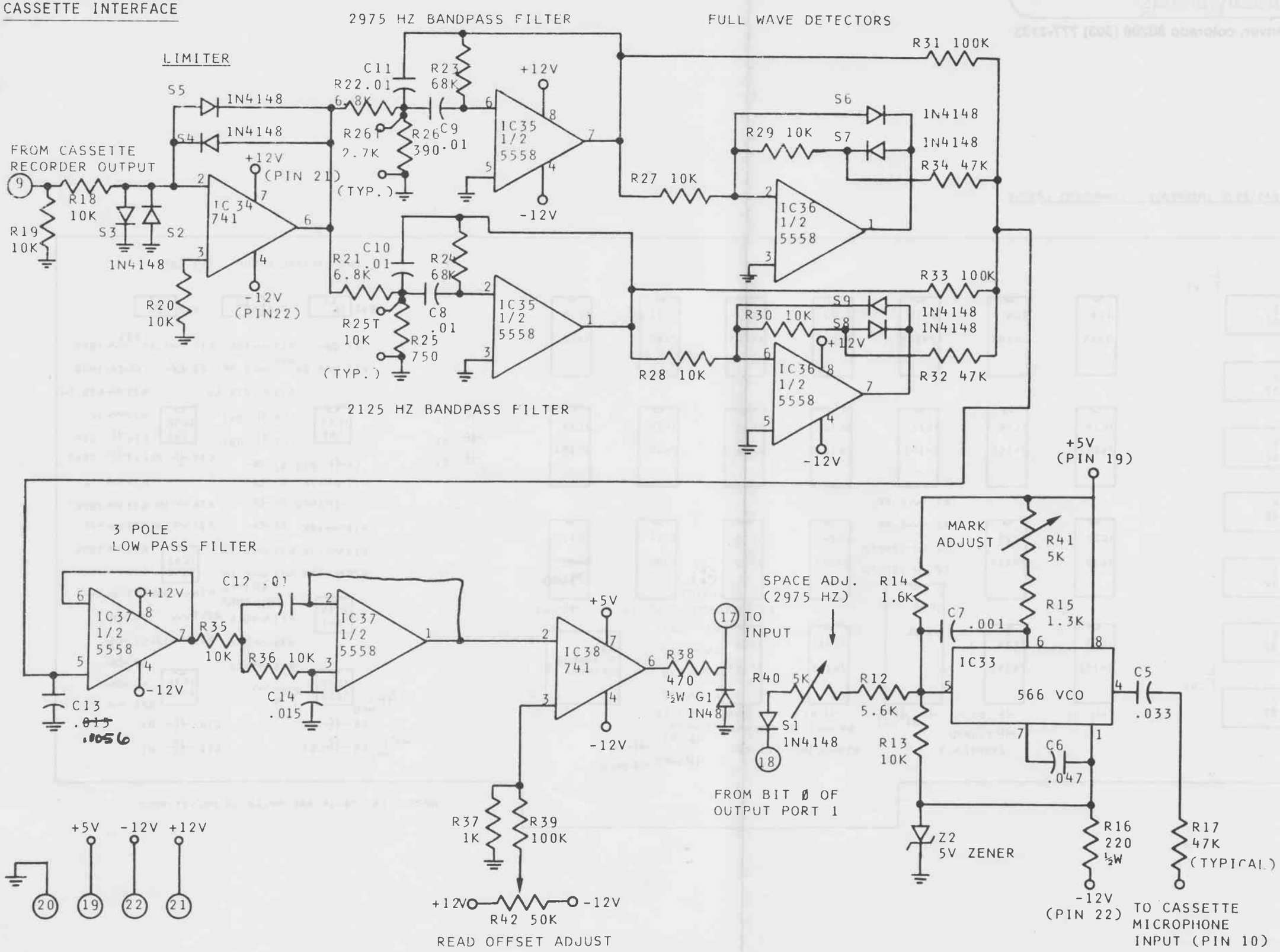
TV READOUT & CASSETTE INTERFACE - COMPONENT LAYOUT

DG-1003-A



NOTE: C6, C8-14 ARE MYLAR OR POLYSTYRENE

CASSETTE INTERFACE



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512 CHARACTER TV READOUT